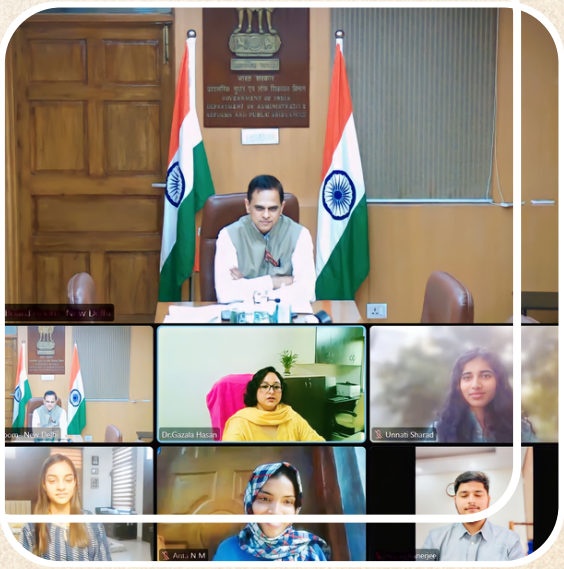
सत्यमेव जयते
Government of India

NCGG

NATIONAL CENTRE FOR GOOD GOVERNANCE

INTERNSHIP COMPENDIUM 2023

BATCH 1



FOREWORD

Shri V. Srinivas, IAS

Director General, National Centre for Good Governance

The National Centre for Good Governance (NCGG) has been at the forefront of fostering excellence in public administration and citizen-centric governance. It acts as an apex institution of the country on governance, public policy, advocacy and capacity building for National and International Civil Servants.

The NCGG Internship Programme stands as an embodiment of our commitment to nurture the future leaders of governance in the country. The Internship Programme serves as a vital stepping stone for budding administrators, equipping them with the skills and knowledge necessary to excel in their future roles. This Internship Programme offers a platform for young minds to acquire new skills and apply them in practical scenarios to surmount challenges by providing them exposure to a gamut of governance and public policy related issues and involving them in possible way ahead to overcome challenges in the way of citizen-centric governance.

Throughout the internship, participants had the opportunity to delve into real-world case studies and contribute to the collective mission of achieving excellence in public administration. The emphasis of the NCGG internship programmes is not only on theoretical knowledge but also on practical exposure, allowing interns to witness firsthand challenges and triumphs of public administration in various ongoing schemes and programmes of Government of India.

NCGG is delighted to witness the continuous influx of bright and dynamic individuals who bring fresh perspectives and innovative ideas to the table. The ability to adapt, collaborate, and think critically is evident in the quality of the work presented by interns and the NCGG. Consequently, this compendium of internship reports has been introduced by NCGG as a testament to the dedication, diligence, and innovative spirit demonstrated by the interns.

ACKNOWLEDGEMENT

Gazala Hasan
Assistant Professor, National Centre for Good Governance

In the symphony of professional growth, there are those whose harmonious efforts compose the melody of success. In line with this sentiment, I would like to extend my heartfelt appreciation for the collective efforts of all who orchestrated the transformative journey of the NCGG Internship Programme since its inception.

Foremost, I would like to extend my gratitude to Shri V. Srinivas, Director General, NCGG and Secretary, DARPG for his vision and guidance in planning and executing the NCGG Internship Programme. He has consistently provided his support in empowering the team to explore and venture beyond our abilities.

I am extremely grateful to my colleagues Dr. A.P. Singh, Dr. B.S. Bisht and Young Professionals working at NCGG for their unwavering support in seamless execution of this internship programme. Their efforts in designing internship curriculum and strategic insights helped in shaping the internship programme that meets the needs of the interns and aligns with the objectives of NCGG.

A big thank you to all the mentors who generously shared their time, expertise, and wisdom with the interns. The mentorship of all the mentors has left a lasting legacy of knowledge, inspiring interns for their professional journeys.

Furthermore, appreciation is extended to every supporting staff member whose invisible hands ensured that every facet of this internship programme sparkled with precision and care. The collaborative efforts of each individual involved have been indispensable, and this internship program would not have been possible without their dedication.

TABLE OF CONTENT

PREFACE

The NCGG Internship Programme serves as a short-term engagement opportunity for students from various domains, spanning a minimum of 8 weeks and a maximum of 6 months. This initiative provides a temporary platform for participants to collaborate with various verticals and units within the National Centre for Good Governance (NCGG). The overarching goal is to mutually benefit both the interns and the Centre by introducing students to the intricacies of public policy and governance concerns. The primary objective is to involve Indian youth to a diverse range of governance and public policy challenges, encouraging their active involvement in analyzing the concerns and conceptualizing solutions for citizen-centric governance.

The Internship Programme seeks to leverage the talents of the country's youth, fostering their growth in terms of knowledge, skills, and theoretical education. The programme offers a unique avenue for interns to delve into specific subjects or areas related to academic research and NCGG's operational functions. A comprehensive nationwide selection process resulted in the selection of approximately thirteen Indian students holding graduate degrees or pursuing post-graduation. Interns were strategically assigned diverse themes encompassing public policy and governance, such as Innovation and Entrepreneurship, Public Service Delivery, Climate Change, Environment and Clean Energy, Water Sanitation, Hygiene and Public Health, Education, Sustainable Development, Agriculture, Project Planning, Designing, and Data Analytics. An orientation programme was conducted seamlessly to provide them with insights into their specific verticals. Each intern is assigned a dedicated supervisor responsible for task assignment, attendance monitoring, and reviewing work. In essence, the NCGG Internship Programme is designed to offer a rich learning experience, facilitating the holistic development of interns while contributing to the advancement of public policy and governance practices.

The compendium of NCGG Internship Programme, 2023 is a compilation of the research reports and their findings submitted by the interns on their specific domains, including, Public Health, Climate Change, Education, Sustainable Development, Agriculture, Waste Management, Land Use Coverage, Service Delivery, and Artificial Intelligence. This compendium throws the light on the research conducted by the interns to overcome challenges in the way of citizen-centric governance. The findings of the researches conducted by the interns are presented in this compendium for wider dissemination. The compendium will act as a knowledge repository to march towards achieving the objectives of citizen-centric governance.

INTRODUCTION

The National Centre for Good Governance (NCGG) is an autonomous institution operating under the aegis of the Department of Administrative Reforms and Public Grievances (DARPG), Ministry of Personnel, Public Grievances and Pensions. NCGG is dedicated to promoting excellence in governance. Serving as a think tank for governance and policy reforms in diverse domains such as social, economic, administrative, and financial sectors, NCGG extends its capacity-building support to public officials not only in India but also in other developing nations.

Since its inception, the NCGG has been extensively working in areas such as primary and elementary education, decentralized planning at district and block levels, capacity building of Panchayat Raj Institutions (PRIs) and Civil Officers of various countries, participatory models of learning and action, rural development, and public sector management. In addition, it focuses on issues related to good governance, social accountability, water, sanitation and hygiene (WASH), among other sectors.

The center encapsulates the core principles of good governance, emphasizing the significance of the rule of law, transparency, and the promotion of public participation in governance, service delivery, and reforms. It is committed to cultivating individuals with diligence and expertise in the ever-evolving landscape of public administration.

In the dynamic landscape of public administration, experiential learning is crucible where theory transforms into practice, and skills blossom into expertise. As we navigate the intricate tapestry of governance, the NCGG has embarked on a transformative journey by crafting an enriching internship program. This compendium unravels the narrative of this distinctive initiative, delving into the corridors of practical knowledge and professional growth.The internship program, a cornerstone of this commitment, serves as a crucible for aspiring individuals to immerse themselves in the intricate facets of public service, policy formulation, and good governance practices.

The Compendium 2023 of the NCGG's Internship Program elucidates its structure, objectives, and the invaluable experiences it bestows upon the participants. It unravels the symbiotic relationship between theoretical knowledge and practical application, shedding light on how interns contributed and benefited from the NCGG. In a nutshell, the Compendium 2023 delves into the impact of the internship program on individual professional development, highlighting the dedication and learning experiences of the interns.

Aditi Gupta

M.Sc. in Economics, TERI School of Advanced Studies, New Delhi.
Mentored by Shri Ranjit Kumar, Director, National Jal Jeevan Mission.

Domain for Internship: Public Policy & Governance

Capacity Building of Public Health Engineering Services- An Analysis Research

Capacity building is a multi-faceted process and requires an active involvement of all the stakeholders. The current study delves into the domain of public health engineering services, focusing on safe drinking water. The study comprehensively examines stakeholders involved in the process, identifying capacity constraints at various stages and proposing solutions for redressal. The study evaluates State and Central schemes, such as WASMO Gujarat, Jal Nirmal Karnataka, Jalanidhi Kerala, National Jal Jeevan Mission and Basudha Odisha, highlighting best practices related to capacity building, at both demand-side and supply-side governance. Special attention has been given to the Jal Jeevan Mission, which has demonstrated noteworthy achievements by incorporating effective practices. The study conducted an in-depth review of capacity building initiatives in both rural water supply and urban drinking water sectors. The research briefly touched upon the implementation of Water Safety Plans and explores the WASH services provided by WHO and UNICEF. It has been found in the study that the integral role of education in shaping health outcomes and the need for well-rounded policies that consider not only quantitative targets but also sustainable resource management and community behavioral changes.

Keywords: capacity building, public health, stakeholders, water sanitation and hygiene

Acknowledgement

I would like to take this opportunity to extend my gratitude to Shri V Srinivas, DAR&PG and Director General, NCGG for giving me the opportunity to work on this project and providing the necessary support and guidance. I would also like to thank my mentor Shri Ranjith Kumar, Director, National Jal Jeevan Mission, Department of Drinking Water and Sanitation under Ministry of Jal Shakti without the able guidance of whom, this project would not have been possible. The insights gained from and the experience of my mentor have added immense value to this report. My co-interns and the entire NCGG team speciallyGazala Hasan Ma'am and Akash Sikdar Sir have helped to make this experience an extremely knowledge enhancing and an enriching one.

Introduction

Public Health Engineering Services is a field that broadly deals with provision of clean and safe water supply, sanitation and environmental health services to populations. Capacity building is associated with inculcation and strengthening of skills, instincts and capabilities in order to efficiently manage and utilize resources that help to bring out an outcome that translates into welfare maximizing gains. Water is essential to sustain life and capacity constraints individually as well as in aggregate in the stages of provision of water supply both in the urban as well as the rural areas hinders an effective and timely access to this life-sustaining resource.

At a wider perspective, capacity also takes into account the ability to "perform multi-dimensional concept, encompassing financial, human resources, institutional, socio-political, and technical issues (Lebel and Reed,2010). In the present scenario it is capacity that can help solve the major developmental and environmental challenges that have ever widening catastrophic circumstances. Training, educating, assisting and community outreach and engagement will go a long way in bringing about a transformation that is sustained over a long period of time and goes beyond completion of task to bringing about behavioral changes in attitudes and people's mindset. It is ultimately the behavioral changes that will help in the conservation of life sustaining water resources and its optimal utilization.

Capacity building is a multi-faceted process and requires an active involvement of all the stakeholders in the process of water supply starting from the operators of water catchments to the final consumers. A holistic approach to identify and analyze the capacity constraints in the stages of planning, execution and implementation would help us to understand the gaps and use public policy and good governance in bridging them to realize an outcome that is desirable and public welfare maximizing.

The sustainable development goal (SDG) 6 deals with universal and equitable access to drinking water with section 6A focusing to expand cooperation and capacity building in water and sanitation related programmes and activities specially in developing countries and section 6B aiming to support and strengthen local community participation in water and sanitation management by the year 2030. Capacity building is vital to effectively tackle current challenges both global and national, owing to climate change which leads to environmental, economic and social developmental setbacks affecting the quality of life of people. Achieving the sustainable development goal 6 will help ensure the adequacy of capacity to deal with water related risks and ensure a better access to and development of water resource which is sustainable. A capacity building example from rural India put forward events to raise awareness at village level alongside introduction of Water Safety Plans, including preparation of leaflets particularly targeted at empowering women's groups (Rouse et al., 2010)

Our country is also characterized by heterogeneity in level of awareness, socio-economic development, education, poverty, traditional practices and rituals which add to the complexity of providing safe water. These can be addressed through an inclusive capacity building exercise that includes the complexities of community dynamics.

In terms of public policy and governance, government policies and programmes has also undergone a series of transitions ever since independence. Initially, setting up physical infrastructure in form of handpumps was more emphasized. Thereafter there was a transition from technology measures to a socio-technological approach seeking close participation of

people. For ensuring long termism and sustainability of the systems, steps were initiated in 1999 to institutionalize community participation in the implementation of rural drinking water supply schemes through the sector reforms project. This resulted in a paradigm shift from "Government supply oriented driven approach" to "People oriented and demand responsive approach". People's participation has led to numerous optimistic results. Also, Water quality monitoring has now become an important part of the government programme.

This paper has sections that first identify the capacity constraints across different stages involved in the provision of clean and safe drinking water across dimensions like stakeholders, level of implementation, rural or urban setting and suggesting possible solutions and best practices. It comprehensively analyses the capacity building programmes for a socio-economic aspect, analyses schemes and practices in the water sector and brings out a unique framework to incorporate the socio-economic aspects in addition to the technicalities involved in the process. Communities and people's participation is also paramount. It also looks at the Water safety plans implemented by WHO and progress of wash practices in making the process of water provision sustainable and minimizes wastages.

Objectives

The paper has the following objectives:

- To analyze and document the best capacity building practices across select policies, programmes and schemes and the analysis of their efficiency from a socio-economic point of view in the access and provision of safe water.

- To bring out a socio-economic aspect of water provision and make the best possible useof it in bridging the gap between public's perception of the impact of policies and the actual impact.

- To understand the dual aspect of capacity building both from the point of view of the common people and the designers of policy and good governance.

Stakeholders Involved in Providing Safe Drinking Water

The provision of safe drinking water involves multifarious stakeholders across different stages and may be targeted by capacity building to bridge the various gaps which diverges the efforts and the impacts of well thought of water policies and programmes from bringing about actual and welfare maximizing returns to the society.

This paper aims to analyze the role of capacity building in improving the efficacy and social returns to the following stakeholders.

Operators of drinking water supply systems which may be small or large, a public or private utility or local government employees or contractors directly associated with the responsibility for operations and maintenance.

Local health agencies and national public health agencies act as regulators and are typically responsible for independent surveillance of drinking water supplies.
There is a lot of literature that recommends cooperation and coordination between operators and public health authorities and encourage training of health officers risk management methodologies (Gunnarsdóttir, 2012; Gunnarsdottir et al., 2012; Aghaei et al., 2017)

Technicians both skilled and semi-skilled help in installation of complex systems. In most cases, the responsibility to manage the operations and development are delegated to the Gram Panchayats and sub committees like Pani Samities. Community-based water supplies in high-income as well as low- and middle-income countries share common limitations such as limited access to skilled technicians. (Marks et al., 2018)

National and State authorities help in enabling the environment through policy designing, legislative support and developing welfare and health-based targets. They help in the facilitation and coordination of different experts and ministries and helps to manage scale and effective resource management. Theys also support water supply and safety initiatives financially.

Consumers are responsible for the safekeeping of the delivered water, preventing pollution and contamination during storage and handling and providing feedback on water quality and other constraints. Consumer feedback is important as it can lead to accountability mechanisms where consumers advocate for services and share their concerns with the authorities under charge.

Local And National Civil Society Organizations include non-governmental organizations and not for profit organizations that work for the betterment of the societies and facilitate capacity building and mass awareness programmes. They also help in providing tools and documents which form an important source for developing national guidance and supporting resources.

Research Community works on multiple fronts which supports capacity building and training and works to minimize cost and optimize effectiveness of public policies relating to safe water supply in our case by conducting research and policy evaluation exercises.

Methodology

The methodology involves systematic literature review of both peer reviewed research papers and grey literature involving analysis of reports and articles from policy documents, popular media and other sources. It also includes insights from the Rural Wash Partnership Forum's session. This project has been taken up under the guidance of National Centre for Good Governance and Department of Drinking Water and Sanitation under Ministry of Jal Shakti, Government of India.

A systematic search approach was adopted to review scientific literature on capacity building and training pertaining to drinking water supply. Identification of grey literature as well as peer reviewed articles and research papers was done using Google scholar search limited to first 200 results. The keywords and search terms used were drinking water supply, capacity building and development, sustainability of drinking water supply individually as well as together. Insights from various discussions with my mentor Shri Ranjith Kumar are also included indirectly in the report.

Data Collection and Limitations

The data presented in the analysis and policy evaluations is majorly secondary data collected from the Jal Jeevan Mission Dashboard and IMIS dashboard which presented data on a real time basis.

Limitations

- It was difficult to collect data or find appropriate proxy variables from secondary data for some variables in the stages of the water supply. Thus, data has been taken in the form percentages in relative terms from reliable data sources like World Bank, UN agencies and Niti Ayog reports.

- On some instances it was difficult to draw comparisons and establish conclusions because some data was collected on a yearly basis while some on real time basis.

- The results have been presented as percentage comparisons or tabular forms in the appropriate sections.

- A lot of potential of the paper could not be harnessed to its optimal scope due to time and other constraints.

Stages Involved Provision of Safe Water Supply an Analysis of Capacity Constraints and Possible Solutions

1. Planning and Design of Programmes

A comprehensive design of a water supply management system which is nearer to reality and is flexible to address the capacity constraints in the process is a critical first step. Without the identification looking for solutions would never be a possibility.

Planning and Designing of a system for provision of safe drinking water requires considerable preparation, coordination and cooperation from all the stakeholders and they should work in harmony to complement each other. Water safety issues are multidimensional and need interventions from diverse stakeholders ranging from the local communities to those involved in the fields of research, science and technology. These form the primitive foundation of policy and legislative framework development process which regulates the system's water source, treatment and distribution processes.

Involving people and communities goes a long way in bringing actual results and making sure that the policies are accepted by the public as they feel that their grievances are heard and there are efforts to resolve them. On the other hand, a lot of issues relating to inequality, social mobilization of resources is sometimes witnessed which sometimes leads to inefficiency but to bring in a system that brings about a substantial improvement in the lives of people in terms of access to clean drinking water, better health outcomes and a better quality of life. In order to bridge the gaps in capacity building in this stage widespread awareness programmes which helps the public to understand the relevance of the programme and the benefit that a particular policy or scheme would have on their everyday lives to bring the local communities on the same page as the policy designers would go a long way in making sure that the policy makes a difference in the society and actually trickles down to the grassroot level.

2. Funding And Resource Management

Some schemes regulating the provision of safe water supply are regulated by the respective State Governments while for some there is cost sharing on a predefined ratio basis. In some schemes the cost of pipeline over 25 feet distribution pipe has to be borne by the household. A lot of constraints are faced at this stage which hampers the efficient implementation of

ambitious schemes which hold a lot of potential to make a difference. There are sometimes no clear guidelines about the capital expenditure contribution either in cash or in kind. Recovery of water tariff is a challenge and sometimes there are a lot of obstacles in the collection of water tariff too. This is a necessity so as to manage the cost of motor operator, electrician, repair and management costs and thus there is an active need to address and work on bridging this gap through efficient awareness programs.

The schemes also sometimes do not clearly point out the contribution of operational expenditure from the community. Research and discussion have brought to light the fact that there is a lack of on ground well-functioning institutional arrangements for tariff collection. Also, in case of State funded schemes and policies, the State is deficient of funds to address the problems of scale and efficient implementation. The Jal Jeevan mission has recognized and attempted to bridge these gaps and ensured water coverage on a large scale.

3. Technical Aspects and the Social Aspects

The majority of technicians who supervise the operation and implementation of provision of safe water are civil engineers and as it is evident from the characterization of the Indian Labor Market, there is a huge wave of unemployment affecting the fields of civil and mechanical engineering. Consequently, a majority of the students opt for fields like information technology and computer science which are booming in terms of jobs markets in the present day.

This has led to a dearth of skilled technicians as most students make a switch to booming fields and this has become a major capacity constraint. On the other hand, the curriculum of civil and environmental engineering involves a lot of technical aspects and the aspect of dealing with people is often overlooked. Thus, on the ground level, the technical skills and training just work towards the functioning of the water systems from the catchment to the consumers. The aspect of making it work from the point of view of involvement of final consumers and communities that go a long way in making a plan long term and sustainable and convinces the communities that it is their own water supply system. These capacity constraints have been addressed to an extent in the implementation of Jal Jeevan Mission and also some state sponsored schemes like Gujarat’s WASMO model.

4. Operations And Management

One fundamental pre requisite for a smooth functioning of operation and management of safe water supply through pipelines or otherwise is community engagement and outreach. While analyzing the salient feature of a few States sponsored programme, we found out that the main parameter for success in a majority of the schemes was involvement of the public and community Participation Inclusion of women from self-help groups and awareness creation helps in effective implementation. Lack of prioritization of funds for operations and management, falling groundwater levels in dry regions or otherwise and contamination of ground water due to chemicals used in agriculture activities are serious problems brought out by existing literature and research surveys.

Capacity constraints under Operations and Management affect the delivery of service. This is termed as a governance issue. Some governance structures especially the decentralized models are not perfectly operational in terms of devolution of power and capacities.

There is a challenge to identify appropriate governance structures to develop appropriate

information, education and Communication systems to enhance capacities of the community as a whole. Another capacity constraint is a fragmented approach and absence of coordination between different agencies for supply of water.

5. Quality Testing

Quality testing is an essential stage which requires the intervention of experts who are well experienced and skilled technicians to carry out water quality tests with efficiency. It also requires well equipped laboratories. The lack of both these factors adds to capacity constraints and calls for training of personnel and technicians. In addition to this, the final consumers of water also need to be sensitized and made aware of the need and relevance of being vigilant about the water quality and getting the water they use for domestic purposes to make sure it is of the prescribed quantity and quality.

The Jal Jeevan mission lays special emphasis on quality testing and has advocated and supported the setting up of laboratories for the same. Data about the number of labs in the countries and the number of tests carried out by the team assigned to this task. The table below summarizes the data from the Jal J

LAB TESTING STATUS				FIELD TESTING KIT (FTK) STATUS			
Active Laboratories	Samples Tested in Laboratories	Total Villages where testing has been done	Number of contaminated Samples found	No. of Women trained for testing water samples using FTK	No. of villages where women have been trained for testing using FTK	Samples tested using FTK	Total no. of Villages where FTK test has been done
2,087	2423516	331641	150526	2258697	478959	3438232	225441

Figure: Real time data on water quality from Jal Jeevan Mission Dashboard as on 7th August

6. Final Delivery and Sustainability aspects

An effective service delivery marks the completion of the journey of safe water from the catchment to the final consumer. An unsustainable service delivery of WASH (Water, Sanitation and Hygiene) is called slippage. It is gaining attention at the policy level recently though this problem is as old as the coverage of water supply services. This can be termed as a governance issue and is influenced by multifarious factors ranging from geo-hydrology of the place, climatic conditions and socio-economic perspectives.

In terms of service delivery, some systems start slipping almost immediately from the moment they are installed others are fine for a while before they start to slip. Also, the rate of slippage is erratic and non-uniform. Some systems slip at an increasing rate initially and then at a diminishing rate. The majority of existing literature on water supply and management deals with the constraints in the supply side of water economics, while these are important and have been given much significance, it is the demand side factors like community engagement, decentralization of drinking water management responsibilities to gram panchayats and absence of feasible solutions of governance issues that have been overlooked since years.

Public policy and governance relating to drinking water often goes unrecognized and thus the

strategies preferred for addressing slippage tends to be inclined towards the supply side. These include providing and encouraging rainwater harvesting structures, Rejuvenation of old schemes which are functioning below the capacity efficiency, source strengthening measures, combining of efforts of relevant Departments in watershed development, extending new pipelines and providing regional schemes from alternate safe sources.

While all these strategies are crucial in dealing with slippage, they are one sided and do not majorly incorporate the demand side. They therefore do not provide comprehensive solutions to the problem. They focus on supply augmentation through various mechanisms and thus there is a demand supply mismatch. In the long run source sustainability can be assured only with better governance of source structures and not merely structures like rain water harvesting structures, percolation tanks, watershed development. These structures are necessary but not sufficient for sustainable resource management and protection.

The problems people experience with water supply and sanitation are numerous and complex. The Sustainability, in the sense of continued delivery and uptake of services is threatened by numerous attitudinal, institutional and economic factors. There is need for comprehensive understanding and management of governance in water resources in an integrated manner incorporating supply, demand and institutional approaches. The problems faced by people and their experience with water supply and sanitation are multifaceted and complex.

The Sustainability, in the sense of continued delivery and uptake of services is threatened by numerous behavioral, institutional and economic factors. Therefore, supply sided or demand sided or community participation approaches on their own are no guarantee for success. There is need for comprehensive understanding and management or governance of water resources in an integrated manner incorporating supply, demand and institutional approaches.

Best Practices under various schemes introduced by the centre and the states- A brief overview of Jal Jeevan Mission

Good Governance involves people's participation and inclusion of communities to ensure that the benefits of public policies reach the grassroot levels and bring about a positive change in the lives of everyone in the process and lead to productive transformation in the society.

In the last few decades, governance reforms in the water sector have pushed for greater community involvement in water supply and distribution, adoption of various demand responsive approaches by states and civil societies leading to strengthening of community capacity, skills, quality of leadership and willingness of the community members to pay for water.

Various schemes and programmes have incorporated the community models and have been successful to some extent in developing piped water infrastructure in rural areas and improving coverage levels

We briefly analyze some best practices and the lessons that can be drawn from the past programmes

1. Gujarat's **Water and Sanitation Management Organization** (WASMO).

The Salient features of the programme are

Technical Assistance - It provided technical assistance and support in addition to the necessary technical assistance by contributing 90 percent of the funds. It conducted training and workshops to build the capacities of communities and Pani Samities to construct, operate and implement the scheme.

Decentralized Institutions - The decentralized approach focuses on the demand side which hasa great involvement of community participation in planning, designing, site selection and implementation. This led to social inclusion and led to reliable and assured services.

Intensive Capacity Building- Stakeholders were trained in construction, supervision, financial management, surveillance of water quality and maintenance and operation of village water supply system. Awareness generation and capacity building initiatives were taken up by NGOs that were involved as support organizations.

Implementation and follow up period-The programme was implemented in three cycles Community mobilization (first cycle of 3-6 months). Execution and completion of the project (second cycle of 12 months). Post implementation and follow up (third cycle of 12 months). This ensures regular, adequate and safe water to all the communities.

Support- WASMO provided ongoing support in operation, maintenance and capital maintenance support task whenever a Pani Samiti requested it

Source Sustainability - WASMO promoted roof rainwater harvesting to deal with poor water quality due to salinity in coastal areas.

2. Jal Nirmal

Jal Nirmal is a world bank assisted, a community based rural water supply project by Karnataka Rural Water Supply and Sanitation Agency (KRWSSA) and was implemented between 2001 and 2014. Its three key principles were capital-cost sharing, integrated approach to water and sanitation and operation and maintenance by the community.

The salient features of this scheme are

- **Training and capacity building of Village Water and Sanitation Committee (VWSC) -** VWSC were formed as support committees and trained on various aspects on operation and management of the project. To build and facilitate flow of knowledge, information and communication activities within the communities. Training was also provided through workshops and technical support for operation and tariff collection. The water distribution responsibilities were delegated to the gram panchayat.

- **Capacity Development of institutions -** A Social Development Unit was established at the cluster and district level for capacity building of communities and VWSC on different aspects of planning, execution and infrastructure maintenance of water supply under the Jal Nirmal Project. There was a close coordination between the social development experts and technical engineering team. The communities were adequately trained and educated in record keeping, administrative duties, maintenance tasks and quality testing.

- **Community Engagement -** The sub committees like VWSC were authorized to fix user

charges, tariff collection and was empowered to recruit maintenance staff locally. Eventually the community was able to bear the recurrent costs of labor, materials, fuel and salary of pump operators. The VWSC have played a significant role in service delivery, service expansion and sensitization of village leaders with respect to service provisioning and system operation. Other good practices that led to the success of this project were social intervention design, its implementation, software support to community, community engagement and capacity development and training and evaluation of performance.

- **Innovative solutions in Technology, Metering, Pricing and sustainability -** Technological innovations like use of solar energy, groundwater recharging mechanisms to improve source sustainability, introduction of metering systems and restricted service delivery in high consumption seasons like summers as decided by the communities helped in water management and sustainability of source and systems.

3. Jalanidhi, Kerela

Jalanidhi was a World Bank-assisted Rural Water Supply and Environmental Sanitation Project implemented in Kerala between 1999 and 2008. The project was inspired by principles like demand responsiveness, community ownership and sustainability of investments through cost recovery and participatory operations and management.

Salient features

- **Community involvement and engagement**

The users of final services themselves were fully involved in all the stages from identification of sources, decision on the technology to be used, community contracting and implementation of operation and management aspects of the schemes. For this adequate training was provided and appropriate guidelines were made available.

- **Strengthening of Gram Panchayats**

This project aimed to and involved the empowerment of decentralized planning and was implemented through Gram panchayats. In the socio-economic scenario in the state of Kerela there was a special emphasis on rural local governance and this played a pivotal to bring out an equitable, inclusive and decentralized rural water delivery system and thus the benefits did reach the grassroot level.

4. Basudha, Orissa

The Buxi Jagabandhu Assured Drinking Water to all Habitation (BASUDHA) scheme launched in November 2018 is a renewed version of the Government of Odisha's water scheme for universal access to drinking and domestic water to all rural people on a sustainable basis. the scheme ensures that all households should have access to safe and adequate drinking water within a reasonable distance, enables communities to monitor and keep surveillance on their drinking water sources and ensures potability, reliability, sustainability, convenience, and equity. The government also launched the grievance helpline number 1916 for BASUDHA.

Impetus on use of renewable energy

Under this scheme, Mega Pipe Water Scheme (PWS) projects are being brought to energy scarce areas using renewable energy. To ensure consistent and regular water supply from

existing handpump/tube-well solar dual pump water supply in thinly populated areas, remote and energy starved habitations.

Role of State Government in Financing of Rural Pipe Water Supply (PWS)
The Panchayati Raj and Drinking Water Department of Orissa issued a government order on February 28th,2017 making it mandatory to use 30 percent of the funds from the 14th Finance Commission and 4th State Commission for rural water indicating the pivotal role of state government in public financing of water supply in rural areas.

A Brief Overview of Jal Jeevan Mission

The Government of India has recently set a target and aimed to provide clean drinking water to all rural households by 2024. This mission will focus on the integrated management of demand and supply side at the local level and encouragement of source sustainability through rainwater harvesting, recharge of groundwater and household wastewater management for reuse in agriculture and other activities. It also aims to create local infrastructure. This mission is under the Department of Drinking Water and Sanitation and has been christened as the Jal Jeevan Mission.

This mission will converge with other Central and State Government Schemes in order to accomplish its objectives of providing sustainable water supply management across the country. The Department of Drinking Water and supply together with the State Governments has been working tirelessly to achieve the aim to provide functional piped water supply through tap connections (‘Har Ghar Jal') assuring water supply in adequate quantity and of prescribed quantity on a long-term regular basis to every household in India by 2024.

According to Ministry of Jal Shakti, Department of Water and Sanitation’s document on “100 days Campaign to provide piped water supply in Anganwadi Centres, Ashramshalas and schools” states that in one-year of JJM, 2.40 crore rural households have been provided new tap water connections. Around l.61 lakh habitations have 100 percent coverage of tap connections. Goa became the first state in the country to have achieved 100 % Household tap water supply connections.

Training and capacity building

In order to meet the training management need of the National Jal Jeevan Mission (NJJM), JJM Training Portal has been created.

The portal acts as a consolidated platform for trainees, trainers and NJJM to know demand and supply and undertake the intermediate processes like registration, alerts, nomination, attendance of trainees in a course, feedback for a smooth record and coordination.

The main functions of Key Resource Centres (KRC) are as defined below:

Training Need Assessment (TNA): Assignments will be given to empaneled agencies based on the requirements and procedure defined by the NJJM, DDWS. Based on the assignment given, the KRCs are required to identify the training needs before designing the training programme.

Content creation: Based on the TNA, necessary materials, modules, manuals are developed by KRCs. Emphasis is fairly more on online modules, course and contents.

Annual Action Plan (AAP): The KRCs will be required to prepare an Action Plan for the year with details of all proposed activities. This will be examined by the NJJM, DDWS and approved accordingly.

Selection of participant list: The selection of participants will be done by the NJJM, DDWS/ State Governments/ SWSMs / DWSMs as per the specific type of training programme. The task of coordinating with the participants and local authorities for diverse training and logistics purposes also lies with the KRCs.

Assurance of quality of training: After completion of each training programme, the KRCs are required to obtain credible and well-structured feedback from the trainees and incorporate the same in updating and making relevant changes in the subsequent training modules and sessions.

Other than training and capacity building activities, the KRCs will also be required to take up other activities as part of Human Resources Development and JJM 'Knowledge Network' as per the requirements of NJJM, DDWS:

a) The KRCs are required to organize national, regional and state level webinars, workshops and seminars which will also be supported by the NJJM, DDWS

b) KRCs are expected to take up field exposure visits to States/ districts and even other countries for cross–learning from best practices. For international exposure visits, KRCs have to research and have an idea of relevant international experience and institutions, efficiently network with them and demonstrate a value addition to the substantial knowledge and experience that already exists in the country.

c) KRCs will also perform documentation of case studies and best management practices on topics pertaining to drinking water service delivery, monitoring and surveillance, for further dissemination of knowledge.

d) As and when needed, KRCs will conduct research and evaluation on various issuespertaining to drinking water and organize events like hackathons, quizzes and others to promotethe goals of the Jal Jeevan Mission from time to time.

Jal Jeevan Mission as a Rational Amalgamation of The Best Practices of The State Water Schemes

The central goal of the Jal Jeevan Mission is to improve quality of lives of people by ensuring potable water in their households. This will help in ensuring the basic right to water to all citizens. The mission also aims to forge partnerships with diverse organizations for smooth implementation and better outcomes of JJM. Thus, Department of Drinking Water and Sanitation (DDWS), Ministry of Jal Shakti has sought interest from foundations, trusts, NGOs, Community Based Organizations (CBOs), academic institutions to work closely with the mission as ‘Sector Partner’ so as to have a better social outreach and work proactively in sectors water, sanitation and hygiene, natural resources management, community engagement, capacity building & awareness generation, education, health, tribal development and gender

& equity.

The Sector assist the States to adopt appropriate Operation and maintenance mechanisms to ensure long term sustainability of sources with special focus on water quality. Further, providing capacity building support to different stakeholders, identification of successful models in community mobilization for replication, field visits to understand social inclusion, social audit/ monitoring under JJM also fall under the scope of responsibilities of the Sector.

JJM aims to harness the huge potential of the local communities by engaging organizations working at the local level and are enthusiastic to work towards mobilizing and enhancing the capacities of the communities.
The mission aims at capacity building of Gram Panchayat and/ or its sub-committee, i.e., Village Water & Sanitation Committee (VWSC)/ Paani Samiti on managerial, technical and financial aspects. Communities are also to be enabled to take up surveillance of quality of water supplied by training five persons, preferably women, in every village for quality through Field Test Kits (FTKs). To take forward these activities, role of organizations working in rural areas will be very vital especially in mobilizing the community as well as handholding them.

The mission has also engaged the private and corporate sector to optimize the best outcomes to the society through Corporate Social Responsibility initiatives. In order to achieve the ambitious target of water security for all, all the organizations will have to work together and build a synergy for efficient outputs.

Employment Generation Through the Jal Jeevan Mission

A report titled an assessment of employment potential of Jal Jeevan Mission by Centre of Public Policy under IIM Bangalore has analyzed the potential of employment generation at various stages of the implementation of the Jal Jeevan Mission in the country. It also includes the aspects of direct employment through construction and allied employment like long-term engagement for operation and maintenance activities of pipe drinking water supply systems and the labor employment in the generation of the requisite infrastructure for the implementation. Indirect employment is also created through transportation are also being generated.

The funds invested under the Jal Jeevan Mission is facilitating the construction of public assets and creating direct, allied and induced impacts on employment in the country. The production of inputs used for construction as well as operation and management stages also lead to employment. The study adopts both micro and macro approaches to understand the impact of the investment on employment generation across industries as well as states.

According to the findings of recent publication of Nobel Laureate Professor Michael Kremer, availability of safe drinking water has the potential to avert 1.36 lakh child deaths (below 5 years) in the country leading to almost 33.33 percent reduction in child mortality rates. In terms of the impact of Jal Jeevan Mission on public health, the World Health Organization has recently published that an estimated number of 4 lakh diarrheal deaths can be averted which effectively translates into economic savings of more than 8 lakh crore on account of 14 million DALYs (Disability Adjusted Life Years) averted thereby. This will be a feat in terms of public health outcomes and lead to a better quality of life. The Jal Jeevan Mission has played a pivotal role in improving the lives of rural women and helping them reduce the time spent by them in travelling to collect water for domestic purposes. The overall structure of the Jal Jeevan

Mission has spillover effects in terms of better health & more economic opportunities for people, especially for women.

Capacity Building – A Review

Capacity building involves training, awareness, development of skills and other on the spot decision making skills that help to facilitate the provision of safe water to all the people within a specified area.

The training approach selected must give adequate emphasis to stages of learning. A phased and a step-by-step approach helps in breaking up of activities into activities and skill sets. Provision of safe drinking water is a crucial subject and a one which carries huge potential to make a difference in the life of the people by improving their standards of lives, improving health outcomes and empowering people socio-economically.

The involvement of students pursuing education in the water relevant fields can be focused on and after adequate training and capacity building, water professionals can be recruited on site for their respective roles and responsibilities.

Even if emphasis is on education rather than training, universities and higher education institutions have a pivotal role in developing capacity and preparing water professionals to contribute in the water sector. Through simplified stages of learning like introduction, practice and reinforcement the technical skills can be honed and interdisciplinary interactions in active learning environments will lead to awareness of the multidimensional aspect and sensitization about drinking water safety and issues across multiple disciplines.

The different stages of learning will enable the learners to move from basic knowledge to a deeper understanding and more amount of autonomy in the process.

In the introductory phase the learners will help the learners to start from the fundamental awareness of the need of water safety and supply mechanisms in the urban and the rural areas and steadily move towards hands on practice and reinforcement. On site visits and a supplementation with technological advancements and innovations will help to bridge the gap between learning the principles of water sector and their on-ground implementation.

The process of learning should continue through phased processes wherein after the introductory phase learners should be given freedom and flexibility to assume and carry out their responsibilities and improve their learning outcomes through experimental learning. Moreover, to inculcate problem solving skills among the learners, appropriate guidance about dealing and coordinating with a variety of stakeholders should be encouraged.

In order to make the capacity building exercise sustainable and improve the relevance and longevity of it, regular updating, introduction of social skills of communicating and understanding the needs of the communities, refresher courses, peer reviewed policies and practices in water supply and technical assistance to overcome challenges will be required. To add to it, further training and rounds of feedback and revision could help in addressing the gaps identified in the monitoring and review process. ***Peletz et al. (2016)*** stresses at the importance of continuing to process and apply monitoring data to enable re-evaluation of the program.

Capacity building of consumers and communities through community engagement in the stages of provision of clean and safe drinking water, consumer education in mitigation of water

pollution and safeguarding of the final water being delivered and undertaking methods to improve the quality of data collected specially from the rural areas will go a long way in translating the water relating public policies and governance practice from documents to reality.

Sustainability of capacity building for provision of safe water supply is likely to be different depending on the types of supplies, their size, location and the governance. For example, some literature considers training for capacity building more challenging in rural areas because of the local traditions, language barriers, greater attention and additional resources. In order to achieve sustainable capacity to efficiently implement skillfully designed policies till it actually benefits the final users, the prerequisites are community engagement, sustainable financing and iterative re-evaluation. ***Kayaga (2013)*** suggests that a memorandum of understanding (MoU) be made as a formal document where the mutually discussed and agreed roles and responsibilities of utility and the community members should be tracked. It is hence recommended to include all target groups in capacity building and training activities at the locallevel.

Also, with the water supply and safety practices there is a strong risk of tokenism where documentation of best practices is developed but it does not successfully trickle down to the grassroots via culture and practices.

The capacity development components that require strengthening depends the roles of different stakeholder groups involved in implementation, scaling up. Specifically in case of small systems, selection of materials, approaches and training customization should reflect the target group, local language and preferred mode of learning. Customizing training and capacity building according to size, location and governance structure will catalyze long term sustainability.

The Urban Scenario:
Ministry of Urban Affairs has undertaken several initiatives under Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and other programmes to augment the capacity development of urban local bodies to implement projects and reforms. They are enumerated below

Hubs and Networks:
In order to meet and fulfil the training demands on ground six empaneled regional hub institutions (RHIs) and a range of Network Institutions aligned to them have been schematically arranged.

A Rapid Training Program (RTP):
This has been launched focusing on the slow performing cities in accessing JNNURM funds on prioritized module of Governance and Reforms, Supervision/Preparation of Detailed Project Reports Project Management and Implementation.

The Peer Experience and Reflective Learning (PEARL) Programme:
This programme has been launched to facilitate cross learning among cities and institutions in order to learn from their experiences in implementing different schemes. These cities and institutions have been clustered into five groups based on similar and common socio-economic profiles. Every group has a knowledge manager assigned who coordinates and facilitates technical support to organize events of common welfare relating to relevant areas and value addition with the support of Ministry of Urban Development.

Capacity Building for Urban Development (CBUD) Project under the assistance of World Bank:

This Project has been put forward as a Central Scheme to intensify capacity building and strengthening at an institutional level of selected Urban Local Bodies to implement urban reforms mandated under JNNURM, with World Bank credit on IDA terms. The Projectwould also provide capacity building support to select cities for urban poverty reduction and livelihood opportunities.

Public Health Engineering (PHE) Training Programme:

Started by the Ministry in 1956, the public health engineering training programme has been set up with the objective of providing training to Engineers in service and Para Engineering Staff of the various State Public Health, Engineering Departments, Water Supply and Sewerage Boards, Urban Local Bodies and others. The details are as follows:

- **Post Graduate Course in Public Health Engineering/ Environmental Engineering**

Institutions offering the Program	Duration of the postgraduation course: 24 months
All India Institute of Hygiene and Public Health, Kolkata, West Bengal	
Veermata Jeejabai Technological Institute, Mumbai	
Anna University, Chennai	
Visvesvaraya National Institute of Technology, Nagpur	Stipend offered: Rs. 2000/- per month for outstation trainees.
Motilal Nehru National Institute of Technology, Allahabad	
Shri Jayachamarajendra College of Engineering, Mysore	
Jawaharlal Nehru Technological University, Hyderabad	

Short Term Courses in Public Health Engineering

This programme helps working professionals like Diploma Engineers working in State Public Health Engineering Departments and Water Supply gain adequate exposure and improve theircapacity in accordance with the requirements of the present day. The duration of the short-termcourses is 3 months. There is also an extension of financial support in the form of grants, stipend, tuition fee and field visit expenses.

The institutions offering short term courses are:

1) Anna University, Chennai and
2) Shri Jayachamarajendra College of Engineering, Mysore.

Refresher Courses

In addition to long term and short-term courses, several refresher courses on various specializations are conducted by the Ministry through different academic, research & professional institutions and State Departments. Financial assistance is also extended in the form of honorarium to lecturers and expenses on field visits.

Conducting of workshops, conferences and research studies

The Ministry has been extending full support for workshops and conferences related to urban issues. In order to promote excellence in specific areas of urban governance, Centres of

Excellence have been proposed to be set up in reputed institutions in the country to create the necessary knowledge infrastructure for improving municipal service delivery and management. Each of the centres will be unique in its area of research and all COEs will foster, capacity building and technical knowledge base.

Institutional Arrangements

Regional Centres for Urban and Environmental Studies

These have been set up by the Ministry of Urban Development, Government of India in Mumbai, Lucknow & Hyderabad. These centres help in skill-building and capability development of elected and official functionaries of Urban Local Bodies by improving knowledge, work and exposure required for good urban governance and provide impetus to novel thoughts around thematic issues in a conducive environment.

National Institute of Urban Affairs

This is a prestigious and premier institute focusing on research, development, training and information dissemination in the field of urban development and management.

All India Institute of Local Self-Government

The central focus of this institute is to promote and support the research and training in municipal administration. This focusses on the capacity building of urban local bodies.

Administrative Training Institute

The Administrative Training Institutes are set up at the State level to disseminate knowledge on different aspects of good governance. These institutes also impart training in effective manpower and financial management to State Government, Local Bodies, Autonomous Bodies, and Public Sector Undertaking employees.

Major Capacity Constraints in the urban scenario

1. Dearth of appropriately skilled personnel
Urban planning and management are in urgent need for identification as a formal and regular stream of training and professionalization in academic institutions. The concerned personnel involved in urban management affairs are under trained and lack the required skill sets. Socio-economic planning, urban planning, financial accounting and management are major areas which require attention and skilled manpower for efficient functioning. Trained manpower is also needed for plumbing and mason services.

2. Insufficient up skilling of employed personnel
The employees already employed for various services in the water and public health engineering sector and urban local bodies have majorly not received any training throughout their career as per the experience of training and capacity building programmes. This problem is grave in smaller urban local bodies where training programmes are hardly present.

Water Safety Plans and WASH

The United Nations General Assembly recognized the essential human right to water and sanitation in 2010.Seeing the vitality of the right to sufficient, continuous, safe, acceptable,

physically accessible, and affordable water for personal and domestic use, this was the need of the hour.

Water Safety Plans are an inclusive approach that focusses on a comprehensive risk assessment and management covering all the levels from a catchment to a consumer. They aim to be consistent in their assurance of safety and acceptability of a drinking water supply.

A comprehensive guide for small drinking water supplies and an encouragement of the application of water safety plans for the provision of safe drinking water is promoted by the World Health Organization at the global level. The use of water safety plans is considered a proactive approach to identifying and managing the potential risks and taking precautions as necessary (WHO, 2012). According to WHO report,2012, page 9, the World Health Organization defines the following six tasks to develop and maintain a water safety plan

- Community engagement and team assembling

- Description the community water supply
- Identification of and assessment of hazards, hazardous events, risks, and existing controlmeasures
- Development and implementation of an improvement plan
- Monitoring of and control measures and verification of the effectiveness of the water safetyplan
- Documentation, review and improvement of all aspects of water safety plan implementation

WHO produces a series of guidelines on water quality, including on drinking-water, safe use of wastewater and safe recreational water environments which are based on risk management and assessment. At the global level, WHO also supports countries to implement the drinking-water quality guidelines through the development of practical support and materials to enlighten and facilitate the provision of direct country support. The development safe drinking water quality regulations which also go well with the principles prescribed by the WHO guidelines and are of relevance locally are also developed by WHO. These regulations catalyze and facilitate the development, implementation and auditing of Water Safety Plans and strengthening of surveillance and monitoring practices.

Now focusing specially on the Water Safety Plan implementation in India, WHO has been extending support and guidance to key stakeholders involved in the betterment of drinking water quality, development of regulations and guidelines to help overcome the loopholes in the implementation. It also supports research activities, development of training manuals and capacity building of stakeholders and providers of safe water supply. It also helps in the promotion of best sustainable practices

WHO has facilitated the testing of a Water Safety Plan in the Indian cities of Hyderabad, Nagpur, Bengaluru, Chandigarh and Surat. In order to provide a formal framework for cooperation in the areas of water quality monitoring and assessment activities, a memorandum of understanding has been signed with the Water Quality Assessment Authority, Government of India.

Poor sanitation can also have a ripple and vicious effect when it hinders national development because when workers are suffering from illnesses, they live a shorter and a fairly unproductive life, they produce and earn less, and thus are unable to afford education and stable future

income for their children. Inadequate water, sanitation and hygiene (WASH) services in India's affects the public health adversely for instance India's neonatal mortality rate is currently 24 deaths per 1000 live births as per WHO data which is high. Provision of safe drinking water and effective Water Sanitation and Hygiene will help in curbing mortality owing to contaminated water practices and will go a long way in improving the public health.

Chemical contamination of water, mainly through fluoride and arsenic, is present in the majority of dwellings. Moreover, less than 50 percent of the population has access to safely managed drinking water which is located on-premises, available when needed, safe and free of contamination.

Moreover, two-thirds of India's districts are affected by extreme water depletion and scarcity, and the current lack of water safety and security planning is a major concern.

Collaboration and convergence are the vital features of the UNICEF's Country Programme in India are collaboration and convergence and WASH is positioned in such a manner that it supports development of an overall aspect of a child's survival, growth and development.

The WASH programme is also aims and works to prevent malnutrition and preventable diseases, reduce neonatal mortality, and enhance education outcomes. This will lead to better health outcomes, secure a stable future, overall mental and physical development and eventually better national development ensuring a better standard of living for the citizens.

UNICEF supports the Government of India's flagship programmes like Swachh Bharat Mission, the Jal Jeevan Mission and WASH in schools to develop sanitation and hygiene etiquettes among children right from the start.

In addition of schools, UNICEF also supports WASH in health care facilities, supporting planning and implementation and incorporating behavior change into state and national guidelines and costed plans.
UNICEF, supports the Government in the technical aspects, assists in alternative service delivery approaches, and mobilizes public institutions and partners, including the private sector to contribute to and support WASH services.

WASH programming is grounded in empirical data collection through well-structured surveys, rigorous research and insightful analysis. To ensure community participation, gender mainstreaming, and efficient programming, all water, sanitation and hygiene (WASH) interventions get supported by Social and Behavior Change Communication (SBCC)
The interventions are also supported by Monitoring and Evaluation (M&E) and knowledge management (KM) frameworks.

India has accelerated its efforts over the past five years to assure its citizens, especially children, the right to WASH services.
The process includes external monitoring and system monitoring and the support extension of government partnerships for setting up monitoring systems like management information systems, online applications, and dashboards for smooth access and functioning.

Lessons from Abroad

Source water protection is the development and optimal utilization of institutional arrangements like municipalities assessing a drinking water safety risk and managing them

with relevant stakeholders to minimize pollutants from contaminating drinking water sources which can be used for drinking water purposes. (Ivey et al.,2006)
It is the most effective and efficient practice for water safety and a lot of literature concludes that cost of treating contaminated water is 30 to 40 times the cost of source protection from pollution (Minnes,2017)

The outcomes of inadequate protection of drinking water sources can be devastating as evident by various contaminated water incidents in Canada and elsewhere.

Canada's Ontario Quality management standards ensures compliance in various aspects areas of the water system operations by focusing on technical components and delegation of responsibilities for regular operation (MOECC,2015) but it lacks social dimensions like community capacity and safe drinking water awareness. Source water protection plans, complementing the water management framework of Ontario's community water systems have been successfully implemented.

In case of New Zealand, a significant drawback is the exclusive focus on the technical and environmental parameters where community outreach and engagement processes, training opportunities and financial planning are not adequately taken into consideration. The central theme of Water Safety plans is risk assessment and management.

The European Union strategy lacks several important components, such as training requirements, source water protection, financial planning, and community awareness.

Conclusion

Now as we move towards the concluding remarks of this paper, we will quickly review the aspects that we have discussed and shed a considerable amount of light on. We started with what public health engineering services are and narrowed our study to specifically the provision of safe drinking water, stakeholders involved in the process, the possible and currently faced capacity constraints in the different stages of provision of safe drinking water that needs redressal ,State and Central schemes and best practices in terms of capacity building, demand side and supply side governance as implemented by the state level schemes and the Jal Jeevan Mission which incorporated the good practices and accomplished stupendous and ambitious results. We also undertook a very detailed review of the capacity building in the rural water supply and urban drinking water supply sectors. Towards the end we had briefly touched upon the Water Safety Plans implementation and WASH services undertaken by WHO and UNICEF respectively.

A very detailed analysis of the literature review helped us to understand the basic problems faced in the provision of this life sustaining resource, water. For the citizens these small problems have an everlasting and hazardous impacts on their livelihoods and quality of life. The solutions to these crises lie in behavioral, attitudinal and governance pattern shifts towards more realistic and efficient models.

State, cities, districts and villages where the literacy levels were high seemed to have better health outcomes. Awareness about drinking water and sanitation hygiene as people adopt to healthy conservation practices and realize the importance and impacts of the implementation of good policies and thus end up having better health outcomes. Thus, improving the educational outcomes and working on a large-scale provision of access to education would help in overall development and add to the public acceptability of policies.

General improvement in the status of literacy would go a long way in minimizing slippage. Higher literacy also helps in a stronger and decentralized service delivery of WASH services. This emphasizes the need for strong IEC activities at different levels for building their capacities in ensuring functional efficiency of the program. Water quality is also an important aspect that needs policy attention.

The policy should also address resource sustainability, conservation and behavioral change goals instead of relying upon a one-sided target driven approach. The effective implementation keeping a central focus on these aspects needs to be ensured.

Water, sanitation and hygiene services are significant and central to addressing social issues of poverty, livelihoods and health. They are also critical in addressing the needs of poor communities and in achieving the Sustainable Development Goals (SDGs). The efforts of Government to reach these targets are often subjected to many challenges and obstacle.

References

- Giuliana Ferrero, et al., International Journal of Hygiene and Environmental Health,
- Rohilla, S.K., Datta, P.S. and Bansal, S.P. 1999. Delhi's water and solid waste management: emerging scenario. New Delhi: Vigyan Prasar Publications.
- North, D.C. 2006. Understanding the process of economic change. New Delhi: Academic Foundation.
- UN, 2018. Sustainable Development Goal 6. Synthesis Report on Water and Sanitation
- UNDP, 2010. Measuring capacity. http://content-ext.undp.org/aplaws_publications/2679640/UNDP_Measuring_Capacity_July_2010.pdf,
- Prakash, A. (2022). *Water resource management in South Asia*.
- World Health Organization: WHO. (2020). Water, sanitation and hygiene (WASH) - India. Water, Sanitation, Hygiene and Health. (2009). Water safety plan manual (WSP manual).
- Minnes, Sarah & Vodden, Kelly. (2017). The capacity gap: Understanding impediments to sustainable drinking water systems in rural Newfoundland and Labrador. Canadian Water Resources Journal
- Participation of community-based institutions in piped drinking water supply WaterAid/ Ashima Narain Analysis of select schemes and programs
- Meinzen-Dick, R.; Chaturvedi, R.; Domenech, L.; Ghate, R.; Janssen, M.A.; Rollins, N.; Sandeep, K. Games for groundwater governance: Field experiments in Andhra Pradesh, India. Ecol. Soc. 2016
- Hossain, A.Z.; Banerjee, P. Shifting Grounds: Institutional Transformation, Enhancing Knowledge and Capacity to Manage Groundwater Security in Peri-Urban Ganges Delta Systems; Urbanising Deltas of the World—Integrated
- Kot, M., Castleden, H., Gagnon, G.A., 2015. The human dimension of water safety plans: a critical review of literature and information gaps. Environ. Rev.
- Compendium of best practices in Water Management, 2021, Niti Ayog, Government of India
- Reddy, V. Ratna, M.S. Rammohan Rao, and M. Venkata swamy. 2010. 'Slippage': The Bane of Drinking Water and Sanitation Sector (A Study of Extent and Causes in Rural Andhra Pradesh). Hyderabad: WASH Cost India-CESS Working Paper.
- Shashi Kala Saroj, Srinivas Goli, Md Juel Rana, Bikram aditya K. Choudhary, Availability, accessibility, and inequalities of water, sanitation, and hygiene (WASH) services in Indian metro cities, Sustainable Cities and Society, Volume 54,2020, 101878, ISSN 2210- 6707
- https://www.thehindu.com/sci-tech/health/providing-piped-potable-water-across-india-will-avert-400000-diarrhoea-deaths-who-study/article66950218.ece
- https://www.cfr.org/backgrounder/water-stress-global-problem-thats-getting-worse
- https://www.globalwaters.org/wherewework/asia/india
- https://thewaterproject.org/water-crisis/water-in-crisis-india-women

- https://www.businesstoday.in/latest/economy/story/indias-sanitation-economy-is-booming-but-basic-data-on-water-and-hygiene-still-missing-346100-2022-09-01

ANUSHREE RAI

B.A., L.L.B. (Hons), National Law University, Gujarat, Gandhinagar.
Mentored by Mr. Satish, Asst. Advisor, CPHEEO.

Domain for Internship: Sustainable Development Goals

Service Delivery of Water Supply in Alwar

Alwar's water resources have been overexploited, leading to a potential crisis. The present study analysed the current system of water supply in the city, with actual and projected statistics, in order to identify gaps and lacunae. The study used the information provided by PHED Alwar and surveyed 60 households to analyse the status and situation of water supply in the city. The study found that the impending water scarcity crisis stems from complete reliance on groundwater, non-availability of renewable source water and inadequate water table recharge mechanism. Furthermore, the study shed light on deficiencies in grievance resolution, data collection, and meter functionality, calling for fair billing practices. Thus, the recommendations of the study included implementing rainwater harvesting, stormwater management, supplementing water supply with treated water, regularizing and centralizing private water tanker operations, and improving grievance redressal mechanisms.

Keywords: service delivery, water supply, income groups, ground water, climate

Acknowledgements

I express my deep gratitude to Shri V. Srinivas, Director General, National Centre for Good Governance and Shri Bharat Lal, former Director General, National Centre for Good Governance, for providing me with this opportunity. I would also like to thank Smt. Roopa Mishra, Joint Secretary, Ministry of Housing and Urban Affairs, Government of India, for having kindly agreed to support me with this project at various levels. I am extremely grateful to Shri Sathishkumar, Assistant Adviser (PHE), Ministry of Housing and Urban Affairs for having agreed to mentor me throughout this journey, without whose constant support this study would not have come into its present shape. I am thankful to Dr Gazala Hasan, Shri Akash Sikdar and Shri Sachin from NCGG for their unwavering support. My gratitude to Shri Manish Faujdar, Municipal Commissioner, Alwar and Shri Kamal Kumar Narang, Executive Engineer, PHED for providing all the necessary information which forms the base of this paper. I would also express thanks towards all the respondents who participated in the survey without which the study would not have come to its culmination. I would be failing my duty if I did not acknowledge the efforts of my co-interns at the National Centre for Good Governance, for providing valuable inputs and helping me gain deeper insights into the issue.

Background

Alwar is a district located in the desert state of Rajasthan, with an area of 8380 square km, and an average rainfall of 631 mm as in the year 2013. Alwar city is the headquarter for Alwar district. The length and breadth of the city are 17.8 and 16.4 kilometers respectively.[1]The total area of the city is approximately 272 square kilometers. The distance between Alwar and Jaipur, the capital of the state of Rajasthan is 150 km and the distance between Alwar and New Delhi is 160 km.[2]The region is primarily flanked by flat topped hills, which are more prominent is in the south western part of Alwar.[3] Alwar primarily has alluvial and sandy soils.[4] The district is flocked by the Aravali hill range which runs through the city. The city does not have a perennial river. However, there are a few seasonal rivers, namely Sabi, Ruparail, Chuhar Sindh and Landoha. The depth of the ground water table depends upon a number of factors, including topography, geology, drainage etc. Moreover, the season also governs the level of the water table, leading to fluctuations. Alwar can be classified as a semi-arid region, with extreme heat during summers and extreme cold during winters, and rainfall primarily taking place during the South West Monsoon period.[5]

Considering the rapid growth of population, low levels of rainfall and depleting water table, with complete reliance on the underground water for fulfilment of the needs of the population of the city, there is an urgent to need to devise ways to ensure that the city does not run out of water for its own population. This requires not only an analysis of the current state of water and position of water supply in the city, but also calls for devising new techniques and reviving the existing ones to avert a fast-approaching situation of crisis. Alwar is in the dark zone, (Dark Zone refers to an area wherein the rate of depletion of ground water exceeds the rate at which the ground water is replenished/recharged) and is at a risk of running out of water very soon. This report analyses the current system of water supply in the city, with actual and projected statistics, in order to identify gaps and lacunae. The paper also suggests ways to overcome those gaps by suggesting practical and workable solutions, in order to ensure sustainability.

---

[1]Chauhan, Divya, and Vijay Kumar Verma. "Rainfall Fluctuations and Depleting Water Levels In Alwar City." *SGVU J CLIM CHANGE WATER*, vol. 6.

[2]"पोर्टल, राजस्थानसरकार: Geographical Information." *District Informarion*, Government of Rajasthan, https://alwar.rajasthan.gov.in/jankalyan-category-and-entry-type/23/1/4. Accessed 26 July 2023.

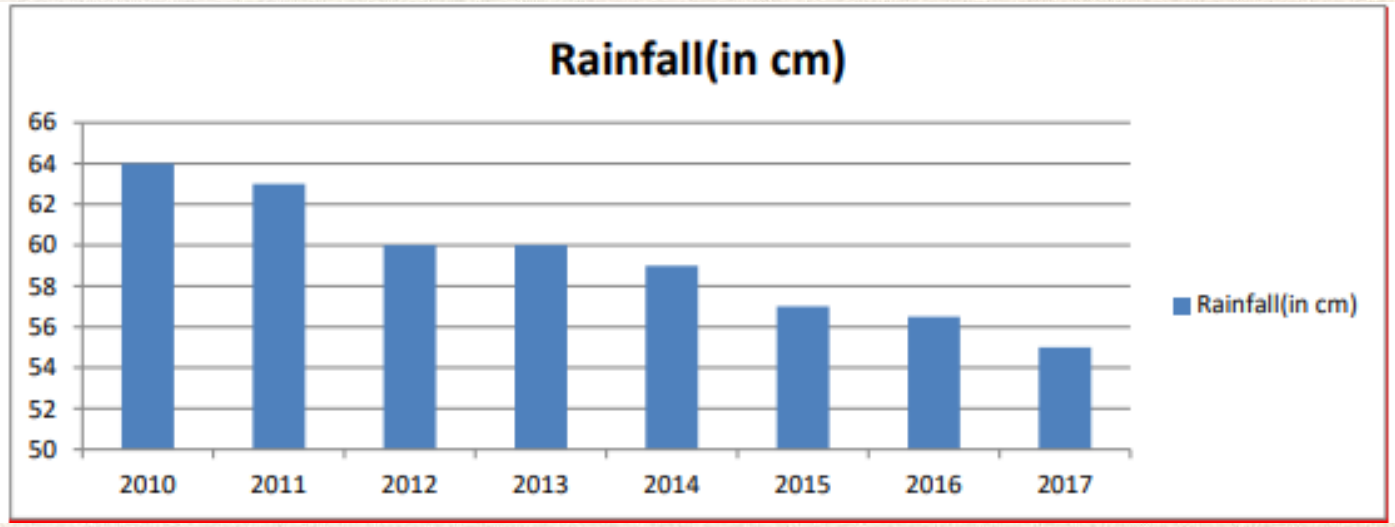
[3]Yadav, R. N., and Ajit Singh. "Study of Water Management and Scarcity of Drinking Water in Alwar City (Rajasthan)." *Ecology, Environment and Conservation*, Feb. 2022, pp. 506–11. *DOI.org (Crossref)*, https://doi.org/10.53550/EEC.2022.v28i02s.076.

[4]*GROUND WATER INFORMATION ALWAR DISTRICT RAJASTHAN*. Central Ground Water Board , 2013, https://cgwb.gov.in/District_Profile/Rajasthan/Alwar.pdf.

[5]*GROUND WATER INFORMATION ALWAR DISTRICT RAJASTHAN*. Central Ground Water Board , 2013, https://cgwb.gov.in/District_Profile/Rajasthan/Alwar.pdf.

The graph appended below provides an overview of the declining trends in rainfall in the city between 2010 and 2017 –

Figure 1: Rainfall Trends in Alwar City[6]



This graph represents the how the level of rainfall has been declining over the years. While the city received 64 cm rainfall in the year 2010, it came down to merely 57 cm in the year 2017, which reflects a concerning picture given the already low levels.

Need for the Study

Alwar belongs to the Dark Zone, wherein the water resources have been over exploited.[7] There also is no comprehensive literature available which analyses the status of water supply in the city. Thus, there is a need to evaluate the current system of service delivery of water supply in the city, given the paucity of literature on the same and the need for a comprehensive study in order to devise workable solutions. Moreover, since Alwar belongs to the Dark Zone, there is an urgent need to improve the water management system which requires the identification of gaps and suggest readily achievable ways to improve and sustain the same. This study would also be beneficial for documentation for future reference.

Research Methodology

This study is based on primary as well as secondary data collection. The information provided by PHED Alwar, Alwar Municipality and the official documents has been used to analyze the status and situation of water supply in the city and reach to workable solutions. A major proportion of the data as well as factual information has been provided by the PHED. Survey method has also been used to collect information not available with the PHED, such as the extent to which rainwater harvesting systems have been done as well as the situation with

[6]Chauhan, Divya, and Vijay Kumar Verma. "Rainfall Fluctuations and Depleting Water Levels In Alwar City." *SGVU J CLIM CHANGE WATER*, vol. 6.

[7]"Dark Zones." *Press Information Bureau*, 2013, https://pib.gov.in/newsite/PrintRelease.aspx?relid=98849.

regard to private tankers. A total of 60 households were surveyed, from different parts of the city and belonging to different income groups, in order to evaluate the parity between the official information and the actual situation of water supply in the city. A few sample responses have been attached in the appendix at the end of this report. The study also takes help of the existing literature and research papers, in order to make the same comprehensive.

Current Status of Water Supply in Alwar

The Public Health Engineering Department, also known as the PHED, has the primary responsibility of water supply and distribution in the city. However, the Municipality is responsible to supply water to the gap areas, where the PHED is unable to supply due to various limitations. The proportion of population covered by the Municipality is very low, amount to approximately merely 15% of the total. The paper focuses on the water supply and distribution undertaken by the PHED, given that a major chunk of the same is the responsibility of the Department.

Sources and Distribution System

The primary source of water supply in the city is ground water from wells (refer Annexure). As per the information provided by the PHED officials, the average level of the water table (as of July 2023) is 70 meters below the ground. The absolute absence of any surface water source for water supply is a major challenge hindering adequate supply of water in the city, given that the level of water below the ground is considerably low and is dipping every year at a rate of approximately 15 meters annually. Water from the wells is first sent to the Clear Water Reservoirs, also known as CWRs, located at various places throughout the city. There is no full-fledged water treatment plant in the city. However, the water is disinfected through Chlorination using bleaching powder in the CWRs. The dosage for chlorination is 2ppm. From the CWRs, the chlorinated water goes to the OHRSs through the pump house.[8], from where it is supplied to the public through pipelines. The retention capacity of the OHSRs is between 10-24 hours.

Availability of Water

The city is completely reliant upon ground water for all its water requirements. The following table depicts the prospective demand for water by the year 2025-

[8]Yadav, R. N., and Ajit Singh. “Study of Water Management and Scarcity of Drinking Water in Alwar City (Rajasthan).” *Ecology, Environment and Conservation,* Feb. 2022, pp. 506–11. *DOI.org (Crossref),* https://doi.org/10.53550/EEC.2022.v28i02s.076.

Table 1. Prospective demand of drinking water in Alwar by 2025 AD.

Year	Population	Daily demand (ML)	Daily Local supply (ML)	Short supply (ML)	No. of T/W at present time
2018	367459	49.6	36.0	13.6	230
2019	373872	50.4	36.8	13.6	234
2020	380285	51.3	36.5	14.8	266
2021	386707	52.2	36.5	15.7	290
2022	393120	53.0	-	16.5	-
2023	399533	53.9	-	17.4	-
2024	405946	54.8	-	18.3	-
2025	412359	55.6	-	19.1	-

Table 1: Prospective Demand of Drinking Water in Alwar by 2025[9]

The above table reflects the demand for drinking water by the year 2025. The fourth column represents the actual daily local supply. The fifth column reflects the quantum of short supply, which is the difference between the daily demand and the actual daily supply. The last column informs the number of tube-wells of the corresponding year. Though it is stated in the table above that the daily water supply is 36.5 MLD, as per information provided by the PHED, the current daily water supply (as of 2023) is only 32 LPCD, which amounts to only 23.6 MLD.

Presently the level of the water table in the city is approximately 70 meters below the ground. Due to extremely low levels of rainfall, and the absence of a robust recharge mechanism, the rate of recharge of ground water is negligible. It has been mentioned by PHED officials that the existing water resources can sustain only for a period 6 months in some areas to 6 years in others.

Receding Water Levels

With high levels of extraction due to the absence of other sources of water supply and meagre rate of recharge due to extremely low levels of rainfall and non-efficient utilization and no reuse and recycling mechanism in place, the ground water table is receding at an increasing rate, thereby leading to the drying up of tube-wells. The months during which the demand for water is the highest, i.e. March to July, the level of the tube-wells tends to decline the quickest, leading to disruption of water supply.

Quantum of Supply

While the level of ground water in the city is depleting, the demand for water is increasing due to the growing population. The rate of recharge is much lower than the rate of consumption, owing to population pressure and low levels of rainfall. Moreover, the unavailability of any surface water source adds to the already building pressure on the ground water. As per urban water supply norms, the recommended quantum of water supply is 135 liters per capita per

[9]Yadav, R. N., and Ajit Singh. "Study of Water Management and Scarcity of Drinking Water in Alwar City (Rajasthan)." *Ecology, Environment and Conservation*, Feb. 2022, pp. 506–11. *DOI.org (Crossref)*, https://doi.org/10.53550/EEC.2022.v28i02s.076.

day.[10] However, as per data received from the PHED, 64 liters per capita of water is supplied every alternate day, which comes down to approximately 32 LPCD of water. It is also essential to note that these 64 liters per capita every alternate day is achieved after addition from temporary borewells/tube-wells, in the absence of which the department would only be able to achieve 46 liters per capita every alternate day. However, the city could not maintain uniformity in the quantity of water supplied in all areas because of a number of factors. As these factors are beyond the control of the PHED, the amount of water supplied in some areas is more than that of others.

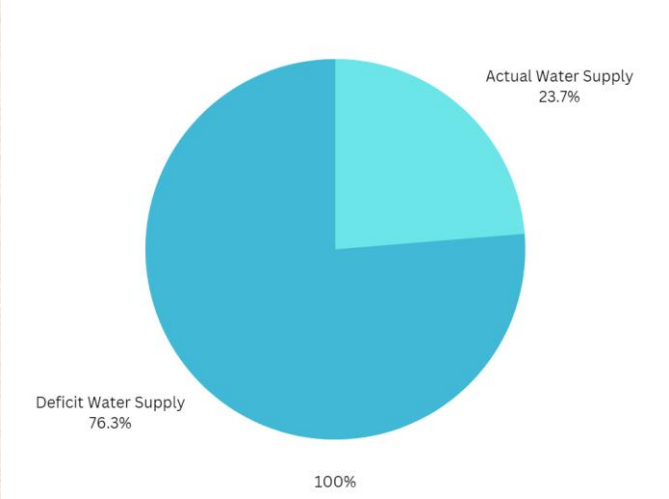


Figure 2: Water Supply (LPCD)

The above graph depicts that the actual water supply (approximately 32 LPCD) is merely 23.7% of the intended water supply (135 LPCD), which has been recommended by the Urban Water Supply Norms. This depicts a major deficit of 76.3%.

Frequency of water supply (as per survey)-

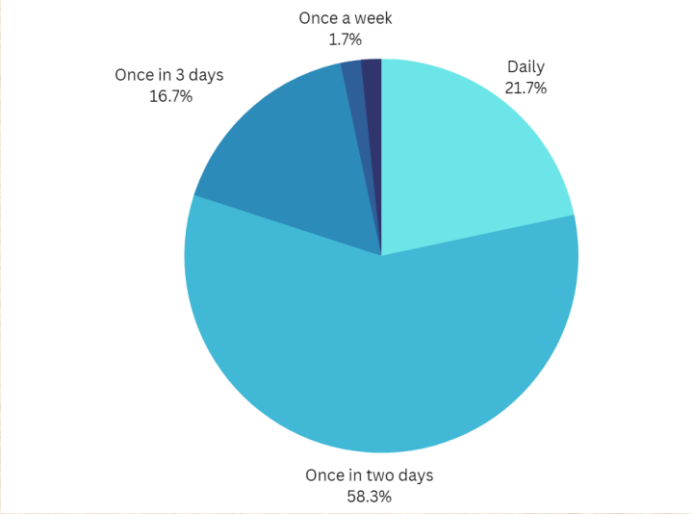


Figure 3: Frequency of Water Supply

[10] *Report of the Committee Set up to Frame National Sustainable Habitat Standards for the Urban Water Supply and Sewerage Sector*. Ministry of Housing and Urban Affairs, https://mohua.gov.in/upload/uploadfiles/files/uwss.pdf.

Frequency	No of Households	Percentage of Households
Daily	13	21.7%
Once in two days	35	58.3%
One in three days	10	16.7%
One in a week	1	1.7%
No water since last 6 weeks	1	1.7%

A majority of the respondents (58.3%) informed that they receive water every alternate day. 21.7% receive water daily and 16.7% receive water once in three days.

What is concerning here is that one respondent informed that they receive water only once a week and another has not received water since the last 6 weeks. Despite having informed the PHED multiple times, they have received no respite and the issue remains unresolved. Duration of water supply (as per survey) –

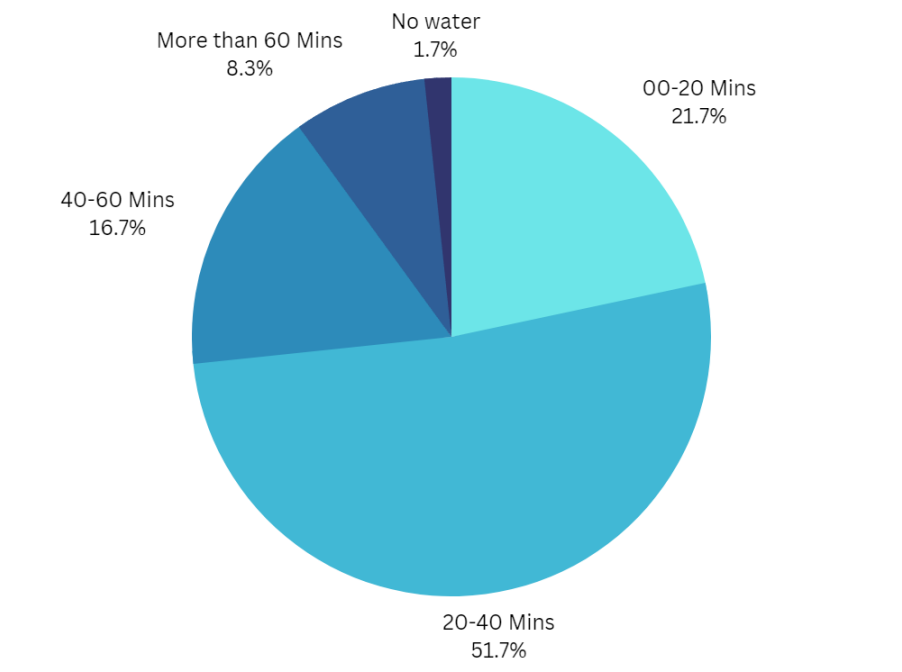


Figure 4: Duration of Water Supply

Duration of Water Supplied	Percentage of Households	Number of Households
0 – 20 Minutes	21.7%	13
20 – 40 Minutes	51.7%	31
40 – 60 Minutes	16.7%	10
More than 60 minutes	8.3%	5
No water	1.7%	1

A majority of the households (51.7%) receive water for 20-40 minutes. 21.7% receive water for less than 20 minutes and 16.7% receive water for 40-60 minutes. One respondent responded that they receive no water at all despite having a functional water connection.

Pipelines and Water Connections

The total length of the rising main in the city (from tube-wells to the Clear Water Reservoirs) is approximately 177 km. The distribution lines are approximately 722 km in length.

The current pipelines for water supply and distribution in the city were installed in three phases. The first set was installed between 2007-10, the second between 2016-18 under NCRPB and the third between 2017-19.

There are approximately 60,000 water connections in the city. The total percentage of households with water connection is approximately 75%, taking five as the average number of members per family, as per the data provided by PHED.

Extent of Metering

Almost every household with a sanctioned water connection through the PHED has a meter installed. However, a huge number of meters are non-functional. Identification of such non-functional meters is a challenge. This is because the meter readers/persons in charge of recording the readings do no report about the non-functionality and its extent. The water bill is thus based on average consumption at a fixed rate. These meters are fully funded by the government.

Extent of metering (as per survey) -

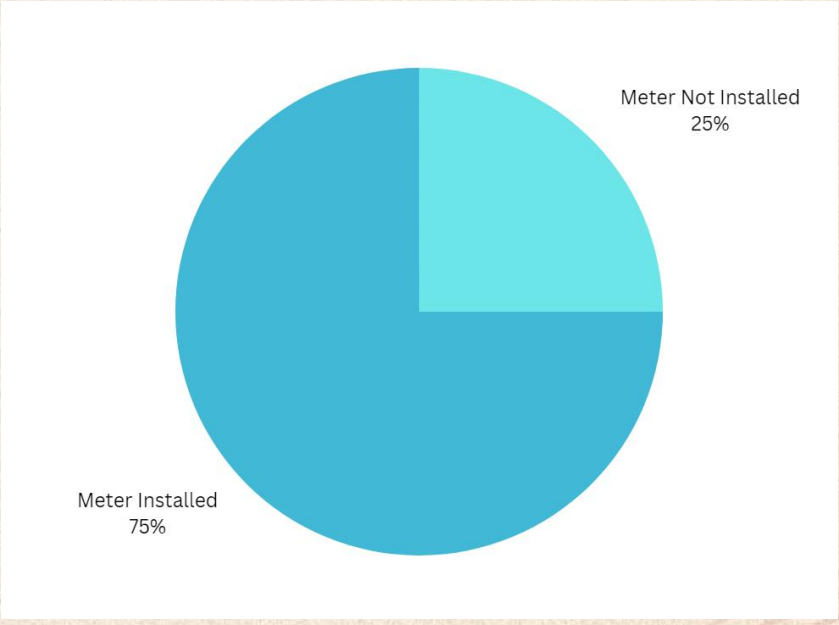


Figure 5: Extent of Metering

Whether Water Meter Installed	Percentage of Households	Number of Households
Not Installed	25%	15
Installed	75%	45

25% of the households surveyed do not have water meters installed. This is in contrary to what was informed by the PHED officials, citing 100% households having meters installed.

Extent of functional meters (as per survey) -

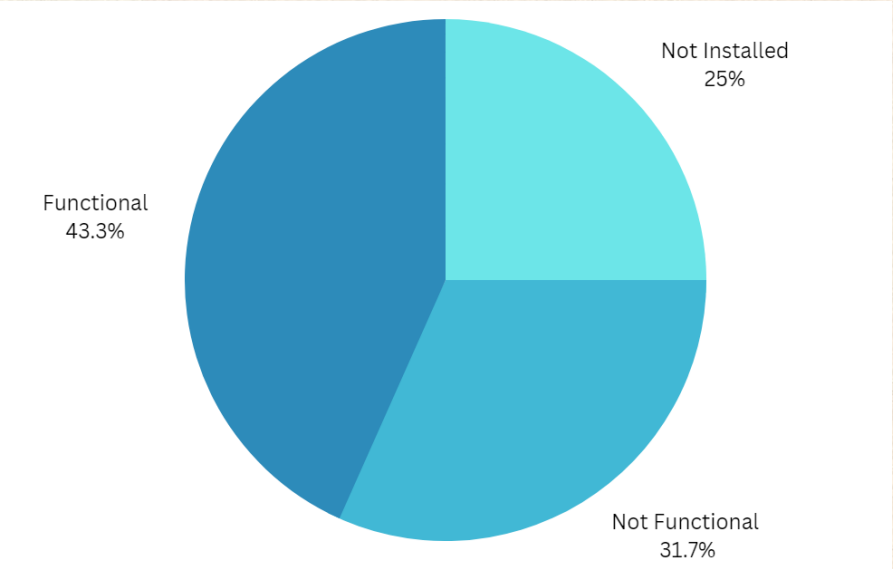


Figure 6: Extent of Functional Meters

Whether Water Meter Installed	Percentage of Households	Number of Households
Not Installed	25%	15
Not Functional	31.7%	19
Functional	43.3%	26

While 25% of the households do not have any meters installed, 31.7% households, despite having meters installed, have non-functional meters. This means that a mere 43.3% (of the total households surveyed) have functional water meters. The other households are charged on a uniform rate based on average levels of consumption.

Used Water Management System

As per the information from the PHED, there is no used water management system in place. The used water is discharged into drains with no reuse mechanism in place.

Rainwater Harvesting

The level of rainfall in the city is extremely low, which is why the rate of replenishment of ground water also remains low. In such a situation, it becomes even more important to catch the water wherever it falls. Rainwater harvesting is thus an essential requirement for the city.

In Alwar, all plots with a size of 20 square meters or more are required to have a rainwater harvesting system in place. However, no robust mechanism exists for the implementation of the same. While the initiative is a wonderful one, it would reap results only if and when the mandates are followed as well as enforced well.

As per surveys conducted and collating it with the information received from PHED, only about 15% of households belonging to the high-income group category, about 10% of households belonging to the middle-income group category and an insignificant percentage of households belonging to the low-income group category have rain water harvesting systems in place.

Households with a functional rainwater harvesting system (as per survey) -

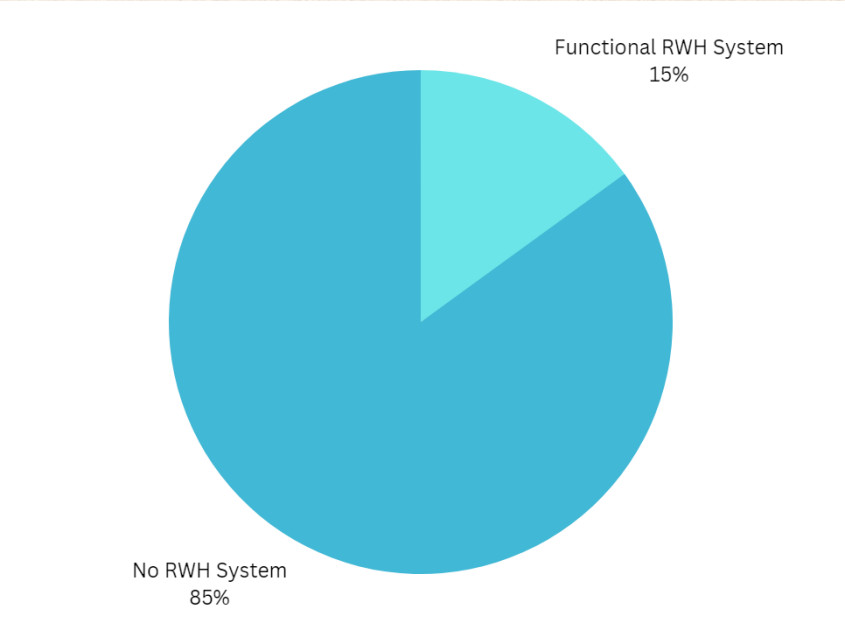


Figure 7: Extent of Rainwater Harvesting

Whether RWH System in Place	Percentage of Households	Number of Households
Functional RWH System	15%	9
No RWH System	85%	51

Only 15% of the households surveyed had a functional rainwater harvesting system in place, while a whopping 85% had no means to catch and collect rainwater.

Stormwater Management

There is no stormwater management system in place in the city. As a result, the water just runs off with no mechanism to collect and channelize it into the ground for recharging the water table. Given the low levels of rainfall, it is essential to effectively and efficiently collect and utilize the rain water to the maximum possible extent.

Water Quality Testing Mechanism

There is a well-established and fully functional lab in the city for the purpose of water quality testing. The samples for testing are collected primarily from four sources, namely, Tube-wells, CWRs, OHSRs and consumer taps. Tests are conducted from each category of source every 7 days, except consumer taps which are checked randomly.

Appended below are the water quality testing reports of samples collected from various sources in the city –

1. Lake Siliserh

MONITORING OF INDIAN NATIONAL AQUATIC RESOURCES

1. STATION CODE	2937	STATION	LAKE SILISED, ALWAR, RAJASTHAN
2. DATE AND TIME OF SAMPLE TAKEN (DD/MM/YYYY)	04/04/2023 11-30		
3. WEATHER	Clear		
4. APPROX.DEPTH OF MAIN STREAM	> 100 cm	TYPE	LAKE
5. COLOUR AND INTENSITY	Clear 1=Light	COMPLETED BY	Regional Laboratory Alwar
6. ODOUR	None	VERIFIED By	Chief Scientific Officer, Regional Laboratory Alwar
7. VISIBLE EFFLUENT DISCHARGE IN PROXIMITY	None	AGENCY	RAJASTHAN STATE POLLUTION CONTROL BOARD
8. HUMAN ACTIVITIES AROUND STATION	Others		
9. LOCATION DETAIL	U/s of Town or Industrial Area		

DETERMINAND	WHO CODE	AQC	VALUE
Cadmium as Cd mg/l			BDL
Copper as Cu mg/l			0.20
Iron as Fe mg/l			0.12
Total Chromium as Cr mg/l			BDL
Nickle as Ni mg/l			BDL
Zinc as Zn mg/l			0.11
Lead as Pb mg/l			BDL

DETERMINAND	ARBITRARY CODE	AQC	VALUE

Lab Incharge / Board Analyst

MONITORING OF INDIAN NATIONAL AQUATIC RESOURCES

1. STATION CODE	2937	STATION	LAKE SILISED, ALWAR, RAJASTHAN
2. DATE AND TIME OF SAMPLE TAKEN (DD/MM/YYYY)	04/04/2023 11-30		
3. WEATHER	Clear		
4. APPROX.DEPTH OF MAIN STREAM	> 100 cm	TYPE	LAKE
5. COLOUR AND INTENSITY	Clear 1=Light	COMPLETED BY	Regional Laboratory Alwar
6. ODOUR	None	VERIFIED By	Chief Scientific Officer, Regional Laboratory Alwar
7. VISIBLE EFFLUENT DISCHARGE IN PROXIMITY	None	AGENCY	RAJASTHAN STATE POLLUTION CONTROL BOARD
8. HUMAN ACTIVITIES AROUND STATION	Others		
9. LOCATION DETAIL	U/s of Town or Industrial Area		

DETERMINAND	WHO CODE		AQC				VALUE
Fecal Streptococci MPN/100 ml							14
Total Alkalinity mg/l	Y						256
B.O.D. mg/l	0	8	2	0	1	N	1.64
C.O.D. mg/l	0	8	3	0	1	N	18
Calcium as Ca mg/l	2	0	1	0	1	N	33.6
Chloride mg/l	Y						5.672
Conductivity µmho/cm	0	2	0	4	1	N	252.5
Dissolved Oxygen mg/l	0	8	1	0	1	N	5.8
Fecal Coliform MPN/100ml	3	6	0	1	1	N	20
Magnesium as Mg mg/l	1	2	1	0	3	N	1.94
pH	1	0	3	0	2	N	7.67
Phenolphthalein Alkalinity	Y						NT
Sodium mg/l	1	1	1	0	3	N	97.5
Sulphate mg/l	Y						16.4
Temperature 0C	0	2	0	0	1	N	23

DETERMINAND	ARBITRARY CODE			AQC			VALUE
Ammonia Nitrogen mg/l	Y						0.21
Boron Dissolved mg/l	0	5	1	0	5	N	0.19
Fluoride As F mg/l	Y						0.51
Total Hardness As CaCO3 mg/l	2	2	1	0	1	N	92
Nitrate as N mg/l	Y						1.44
Nitrite As N mg/l	Y						0.0051
Phosphate As PO4 mg/l	Y						0.16
Potassium As K mg/l	Y						8.7
Total Coliform MPN/100ml	3	7	0	0	1	N	34
Total Dissolved Solids mg/l	3	3	3	3	3	N	156
Turbidity JTU/NTU	0	2	1	0	1	N	0.17

Incharge / Board Analyst

2. Tubewell, MIA, Alwar

MONITORING OF INDIAN NATIONAL AQUATIC RESOURCES

1. STATION CODE	1706	STATION	TUBEWELL NEAR RIICO PUMP HOUSE NEAR MONTO MOTORS, MIA, ALWAR, RAJASTHAN
2. DATE AND TIME OF SAMPLE TAKEN (DD/MM/YYYY)	20/04/2023 11-30		
3. WEATHER	Clear		
4. APPROX.DEPTH OF MAIN STREAM	> 100 cm	TYPE	TUBE WELL
5. COLOUR AND INTENSITY	Clear 1=Light	COMPLETED BY	Regional Laboratory Alwar
6. ODOUR	None	VERIFIED By	Chief Scientific Officer, Regional Laboratory Alwar
7. VISIBLE EFFLUENT DISCHARGE IN PROXIMITY	None	AGENCY	RAJASTHAN STATE POLLUTION CONTROL BOARD
8. HUMAN ACTIVITIES AROUND STATION	Others		
9. LOCATION DETAIL	Abstraction for Water Supply		

DETERMINAND	WHO CODE		AQC				VALUE
Cadmium as Cd mg/l							BDL
Copper as Cu mg/l							BDL
Iron as Fe mg/l							0.16
Total Chromium as Cr mg/l							BDL
Nickle as Ni mg/l							BDL
Zinc as Zn mg/l							0.12
Lead as Pb mg/l							BDL

DETERMINAND	ARBITRARY CODE			AQC			VALUE

Lab Incharge / Board Analyst

MONITORING OF INDIAN NATIONAL AQUATIC RESOURCES

1. STATION CODE	1706	STATION	TUBEWELL NEAR RIICO PUMP HOUSE NEAR MONTO MOTORS, MIA, ALWAR, RAJASTHAN
2. DATE AND TIME OF SAMPLE TAKEN (DD/MM/YYYY)	20/04/2023 11-30		
3. WEATHER	Clear		
4. APPROX.DEPTH OF MAIN STREAM	> 100 cm	TYPE	TUBE WELL
5. COLOUR AND INTENSITY	Clear 1=Light	COMPLETED BY	Regional Laboratory Alwar
6. ODOUR	None	VERIFIED By	Chief Scientific Officer, Regional Laboratory Alwar
7. VISIBLE EFFLUENT DISCHARGE IN PROXIMITY	None	AGENCY	RAJASTHAN STATE POLLUTION CONTROL BOARD
8. HUMAN ACTIVITIES AROUND STATION	Others		
9. LOCATION DETAIL	Abstraction for Water Supply		

DETERMINAND	WHO CODE			AQC			VALUE
Fecal Streptococci MPN/100 ml							<3
Total Alkalinity mg/l	Y						216
C.O.D. mg/l	0	8	3	0	1	N	20
Calcium as Ca mg/l	2	0	1	0	1	N	36.8
Chloride mg/l	Y						87.91
Conductivity µmho/cm	0	2	0	4	1	N	954.3
Fecal Coliform MPN/100ml	3	6	0	1	1	N	2
Magnesium as Mg mg/l	1	2	1	0	3	N	40.82
pH	1	0	3	0	2	N	7.92
Phenolphthalein Alkalinity	Y						NT
Sodium mg/l	1	1	1	0	3	N	75.1
Sulphate mg/l	Y						123
Temperature 0C	0	2	0	0	1	N	27

DETERMINAND	ARBITRARY CODE			AQC			VALUE
Boron Dissolved mg/l	0	5	1	0	5	N	0.31
Fluoride As F mg/l	Y						1.06
Total Hardness As CaCO3 mg/l	2	2	1	0	1	N	260
Nitrate as N mg/l	Y						2.51
Nitrite As N mg/l	Y						0.0194
Phosphate As PO4 mg/l	Y						0.24
Potassium As K mg/l	Y						5.1
Total Coliform MPN/100ml	3	7	0	0	1	N	6
Total Dissolved Solids mg/l	3	3	3	3	3	N	585.5

Lab Incharge / Board Analyst

Standard Parameters for Determining Water Quality –

GENERAL STANDARDS FOR DRINKING WATER

(IS 10500: 2012) [18]

Sr. No.	PARAMETERS	DESIRABLE/ACCEPTABLE LIMIT	PERMISSIBLE LIMIT IN THE ABSENCE OF ALTERNATE SOURCE
1	Colour (Hazen Units)	5	15
2	Odour	Agreeable	Agreeable
3	Taste	Agreeable	Agreeable
4	Turbidity, NT Units	1	5
5	pH	6.5 – 8.5	No Relaxation
6	Total Hardness as $CaCO_3$, mg/l	200	600
7	Iron as Fe, mg/l	0.3	No Relaxation
8	Chloride as Cl, mg/l	250	1000
9	Free Residual Chloride	0.2	1
10	Total Dissolved Solids, mg/l	500	2000
11	Calcium as Ca	75	200
12	Copper as Cu	0.05	1.5
13	Manganese as Mn, mg/l	0.1	0.3
14	Sulphate as SO_4, mg/l	200	400
15	Nitrate as NO_3, mg/l	45	No Relaxation
16	Fluoride as F, mg/l	1.0	1.5
17	Phenols as C_6H_5OH	0.001	0.002
18	Mercury as Hg	0.001	No Relaxation
19	Cadmium as Cd	0.003	No Relaxation
20	Selenium as Se	0.01	No Relaxation
21	Arsenic as As	0.01	0.05
22	Cyanide as CN	0.05	No Relaxation
23	Lead as Pb	0.01	No Relaxation
24	Zinc as Zn, mg/l	5	15
25	Nickel as Ni, mg/l	0.02	No Relaxation
26	Anionic detergents as MBAS	0.02	1.0
27	Total Chromium as Cr	0.05	No Relaxation
28	Mineral Oil	0.01	0.03
29	Pesticides	Nil	0.001
30	Radioactive materials - Alpha emitters, Beq/l - Beta emitters, Pci/l	 - -	 0.1 1.0
31	Alkalinity as $CaCO_3$, mg/l	200	600
32	Aluminium as Al	0.03	0.2
33	Boron	1	5
34	Fecal Streptococci	Nil	-
35	Coli form M.P.N. (in 100 ml)	1	10
36	Cyclopes (or Guinea Worms)	Nil	Nil

* Charges on cations and anions are omitted

Some of the parameters of the tested samples are within desirable limits, most of the parameters are within the permissible limits, and only a few parameters are beyond the permissible limits.

Public satisfaction with water quality (as per survey)

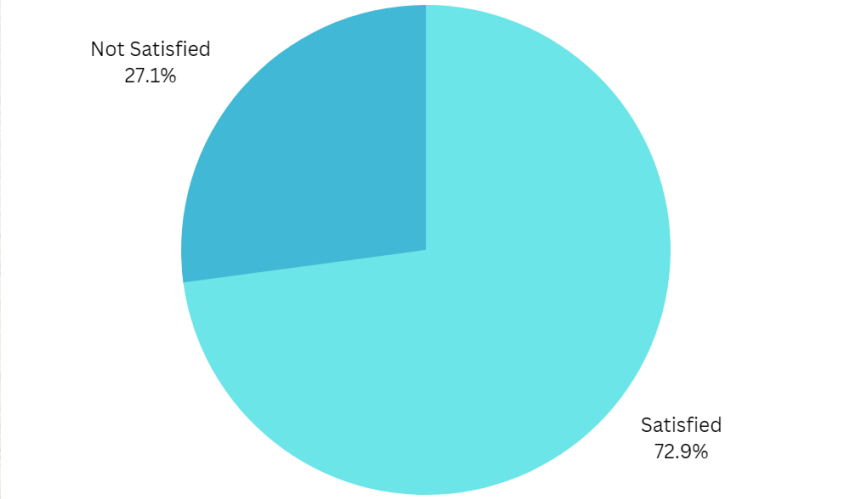


Figure 8: Extent of Public Satisfaction with Water Quality

Satisfaction with Water Quality	Percentage of Households	Number of Households
Satisfied	72.9%	43
Not Satisfied	27.1%	16

While a majority of the respondents (72.9%) were by and large satisfied with the water quality, 27.1% were dissatisfied by the same. The major reasons for dissatisfaction cited were muddy water, unpleasant taste/smell, unusual color etc.

Operations & Maintenance

Operations and maintenance are carried out at regular intervals as a preventive measure. Moreover, there is an active response in case of a breakdown or failure. The process of the same is outsourced as well as departmental in nature.

The components which are outsourced include maintenance of tube-wells, submersible pumps, fixing leakages in the pipelines and maintenance of centrifugal pumps. The components looked after by the PHED include billing and operation of the pumps and pump houses.

The billing for last year was primarily under two heads, namely Pump & Machinery and Distribution. The former was approximately 80 lakhs, and for the latter was 1 crore 20 lakhs pertaining to last year.

Recovery of O&M Costs

The revenue collected by way of water bills, which is approximately just ₹200 per month per connection. As per the information provided by the PHED officials, approximately 70-75 per cent of the costs are recovered through user charges. Since a number of meters are non-functional, the bills are based on average consumption based on fixed rate. Water bills are

generated once in every two months. The rate of charging for water remains throughout all income groups. Most payments of bills by the public are made through E-Mitra portals. The balance amount is funded by the State Government, and therefore the question of deficits does not arise. Further, a deposit of ₹1210 per connection is being collected for every new connection.

Grievance Redressal

The grievance redressal is done through a toll-free number (0144-2337900) through which the aggrieved can register their complaints. The records of complaints are maintained for a period of one year. Any unresolved complaints during a particular year are carried forward to the next. As per the PHED officials, the rate of redressal is 100%. However, the veracity of the same has to be looked into. Moreover, hundred percent uniformity in the quantity and quantum of water supply cannot be maintained. This means that a number of complaints are registered alleging that a particular area receives less water than other areas. However, the same is impossible and unfeasible to be addressed because it depends on factors such as the location of tube wells, yield of tube well etc., which cannot be uniform at all places. Public experience with the grievance redressal mechanism (as per survey) -

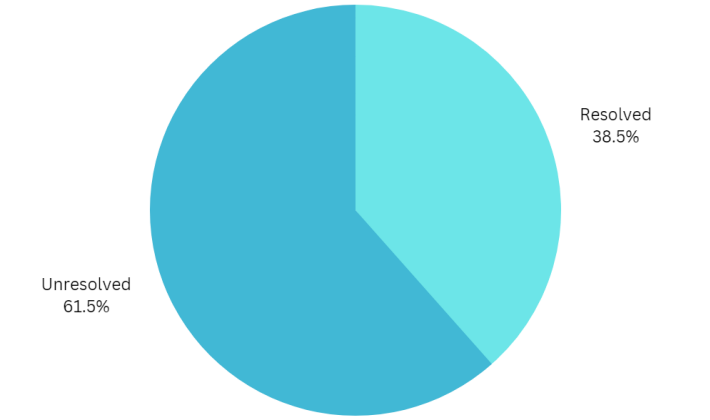


Figure 9: Public Experience with Grievance Redressal Mechanism

Resolution of Grievance	Percentage of Households	Number of Households
Resolved	38.5%	15
Unresolved	61.5%	24

Out of the households surveyed which had lodged grievances with the Department, a mere 38.5% grievances were resolved, while a whopping 61.5% remained unresolved. This is in stark contrast to the 100% grievance redressal which was cited by the PHED Officials.

Tankers for Deficit Fulfilment

Tankers are usually supplied as per the demand. Usually, the demand arises due to factors such as a locality not receiving enough water supply for a long period, or receiving no water at all through the piped water connection system. The demand is much higher during the summer

months, primarily March to July, as compared to that in the other months. These tankers are completely free of cost for the public.

The demand for water fulfilled by tankers is less than 1% of the total demand of the city by volume. The department currently has a total of 24 tankers, which carry out 225 trips per day. The cost per tanker amounts to ₹450 per trip. The volume of water carried by each tanker is between 4000-5000 liters. In most cases as well as in the slum areas, the tanker is emptied into a common water tank, to which taps are attached. The people come and collect water from such common tanks through the taps.

The entire demand for water in the city is not fulfilled by the PHED tankers due to a number of reasons. Moreover, the tankers supplied by the PHED are not accessible to all and are available to only the influential and privileged few, and the rest have to pay and call for private tankers. As a consequence, a number of persons have to call for private tankers, and pay huge sums of money for the same. The data on the same is not readily available as they are unorganized.

However, as per the information collected through interaction with the public it appears that these private tankers are getting water from private borewells. The cost per tanker is approximately ₹500, but it varies according to the areas to which the water is supplied as well as the service provider.

Source of tankers (as per survey) -

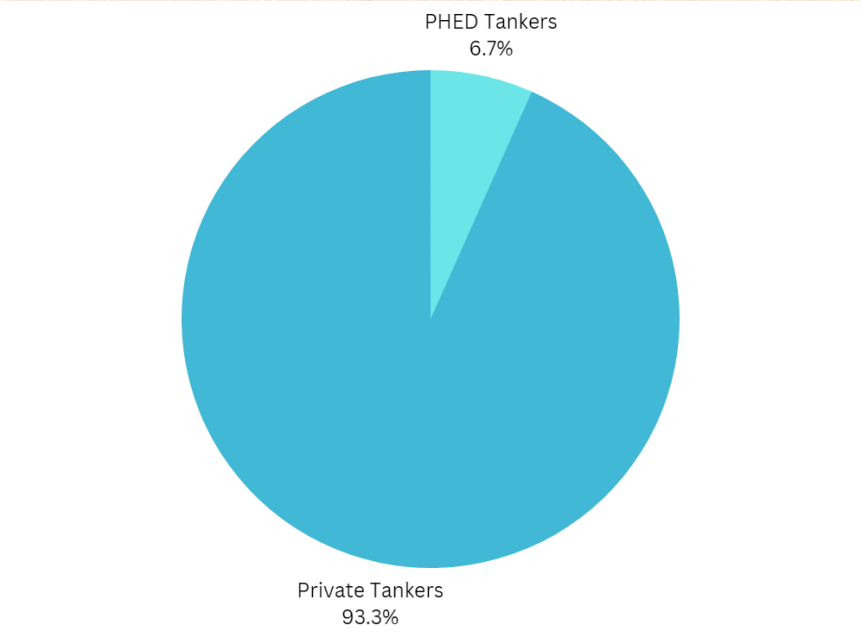


Figure 10: Source of Tankers

Source of Tankers	Percentage of Households	Number of Households
PHED Tankers	6.7%	3
Private Tankers	93.3%	42

Out of the respondents who call for tankers for fulfilling the deficit water requirements of their households, a whopping 93.3% had to call for private tankers and merely 6.7% received water from PHED tankers.

Power Supply

Small scale solar power plants have been installed in some places where there is absence of electricity supply, or where it is not feasible to install electric poles due to weather conditions. In the city, around ten such plants are in place and functional. There is, however, no solar power-based electricity backup for the city as a whole due to paucity of resources.

Non-Revenue Water (NRW)

NRW refers to the water which is lost before it reaches the end user. As per the information provided by the PHED officials, the percentage of thefts is about 10% and leakages are negligible, amounting to merely 1-2% of the total water supplied. Thus, the total percentage of non-revenue water is approximately 12%, which is well within the targeted limits. The Service Level Benchmarks recommend a maximum threshold of 15% for NRW.[11]

A few projects have been proposed in order to fulfil the deficit between the demand for water and the supply of water. These have been discussed below –

Future Plans

A. East Rajasthan Canal Project

The ERCP was proposed by the previous BJP government to address the drinking and irrigation water issues in 13 districts of eastern Rajasthan.[12]

The Navnera-Belwa-Bisalpur-Israda Link Project, the Navnera Barrage and Israda Dam, the Ramgarh and Mahlpur Barrages, and Mej Anicut will all be constructed with the approval. By 2040, additional drinking water demands for various districts will be met owing to water management activities pursuant to the ERCP. The Yamuna River, which ordinarily drains into the sea through the state's tributaries, will no longer empty into the sea due to the construction of dams under the ERCP. However, no reservation for Alwar has been mad under the project yet. In the state budget for 2023–2024, the government has allocated Rs 13,000 crore for a variety of tasks associated with this project.[13]

The Government of Rajasthan submitted the Detailed Project Report (DPR) of the Eastern Rajasthan Canal Project (ERCP) for techno-economic evaluation in November 2017 with a

---

[11]*HANDBOOK OF SERVICE LEVEL BENCHMARKING*. MINISTRY OF URBAN DEVELOPMENT GOVERNMENT OF INDIA, https://cpheeo.gov.in/upload/uploadfiles/files/Handbook.pdf.

[12] Correspondent, Special. “Eastern Rajasthan Canal Project Takes Political Twist after Centre’s Directive to Stop Work.” *The Hindu*, 4 July 2022. *www.thehindu.com*, https://www.thehindu.com/news/national/other-states/eastern-rajasthan-canal-project-takes-political-twist-after-centres-directive-to-stop-work/article65600112.ece.

[13]PTI. “CM Gehlot Approves Financial Proposal For Construction Of East Rajasthan Canal Project.” *Outlook*, 2023, https://www.outlookindia.com/national/cm-gehlot-approves-financial-proposal-for-construction-of-east-rajasthan-canal-project-news-269288.

projected expenditure of Rs. 37,247.12 crore (at 2014 pricing level). The projects on interstate rivers must be designed for a 75% reliable yield in accordance with current standards. Due to the project's anticipated 50% dependable output, which is outside of accepted limits and is also unacceptable to the government of Madhya Pradesh (MP), a co-basin State, the project's appraisal could not be completed. The Rajasthan government has been asked by the Central Water Commission to update the project planning at a 75% dependability level. The updated DPR, which uses a 75% reliable yield, has not yet been submitted.[14]

The Eastern Rajasthan Canal Project (ERCP) and the Parbati-Kalisindh-Chambal River Link are two projects that the Union government has produced a massive proposal to combine. In January 2023, Prime Minister Narendra Modi made this announcement.

The Center has submitted a draft plan for the major endeavor with the state governments of Rajasthan and Madhya Pradesh. This project will integrate the canal project in Rajasthan with the Chambal River connection project.[15]

B. Chambal

In the 2013-14 budget, the Rajasthan Government announced bringing water from Chambal and supplying it to various parts of the city and district. The estimated cost of the project was announced to be ₹950 crores. The state government has given its in-principal approval to the water projects and the NCRPB will fund the project, but it will be in the form of loans. These projects will cater to the major parts of Alwar, especially where there is acute water scarcity.[16]

C. Siliserh Lake

It has been proposed that approximately 2800 lakh liters of water per year would be earmarked for the purposes of water supply and distribution in the city. A part of the same would also be designated for other purposes like fish culture and irrigation. The Water Works Department has been entrusted with the responsibility of implementation of the project, and the ancillary responsibilities such as laying of pipelines and establishment of a water treatment plant.[17]

---

[14] "EASTERN REGION CANAL PROJECT." *Press Information Bureau*, 2023, https://pib.gov.in/pib.gov.in/Pressreleaseshare.aspx?PRID=1898806.

[15] Saxena, Ankit. "Centre To Merge Eastern Rajasthan Canal Project And Chambal River Link To Ensure Supply In Water Scarce Districts Of Rajasthan." *Swarajyamag*, https://swarajyamag.com/infrastructure/centre-to-merge-eastern-rajasthan-canal-project-and-chambal-river-link-to-ensure-supply-in-water-scarce-districts-of-rajasthan. Accessed 3 Aug. 2023.

[16] "Drinking Water Projects in Alwar District to Get Rs 1,132 Crore." *The Times of India*, 10 June 2012. *The Economic Times - The Times of India*, https://timesofindia.indiatimes.com/city/jaipur/drinking-water-projects-in-alwar-district-to-get-rs-1132-crore/articleshow/13981672.cms.

[17] "अलवर की प्यास बुझाएगी सिलीसेढ़ झील, सिंचाई विभाग ने सरकार के पास भेजा प्लान." *News18 हिंदी*, 7 Dec. 2022, https://hindi.news18.com/news/rajasthan/alwar-water-supply-from-silisedh-lake-in-alwar-irrigation-department-sent-plan-to-rajasthan-government-for-approval-5015531.html.

Major Gaps

Based on the above discussion, the following major gaps can be identified –

Deficit Water Supply

The population of the city, as of July 2023, is approximately 4.16 lakhs. As per the 2011 census, the population of Alwar was 3.22 lakhs. This shows an increasing trend in water supply. As per the Urban Water Supply Norms, a minimum 135 LPCD of water ought to be supplied. According to this, the demand boils down to approximately 56.1 MLD.

However, the actual quantity of water supply is approximately 23.6 MLD at an average rate of 32 LPCD, which reflects a significant deficit.

Whether water supplied by PHED is enough (as per survey)

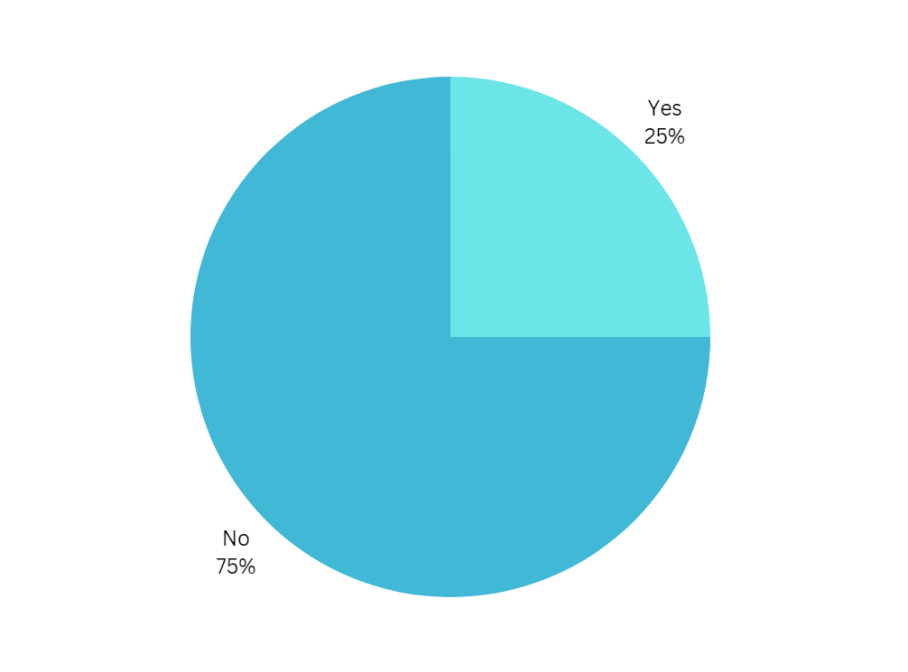


Figure 11: Sufficiency of PHED Water Supply

Whether Water is Enough	Percentage of Households	Number of Households
Yes	25%	15
No	75%	45

Only 25% of the respondents surveyed found the water supplied by the PHED enough to fulfil their daily consumption requirements. They rest 75% inevitably rely upon water tankers (whether supplied by PHED or by private contractors) to fulfil their daily consumption requirements.

Fulfilment of deficit consumption requirements (as per survey) -

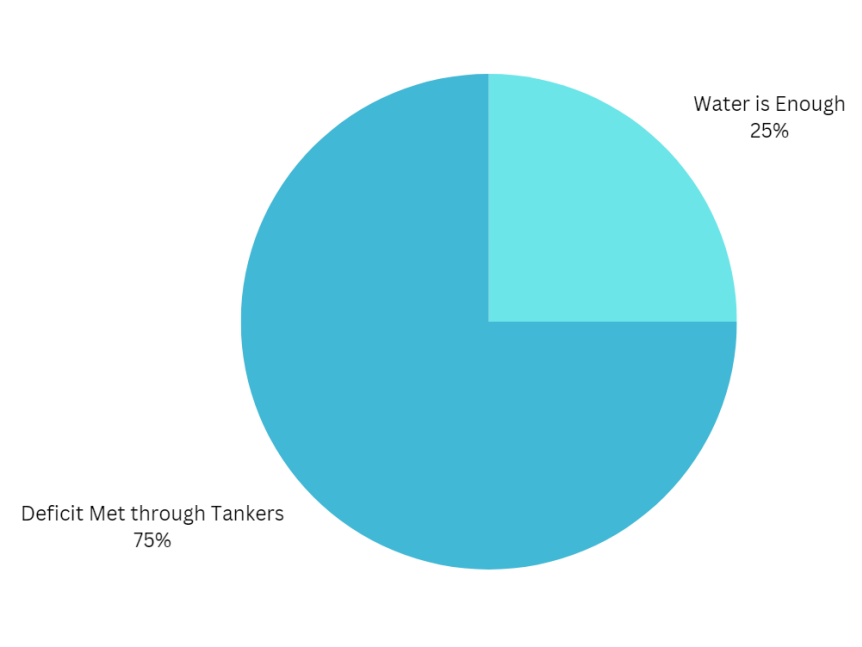


Figure 12: Fulfilment of Deficit Requirements

How is Deficit Met?	Percentage of Households	Number of Households
No Deficit	25%	15
Tankers	75%	45

For the respondents who found the water supplied by the PHED insufficient, complete reliance is on water tankers.

Lack of Data

There exists lack of data which leads to information gaps. These information gaps can lead to a number of other issues. One such issue which can be highlighted is that of inadequate information on non-functional meters. There is no data available with the PHED regarding the extent of non-functional meters, due to which most households are charged with a uniform rate, based on average consumption levels. This leads to some houses being charged for more water than has been consumed, and others are charged for less than what has actually been consumed. Another challenge which can be highlighted stemming from the problem of lack of data is that of tankers. Which some proportion of deficit demand is fulfilled by tankers supplied by the PHED, a huge chunk is also fulfilled by tankers supplied by private operators. There is no data on the extent of water supplied by such privately owned tankers. Thus, in the absence of sufficient data, bridging the gaps becomes difficult.

Absence of Water Treatment Plant

Another major drawback is the absence of a Water Treatment Plant in the city. The water is merely disinfected by the process of chlorination and using bleaching powder. The absence of

a robust water treatment mechanism may lead to supply of bad quality water especially during monsoon seasons and thus affect the health of the individuals consuming the same. While the quality of water presently is well within the permissible limits, and disinfection is working well, there is a need to put a water treatment plant in place, considering future needs and health of the population in the times to come.

Low Water Pressure

The water pressure in the pipelines is extremely low. As a consequence of this, the tail end of the pipelines receives a negligible amount of water. Such deficit demand is fulfilled by supplying tankers.

The distance up to which water can travel without pumping is hardly 1 meter, given that the water pressure is extremely low and almost all households have motors installed.

Lack of Proper Rainwater Harvesting and Stormwater Management

Alwar neither has a robust system of rainwater harvesting, nor that of stormwater management in place. It is also known that the level of rainfall is extremely low and the only source of water supply in the city is ground water. This means that in order to sustain the ground water table for longer, the city need to focus on recharging the ground water and collecting the rainwater wherever possible. However, onlya very meagre proportion of houses actually have rainwater harvesting systems in place, which is a major lacuna stemming from non-enforcement.

Power Cuts and Absence of Power Backup Mechanism

Power cuts are frequent, especially during the summer months. The absence of a power backup mechanism leads to a failure of water supply during power cuts, since the entire process of water supply is based upon the supply of electricity.

Lack of a Sufficient Drought Management Plan

As per information provided by the PHED officials, in case of a drought, there are plans to utilize the water from Siliserh Lake. However, the same is only in the proposal stage, and no further action has been taken in this regard yet. The lake cannot be utilized for water supply on a daily basis because of its low and dropping water level. Thus, it can only be used as a resource during exigencies. Moreover, an artificial reservoir to be used in case of exigencies has been constructed in the Lal Diggi area. While the reservoir has been constructed, it has not been supplied with water yet. This is because the canals leading to the reservoir have been encroached upon, which is hindering the water supply route. The source of water for this reservoir is Siliserh Lake. The dimensions of the reservoir are approximately 120 meters in length, 60 meters in width and 10 meters in height.

Issues with Water Quality

Public satisfaction with water quality (as per survey) -

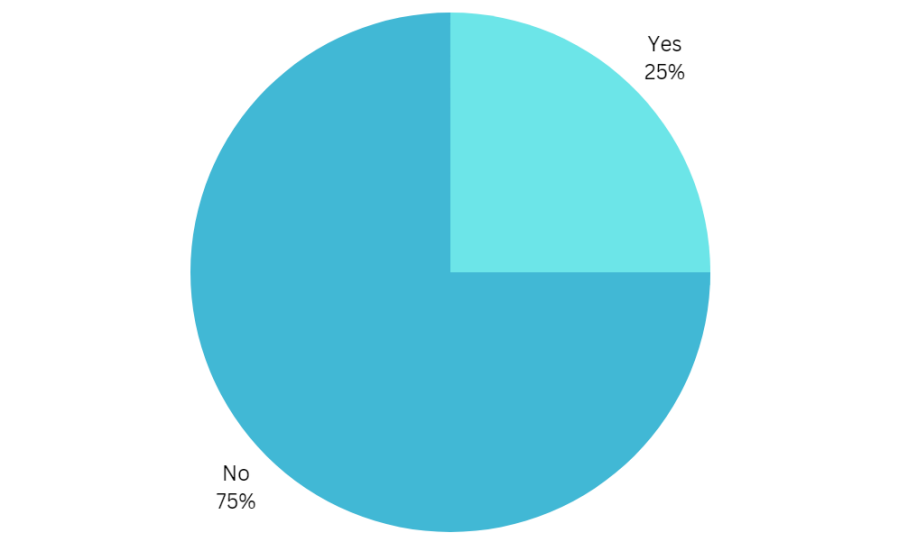


Figure 13: Public Satisfaction with Water Quality

Satisfaction with Water Quality	**Percentage of Households**	**Number of Households**
Satisfied	72.9%	43
Not Satisfied	27.1%	16

While a majority of the respondents (72.9%) were by and large satisfied with the water quality, 27.1% were dissatisfied by the same. The major reasons for dissatisfaction cited were muddy water, unpleasant taste/smell, unusual color etc.

Extent of water sample testing by respondents (as per survey) –

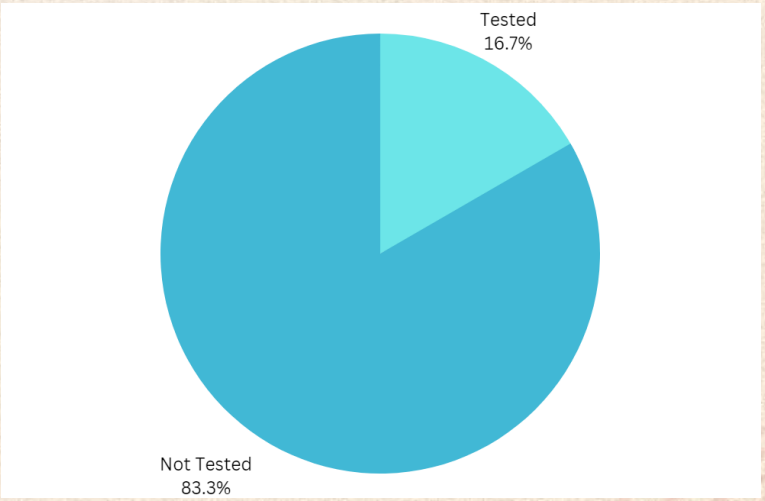


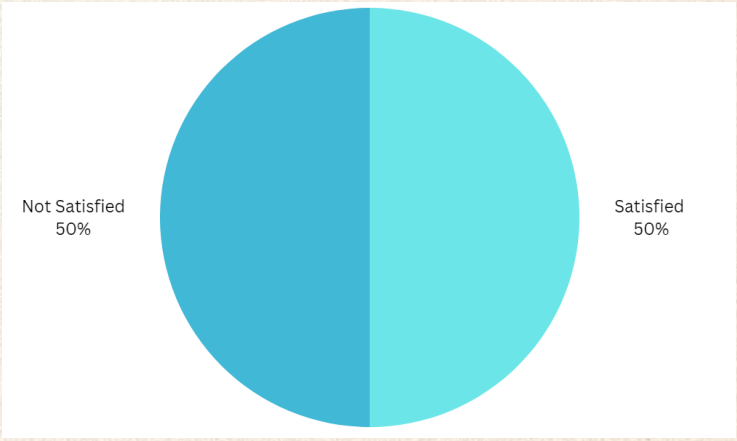
Figure 14: Extent of Water Sample Testing by Respondents

Whether tested	Percentage of Households	Number of Households

Tested	16.7%	10
Not Tested	83.3%	50

16.7% of the respondents got the water samples of their own consumer taps tested in the laboratory, while 833% did not.

For those who got samples tested (as per survey) –



Whether Satisfied After Testing	Percentage of Households	Number of Households
Satisfied	50%	5
Not Satisfied	50%	5

While half of the respondents were satisfied with the results of the sample testing, half found the quality to be unsatisfactory.

Unsatisfactory Grievance Redressal

Respondents who registered a grievance with the PHED (as per survey) -

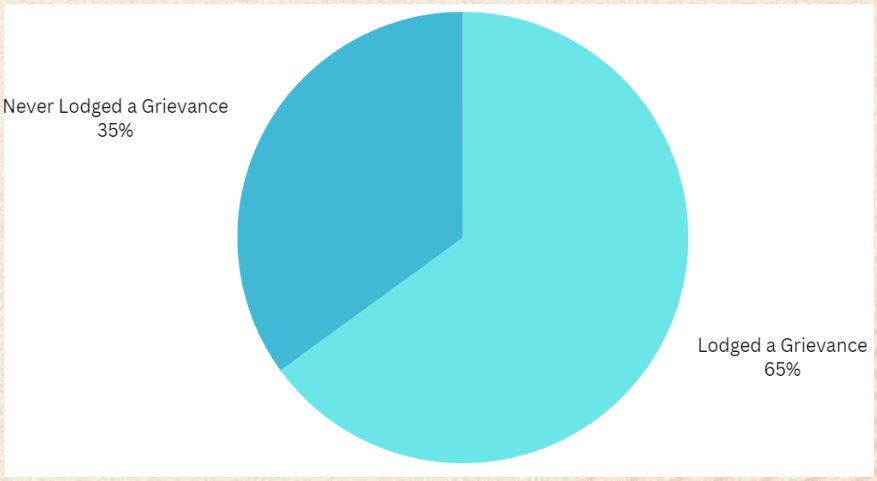


Figure 15: Response of respondents who got the samples tested

Whether Ever Lodged a Grievance	Percentage of Households	Number of Households
Yes	65%	39
No	35%	21

65% of the respondents surveyed had registered grievance(s) at some point with the PHED. 35% of the respondents had never registered any grievance with the Department.

Grievance Issue (as per survey) -

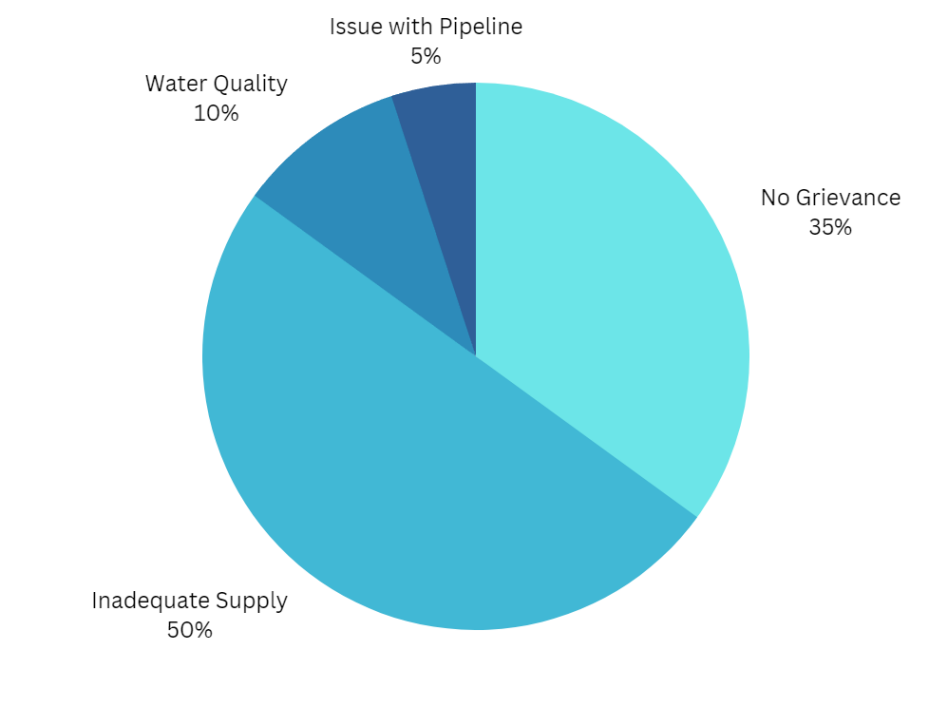


Figure 16: Grievance Issues of Respondents

Whether Ever Lodged a Grievance	Percentage of Households	Number of Households
Never Lodged	35%	21
Inadequate Supply	50%	30
Water Quality	10%	6
Issue with Pipeline	5%	3

50% of the respondents were aggrieved with inadequate water supply, by volume and/or by frequency. 10% had issues with the water quality whereas 5% had issues with the repair and maintenance of water supply pipelines.

Resolution whether achieved (as per survey)

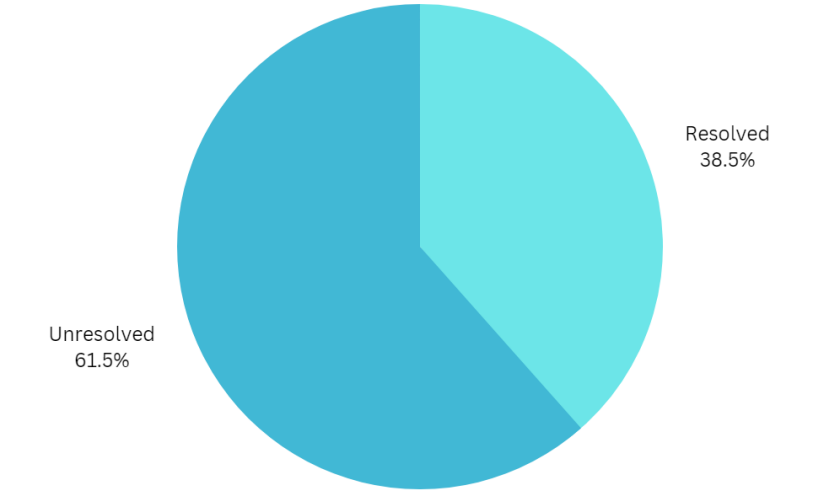


Figure 17: Resolution whether Achieves

Resolution of Grievance	Percentage of Households	Number of Households
Resolved	38.5%	15
Unresolved	61.5%	24

The survey revealed that merely 38.5% of the grievances were redressed and a whopping 61.5% remain unresolved.

Time taken for resolution (as per survey) -

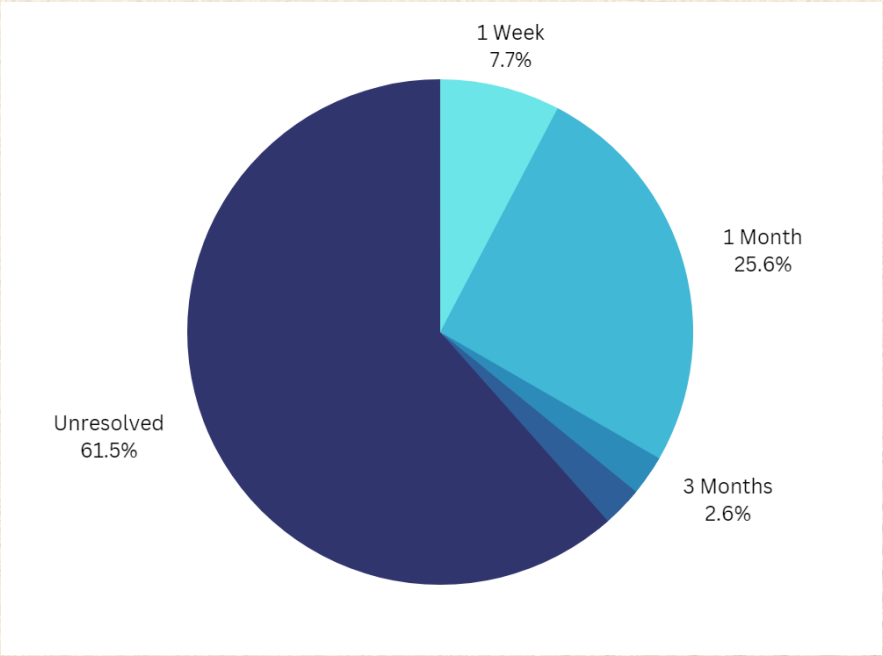


Figure 18: Time Taken for Resolution

Time Taken for Redressal	Percentage of Households	Number of Households
1 Week	7.7%	3
1 Month	25.6%	10
3 Months	2.6%	1
6 Months	2.6%	1
Unresolved	61.5%	24

7.7% of the complaints were resolved within a week. 25.6% grievances were resolved within a month. 2.6% grievances took 3 months to be resolved and the same percentage took 6 months to be resolved. However, 61.5% of the grievances remain unresolved to date.

Unsatisfactory Bill Amount

Extent of respondents satisfied with bill amount (as per survey)

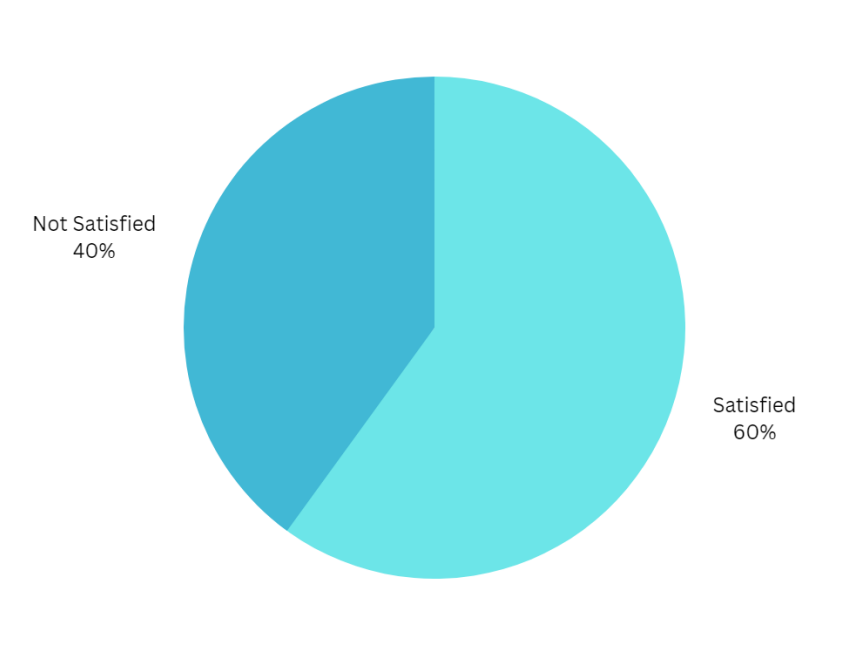


Figure 19: Extent of Satisfaction with Bill Amount

Opinion on Bill Amount	Percentage of Households	Number of Households
Satisfied	60%	36
Not Satisfied	40%	24

Out of not satisfied – 10 are with functional meters

A majority of the respondents (60%) are satisfied as satisfied with the billing amount. 40% are unsatisfied with the same. Out of the respondents who are unsatisfied with the amount, 41.7%

are with functional meters, who find the amount billed to be higher than the actual consumption. One respondent believes that the same could be because of air in the water supply in the pipelines. While the meter keeps churning because of the air, no water is received but the bill amount increases.

Absence of Surface Water Source

The absence of a surface water source for supply and distribution of water stands as a major roadblock. While proposals have been made to channelize water from Siliserh Lake, the same is still at the proposal stage and no further progress has been made in this regard. While utilizing water from lakes and reservoirs is a disaster response mechanism, a permanent solution needs to devised.

Considering that there is no sustainable way to supply water from surface water sources, and the levels of rainfall are very low, it is not recommended to depend solely on ground water. The city is yet to get any allocation under the Chambal Project and the ERCP.

Non-Functional Meters

While meters have been installed in almost every household, a huge quantum of those are either defunct or non-functional in nature. The primary reason behind the same is non-cooperation by the public.

Non-Institutionalized Tankers and Public Taps

Given that ground water is not sufficient to fulfil the water demand of the city, tankers to fulfil the deficit demand are inevitable. As per norms, the tankers have to provide 10 liters of water per member. However, the same is seldom followed due to a number of factors. However, what sometimes happens in the urban areas is that the entire water of the tanker is emptied into the underground storage tank of the house, which deprives the others of their rightful water. However, the percentage of such occurrences is very small. Moreover, the tankers supplied by the PHED are not accessible to all and are available to only the influential and privileged few, and the rest have to pay and call for private tankers. The cost per private tanker is approximately ₹500, but it varies according to the areas in which the water is supplied as well as the service provider. A major drawback of this entire process is that the private tankers are non-regularized and not monitored by the PHED. Public taps, though present, are non-functional due to extremely low water pressure.

Source of tankers for deficit fulfilment (as per survey) -

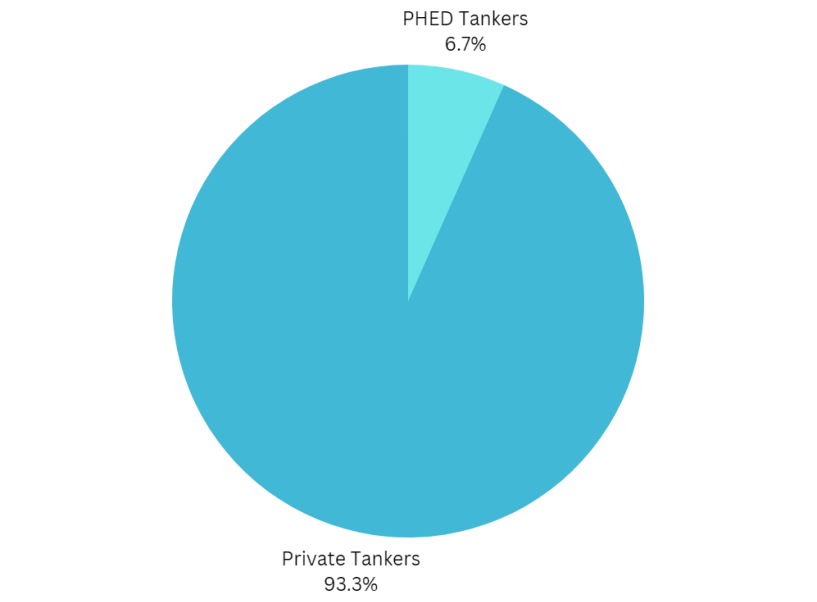


Figure 20: Source of Tankers for deficit Fulfilment

Source of Tankers	Percentage of Households	Number of Households
PHED Tankers	6.7%	3
Private Tankers	93.3%	42

Merely 3% of the respondents who face deficit water supply are able to avail the benefit for free tankers provided by the PHED. A whopping 93.3% rely on tankers supplied by private contractors for deficit fulfilment.

Cost per tanker from private service providers (as per survey)

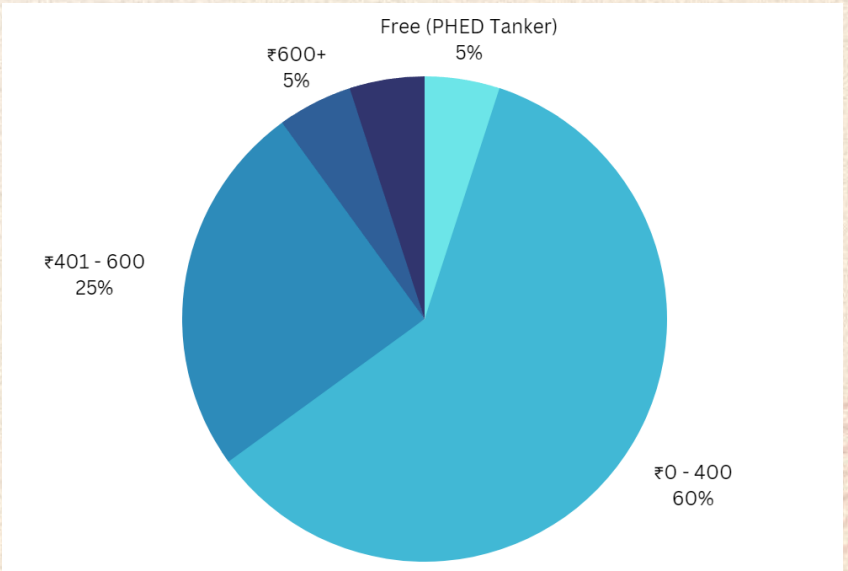


Figure 21: Cost per Tanker from Private Contractors

Cost Per Tanker	Percentage of Households	Number of Households
Free (PHED Tanker)	5%	3
₹0 - 400	60%	36
₹401 - 600	25%	15
₹600+	5%	3
Never Used	5%	3

60% of the respondents pay between ₹0-400 per tanker. 25% pay between ₹401-600 per tanker and 5% pay more than ₹600 per tanker.

Recommendations

Based on a thorough analysis of the current status of service delivery of water supply in Alwar and the major gaps occurring in the same, the following recommendation and solutions can be proposed-

Ensuring Data Availability

The inadequate availability of data leads to a number of issues and challenges as have been discussed above. Therefore, it is extremely important to have sufficient requisite data in place, not only to formulate new plans and policies, but also to effectively implement/manage the existing ones.

Robust Rainwater Harvesting and Storm Water Management

In order to sustain the ground water table for longer, the city need to focus on robust rainwater harvesting and stormwater management plan for collecting and recharging the ground water wherever possible. While there is a mandate to install rainwater harvesting system in all plots with a size of 20 square meters or more, this needs to be actually implemented in practice. The Department needs to ensure that the mandate is adhered to on paper as well as in practice.

Another way to effective recharge and sustain ground water is through stormwater management. Stormwater management essentially refers to managing surface runoff, and using it to recharge ground water or recharge artificial and natural lakes.

In addition, the city shall also resort to the ancient system of Johads for collecting and utilizing rainwater.

Supplementing Water Supply with Treated Used Water

Another way of reducing reliance on fresh water can be by using treating used water and mixing it with fresh water up to safe levels. Also, these can be effectively used for irrigation purposes. This would increase the availability of water by diverting the water earmarked for irrigation purpose to water supply . Therefore, the city shall take the used water management proposal urgently under any of the ongoing schemes as under AMRUT Mission of Government of India Sewerage and septage management is an eligible component for funding. This framework

would not only reduce the reliance on fresh water but also avoids existing sources being polluted by them.

Further, Small/medium scale used water treatment plants should be installed at the institutional or community level, which collect and treat the used water generated by them and use it for non-drinking purposes like gardening, flushing, cleaning etc. This would reduce their complete reliance on fresh water thereby relieving stress on the ground water table and the existing water supply system.

Regularisation of Private Takers

All the private tankers in the city needs to be regularised and operated through the city. The sources for these tankers are also to be regularized so that excessive withdrawal shall be avoided. These steps will be helpful in the effective management of water supply in the area.

Improvement in Grievance Redressal Mechanism

An improvement in the grievance redressal mechanism is the need of the hour. There is evidence of widespread public dissatisfaction with the current mechanism. While the PHED claims that the redressal rate is 100%, the survey shows that redressal rates are considerably lower than that. This calls for the setting up of a dedicated grievance redressal and complaint handling team, which would ensure that all the complaints lodged are disposed of at the earliest, and to the satisfaction of the complainant.

Metering

It is essential to ensure functionality of the water meters that are already installed in households. This would not only ensure that each household would be charged only for the water they actually consumed, but also would helpful in implementing varied tariff rate for excessive users, thus helpful in sustainability of the system. Further, this will be very helpful in exact quantification of the NRWs.

Identifying New Renewable Sources of Water

Considering the current rate of depletion of water, the city would run out of ground water very soon. Therefore, it is important to identify new sources of water which are renewable in nature, in order to ensure sustained supply of water in the future. Also, the city can urge the State Government to allocate a share in any of the ongoing water supply scheme in the State.

Establishment of a Water Treatment Plant

Currently, the quality of water in the city is well within the permissible limits. This means that disinfection of water is functioning well. However, considering the long term requirements and the health of the future population, a water treatment plant becomes a necessity.

Implementing the Proposed Projects

As discussed in the previous section, there are projects such as the ERCP and Chambal Project which have been proposed to aid the availability of water in the city, have not been acted upon yet. These are still in the proposal stage and no further progress has been made to date. If

implemented, these would help take water from the water surplus areas and supply them to the water deficit areas. Alwar, being one such area, would greatly benefit if these projects are implemented and some percentage of water is reserved for Alwar under them. However, no reservation has been made under these projects for Alwar yet.

Conclusion

After a thorough analysis of all the information appended above, the conclusion can be reached that a major proportion of the problems with respect to the service delivery of water supply in the city is stemming from factors such as complete reliance on ground water, non-availability of a renewable source water, inadequate water table recharge mechanism and the lack of availability of data. Moreover, a number of projects proposed have not yet seen the light of the day, neither has any allocation been made under them for the city yet.

There are visible and widespread disparities between the information provided by the Department and the outcome of the field surveys conducted, with the latter showing a picture which is much bleaker than what has been claimed by the former.

While the city certainly has come a long way, there is still a long way to go. There is no doubt that the geography and climate of Alwar make the situation and the process of improvement very challenging. However, the recommendations, if implemented, would substantially improve the status of water supply as well as the living standards of the residents.

Way forward

In order to further improve the status of the service delivery of water supply in the city, further studies can be taken up with respect to the identification of new renewable sources of water supply near the city. Studies can also be taken up with regard to treating used water and utilizing it for purposes of irrigation & non-drinking needs of the city especially in the institutions & residential clusters. Moreover, studies can be made on institutionalization and regularization of private tankers by the PHED – its feasibility and implications.

Arifa N M

M.Sc. in Applied Geography, University of Madras, Chennai.
Mentored by Mr. Pravin Bharadwaj, National Institute of Urban Affairs (NIUA).

Domain for Internship: Urban Governance

Impacts of Land Use Land Cover Changes on Water Resources of Noida and Nava Raipur

As populations increase and economies evolve, cities are becoming hubs of innovation, opportunity, and diversity. The study represents a comprehensive study on data collection and methodology used for analyzing land use and land cover changes in Noida (Uttar Pradesh) and Naya Raipur (Chattisgarh) between 2013 and 2022. The methodology involves satellite image acquisition, preprocessing, supervised classification, and digitization of water bodies from Google Earth Pro Imageries. Results revealed that in Noida, the proportion of barren land decreased while urbanization increased in built-up land. Water bodies saw a slight increase and vegetation remained stable. However, in Naya Raipur, significant urbanization is observed with a decrease in barren land and substantial increase in built-up land. Vegetation increased as well, demonstrating efforts towards sustainability. Water body area increased slightly, indicating attention to water resource management. The study underscores the critical importance of informed decision-making and continuous monitoring for ensuring sustainable city planning amidst the challenges posed by urban expansion and climate change. Also, the study recommended the requirement of protection and improvement of surface water resources, urban planning and urban governance in building up the cities and the need for management of water resources and environment for the climate resilient cities.

Keywords: land use, land cover, urbanization, barren land, water bodies, decision making

Introduction

Urbanization is a process of population concentration in the cities [1]. The urbanization refers to the changes in the infrastructure and land use patterns in urban space. The infrastructure in the villages and cities differ. The sky scrapers are absent the villages but not in the cities. The land use pattern also changes in the urban and rural areas. The industrialization led to the urbanization, that we have learned. The number of industries would be higher in the urban land, that needs more space. To work in these industries, we need people. The people need housing and other necessary infrastructures like schools for their children, colleges, hospitals, service centres, railway stations, connectivity networks and all and all. These need more space. So, in order to build these infrastructures, we need to compromise on the arable lands, wetlands, water bodies, hills, mountains etc. this would disrupt the harmony of nature and further lead to disasters. Climate change is an evident disaster that happens in front of our eyes. The water bodies play an important role in maintaining the whole climate of a region. The disturbance in the hydrological cycle would affect the climate of the area and thereby the people too.

The rapid pace of urbanization is reshaping the world as we know it. As populations increase and economies evolve, cities are becoming hubs of innovation, opportunity, and diversity. This transition presents both promise and challenge. On one hand, urban centres offer improved access to education, healthcare, and employment opportunities. On the other, they strain under the weight of inadequate infrastructure, housing shortages, and environmental issues. India, with its vast population and cultural tapestry, exemplifies this urban transformation. As the nation's cities experience unprecedented growth, they bridge ancient traditions with modern aspirations. This complex interplay fuels the emergence of novel challenges and prospects. The government's initiatives, such as the Smart Cities Mission and Clean India Campaign, underscore a commitment to sustainable urban development and improved living standards for all. As we navigate this urban journey, striking a balance between growth and sustainability is paramount. The success of our cities will define the quality of life for billions and set a precedent for global urbanization. It is a journey that requires collective effort, innovative solutions, and a deep understanding of the intricate dynamics that mould our urban landscapes.

India is a country with full of agricultural lands. India is mostly of plateaus and plains. That make it suitable for the agriculture. These agricultural lands are transformed to urban lands to forms the nodes of the nation. The arable lands and water bodies are get filled and there the cities are established. This will affect the cities as well as the nation adversely.

Urban land use changes can have profound effects on water bodies and their associated ecosystems. The conversion of natural landscapes into urban areas often results in increased runoff, elevated flooding risks, and disrupted hydrological cycles due to the proliferation of impervious surfaces. This alteration of land cover contributes to the degradation of water quality through the transportation of pollutants such as heavy metals, pesticides, and sediment into water bodies. The loss of natural habitats, including wetlands and riparian zones, poses a threat to biodiversity and the intricate balance of aquatic ecosystems. Concurrently, shifts in species composition and the proliferation of invasive species become prevalent. Nutrient loading from urban areas leads to eutrophication, creating oxygen-depleted zones detrimental

to aquatic organisms. Urbanization also drives stream channelization, causing changes in flow dynamics and habitat degradation. Mitigating these impacts necessitates the implementation of green infrastructure, stormwater management systems, and preservation zones, all aimed at replicating natural processes, curbing runoff, enhancing water quality, and safeguarding urban aquatic environments.

NOIDA and NAYA RAIPUR are the two cities taken as study area. The Noida is an example of brown field planning and the Naya Raipur is an example of green field planning. Both cities are in its phase of sustainable development. This means it give more importance to the nature and the physical environment and try to plan according to the nature. This will revive the ecosystem of both cities. The study focuses particularly on how the urban land use changes affect the water bodies of both cities. For that we have took a geospatial approach. The satellite imageries are taken to understand, calculate and analyse the urban land use changes and its impacts over the water resources. Here the surface water is given more importance. The increase in the area of water bodies will definitely make the city more drought resilient, flood resilient and even climate resilient and the decrease in the water bodies will reverse the situation.

Literature Review

India, a country with a large rural population, is transitioning slowly but steadily and broadly towards urbanisation. In 2011, there were 7,935 cities and megacities, up from 5,161 in 2010. According to UN estimates, 600 million people, or 15% of the global urban population, would reside in Indian cities by the year 2031. The effects of this rise in urban population on the environment, ecology, and sustainability will show up in the demand for urban services and management of the urban ecosystem. Urbanisation also creates a great deal of conflict with regard to biodiversity, protected areas, natural ecosystems, land use, and other ecosystem services essential to human well-being [2].

Urbanisation in India is becoming more and more noticeable, with far-reaching effects on physical landscapes around the nation. The land cover, natural habitats, biodiversity, and ecosystem services that support human well-being will all be impacted by these changes [3]. Wetlands are crucial for replenishing aquifers and stabilising the urban eco-system. Wetlands improve water quality, provide home for various species of flora and wildlife, and mitigate severe floods by storing water. Consequently, wetlands are essential to urban ecology. Many of the water bodies have been lost and some are completely polluted as a result of the fast urbanisation. Urban sprawl, which places a greater demand on natural resources and is consequently linked to the loss of wetlands, is the main driver of environmental degradation. On several of these lakes, medium and high-rise structures have sprouted up, demonstrating the deterioration in the natural catchment flow and lowering the water quality. Unplanned urbanisation and construction activities have had a significant negative impact on these wetlands and significantly reduced the aquifers' ability to store water [4]. As growth and development are concentrated in the urban centres of towns and cities, India's urbanisation phenomenon over the past few decades has resulted in a rural-urban movement.

Urban water bodies must be recognised in planning laws and procedures since urban growth and development are frequently haphazard or unplanned, making it important to preserve and revitalise this priceless resource [5]. Rapid and unplanned urbanisation is responsible for the exponential growth of Indian cities. The management of surface water is severely hampered by the exceptional rate of increase. Urban planners and policymakers view the decrease of surface water bodies as a crucial factor [6]. An area with more urban growth had a higher chance of seeing an increase in yearly surface runoff. Areas that are heavily populated were more likely to flood. Urbanisation reduced the maximum amount of storage possible, which led to higher runoff coefficient values [7].

This is a major problem in cities. The Indian cities becomes flood prone and drought prone too. The quality of water also gets affected by the concentrated built-up area of the urban spaces [8]

Here is an attempt to study how the urban land use changes impact the water bodies of two cities, NOIDA and NAVA RAIPUR, with the help of geospatial technologies, remote sensing and geographic information system. This study focuses on how the urban land use changed from 2013 to 2022. How the change affected the water bodies of both cities. Give some suggestions to build a sustainable city without harming the environment.

Study Area

The NOIDA and NAYA RAIPUR are the two cities taken as the study area. Noida is located in the state of Uttar Pradesh at the fringes of Delhi, the national capital. Located at the doorstep of Delhi, NOIDA is only 14 Kms. away from Connaught Place. Noida belongs to Delhi-NCR. The 550 metre long, eight lane NOIDA Toll Bridge across Yamuna connecting Maharani Bagh in Delhi to NOIDA has further reduced the distance, time and cost of commuting to and from Delhi-NOIDA. Noida lies between 28°34′47″ N Latitude and 77°19′47″ E Longitude. It has all the key advantages of Delhi without having its disadvantages. The development area encompasses about 20, 316 hectares of land consisting of 81 villages of district Gautam Buddha Nagar.

Noida is bounded by NH-24 Bye-Pass in the North beyond which the Ghaziabad Development Area exists, in the East by River Hindon beyond which Greater Noida Industrial Development Area exists, in the West by River Yamuna, beyond which are the States of Delhi and Haryana and in the South is the meeting point of the rivers Yamuna and Hindon.

Noida, an acronym for New Okhla Industrial Development Authority, traces back to the 1960s when the need for planned urban expansion to accommodate the burgeoning industrialization near Delhi was recognized. The New Okhla Industrial Development Authority (NOIDA) was established in 1976 under the Uttar Pradesh Industrial Area Development Act, with a primary focus on fostering industrial growth and providing a well-structured industrial environment. Over the ensuing decades, Noida witnessed remarkable progress and transformation (official website of Noida Authority)

Noida's history underscores its dedication to modern infrastructure, organized sectors, and the attraction of industries and enterprises. Its journey has been steered by careful urban planning and the development of a diverse array of residential and commercial spaces. Presently, Noida

stands as a significant satellite city of Delhi, playing a pivotal role in the region's economic advancement and urban expansion, all while conscientiously balancing industrialization with the principles of sustainable urban living. Now, the urban planning gave more importance to the physical environment too. This paved way for the sustainable development in the cities. The Noida is in its initial phase of sustainable development. The changes are evident. The study also focuses on how the brown field urban planning make a way to sustainable development by protecting the nature.

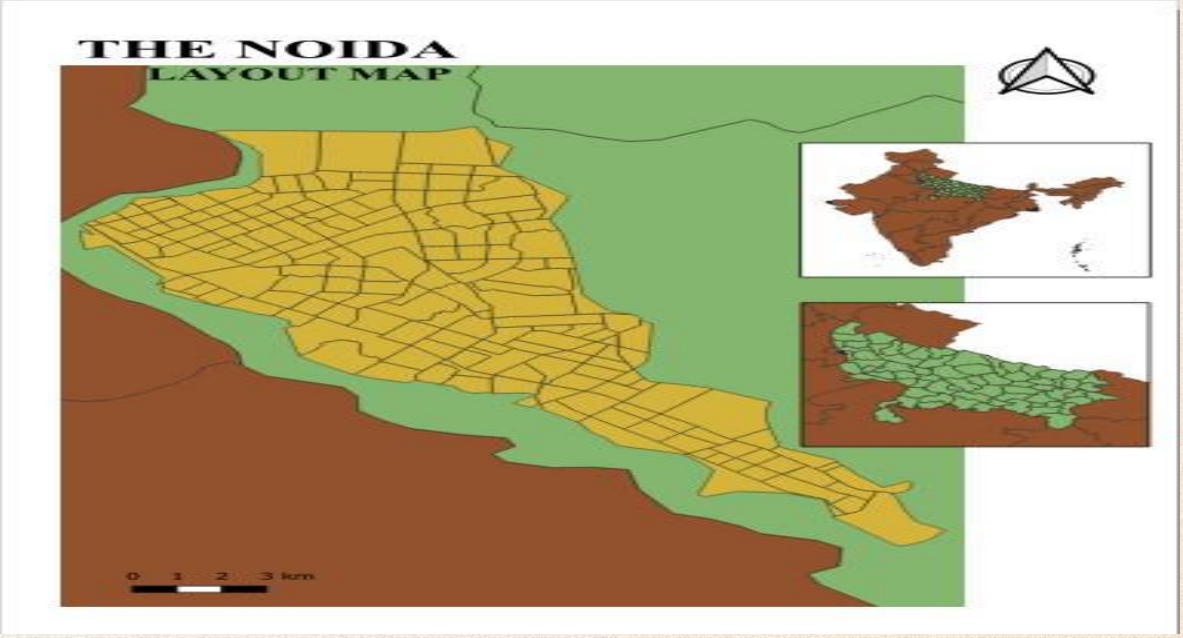


Figure 1: *Study area of Noida*

Naya Raipur Atal Nagar, as the name suggests, is the new upcoming state capital of Chhattisgarh. It lies between the coordinates of 21° 9' 53.9748" N and 81° 8' 15.307" E. Nava Raipur is a plain area located in the central part of India. Raipur is also called the “Rice Bowl of India” because hundreds of varieties of rice are grown here.

Naya Raipur Atal Nagar came into existence as a much-required project when the governance sought the requirement of a completely redesigned and planned capital city for this newly formed state. The metropolitan aims in bringing together a conglomerate of the latest real estate development trends to ensure a fruitful progression of this integrated smart city project of India. It all began on the dawn of 1st Nov 2000, when India got its 17th most populated state named after its 36 Forts (Chhattisgarh) and Raipur became the honorary capital of this new state.

However, within a few years of its progression, Chhattisgarh realized the need for a dedicated and modern administrative block. So, in an attempt to embrace innovation and gift the state a new capital, the development plan for an integrated smart city came to the surface. Situated 17 km to the South-East of the old urbanite, Nava Raipur Atal Nagar started gaining shape through the hands of NRANVP (Naya Raipur Atal Nagar Vikas Pradhikaran).

NRANVP or Naya Raipur Atal Nagar Vikas Pradhikaran embraced plan 2031 comprising of a wholesome metropolitan development. It comprises of 41 villages under its jurisdiction which consists of 3 layers of smart city development. One is 95 sq. km comprising of a dedicated

green belt. Second, a peripheral region covering 130 sq. km. and third, another 12 sq. km comprising Raipur and Nava Raipur Atal Nagar's international airport. This city justifies its green field tag by adopting a green, cross connected walking belt that runs across the length and breadth of the city. Moreover, a linear design facilitates the construction of an urban transport project including Nava Raipur Atal Nagar's BRTS as well. In this respect, this green field smart city brings together the following development approaches which justify its name as the first integrated smart city of India.

In an attempt to make Naya Raipur Atal Nagar one of the finest smart cities in India, NRANVP opts for a CBD concept. This Central Business District approach provides the following amenities: - Dedicated commercial hubs in each sector ensuring easy access, Smart LED lighting saving power considerably and ultra-planned and state-of-the-art roads. The biggest aspect of incorporating a CBD approach is the establishment of a dedicated IT hub. NRANVP aims at inviting all major MNC and IT sectors from around the globe. NRANVP has developed Nava Raipur Atal Nagar keeping in mind a number of aspects which make it an apt selection over others when concerning a residential area. The city opts for compete underground drainage system to keep away wastes from surfacing this metropolitan. 24 hours water supply is available to this integrated smart city project of India owing to the SCADA distribution system.
The standard communication facilities include a proposed train line connecting Naya Raipur Atal Nagar to Mumbai and associated regions, BRTS system joining the old city to its new counterpart.

State-of-the-art medical amenities assuring complete protection and health services to its residents. So, residing in one of the planned and ultra-modern blocks of Nava Raipur Atal Nagar can be your contribution to the sustainable future. This integrated smart city project of India is sure to fulfil all your expectations (official website Nava Raipur Atal Nagar)

Both cities are satellite towns developed near by the biggest cities of the state. Both have the responsibility to provide better amenities to their people without compromising on the nature. This led to the need of eco-friendly and sustainable cities. The study emphasizes on how the urban development changed the land use pattern of these cities and how those changes influence the water bodies of the cities. This is an attempt to show the impacts of land use changes on the water resources.

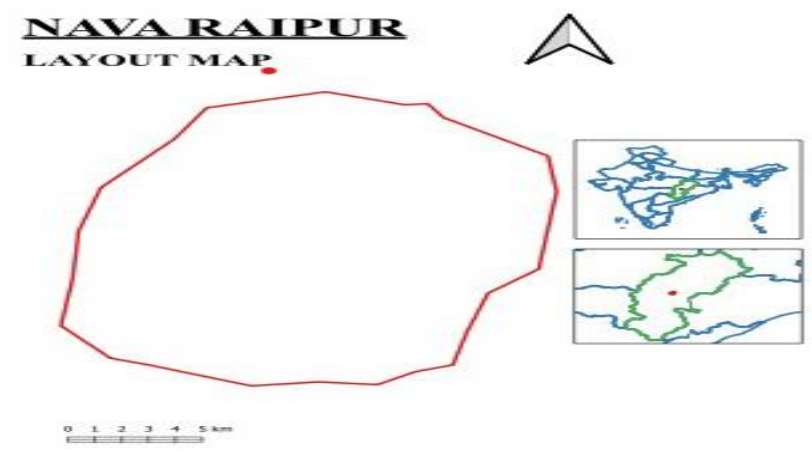


Figure 2: *Study area of Nava Raipur*

Data Collection and Methodology

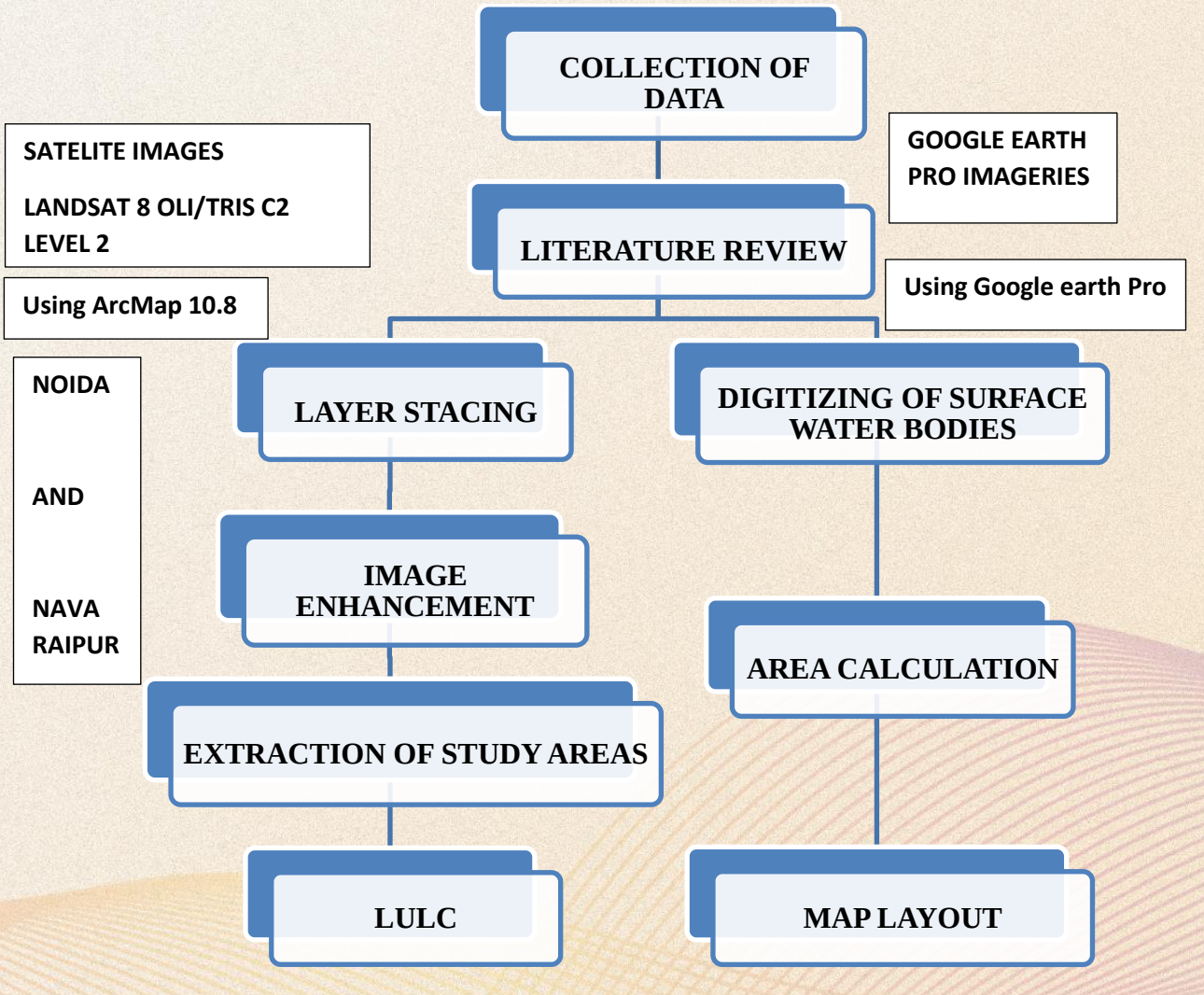


Figure 3: *Flowchart of Methodology*

Multi-spectral Landsat TM for the year 2013 and 2022 and manually digitized water bodies of Noida and Nava Raipur of 2013and 2022 from google earth pro is considered for the study. Water body features were extracted from Google Earth Pro which represent the geological features of the earth. It is published by the Maxar technologies. The water bodies of the study area are extracted by manual digitization. The data of 2013 and 2022 are collected. Landsat satellite images were downloaded from the United States Geological Survey (USGS) Earth Explorer a public domain that provides topographic and geographic maps of the required region in GeoTIFF format. These data sets were used for the land use and land cover (LULC) classification.

Table 1: Data collected for the study.

Sl. No	Type of data used	Scale/ Resolution	Path and Row	Date of Acquisition
1	LANDSAT 8 OLI/TRIS C2 LEVEL - 2	30 M	NAVA RAIPUR: 142 AND 045 NOIDA: 146 AND 040	2013/05/02
2	LANDSAT 8 OLI/TRIS C2 LEVEL - 2	30 M	NAVA RAIPUR: 142 AND 045 NOIDA: 146 AND 040	2022/05/01
3	GOOGLE EARTH PRO	1 M		2013/05
4	GOOGLE EARTH PRO	1 M		2022/05

Geographical information systems (GIS) together with remote sensing data are used for monitoring the emerging urbanization of the cities using digital satellite images. The Landsat 8-9 Operational Land Imager (OLI) - Thermal Infrared Sensor (TIRS) Collection 2 (C2) Level 2 (L2) data is acquired from the USGS Earth Explorer platform. Landsat is an Earth observation satellite program formulated, implemented, and operated by the National Aeronautics and Space Administration (NASA) and the Department of the Interior (DOI) U.S. Geological Survey (USGS). Landsat's ongoing record of data focuses on medium-resolution remote sensing of Earth's land surfaces. The goal of Landsat is to continue the collection, archive, and distribution of multispectral imagery affording global, synoptic, and repetitive coverage of land surfaces at a scale where natural and human-induced changes can be detected, differentiated, characterized, and monitored over time. The mission's programmatic goals are stated in the United States Code, Title 15 Chapter 82 "Land Remote Sensing Policy" (derived from the Land Remote Sensing Policy Act of 1992). This policy requires the Landsat program to provide data into the future that are sufficiently consistent with previous Landsat data, allowing the detection and quantitative characterization of changes in or on the Earth's surface. The highly successful Landsat series of missions has provided satellite coverage since 1972. The data from these missions constitute the longest continuous record of Earth's surface as seen from space.

Level 2 Output Files Overview the standard L2SP is a Digital Number (DN) product stored in a 16-bit unsigned integer format. Refer to LSDS-1747 Landsat 8-9 Calibration and Validation (Cal/Val) Algorithm Description Document (ADD) for a description of the atmospheric auxiliary data pre-processing, the SR algorithm, and the Single Channel algorithm for ST. SR

bands approximate what a field spectroradiometer sensor held just above the Earth's surface would measure. Coarse Resolution Water Vapor and Ozone datasets from the Moderate Resolution Imaging Spectrometer (MODIS) instrument on NASA's Terra and/or Aqua satellites are used in the SR algorithm. SR bands require Top of Atmosphere (TOA) reflectance bands corrected for per-pixel sun angles. SR bands are generated only for scenes with the Solar Zenith Angle (SZA) less than 76°. The SZA is 90° minus the sun elevation angle. Most L2 products are from scenes between 65 degrees north and 65 degrees south latitude. Table (3) lists specifications for the SR bands. The values output from Land Surface Reflectance Code (LaSRC) are scaled to fit in unsigned integers for the files named in the values for FILE_NAME_BAND_X; where X = [1, 7]. The range of values output by LaSRC in conjunction with the values for REFLECTANCE_MULT_BAND_X and REFLECTANCE_ADD_BAND_X limit the value in the named files to 65455. SR might have noticeable errors for scenes captured greater than 10 degrees off-nadir. The ST band provides the temperature of the Earth's surface in Kelvin (K). The emissivity auxiliary data, used by the ST algorithm for Thermal Infrared Sensor (TIRS), is obtained from the Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Emissivity Dataset (ASTER GED) by Land Processes Distributed Active Archive Center (LP DAAC). Goddard Earth Observing System Model, Version 5 (GEOS-5) Forward Process for Instrument Teams (FP-IT) data are used in the Single Channel algorithm for atmospheric correction.

The L2SP image data are atmospherically corrected and available as COG files. Table (2) shows the band identification. If ST cannot be produced, an SR-only product is attempted. Atmospheric auxiliary data used in processing a L1 product into the L2 product are described in LSDS-1329 Landsat Atmospheric Auxiliary Data Format Control Book (DFCB). Seven ST intermediate bands are included in the L2SP when the Single Channel algorithm is used to generate ST. These ST intermediate bands consist of a thermal band converted to radiance, upwelled radiance, down welled radiance, atmospheric transmittance and emissivity estimated from ASTER GED, emissivity standard deviation, and pixel distance to cloud.

Table (2): Band Reference Table

Band Number	Band Description	Band Range (nm)
1	Coastal Aerosol (Operational Land Imager (OLI))	435-451
2	Blue (OLI)	452-512
3	Green (OLI)	533-590
4	Red (OLI)	636-673
5	Near-Infrared (NIR) (OLI)	851-879
6	Short Wavelength Infrared (SWIR) 1 (OLI)	1566-1651
7	SWIR 2 (OLI)	2107-2294
10	Thermal Infrared Sensor (TIRS) 1	10600-11190

Table 2-1. Band Reference Table

Band Number	Identifier FT	Units	Valid Range	Fill Value
1	SR_B1	Unitless	1 through 65455	0 (No Data)
2	SR_B2	Unitless	1 through 65455	0 (No Data)
3	SR_B3	Unitless	1 through 65455	0 (No Data)
4	SR_B4	Unitless	1 through 65455	0 (No Data)
5	SR_B5	Unitless	1 through 65455	0 (No Data)
6	SR_B6	Unitless	1 through 65455	0 (No Data)
7	SR_B7	Unitless	1 through 65455	0 (No Data)

Table 2-2. OLI SR Band Specifications

Table (3): Specifications of OLI SR bands

For example, the downloaded SR Image Files for Nava Raipur are:

LC08_L2SP_142045_20130501_20200913_02_T1_SR_B1
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B2
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B3
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B4
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B5
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B6
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B7

Satellite images are needed to be pre-processed to obtain clear pixels in an image to perform image classification algorithms. ArcMap 10.8 software is used to make LULC maps of the study area. The data of both 2013 and 2022 are calculated. The supervised classification is used to make the Land Use Land Cover maps. The first level classification is made for the study. The study needed 7 bands of Landsat 8-9 OLI/TRIS C2 Level 2 data. The 7 bands were merged together to get a composite bend. The near infrared (OLI, 5 with band width of 851 -879) red (OLI, 4 with band width of 636 – 673) and green (OLI, 3 with band width of 533 - 590) layers were made visible. This made a map of FCC, i.e., false Colour Composite satellite imagery. And created signature files of the false colour composite satellite imagery. The Maximum Likelihood classification is used to perform on the set of raster bands and creates a classified raster as output. The classes were made as built-up land, vegetation, water body and barren land. From the classified images the urban land features are extracted from raster to vector format. Then the raster images are converted to vector format as polygons. These polygons are calculated to find the area of the classes.

Google Earth Pro are considered for abstracting surface water body features. Manual digitization is done. The data of 2013 and 2022 are extracted from the google earth pro, published by Maxar technologies. Those are the data from Landsat, Copernicus etc. For the analysis of urbanization impacts on surface water bodies, the area of extracted water bodies is compared with the data of previous year. And came into a conclusion by understanding the change in the area of water bodies. This is performed in the ArcMap 10.8 Software. The KML files of google earth pro is converted into a layer with the use of ArcMap 10.8, and made calculations. The methodology involves quantifying the extent of each category in terms of area and calculating the percentage contribution to the total land area.

Results And Discussion

The satellite image of the study area is classified into various classes such as water body, urban built up, vegetation and barren land. The results of these classifications are shown below. The water body features are extracted from geo-referenced Google Earth Pro imageries. The Land use and land cover classifications are done by a supervised classification for the satellite images.

LULC Classification of Noida 2013

The Landsat satellite image of 2013 is clipped using the shapefile of Noida. The clipped satellite image corresponding to the study region is classified using a supervised classification method. The classification was carried out for four land use categories such as waterbody, urban, vegetation and barren. The classified image is shown in Figure 4.

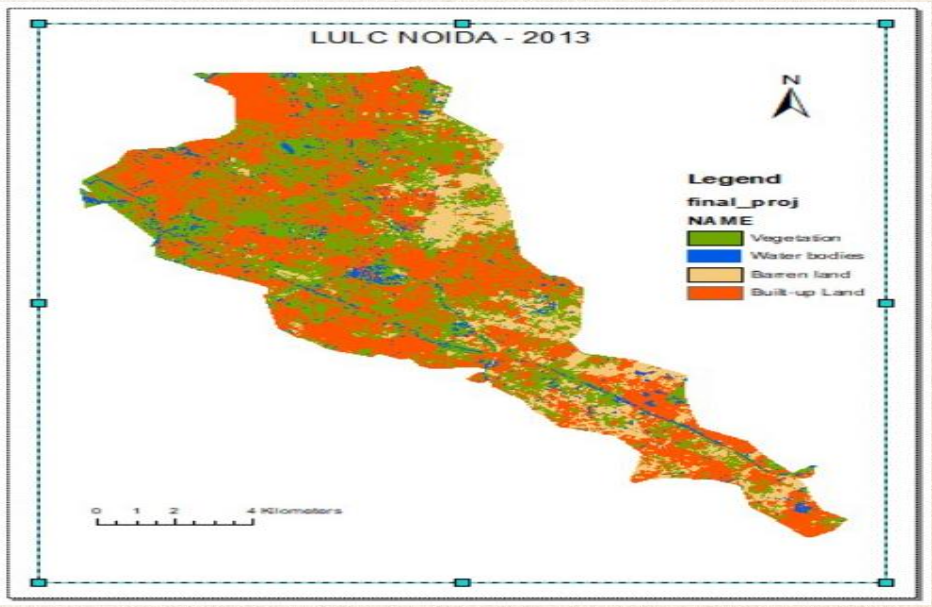


Figure 4: *LULC of Noida (2013)*

The Land use Land Cover of Noida in 2013 represent as follows:

Table 4: LULC of Noida 2013

Land use	Area (sq.km)	Percentage
Barren Land	18.27125844	5%
Built Up land	73.62306645	53%
Vegetation	52.37933112	37%
Water Body	6.316057495	5%
Grand Total	150.5897135	100%

The area occupied by each land use class is given in the table (4). The urban built-up land occupies almost 73.6 sq.km. this contributes to the 53% of the total study area of Noida. The level urbanization happened in Noida compared to 2022 is less.

Barren Land (5%): The findings reveal that approximately 18.27 sq.km of NOIDA's land area is categorized as Barren Land, indicating regions with minimal vegetation or development. This category encompasses rocky terrains, uncultivable land, and areas with limited productivity.

Built-Up Land (53%): The analysis demonstrates a significant urbanization trend, with 73.62 sq.km designated as Built-Up Land. This classification encompasses residential, commercial, and industrial zones, showcasing the city's dynamic growth and infrastructure expansion.

Vegetation (37%): A noteworthy 52.38 sq.km is characterized as Vegetation, highlighting the presence of natural ecosystems, green spaces, and various forms of flora. This percentage underscores the city's efforts to preserve ecological balance amidst rapid urban development. This is by the collective efforts people and government.

Water Body (5%): Water Bodies, covering approximately 6.32 sq.km, constitute a crucial aspect of the landscape. This category encompasses rivers, lakes, and ponds, serving as vital components of aquatic ecosystems and water resource reservoirs. The share of water bodies is less in Noida because of the unscientific planning happened in the 1990s. after the Paris agreement of 2015, every nation gave importance to the climate change and made measures to cope. Preserving the water bodies would be the easiest way to cope climate change. The water is the major force which influence the climate.

LULC Classification of Noida 2022

The Landsat satellite image of 2022 is clipped using the shapefile of Noida. The clipped satellite image corresponding to the study region is classified using a supervised classification method. The classification was carried out for four land use categories such as waterbody, urban, vegetation and barren. The classified image is shown in Figure 5.

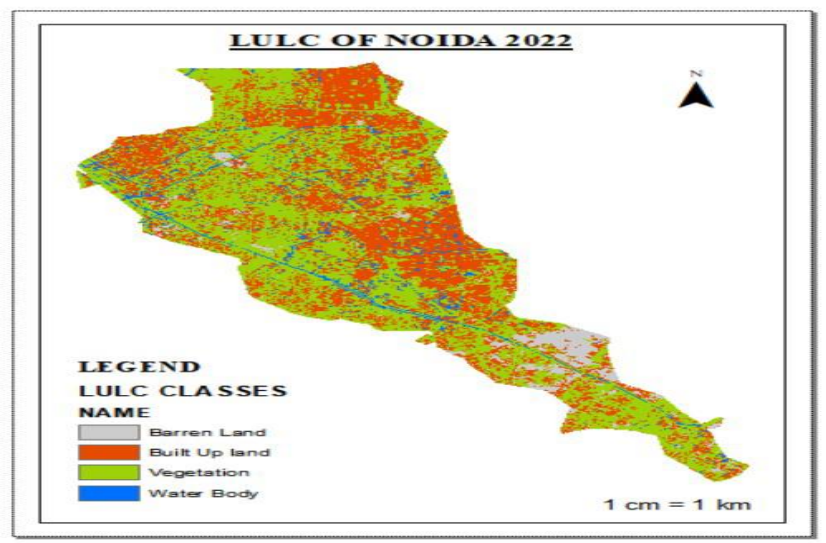


Figure 5: *LULC of Noida 2022*

Table 5: LULC of Noida 2022

Name	Area (sq.km)	Percentage
Barren Land	7.800142786	5%
Built Up land	75.71578275	53%
Vegetation	59.76313445	37%
Water Body	7.307984706	5%
Grand Total	150.5870447	100%

The data is divided into four categories: Barren Land, Built Up Land, Vegetation, and Water Body.

The barren land occupies an area of 7.800142786 sq.km. Barren land refers to areas with minimal or no vegetation cover, typically consisting of rocky, sandy, or gravelly surfaces. Noida has a relatively small proportion of barren land, occupying 5% of the total area.

The urban Built-Up Land occupies an area of 75.71578275 sq.km. Built-up land includes urban infrastructure, residential, commercial, and industrial areas. This is the largest land category, covering a significant portion (53%) of Noida's total area. This indicates urbanization and economic development.

The Vegetation is given more importance in nowadays. But it is hard to maintain and improve a brown field with is already planned unscientifically without giving prior importance to the nature. But in this case Noida being a brownfield successfully maintained and improved its share of vegetation in terms of area. Even the percentage remains the same the share of area got increased in last decade. The area of 59.76313445 sq.km is occupied by vegetation cover or green belt. The Vegetation refers to areas covered by trees, shrubs, grass, and other forms of plant life. With 37% of the area covered by vegetation, Noida seems to have a substantial green cover, which contributes to environmental health, aesthetics and even for the mental health of human beings.

Water Body is the other significant feature that need to protected and maintained for the sake of healthy natural environment. Without water nothing can survive. The Indian cities have been built-up on the wetlands and arable lands [10]. After Paris Agreement the world got aware of the climate change. This made the nations to rethink and go for climate resilient cities with its full bunch of water bodies which can collect, store water and decrease the runoff and helps in percolation and maintain the hydrological cycle, which will be a great save from the climate change. The share of water bodies in Noida in the year 2022 is 7.307984706 sq.km. Water bodies include rivers, lakes, ponds, and reservoirs. Noida's water bodies cover 5% of the total area, providing important natural resources and recreational spaces.

The majority of Noida's land is divided between Built Up Land (53%) and Vegetation (37%). This balance suggests that while urbanization and development are significant, efforts have been made to maintain a substantial green cover. The presence of 5% barren land indicates some areas might be less conducive to vegetation growth due to natural or human-induced factors. The presence of water bodies (5%) signifies the importance of water resources within the city's landscape. The distribution of land categories is relatively balanced, indicating that urban development has taken into account ecological considerations. It would be important for urban planners and policymakers to ensure sustainable development practices that maintain this balance between urbanization, green cover, and water resources. As Noida continues to grow and evolve, monitoring changes in these land categories over time will be crucial to understanding the city's environmental health and urban development trajectory.

Comparison of LULC 2013 and 2022 of Noida

Barren Land (5%): Between 2013 and 2022, the area of Barren Land experienced a reduction from 18.27 sq.km to 7.80 sq.km, maintaining a consistent 5% share. This suggests that the extent of non-vegetated, unproductive land remained relatively stable over the period. The

stability in the percentage of Barren Land suggests that the share remain the same but the spatial distribution of unproductive land got changed from the central part to the southern side.

Built-Up Land (53%): The Built-Up Land category expanded by 2.10 sq.km, increasing from 73.62 sq.km to 75.72 sq.km. Despite this increase, the percentage remained constant at 53%, indicating the continuation of urbanization trends. The expansion of Built-Up Land aligns with ongoing urban development trends and underscores the importance of managing urban growth sustainably. The sustainable growth of Noida city is highlighted here.

Vegetation (37%): Vegetation area increased significantly from 52.38 sq.km to 59.76 sq.km, contributing to a consistent 37% of the total area in both years. This demonstrates a concerted effort to preserve and expand natural ecosystems within the urban landscape. The eco-friendly approach of the city is seen well. The consistent percentage of Vegetation highlights the city's commitment to balancing urbanization with ecological preservation.

Water Body (5%): Water Body area experienced a marginal increase, growing from 6.32 sq.km to 7.31 sq.km. The percentage remained constant at 5%, indicating that water bodies maintained their proportion within the landscape. The modest increase in Water Body area indicates that aquatic ecosystems continue to be managed effectively. The effort of maintaining the water bodies in a brown field is definitely a herculean task. The area also got increased, even a slight change is a good sign towards a climate resilient city.

LULC Classification of Naya Raipur 2013

The Landsat satellite image of 2013 is clipped using the shapefile of Nava Raipur. The clipped satellite image corresponding to the study region is classified using a supervised classification method. The classification was carried out for four land use categories such as waterbody, urban, vegetation and barren. The classified image is shown in figure 6.

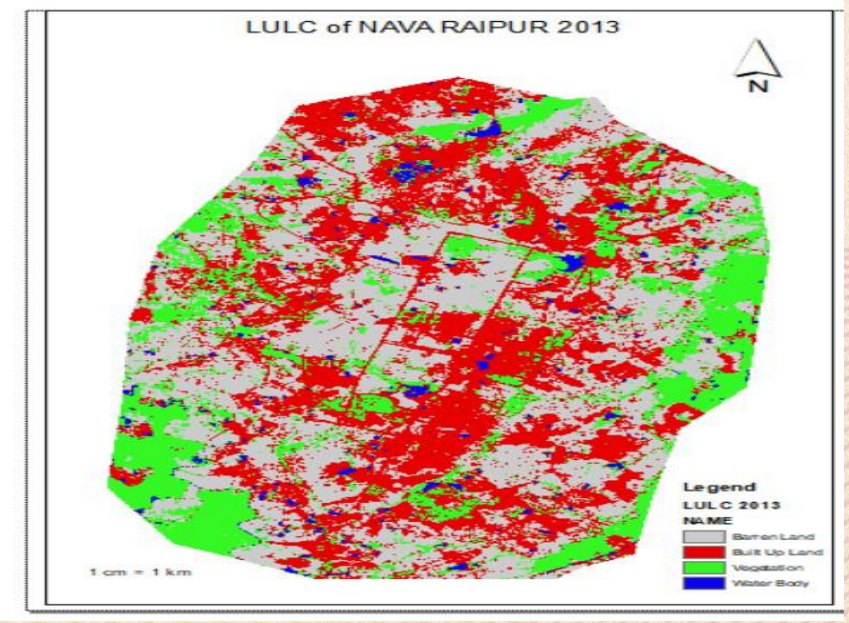


Figure 6: *LULC of Nava Raipur 2013*

Table 6: LULC of Nava Raipur 2013

Land use	Area (sq.km)	Percentage
Barren Land	150.6091399	42%
Built Up Land	128.9848224	36%
Vegetation	73.84475574	20%
Water Body	7.983884336	2%
Grand Total	361.4226024	100%

Naya Raipur is divided into various categories based on the land use types, and the data presents the area in square kilometres (sq.km) and the percentage of the total area that each land use type occupies.

Barren Land (42%): Barren land comprises the largest portion of the area, occupying approximately 42% of the total land. Barren land typically refers to areas that have limited or no vegetation cover and are devoid of significant human activity. This could include rocky terrains, deserts, inarable land and areas with little to no plant growth.

Built Up Land (36%): Built-up land covers around 36% of the total area. This category includes areas with infrastructure development, such as residential, commercial, and industrial buildings, roads, and other urban structures. The relatively high percentage indicates significant urbanization and human settlement in Nava Raipur. The

Vegetation (20%): Vegetation covers about 20% of the total area. This category represents areas with plant growth, which could include forests, grasslands, parks, and other green spaces. The presence of vegetation is essential for maintaining ecological balance and providing natural habitats. But the region is of little vegetation compared to the barren land. This is a central region of India which is dominated by the plains and plateaus. Even though, the inadequate water supply is the reason for the less vegetation. It is evident that the built-up area never caused harm for the vegetation directly filling up. But indirectly by the unscientific planning.

Water Body (2%): Water bodies, including rivers, lakes, and ponds, account for approximately 2% of the total area. While this is a relatively small percentage, water bodies play a crucial role in the environment, supporting biodiversity and providing water resources for various purposes.

The analysis of the data suggests that Naya Raipur in 2013 had a significant proportion of barren land, followed by built-up areas, vegetation, and water bodies. As a green field, this distribution reflects a mix of urban development, natural landscapes, and water resources in the region. The data highlights the importance of managing urban expansion while also considering the preservation of natural ecosystems and water sources. The plan for an integrated city rises after this year.

LULC Classification of Naya Raipur 2022

The Landsat satellite image of 2013 is clipped using the shapefile of Nava Raipur. The clipped satellite image corresponding to the study region is classified using a supervised classification

method. The classification was carried out for four land use categories such as waterbody, urban, vegetation and barren. The classified image is shown in figure 7.

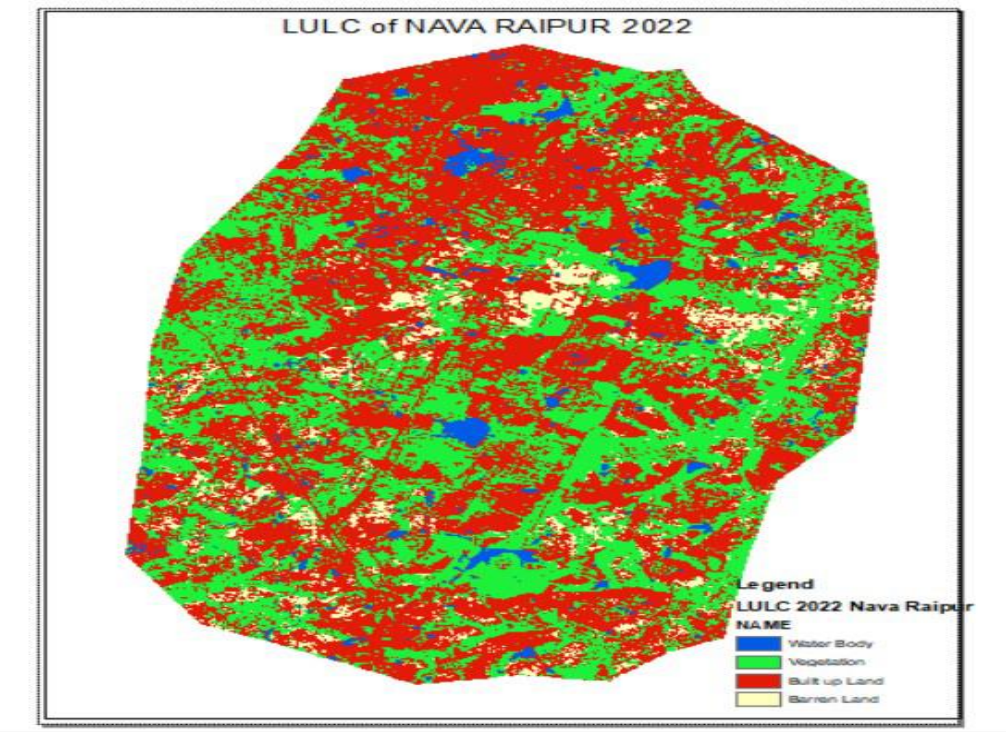


Figure 7: *LULC of Nava Raipur 2022*

Table 7: LULC of Nava Raipur 2022

LAND USE	AREA (SQ.KM)	PERCENTAGE
Barren Land	19.22393051	5%
Built up Land	191.7096849	53%
Vegetation	139.8193339	39%
Water Body	10.65509089	3%
Grand Total	361.4080402	100%

The provided data represents the land use distribution in Nava Raipur for the year 2022. Let's analyse this data in detail:

Barren Land occupies 19.22393051 sq.km of the total area. The barren land got concentrated over the central part of the city. Barren land refers to areas that are devoid of vegetation and have minimal or no human development. These areas might include rocky terrain, desert-like landscapes, and similar environments. In Nava Raipur, barren land occupies a relatively small portion of the total area, constituting 5% of the total land.

Urban Built-up Land occupies 191.7096849 sq.km of the total area. The urban infrastructures are spatially distributed evenly. The northern part of the city seems very concentrated with the built-up lands. Towards the middle or centre the build-up land gets sparser compared to the outer edges. This is because of the administrative buildings and all. Even the water bodies are

also concentrated in this part make the city planners to leave those sites and enhance the natural ecosystem of the city.

Built-up land refers to areas that are urbanized or developed, including residential, commercial, industrial, and infrastructure zones. This category includes buildings, roads, and other man-made structures. In Nava Raipur, built-up land occupies the largest portion of the total area, comprising 53% of the land.

Vegetation occupies an area of 139.8193339 sq.km. The vegetation is evenly distributed in the city. Vegetation refers to areas covered by plants, trees, and other forms of natural greenery. It includes forests, parks, gardens, and agricultural land. Vegetation is vital for ecological balance, air quality, and aesthetics. In Nava Raipur, vegetation covers a significant portion of the total area, accounting for 39%. The vegetation includes public parks and all. These plays a very important in the stressful life or urban people. These gives a smoothening effect from the urban busy life.

Water Body occupies a portion of 10.65509089 sq.km in Nava Raipur. Water bodies encompass all types of water features, such as lakes, ponds, and reservoirs. These areas contribute to the overall ecosystem health, provide habitats for various species, and offer recreational opportunities. In Nava Raipur, water bodies cover a relatively small proportion of the total area, making up 3%. The new master plan of 2031 emphasizes on increasing and protecting the water bodies as a sponge city strategy. But as a green field, it needs more care to build an integrated sponge city for collect and store water and replenish the riparian areas and wetlands. These are the pillars for the conservation of water resources.

In summary, Naya Raipur's land use in 2022 is dominated by built-up land, indicating significant urban development. Vegetation also covers a substantial portion, contributing to the ecological balance and aesthetic value of the region. Water bodies and barren land are present but occupy relatively smaller portions of the total area. This analysis showcases the spatial distribution of different land use types and their relative significance in Nava Raipur.

Comparison of LUlC of 2013 And 2022 (Naya Raipur)

Let’s compare the land use data for Nava Raipur between the years 2013 and 2022 to identify the changes and trends:

Barren Land:

- 2013: 42% of the total area (150.61 sq.km)
- 2022: 5% of the total area (19.22 sq.km)
- Change: There is a significant decrease of 37% in the proportion of barren land. This suggests that efforts have been made to reclaim or repurpose barren land for other uses, due to urbanization and land development projects. These projects include the rejuvenation of water bodies and make the first integrated sponge city.

Built Up Land:

- 2013: 36% of the total area (128.98 sq.km)

- 2022: 53% of the total area (191.71 sq.km)
- Change: There is a notable increase of 17% in the proportion of built-up land. This indicates rapid urbanization and expansion of infrastructure in Nava Raipur, with a substantial increase in residential, commercial, and industrial areas.

Vegetation:

- 2013: 20% of the total area (73.84 sq.km)
- 2022: 39% of the total area (139.82 sq.km)
- Change: There is a significant increase of 19% in the proportion of vegetation. This suggests that there have been efforts to preserve or enhance natural ecosystems, green spaces, and parks amidst urban development. This makes a sustainable way of development incorporating the preservation of natural environment.

Water Body:

- 2013: 2% of the total area (7.98 sq.km)
- 2022: 3% of the total area (10.66 sq.km)
- Change: There is a slight increase of 1% in the proportion of water bodies. While the percentage increase is small, it indicates that there has been some attention given to maintaining or possibly even creating water bodies, which are crucial for the environment and water resources. This initiative is begun as a part of their master pan 2031. The city is also growing as the first integrated sponge city of India. ‘Sponge cities’’ are emerging as a new trend and pathway for the sustainable development and management of water in cities. The term “sponge cities” is used to describe urban areas with abundant natural areas such as trees, lakes, parks, or other good artificial designs intended to infiltrate the stormwater and recharge the groundwater. This will reduce the overflow of the stormwater into the streams and all, which further causes the overflow of rivers and again causes floods and inundations.

The comparative analysis between 2013 and 2022 reveals several significant trends:

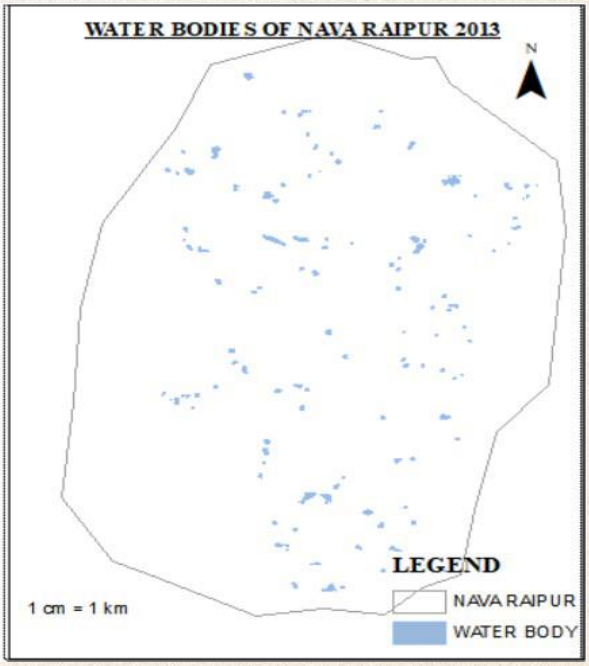
- Urbanization: The increase in built-up land indicates a strong trend towards urbanization and development of infrastructure, including residential, commercial, and industrial areas.
- Vegetation: The increase in vegetation suggests that efforts have been made to balance urban expansion with the preservation of natural ecosystems and green spaces.
- Barren Land: The substantial decrease in barren land indicates successful initiatives to repurpose or reclaim these areas for more productive use.
- Water Bodies: The slight increase in water body coverage indicates attention to maintaining or possibly creating water resources, although this remains a relatively small change.

  Overall, the data highlights a dynamic process of urban development and environmental management in Nava Raipur, with efforts to balance economic growth with ecological sustainability.

Surface water body extraction from Google Earth Pro

The spatial extent of surface water bodies such as lakes and ponds in the study region, Nava Raipur is determined by digitizing the lakes and ponds from the Google Earth Pro of 2013 and

2022. The digitized waterbodies are represented in Figure 8 and 9. The digitized spatial boundary represents the region designated for lakes and ponds as per the 2013 and 2022 Google Earth Pro satellite imageries. The digitized water bodies have a surface area of 2.05198514536312 sq.km in 2013 and 12.11501316 sq.km in 2022, which is considered for the study. The total surface area covered by the surface water bodies (LULC) in the study region is 7.983884336 sq.km in 2013 and 10.65509089 sq.km in 2022 which includes all the water bodies in the digitized surface area. Here we can see an increase of 3 sq.km in the total area of water bodies. Since the area of water bodies in LULC depicts the area covered by all the water bodies and not that of designated lakes and ponds, the data was not used for the analysis.



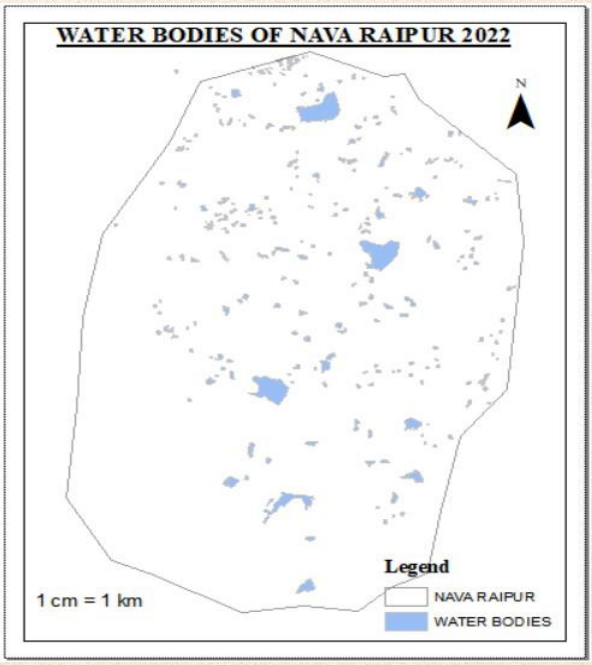


Figure 8: *spatial extension of water bodies 2013*

Figure 9: *Spatial extension of water bodies 2022*

Only Nava Raipur is taken into account for the extraction of surface water bodies. The change in Noida is very less and unable represent diagrammatically. So, for that reason only Nava Raipur's surface water bodies are digitized and represented. The figures 8 and 9 evidently shows the increase in the area of water bodies as well as its spatial distribution too. The concentration of water bodies is high in the central part of the city. There we have the administrative building and all kind of major service providing infrastructure. The well maintenance is a reason for the improved area of water bodies. And it is necessary to ensure that the city won't get drowned especially the administrative buildings. So, in order collect the storm water and store in the aquifers the water act as a natural barrier for flood and drought.

Conclusion

In conclusion, the analysis of land use and land cover (LULC) data for both Noida and Nava Raipur between the years 2013 and 2022 provides valuable insights into the changing landscape and urban development trends in these regions.

For Noida:

- The land use distribution in Noida in 2013 and 2022 shows a significant increase in built-up land, indicating ongoing urbanization and infrastructure development.
- The proportion of barren land decreased, while the proportion of vegetation remained relatively stable.
- The water body area experienced a modest increase, suggesting some level of attention to water resource management.
- The comparison between the two years reflects Noida's efforts to balance urban growth with ecological preservation, with an emphasis on sustainable development practices.

For Naya Raipur:

- The data reveals a dramatic decrease in barren land and a substantial increase in built-up land, signifying rapid urbanization and infrastructure expansion.
- The proportion of vegetation also increased notably, indicating an effort to balance urban development with ecological sustainability.
- The slight increase in water body area highlights the importance of water resource management and its role in urban planning.
- Nava Raipur's shift towards a more balanced distribution of land use categories suggests a growing commitment to integrated and sustainable urban development.

This study helps to raise concerns for the protection and improvement of surface water resources for our present and future demands. The urban planning and urban governance play a crucial role in building up the cities. The study reveals the need for management of water resources as well as environment for the climate resilient cities. Noida and Nava Raipur are the two satellite cities outgrown to the stage of integrated sponge cities. In both cases, the analysis underscores the importance of maintaining a balance between urbanization, environmental conservation, and water resource management. The data reveals how cities are striving to integrate development with nature, preserve natural ecosystems, and adapt to the challenges posed by climate change and urban expansion. The trends observed in these two cities serve as valuable examples for other urban centres aiming to achieve a harmonious coexistence between human activities and the environment. Continuous monitoring of these changes is essential for informed decision-making and sustainable city planning in the future.

An integrative and proactive land use planning and management system at regional strategic level and local action level is considered to be essential if surface water systems are to be conserved and improved. Increased recognition of their societal and ecological value should be reflected in more detailed attention to the spatial requirements of water bodies and riparian areas in urban planning policies [9]. There is possibility for further researches on this area of study. Future research could delve into the specific policies, regulations, and initiatives that contributed to the observed trends, offering a more nuanced understanding of Noida's urbanization journey as well as Nava Raipur’s. Additionally, historical data from more years would enable a more comprehensive long-term trend analysis.

References

1. Tisdale, H. (1941). The process of urbanization. *Soc. F.*, *20*, 311.
2. Nagendra, H., Sudhira, H. S., Katti, M., Tengö, M., & Schewenius, M. (2014). Urbanization and its impacts on land use, biodiversity and ecosystems in India.
3. Nagendra, H., Sudhira, H. S., Katti, M., & Schewenius, M. (2013). Sub-regional assessment of India: effects of urbanization on land use, biodiversity and ecosystem services. *Urbanization, biodiversity and ecosystem services: challenges and opportunities: a global assessment*, (65-74).
4. Sowmyashree, M. V., & Ramachandra, T. V. (2012). Temporal analysis of water bodies in mega cities of India. In *LAKE 2012: International Conference on Conservation and Management of Wetland Ecosystems, November* (pp. 6-9).
5. Laloo, S. W. L., & Ranjan, A. (2017). Urban development impacts on water bodies: A review in India. *International Journal on Emerging Technologies*, *8*(1), 363-370.
6. Sridhar, M. B., & Sathyanathan, R. (2020, August). Assessing the spatial impact of urbanization on surface water bodies using remote sensing and GIS. In *IOP Conference Series: Materials Science and Engineering* (Vol. 912, No. 6, p. 062069). IOP Publishing.
7. Weng, Q. (2001). Modeling urban growth effects on surface runoff with the integration of remote sensing and GIS. *Environmental management*, *28*, 737-748.
8. Khan, H. H., Khan, A., Ahmed, S., & Perrin, J. (2011). GIS-based impact assessment of land-use changes on groundwater quality: study from a rapidly urbanizing region of South India. *Environmental Earth Sciences*, *63*, 1289-1302.
9. Du, N., Ottens, H., & Sliuzas, R. (2010). Spatial impact of urban expansion on surface water bodies—A case study of Wuhan, China. *Landscape and Urban Planning*, *94*(3-4), 175-185.
10. Sridhar, M. B., & Sathyanathan, R. (2020, August). Assessing the spatial impact of urbanization on surface water bodies using remote sensing and GIS. In *IOP Conference Series: Materials Science and Engineering* (Vol. 912, No. 6, p. 062069). IOP Publishing.
11. Official Website of Nava Raipur Atal Nagar
12. Official Website of Noida Authority

Aryan Banerjee

M.A. in Sustainable Development Practice, TERI School of Advanced Studies, New Delhi.

Mentored by Shri Sunil Nautiyal, Director, GB Pant.

Domain for Internship: Climate Change

Pine Trees and Their Contribution to Climate Change in the Western Himalayas

Pine is a dominant tree species that spreads in the Himalayan Forest, and a primary source of forest fires and diminishing water levels. The current study focused on distresses of pine trees in the Indian Himalayan environment hampering the local native flora, fauna and the people, especially in the state of Uttarakhand. Further, the study also examined the contributions of Chir pine forests on climate change and addressed and mitigated their effects. The data was collected primarily from the stakeholders through semi-structured interviews telephonically and secondary data was collected from research papers, journals, and print media. To mitigate the effects, the study recommended that a balance must be made between the environment conservation and the commercial revenue generation. mix-plantation methods to be promoted, Miyawaki Method to establish mixed forests, building and considering a carbon market to curb emissions. The study also suggested better utilization of the Chir pine resources and focus on other resourceful species of trees such as Oak. Also, the capacity building of local people and pilot project to test new conservation approaches can be done.

Keywords: chir pine trees, oak trees, carbon farming, ETS, forest fire, lack of water retention

Acknowledgement

I would like to convey my heartfelt gratitude to National Centre for Good Governance (NCGG), Government of India for giving me with the great chance to work as an intern in the field of Climate Change. This experience has been useful in shaping my understanding of how pine trees contribute to climate change in the Himalayan ecosystem. I am grateful to the MoEFCC and G.B. Pant institute of Himalayan Environment for a wonderful learning experience, inspiring direction, insightful counsel, tender advice, and constant encouragement regarding project implementation.

I am grateful to Shri Bharat Lal, former Director General of NCGG, India, for his constant encouragement and support throughout my internship. His unique thoughts and guidance have helped shape my grasp of the field and instill confidence in my capabilities.

I am also grateful to Shri V. Srinivas, IAS, the present Director General of NCGG, India, for his advice and mentoring. His progressive approach and commitment to fostering innovation have motivated me to explore new possibilities in the field of Climate Change.

I feel privileged to express my sincere gratitude to Mr. Tanmay Kumar, IAS, Additional Secretary, MoEFCC, for his valuable and kind attention, initiation, and vital suggestions during the preparation of this report. He is the one who provided the guidance to kick-start this project. Working under his supervision was a wonderful experience.

I would like to extend my special and heartfelt thanks to Mr. Sunil Nautiyal (Director, G.B. Pant Institute of Himalayan Environment) as well as Dr. G.C.S. Negi (Scientist, G.B. Pant National Institute of Himalayan Environment for their enriching insights and guidance while conducting the study.

I would want to express my heartfelt gratitude to Dr. Gazala Hasan for providing me with invaluable guidance and supervision during my internship. Her knowledge and sound advice were really beneficial to us. I would also want to thank Mr. Aakash Sir and Sachin Sir for their invaluable assistance and knowledge. Their field expertise has been beneficial in enriching my learning experience.

Finally, I'd like to thank all of the staff and colleagues at NCGG for establishing a loving and collaborative environment that aided my development as an intern. Over again, I would like to express my heartfelt appreciation to NCGG, Government of India, for this exceptional opportunity.

Executive Summary

The Himalayan Mountains attract tourists and explorers from all over the world. Thousands of people come every year to visit and spend time in the small hill stations located in the large area of the Himalayas. But the Himalayan ecosystem is a particularly fragile one, considering the array of natural calamities occurring around the region. One sees a sizable area of coniferous pine trees monoculture when one enters into the Himalayas. They are long, perfect, often described as beautiful and are recognized for their ornamental beauty. But this beauty has been costing Uttarakhand, Himachal Pradesh, Meghalaya and other places within the Shiwalik and Himachal ranges of the Himalayas a lot in the last couple of centuries. There is a fiery debate on the utility of pine trees within forest officials and scientists. Pine is a dominant tree species that spreads in the forest, and is often blamed for not allowing undergrowth, a primary source of forest fires and diminishing water levels in the pine dominated areas. According to some foresters, forests are becoming overpopulated with pine tree species that do not yield anything suitable for fauna like monkeys, elephants, or even livestock, that wander into human habitat in search of food. Through this paper we shall focus on the

- Woes pine trees have on the Indian Himalayan environment, especially in the state of Uttarakhand
- How Chir pine forests are contributing to climate change
- Suggest ideas to address and mitigate their effects.Introduction

Reports suggest that climate change would increase the average air surface temperatures by several degrees (+1.8°C to +4°C) in this century. This rise in global temperature has an influence on the Himalayan region, causing more frequent flooding, landslides, and other natural disasters. Air temperatures have risen by nearly over one degree Celsius across the high mountain region, which runs from Afghanistan in the west to Myanmar in the east, since the turn of the century—and the chilly temperatures have warmed up quicker than the rest of the world. As a result, glaciers are receding, permafrost is melting, and weather patterns are becoming more irregular, interrupting formerly reliable water sources and causing more natural disasters. Without coordinated worldwide measures to reduce greenhouse gas emissions, the figures could rise much higher. If present emissions trends continue, research suggests, warming across the Indian subcontinent might range from 2.1 to 2.6°C in the 2050s to 3.3 to 3.8°C in the 2080s. And if emissions continue to climb, that amount might rise to more than 6°C. Farmers cultivating apples or grains on steep mountain slopes must shove their orchards higher upslope to get the cool nights and seasons required by their crops. For others, shifting snow and rain patterns caused the once dependable streams and springs to become dry, or unsafe, with the potential of deadly floods.

Pinus Roxiburghii, locally known as Chir pine or longleaf Indian pine is an Indian species of pine tree which is vastly common in the Himalayas. They are found at altitudes between 600-2300m. They are an evergreen, coniferous species of flora that can grow up to heights of 55m (180 feet) with trunk spanning over 100 cm (60 inches) in diameter when fully matured. They have important usage for timber generation, resin production and also ayurvedic utilities. Chir pine trees are very well adapted to dry and high-altitude environments and can grow on a variety of soil types like well-drained gravelly loamy soil and also on calcareous soil. They have a lifespan of 40-50 years and can reach maturity by 20-30 years of age. A light, well-drained, sandy, or gravelly loamy soil is ideal for the

plant's growth. It tolerates calcareous soils well and dislikes moorland soils with poor drainage. As Chir pines increase the acidity of the soil through their fallen needles, they typically do not allow any vegetation to grow around them. Chir pines are mostly endemic to Myanmar, Nepal, Bhutan, Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, and Arunachal Pradesh. Through Pakistan, it can also be found in Tibet and Afghanistan.

The nature of Pine trees are highly debated for if they are a native species in India and can be mostly regarded as a harmful species in the Himalayas, as they bring along many woes such as making the soil dry, acidic, and non-suitable for vegetation of other species of plants. They also have exceptionally low water retention capacity, which affects the region's water levels. Their dry nature also contributes to forest fires and its circulation in the forests. They also pollinate very quickly and effectively resulting in diminution of scope for other species of native flora such as oak to grow. Present government policies and laws also oblige us to preserve the pine trees in India which is contributing to promoting the monoculture of pines in the Himalayas.

Keeping in mind that over a quarter of forest cover in Indian Himalayas are dominated by pine trees (primarily Chir pine), there has to be effective measures to promote and increase the population of native evergreen and deciduous trees such as Teak, Sal, Deodar, Oak as their numbers have significantly reduced due to having lighter legal regulation for their protection and also the unprecedented growth and takeover of pine trees in the Himalayas, creating a dominating and alarming monoculture of nothing but Chir pine trees. Oak trees are native, resourceful and have been abundant in India during pre-colonial time, but human exploitation and natural replacement has significantly reduced their numbers, along with the environmental and social benefits that Oak trees bring along with them. But the ban on cutting pine trees has led to over exploitation of Oak trees, and over population of the merely resourceful Chir pine trees. The reduction in the variety of biodiversity is affecting the ecosystem and that in turn would compromise the environmental, social and physical well-being of the native humans and animals of the Himalayan regions.

Literature review

The Himalayan Mountain range is home to the world’s highest peaks, such as Mount Everest and K2. It covers a vast area of South Asia, spanning five countries and providing a unique ecosystem for a variety of flora and fauna. In India, the Himalayans span across the northern region, covering states such as Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Sikkim and the state of Northeastern India. The range has a rich history dating back to millions of years ago, with its formation beginning during the Mesozoic era. It has a significant impact on our country’s climate, natural resources, culture and also has been a subject of exploration and study for geologists, botanists and many other scientific domains for centuries. The range, being one of the biodiversity hotspots of the world, consists of a range of native species of flora and fauna. But the biodiversity equilibrium has been significantly affected and altered since the inception of the British in India, introducing exotic species which have taken over the native habitat posing hazards to the fragile ecosystem of the sedimentary young-fold mountains of the Himalayan range.

The story of Chir pine trees in India

Colonialism and commercialization had disastrous effects on Himalayan stability. One such species is the species of Pinus Roxiburghii or locally known as Chir pines, growing in the outer Himalayas and the Shiwalik ranges, with its first appearance ever on the Shiwalik ranges which were planted stocks and not natural ones. Although Chir pine exploitation which led to its increasing population was

supported by the British, there are reports that Chir pine trees date back over many centuries, which were at lesser quantity. On the Mussoorie and Nagtibba chain, deciduous trees were first replaced by Chir Pine trees. These forests extend to the Bhagirathi Ganga Valley where Chir pines almost reach the riverbed and upwards to the northern exposed slopes of Udara and Bhuki where evergreen and coniferous mixed forests can be seen. It is estimated that the coniferous species planted so far in the Himalayas extend to about 20,000 hectares. Exotic trees species such as eucalyptus, pine, Japanese cedar are fast-growing and have contributed to the reduction of native forest cover and also hampered many ecosystem services such as water retention. Among conifers, pine trees, specifically Chir pine trees occupy a major area in the mountains.

It is observed that different regions of the Himalayan forests have seen intense biodegradation in the past century, human exploitation on the native Oak ecosystem has been extreme. While the Oak forests and zones of human settlements broadly overlap, it is regrettable to see the prevailing forest practices show a sharp bias against the oak forest. During the pre-British era before 1816, the populaces of the Himalayas were low and oak and other forests were ample to sustainably support the agro-forestry practices and meet construction demands such as mining and iron smelting. Oak trees are regarded as the best-friends of the people living in the Himalayas as the trees absorb water for a long time and releases the same slowly, maintaining the water springs in the region. Its leaves can be used as fodder, with a leafy canopy and rich undergrowth of grasses, protecting the soil below from directly being hit by rain and its wood having manufacturing implements.

When agricultural activities in the Himalayas accelerated after the inception of the British (1816) for revenue generation, Sal trees were the first to be largely overexploited. Back then, organized forestry had not been conceived, resulting in an unrestrained exploitation. The emergence of the railway era along with the military demand for the two following World wars further led to Sal overexploitation. When the number of Sal trees diminished due to its exploitation, Deodar tree exploitation began to meet the requirements of manufacturing railway sleepers. Chir pine tree exploitation did not begin until the early 20th century, when technology improved for resin tapping from the pine trees. Resin tapping became an important source of revenue generation since 1911 and its yield gained special importance since the fast-growing exotic pine trees of as low as just 25 cm diameter at breast height (dbh) were allowed to be tapped for increasing yield and revenue. It is said that the British used to scatter Chir pine seeds from helicopters into the forests of Uttarakhand to increase its population for yield and revenue. The post-colonial period also saw the same exploitation towards the pines as the government still hailed the colonialist legacy of generating revenue. Below is table 2 indicating the increase in the population density of Chir pine in 20 predominantly pine forest compartments selected at random, comparing changes from a base year up to 1978.

Table 1- Increase in the population density of Pinus roxburgii (Chir pine) in 20 predominantly pines forest compartments selected at random. Density values are in stems >10 cm diameter per ha. (Singh, 1991)

Compartment number and block	Density in base year	Density in 1978
1, Gagar*	16.0	234.4
3, Gagar*	0.6	113.1
4, Gagar*	10.0	86.6
6, Gagar*	24.3	102.8
10, Gagar**	59.1	226.5
11b, Gagar**	61.6	165.4

6a, Jangliya*	24.6	189.4
6a, Lohakhan*	11.0	134.2
8a, Lohakhan*	9.0	187.9
10b, Jakh***	26.1	149.3
13a, Patlot***	127.7	279.2
14, Patlot***	53.2	161.2
6, Raikuna*	22.7	189.1
3a, Bhowali**	77.8	160.8
5, Bhowali*	21.4	253.0
10b, Bhowali**	21.8	129.2
11, Bhowali*	46.6	65.8
2a, Dolmar**	22.4	56.8
26, Garnath**	11.9	196.0
31, Sukhatal**	14.9	341.9

**Base year 1927, **Base year1952, ***Base year 1938*

The silvicultural practices to rejuvenate Sal and Deodar could not be implemented adequately, as they were late successional species, and early successional species such as Chir pines regenerated easily. It is regarded that pine encroaches oak forest from the hill bases to ridge tops making Chir pines abundant in the Himalayas. The easy and early pollination of the pine tree seeds as compared to other native species contributes to its overpopulated monoculture. When an area is invaded by pines, it prevents the possibility of reinvasion of oak trees in the area due to certain characteristics of the pine trees. This man-made forest of pine trees is not capable of maintaining the ecological balance the same way natural forests do. Table 2 below portrays the lion share of forest cover pine trees dominate in the Indian region of the Himalayas.

Table 2- Forest cover under different forest types (1991) (Sinha, 2001)

Forest types	Area (*000ha)	Percentage in total
Subtropical broad leaved hill forest	287	2.72
Subtropical pine forest	**3740**	**35.43**
Subtropical dry evergreen forest + Sub-alpine forest	173	1.64
Montane wet temperate forest	1613	15.28
Himalayan wet temperate forest	2725	25.82
Himalayan dry temperate forest	227	2.15
Moist alpine forest	1790	16.96
Total	10555	

Monoculture of Chir pine trees in the Himalayas is still rampant. If the trend continues, the future of the Himalayan Mountains would be suffocated with pine trees and there would be total impoverishment of the environment.

Benefits and uses of Chir Pine trees

Chir wood is used for a variety of things, including the building industry and the manufacture of panel goods. A crucial oleo-resin that is produced by Chir pine trees is used as a raw ingredient in the rosin and turpentine oil industries. Chir needles produce an essential oil and are ideal for making needle

boards. Its bark can be used to produce tannin that is appropriate for curing leather, and its seeds are a good source of fatty oil.

Chir Pine offers a wide range of products and services to the public. In actuality, every part of the tree has value and is utilised in some way. It is a common timber in North India, especially in the hills, and is used for a variety of things, such as building houses, rafters, poles and posts, doors and windows, roof shingles, flooring blocks, packing boxes, boards, railway sleepers and the production of pulp and paper. It is also used to make flooring blocks and flooring boards. It is appropriate for making boats, tea chests, sporting goods, violin bodies, matchsticks, oars, and other items.

Various uses of the Chir pine tree are given hereunder:

A. Construction-

Chir pine wood has been classified under ordinary group for structural use in construction of buildings and is suitable for nailed and bolted timber construction. The wood is least preferred for local building purposes due to its nature of being most prone to decay but is still used due to lack of alternative timber sources in the pine growing altitudes.

B. Railway sleepers-

Chir pine wood was considered useful for the construction of wooden sleepers for railway tracks. The finished sleepers have a life of about 17 years.

C. Furniture and architectural use-

Chir pine wood is used to manufacture door/windows/shutters and ventilator frames in houses/buildings. They are also used to produce furniture, as they have a strength coefficient of over 50.

D. Packing cases and crates-

Having features such as its light colour, moderate weight, and nail/screw holding capacity, Chir is one of the conifer species most frequently used in the production of packing cases and crates. For packing apples and other horticultural produce, boxes made of Chir wood are just as effective as those made of other common woods. Chir pine can also be used to make plywood tea chest battens.

E. Miscellaneous uses-

Single solid logs of Chir pine tree are used as wooden poles for overhead power and telecommunication lines. They are also used for making fence posts, dunnage pallets, cross-arms and cable drums.

F. Pulp and paper making-

Chir pine contains long fibres that are 0.052 mm in diameter and 3.6 mm in length on average. It has the highest tear and burst factor among the species used to make paper, yielding 40–43.5 percent of bleached grade pulp with satisfactory strength qualities. The printing paper created entirely from Chir pine pulp has good forming and acceptable strength properties.

The species is also appropriate for producing paper used as electrical insulation. The leftover wood from industries and sawmills is highly suited for making white writing and printing paper in the current supply and demand environment. Twisted Chir, which is virtually ever used for anything else, yields around 53% unbleached pulp, which is utilised to make wrapping paper that is sufficiently dense.

G. Resin-

Chir pine produces high-quality oleo resin that, when stem-distilled, yields two crucial industrial products: turpentine oil (approximately 70%) and rosin (17%). Numerous industries, including soap, paper, paints and varnishes, linoleum, sealing waxes, oil cloth,

inks, road construction and disinfectants, use rosin extensively. The creation of paints and varnishes, polishes, chemicals and medications are the main uses for turpentine. Additionally, it is employed in the home and for the dissolution of resin and lipids. Pine resin essential oil can also be extracted from the resin and used in Aromatherapy for its fresh and woody scent; it has a soothing and relaxing effect on the mind and body.

H. Needles, seed and bark-

Chir pine needles are utilised as bedding material in cowsheds as they provide insulation from the cold ground and also as packing wool in vegetable and fruit boxes. The kernels of the Chir pine tree are rich in fats and proteins and are edible by humans. The barks have tannin content in them upto 14 per cent and hence is used in the leather industry. Its raw barks can also be used in making terra-cotta articles.

I. Ayurvedic use-

Turpentine, typically produced from the bark (20%), pinene, and abietic acid are the main chemical components of Chir pine. The main components of the essential oil made from oleoresin are alpha- and beta-pinene, carene, and longifoline. Chir is essential in the treatment and management of respiratory issues like cough, cold, asthma, osteoarthritis, gastrointestinal problems, skin infections, and other wounds and burns because it contains a variety of bioactive components that have antibacterial, analgesic, anti-inflammatory, antioxidant, astringent, anti-ulcer, digestive, expectorant, hypolipidemic, hepatoprotective, diuretic, and diaphoretic properties.

J. Ornamental uses-

The Chir pine tree is used for ornamental purposes such as Christmas trees and wreaths. Pine boughs are also derived from pine trees as they smell soothing and green and cosmetically beautiful. Also, the endless monoculture of Chir pine trees is a common sight in the Himalayas as they stretch in huge areas and act as a symbol of revival and contributes towards tourism.

K. Ecosystem services-

Besides all the timber and recreational uses provided by pine trees, they also sequester carbon dioxide from the environment and release oxygen for us humans, contributing towards fresher air in the hills. They also provide habitat for many species in the forest as well as contribute towards the green cover of the Himalayas.

Benefits of Oak trees in the Himalayas

It is observed that different regions of the Himalayan forests have seen intense biodegradation in the past century, human exploitation on the native Oak ecosystem has been extreme. While the Oak forests and zones of human settlements broadly overlap, it is regrettable to see the prevailing forest practices show a sharp bias against the oak forest. During the pre-British era before 1816, the populaces of the Himalayas were low and oak and other forests were ample to sustainably support the agro-forestry practices and meet construction demands such as mining and iron smelting. Oaks are an unusual species in a predominantly tropical country like India, but they represent the backbone of the temperate moist forest biome found in the Himalayas between 1,500 and 2,700 meters. Oak trees are regarded as the best-friends of the people living in the Himalayas as the trees absorb water for a long time and release the same slowly. The oak roots continue to take water from deeper layers of soil at night. The *water* is subsequently released into the shallow soil layers by the shallow roots, making water available to shallow-rooted plants. This provides a considerable source of water for plants with shallow roots. The trees' strong, deep root systems have proven to be good at ground stabilisation, moderating water absorption and safeguarding valuable topsoil from erosion. *Soil conservation* and

the inclusion of valuable water can reverse the consequences of land degradation, restoring it to a thriving ecosystem. The oak generates a considerable amount of microbial biomass, which includes bacteria and fungi. This releases carbon into the soil, where it accumulates as organic carbon. Over time, the oak population becomes dense within a very limited area, and this, along with the high soil carbon, results in a very high total ecosystem carbon. These factors contribute towards better *carbon sequestion* in the region. Some of the ecosystem goods and services provided by oak and pine forests in the central Himalayas can be found below in the table (Source: Negi, 2022).

Table 3- Ecosystem goods and services provided by Oak and Pine forests in Central Himalayas (Negi, 2022)

Environmental services and goods (ES)	Oak Forest	Pine Forest
Ecosystem Goods		
Fodder	Low-quality, but palatable	Non-palatable
Fuelwood	Good quality	Inferior quality
Seed	Supports wildlife	Edible by human
Medicinal Value	Some	Some
Minor forest products	Many	Few
Small Timber	Rarely used	Frequently used
Agricultural Implications	Good	Hardly used
Resin	No	Yes
Leaf litter as manure	High	Low
Other uses of leaf	None	Roofing/Brooms
Ecosystem Services		
Carbon Sequestration	High	Low
Biodiversity	High	Low
Fire resistance	Low	High
Soil Conservation	High	Low
Water quality regulation	High	Low
Microhabitat for Flora and Fauna	High	Low

From the above table, it can be observed that the economic contribution of Pine Forest outweighs the ecological contribution of Oak forests in the absence of valuation of ES properly. The oak trees do not appear to suffer from any serious pests or diseases. They can grow upto 10-15 meters and age over 200 years. The tree has unlimited value. Its leaves can be used as fodder, with a leafy canopy and rich undergrowth of grasses, protecting the soil below from directly being hit by rain and its wood having manufacturing implements-unlike in Chir pine forests.

Carbon farming, Emissions Trading System (ETS) and Tāmata Hauhā

With the ever-growing pollution and GHG emission in India, techniques to tackle the emissions are the need of the hour. Carbon farming associated with ETS is a way that could tackle and address the issue of Chir pine monoculture in India. Carbon farming is a way to remove carbon dioxide from the atmosphere and store it in the soil and vegetation. This can be done through various practices such as planting cover crops, reducing tillage, and managing grazing. The carbon that is stored in the soil and vegetation can help mitigate climate change by reducing the amount of carbon dioxide in the atmosphere. The Ministry of Environment, Forest and Climate Change (MoEFCC) has launched a program in 2021 called the Green India Mission, which aims to increase the country's forest cover and improve soil health. The Mission has set a target of 10 million hectare on forest and non-forest lands to increase forest/tree cover and improve the quality of existing forest. This program includes

initiatives related to carbon farming. Carbon farming could have several benefits in India, such as improving soil health, increasing crop yields, and mitigating climate change. By sequestering carbon in the soil and vegetation, carbon farming can help reduce the amount of carbon dioxide in the atmosphere, which is a major contributor to climate change. Additionally, carbon farming practices can help improve soil health, which can lead to increased crop yields and better water retention.

An Emissions Trading System (ETS) is a cap-and-trade program where a cap is set on the total amount of greenhouse gas emissions that are allowed to be emitted by a certain industry or company. The companies are issued permits to emit a certain amount of greenhouse gases. If a company emits less than its allotted amount, it can sell its unused permits, also known as Carbon Credits to other companies that need more permits. This creates a market for permits and provides an incentive for companies to reduce their overall greenhouse gas emissions by improving technology and functioning efficiently. This norm puts a certain pressure on polluting industries to curb their emission, otherwise having to pay extra per ton of carbon dioxide produced by the industry. India has not implemented a nationwide emissions trading system. However, some state-level initiatives have been taken to curb greenhouse gas emissions. For example, the state of *Gujarat* has implemented a trading system for renewable energy certificates.

Carbon farming can be associated with emissions trading systems by allowing farmers to generate carbon credits that can be sold to companies or governments looking to offset their carbon emissions. These carbon credits represent the amount of carbon that has been sequestered through carbon farming practices, and can be traded on carbon markets as part of an emissions trading system. By creating a financial incentive for carbon farming, emissions trading systems can help encourage the adoption of sustainable farming practices that can help mitigate climate change.

The model of a company called Tāmata Hauhā, based in Māori, New Zealand is an empowering example of how carbon farming with ETS could contribute towards land-development of barren or unfit land along with generating revenue from plantation of trees. The company aims to return to native forestry, from the profits produced by exotic species such as pine trees. They create forestry of exotic species which is well regulated and maintained that could sequester large amounts of carbon whilst also also producing opportunities for diversification as well as habitat and food supply for our fauna. Although exotic plantations could hamper the ecosystem of the region, the regulated and controlled exotic forests could generate drastically higher rates of revenue than from native forests. The start with exotic plantation with the idea to slowly transition towards more native plants, they would see a wider outcome to the region. They use ETS to help reduce carbon emissions and meet the international targets for climate change in New Zealand by 2050.

The currency they use is New Zealand Emissions Unit (NZU). Each NZU equals one ton of CO2 or its equivalent in other greenhouse gases. NZUs are bought and sold between companies, with emitters paying NZUs based on the amount of carbon dioxide they release. Forest owners can earn NZU's from the government as trees absorb carbon dioxide, removing it from the atmosphere. The foresters can then sell those NZU's to emitters. The price of NZU's depends on a variety of things, but primarily based on supply and demand – how many emission units are available and how much businesses want or need to buy in order to emit. The ETS encourages businesses to search for ways to cut emissions through day-to-day practises and investments in assets and technologies by putting a price on carbon. Such a model would certainly sculpt a sense of responsibility within the citizens to cut their GHG emissions.

Methodology

Statement of Problem

To understand the impact Chir pine trees have on the Indian Himalayan environment, and how they are further contributing to climate change. There is a problem with the growing population of Chir pine trees in the Himalayas, dominating other native species such as Oak. The monoculture of the pine trees without proper policies and mechanisms for its mitigation has affected the Indian Himalayan environment in various ways such as reducing water holding capacity in the soil, causing landslides, forest fires, making the surface warmer and also dominating other forests such as oak.

Aims and Objectives

The primary aim and objective of the study is to highlight the woes Chir pine trees have on the Indian Himalayan ecosystem and suggest ideas to mitigate their effects which are contributing to climate change. Special emphasis has been given to the state of Uttarakhand which has over 28% in Chir pine forest cover. The study seeks to focus on the negative effects that Chir pine trees have on the environment and how their increasing populations in the mountains are hampering the local native flora, fauna and the people up to the present times.

Research Approach

The approach used to formulate the study is the narrative approach. Here, data or facts were gathered from the subjects through interviews, journals and documents over time and is written in a systematic story-like format. This type of approach is based on a theme and the pieces of facts and information are put together in a sequence and in a chronology later, after the data has been collected.

Study Design

Area of study and details of respondents

The study was conducted amongst the residents of the Western Himalayas, especially in the state of Uttarakhand which has the highest cover of Chir pine trees in the country. Stakeholders were consulted at the G.B. Pant Institute of Himalayan Environment, Almora and other residents within the periphery of pine forests were consulted.

Research tool and Technique

A semi-structured interview was conducted with the stakeholders and residents within the Pine Forest in Uttarakhand. Respondents were interviewed telephonically with accordance to the topic of study.

Data Collection Tool

For primary data collection, interviews consisting of qualitative questions were used. The researcher first established a basic rapport with the stakeholders followed with topic related questions. The interviews were done at individual level and through virtual means. The interview, which consisted of socio-economic, cultural and environmental aspects of their lives, was gathered for interpretation. The interviews were conducted to know about how Chir pine forest were affecting their lives and the environment, and also to verify the secondary data that had been collected. For secondary data collection, many research papers, journals, and print media were referred to. The secondary data has been appropriately cited in the reference section.

Results

The following results are primarily derived from secondary sources and have been verified with major stakeholders in the subject for the study.

Negative effects of Pine trees on Himalayan environment

The Earth's atmosphere is warming, and the consequences of climate change are becoming clear. The average levels and variability of temperature and precipitation are changing, which is an important observation. Temperature and water availability fluctuations impose multiple environmental restrictions that cause changes at the molecular and forest stand levels. When most people think of the Himalayas, they imagine tall pines encircling the mountains. Few people realise, however, that many of these conifers are forced intrusions that are substantially to blame for the mountains' delicate status. Before the British arrived in India, the Himalayan woods were a verdant canopy of deciduous and evergreen trees, including these conifers. However, in the early nineteenth century, the British used trees such as Oak, Sal, and deodar for commercial purposes, resulting in a significant loss of the native canopy. Due to the failure of the forest ecosystem to recover to its former state, desert-like conditions have now emerged in many parts of the Himalayan region, including Meghalaya, Ladakh, Kumaon, and Garhwal, accompanied with a loss in dense forest cover. Mentioned below are the effects of pine trees in the Himalayas-

A. Forest Fires-

Pine needles which are typically shed during the autumn season, are highly inflammable and are the leading cause of forest fires in the Himalayan region. The Chir pine trees produce a large number of flammable needles and resins, which can ignite easily and spread flames quickly. Also, pine trees are often found in dry, arid environments which are more prone to forest fires. The inflammable carpet of Chir pine needles (leaves) burn in no time spreading the fire quickly to large swathes of the forest. This fire does not spread to the fire-resistant pine tree, which continues to drop leaves the next year, completing the cycle. This annual fire caused by Chir pine trees damage the new sapling that may be sprouting in the forest and also disrupt human and animal that may be in the path of the forest fire. The annual fire also contributes to air pollution as it releases large quantities of carbon dioxide and other greenhouse gases into the atmosphere which further increase in the overall temperature of the Himalayas.

B. Lack of Water Retention-

Chir pine trees can contribute to a lack of water retention in the soil by absorbing large amounts of water through their roots and needles, making the soil and water springs in the region dry and also making the soil prone to erosion. They are trees with high water demand, leading to depletion of groundwater resources and water availability for other plants and animals. The soil's ability to retain water reduces due to a lack of microbes. Unlike areas which have a lot of broadleaf trees like oak which have high water holding capacity, holding up to 40% of the rainwater they receive and contribute to revival of water springs, the Himalayan region with the pine trees is mostly drought prone. They can carry 8%-16% of the received rainwater resulting in women having to walk sometimes over 10 km to get the water for their normal use.

C. No Bacterial Growth, thus no undergrowth-

A carpet of pine needles covers the forest floor and they do not allow undergrowth of shrubs or bushes due to the acidic nature of the pine needles. Because of the presence of pine,

microorganisms in the soil die and are replaced by a parasitic fungal relationship that only helps pine live and expand while depleting resources available for other plants to grow. The dry nature of pine forests needles inhibits the growth of native oak and other plants, contributing to the disruption of the original ecosystem.

D. Soil erosion and landslides-

The pine forests create an environment prone to rainfall runoff generated soil erosion and landslides because the trees' needles and branches create a dense canopy that prevents rainwater from reaching the ground. The pine trees' roots are not deep enough to hold the soil in place, which makes it easier for the soil to erode during heavy rainfall. The soil erosion can lead to landslides because the soil becomes unstable and can no longer support the weight of the trees and other vegetation. This causes the water to run off quickly, taking soil with it and causing erosion. Landslides can be dangerous and can cause a lot of damage to the environment and nearby communities.

E. Easy pollination-

Pine trees pollinate easily because they produce a significant amount of lightweight pollen that may be blown long distances by the wind. Furthermore, pine trees frequently produce both male and female cones on the same tree, allowing for self-pollination and increasing the likelihood of successful fertilisation. New needles emerge between February and March, and old needles fall between May and June. Flowering occurs from February through April. Cones mature in 25 months (about 2 years). They usually open in April or May, but they might open as early as March or as late as June, depending on the weather. 10-12 seeds weigh one gram, and each cone contains 58 to 42 seeds on average. Winged seeds are released from the cones and are carried away by the wind. With the arrival of the monsoon, the falling seeds germinate. Its easy pollinating nature and its capacity to flourish in adverse environments contribute to its overpopulation in the mountains.

F. No fodder capacity-

The abundant Chir pine forest produces nothing edible for wild animals like monkeys or elephants, which lead the animals to stray into human habitat in search of food. Its leaves cannot be used as fodder for livestock, as they have a high acid content, which makes the land infertile. The depletion of edible plants and the increase of timbre species are affecting the habitat of herbivores, which also serves as an important prey base for carnivorous animals. This finally disrupts the food chain. The lack of fodder capacity within the monoculture of Chir pine trees in the Himalayas can also contribute to soil erosion, as there may be less plant material to hold the soil in place and prevent runoff.

G. Lower albedo (reflectivity)-

Pine trees have lower albedo (reflectivity) reflect less sunlight and absorb more of it. This means that the trees absorb more energy from the sun and release it as heat, which can increase the overall temperature of the environment. This can have an impact on the local climate and ecosystem. For example, if the temperature of a forest increases, it can affect the growth and health of other plants and animals in the area. Additionally, it can have an impact on the amount of water in the area, as higher temperatures can lead to increased evaporation rates, which can affect the water cycle.

H. Felling ban of pine tree-

Because of extensive tree chopping, the Uttar Pradesh (now Uttarakhand) government issued a 10-year prohibition on felling trees more than 1,000 meters tall in 1981. The

restriction was then extended for another ten years. Because silvicultural fellings of Chir Pine forests were prohibited beginning in 1980, many of the areas designated for felling in working plans could not be felled. On December 12, 1996, the Supreme Court imposed a ban on tree cutting in UP (Uttarakhand was then a part of Uttar Pradesh) and Himachal Pradesh while ruling on a writ petition filed against illegal timber extraction from the Nilgiri forests and for the preservation of the bioreserve. The ban is still in effect, giving Chir pine trees immunity to felling and has been ever since growing and multiplying its population in the Himalayas, dominating over the native flora of the region.

I. **Biodiversity Loss-**

Pine trees can contribute to biodiversity loss in a variety of ways. For starters, pine trees are frequently planted in thick monoculture plantations that replace native flora. This can lead to a reduction in the diversity of plant and animal life in the area, as well as soil degradation and erosion. Furthermore, because of their poor fodder capacity, they cannot support as much animal life as other species of plants. This can result in decreased biodiversity and habitat loss for wildlife that rely on grazing livestock for food. Finally, pine trees are frequently planted in non-native locations, which can result in the displacement of native plant and animal species and contribute to biodiversity loss. Every year, forest fires kill many animals and useful plant species that are not fire-resistant like the pine trees, resulting in fauna and flora loss in the region. Pine trees do not support food for animals, dry out springs, promote forest fires and exploit the local native biodiversity. All the above-mentioned factors contribute towards negative implications of the environment and contribute to climate change.

Primary Observations

Whilst the association with the G.B. Pant institute of Himalayan Environment, there were certain takeaways which align with the information that has been collected through the secondary sources. Below are the key points that were verified by the key informants.

A. **Sunil Pant (Director, G.B. Pant Institute of Himalayan Environment)-**

During the virtual conversation with Mr. Pant it was noted that pine trees were present in the Himalayas in the pre-colonial era although they were limited to certain areas and were not in a state of monoculture. It was during the colonial period that its plantation and population increased substantially altering the Himalayan ecosystem. He stated that due to the easy and early pollination of the pinecones and the ability of the Chir pines to grow and bloom in degraded or barren land has led to their overpopulation, replacing and overtaking native trees which are highly resourceful to the local environment, animals and the people such as Oak. It was also stated that due to the terrain and soil type of the Himalayas, not many species of plants can grow in the mountains even though Chir pines easily grow on those environments. The bright side of the situation is that the pine trees contribute to maintaining the green cover of the mountains, regardless of the comparative resource outcomes. He also confirmed that the dry pine needles from the Chir pine trees are the main and most easy source for the annual forest fires in the Himalayan region. These forest fires cause sizable damage to the local people, animals and the whole of the environment. Regardless of all the foes that the Chir

pine trees carry with them, they are one of the greatest sources of revenue for the local administration. Its timber and resin hold high commercial value, where over 50 quintals of resin are sources annually from Almora, Uttarakhand itself.

B. Dr. GCS Negi (Scientist, G.B. Pant National Institute of Himalayan Environment)-

During the interaction with Dr. Negi, certain eye-opening details were verified. Pine forest ecosystem has a multifaceted role to play in shaping the structure and functioning of other forest ecosystems (such as Oak and other broadleaf conifer forests of sub-tropical and temperate parts of the Himalayan region) and associated human activities. Many research studies suggest that Pine forests are responsible for their voracious use of soil water and drying up of mountain springs so crucial for the sustenance of the human beings, poor in floral and faunal diversity, vulnerability to wildfire due to resin rich leaf litter, loss of forest floor water holding capacity and prone to rainfall-runoff generated soil erosion and landslides, low fuel wood and fodder quality etc. It was understood that the main worry of foresters and ecologists is about its fast colonization into the socially valued Oak and mixed broadleaf forests thus reducing both the tangible and intangible ecosystem services of the native forests of this region. Also, recurrent forest fire in the Pine forests in the face of global warming is incurring huge loss to the wealth of the nation in terms of various forest goods and services, particularly rich biodiversity of medicinal and aromatic plants and wild edibles. He also verified that the Pine forests heat up the landscape and generate heat pillars up above the ground surface leading to large amounts of evapotranspiration and altering the site-specific climate (rainfall and temperature) regime.

Recommendations/What can be done?

We have learned that Chir pine trees are depleting the Himalayan ecosystem and contributing further to the agents of climate change. The Chir pine species being the most common tropical pine forest species in India, among all other forest kinds in Himalayan India is alarming. The debate if pine trees are native to India is highly valid as its large-scale plantation for the last 300 years do not seem to be adjusting well with the environment of the Himalayas and the ecosystem, as they are not providing the ecosystem services the most populous species should provide considering its number. Here are some methods of mitigation to address the havoc pines have been creating in the Himalayas

A. Promote mix-plantation methods-

For biodiversity conservation, a proper balance approach between revenue generation and environmental protection is required. As a result, the Finnish mixed tree plantation concept may be an intriguing model to examine for the Himalayas. The Finnish people live in a green and self-sufficient state because of pioneering and stringent conservation tactics such as rigorous replanting, placing culpability on industries for any environmental damage, and monitoring, supporting, and awarding green technologies. We can also encourage mixed tree plantations on the Himalayan slopes to avoid the harm caused by pine monoculture. Multiple cropping is possible even in orchards. Plantation of mixed trees prevents soil depletion, recharges springs, and improves water quality.

B. Miyawaki Technique-

The technique, which is named after the Japanese scientist Dr. Akira Miyawaki, has been extraordinarily effective, with over 17 million trees planted in 1700 places worldwide. The Miyawaki Method is used to establish mixed forests, which generates income prospects for people. The goal is to go beyond forest creation and ensure that forests and humans may

thrive alongside each other rather than at the expense of each other. These forests are multi-layered and resemble the densest areas of native undisturbed forests. Because the process is based on giving the forest the best possible start, such forests can develop up to 10 times faster, be 30 times denser, and have 100 times more biodiversity. Promoting this technique in Van Panchayats to adapt plantation of native trees such as Oak would highly benefit the environment, animals as well as the people of the region likely.

C. Implementation of Carbon Markets

In the times of growing greenhouse gases emission, building and considering a carbon market to curb emissions is the need of the hour. Many countries around the world already operate their carbon markets, although India is still in its developing stage. As it was discussed earlier, the model of Tāmata Hauhā is an interesting example of how we can generate revenue, sequester carbon dioxide and also promote native flora. Although the company grows pine plantation for its fast growing and high yield characteristics, the Indian Himalayas could follow the same model but by limiting pine trees growth and planting other environmentally fruitful species of trees. In the Himalayas, where there is monoculture of Chir pine trees, foresters and stakeholders could start generating revenue from the pine trees and slowly replace the degraded or faulty trees with native species. This model is further appropriate for the Western Himalayas as it would generate revenue from the living trees and not from chopping the Chir pine trees off, which would reduce the green cover. The pieces of barren land could also be targeted, as a properly functioning carbon market would require afforestation to generate the carbon credits required by the GHG emitting industries. India plans to have its first Emissions Trading System by 2025, although later it is, more would be the unaccounted carbon leakage in the environment.

D. Amendments to the existing felling law-

Because of the increased number of Chir pine trees, the water sources in our villages are depleting. Chir pines are responsible for both forest fires and farm fires where many shade-providing and fruit-bearing trees also get damaged in these fires. These forest fires are a regular phenomenon of the Himalayas, and pine trees are considered responsible for the rampant fire as they are the most fire prone. The existing ban on felling of trees over 1,000 meter in height should be amended in some way that would allow mixed as well as Miyawaki method of plantation, which would help replace Chir pines with native and fruitful flora such as Oak, Sal, Deodar etc.

E. Better utilization of the Chir pine resources-

Chir pines can be used for various other uses beside its resin production and timber, such as in the packaging and paper industry. It has the highest tear and burst factor among any species of trees used to make paper. The printing paper made from Chir pine trees also have good forming and acceptable strength properties, also having the characteristic for being used as electrical insulation paper. Using the pine trees from areas where there is overpopulation of the Chir pines can be utilized for manufacturing of products such as paper, as it would decrease the dependency on other species used for paper production such as Subabul. Those regulated cleared forests can slowly be shifted to another forest of resourceful species of trees that would bear benefits such as Oak.

F. Focus on oak trees-

The banj oak forest occupies only a narrow course of the Western Himalayas, but it is highly valued for the variety of organisms it supports, as well as the multifaceted benefits it provides to human residents of the region. It also serves as the backbone of the temperate moist forest

biome, which occurs between 1,500 m and 2,700 m in the Himalayas. A protected oak forest's dense vegetation and leaf litter plainly play an important role in boosting rainwater percolation down into the soil, recharging underground springs and streams. It is stated that as oak trees die, streams, springs, and waterfalls disappear. The leaves of the banj oak are also used for composting and feeding by the locals. The Chir pine brings only resin and timber, whereas the oaks bring firewood, feed for their cattle, fertiliser for their farms, a reliable water supply, and a plethora of forest products. Studies also indicate quantity and value of provisioning and regulating services provided by oak forests to the local people is higher than those provided by pine forests. If seedlings can be defended from grazing goats and cattle, and mature trees can be protected from harvesting, the environmental benefits of reforestation will be substantial. Barren hillsides might be replanted with elegant evergreen Himalayan oaks.

G. Capacity building-

Capacity building of local people can help conservation of native flora by increasing awareness about the importance of preserving local flora, providing training and resources to local communities and empowering them to take an active role in conservation efforts. When local people are empowered with knowledge and skills, they can become effective stewards of their natural resources. For instance, they can learn about the importance of preserving native flora and the benefits of conservation. They can also be trained in techniques such as seed collection, mixed cultivation, and reforestation, which can help to restore degraded habitats. Additionally, they can be provided with resources such as tools, equipment, and funding to support their conservation efforts. By involving local communities, especially women, in conservation activities, they can take ownership of the process and feel invested in the outcome. This can lead to long-term sustainability and better outcomes for both the environment and the people who depend on it.

H. A pilot project-

A pilot project can help conserve and preserve native flora by testing out new conservation approaches on a small scale before they are implemented more widely. This can help to identify potential challenges and opportunities, refine strategies, and build support among local communities and stakeholders. For example, a pilot project could focus on restoring a small area of degraded habitat using techniques such as seed collection, nursery management, and reforestation. The project could involve local communities in the restoration process, providing them with training and resources to support their efforts. The pilot project could also monitor the results of the restoration efforts, collecting data on the success of different techniques and identifying areas for improvement. If successful, the pilot project could be scaled up to a larger area or replicated in other locations, helping to conserve and preserve native flora more broadly.

Conclusion/ Reflections

It can be understood that the Himalayan ecosystem in India is a fragile example considering the changes in forest cover, flora-fauna and temperature over the decades. Developments and infrastructures are being made in the virgin mountains to support the increasing demand of travel, tourism and recourses in the region. With the man-mountain equation altering as a result of greed and commercialization, forests are no longer regarded as a pure form of nature or of major value in terms of the environment and ecology. Instead, they have evolved into a business model as a means of making money. If this tendency is not reversed, it could lead to a huge ecological calamity in the future.

Although Chir pine monoculture is quite visibly prevalent in the regions of Uttarakhand and Himalayas, the resources they provide to the people, animals and the environment are not as significant as their huge numbers. They are told to be the reason for loss of water in the springs, having no fodder capacity, degrading the soil quality, enabling soil erosion and landslides, not allowing undergrowth for other plants, trees and blamed for being the main source of forest fires every year in the forest. The easy, early pollination and ability of growing on degraded soil as compared to other broadleaf trees such as Oak lead to its dominance and monoculture of the Chir pine trees.

However, Chir pine tree is a source of substantial revenue generation as they are a huge source of resin which is used for various activities such as making roadways etc. They also are a source of timber which is used in various commodities such as in railway sleepers, making furniture, crates and paper. Even though Chir pine trees are considered a major source of forest fire, it is said that the intensity and damage caused by fires in oak forest would have been much more hazardous. As the ground is covered with pine needles in pine forest, the fire spreads fast, only for a few seconds and it does not seep into the ground and stays on the surface. Also due to the resilient nature of the Chir pine trees, they grow at any barren land with not enough water. This has a bright side in that they contribute to afforestation of the Himalayas and maintain the green cover of the region.

With all the factors considered, a balance must be made between the environment conservation and the commercial revenue generation aspect of the Himalayans forests. There should be amends made to increase the forest cover of the resourceful native flora species such as Oak, Teak and Deodar in the regions where Chir pines are predominant. This would allow more animal species to strive in the otherwise barren ecosystem of pine trees and would also benefit the local Himalayan people by enabling them to better water accessibility, more fodder capacity and making the ecosystem a more native one as they were the pre-colonial era before the exploitation of the native trees started and unplanned plantations took over for commercial gains, restoring the former glory of the mega-biodiversity hotspot of the great Himalayas.

References

- Kuparinen, A., Savolainen, O., & Schurr, F. M. (2010). Increased mortality can promote evolutionary adaptation of forest trees to climate change. *Forest Ecology and Management*, *259*(5), 1003–1008. https://doi.org/10.1016/j.foreco.2009.12.006
- Sinha, B. (2002). PINES IN THE HIMALAYAS: PAST, PRESENT AND FUTURE SCENARIO. *Energy & Environment*, *13*(6), 873–881. http://www.jstor.org/stable/43734533
- Fulé, P. Z., Garkoti, S. C., & Semwal, R. L. (2021). Frequent burning in chir pine forests, Uttarakhand, India. *Fire Ecology*, *17*(1). https://doi.org/10.1186/s42408-021-00106-3
- Sharma, S. (2015, August 12). To prevent forest fires, Uttarakhand seeks to chop lakhs of chir pine trees. *The Times of India*. https://timesofindia.indiatimes.com/city/dehradun/to-prevent-forest-fires-uttarakhand-seeks-to-chop-lakhs-of-chir-pine-trees/articleshow/48457050.cms
- Scroll.in. (2022, May 22). Blamed by locals for forest fires, Chirpine trees are acutally keeping the Himalayas green. *Scroll.in*. https://scroll.in/article/1024290/blamed-by-locals-for-forest-fires-chirpine-trees-are-acutally-keeping-the-himalayas-green
- Webline Infosoft Pvt. Ltd., Dehradun. (n.d.). *Welcome To Forest Survey of India*. https://fsi.nic.in/isfr-volume-ii?pgID=isfr-volume-ii
- Chandran, M., Sinha, A. R., Bhatt, J., & Gururani, S. (2012). Study on the Impact of ban on green felling of Chir Pine (Pinus roxburghii Sarg.). *ResearchGate*. https://www.researchgate.net/publication/329970050_Study_on_the_Impact_of_ban_on_green_felling_of_Chir_Pine_Pinus_roxburghii_Sarg
- Elwell, J. (2019). Evergreens and conifers: What's the difference? *Casey Trees*. https://caseytrees.org/2019/01/evergreens-and-conifers-whats-the-difference/
- *Pinus roxburghii (चीड़) description - The Gymnosperm Database*. (n.d.). https://www.conifers.org/pi/Pinus_roxburghii.php
- One Earth. (n.d.). *Himalayan Subtropical pine Forests | One Earth*. https://www.oneearth.org/ecoregions/himalayan-subtropical-pine-forests/
- *How to trim pine trees*. (2020, September 3). Garden Guides. https://www.gardenguides.com/94915-trim-pine-trees.html
- Malik, A. (2019, August 25). *Dangerous Beauty: The Story of pine trees in the Himalayas - AIF*. AIF. https://aif.org/dangerous-beauty-the-story-of-pine-trees-in-the-himalayas/#
- Basu, S. (2022, April 12). Chir: Health Benefits, Usage, Dosage And Side Effects Of Pine Tree. *Netmeds*. https://www.netmeds.com/health-library/post/chir-health-benefits-usage-dosage-and-side-effects-of-pine-tree
- An, H., Lee, S., & Cho, S. J. (2019). The effects of climate change on pine wilt disease in South Korea: challenges and prospects. *Forests*, *10*(6), 486. https://doi.org/10.3390/f10060486
- Matallana-Ramirez, L. P., Whetten, R., Sanchez, G. M., & Payn, K. G. (2021). Breeding for Climate Change Resilience: A Case Study of Loblolly Pine (Pinus taeda L.) in North America. *Frontiers in Plant Science*, *12*. https://doi.org/10.3389/fpls.2021.606908
- *Pine pressure*. (n.d.). https://www.downtoearth.org.in/coverage/pine-pressure-14082
- Sharma, S. (2015a, January 2). Are pine trees squeezing out other flora? *The Times of India*. https://timesofindia.indiatimes.com/city/dehradun/are-pine-trees-squeezing-out-other-flora/articleshow/45735328.cms
- Akhtar, M., Agrawal, P. K., & Srivastava, R. C. (2019). Notes on native pines of India. *ResearchGate*. https://doi.org/10.13140/RG.2.2.18106.44480
- *What are the uses of Pine Resin gathered from pine trees?* (n.d.). Quora. https://www.quora.com/What-are-the-uses-of-Pine-Resin-gathered-from-pine-trees

- Tewari, V. P., Verma, R. K., & Von Gadow, K. (2017). Climate change effects in the Western Himalayan ecosystems of India: evidence and strategies. *Forest Ecosystems*, *4*(1). https://doi.org/10.1186/s40663-017-0100-4
- Borunda, A. (2022, January 25). Climate change is roasting the Himalaya region, threatening millions. *Environment*. https://www.nationalgeographic.com/environment/article/himalaya-mountain-climate-change-report?rnd=1689842129174&loggedin=true
- Negi, G. C. S. (2022, February). *Trees, forests and people: The Central Himalayan case of forest ecosystem services*. sciencedirect.com.
- Negi, G. C. S., & Semwal, R. L. (2010). Valuing the Services Provided by Forests and Agro-Ecosystems in the Central Himalaya. *Valuing the Services Provided by Forests and Agro-Ecosystems in the Central Himalaya*.
- Joshi, G., & Negi, G. C. S. (2011). Quantification and valuation of forest ecosystem services in the western Himalayan region of India. *International Journal of Biodiversity Science, Ecosystems Services & Management*, *7*(1), 2–11. https://doi.org/10.1080/21513732.2011.598134
- World Health Organization: WHO. (2021). Climate change and health. *www.who.int*. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health
- https://www.indiascienceandtechnology.gov.in/st-visions/national-mission/national-mission-green-india-gim
- *Learn about the valuable Himalayan Oak Trees*. (n.d.). http://himalayanoaks.com/the-trees/the-valuable-oak/
- *Himalayan oak forests under threat*. (n.d.-b). https://www.downtoearth.org.in/blog/himalayan-oak-forests-under-threat-41826
- *About us – Tāmata Hauhā*. (n.d.). https://tamata.co.nz/about-us/

Prachi Shree

M.A. in Geopolitics and International Relations, Manipal Academy of Higher Education, Karnataka.

Mentored by Dr. A.P. Singh, Associate Professor, NCGG.

Domain for Internship: e-Governance

Sustainable Development of Smart Cities: Technology Trends, Best Practices and Innovations

The sustainable development of smart cities has emerged as a crucial subject for various stakeholders due to the influential role of digital technologies in driving transformative changes in urban development. The current research presented a thorough exploration of the Smart Cities Mission in India, delving into key initiatives, challenges, and sustainable development practices. The present study examined the role of emerging technologies in sustainable development of smart cities such as Dehradun. The deductive approach was adopted to fulfill the objectives of the study. The study scrutinized the Smart City Mission in India to evaluate the effectiveness of associated urban development projects, and identify challenges and opportunities in achieving sustainable, technology-driven growth. The study encompassed both primary and secondary sources, including government reports, academic publications, and news articles, to provide a holistic view of the subject. The analysis provided valuable insights into the current state of Smart Cities in India, offering a nuanced understanding of achievements, challenges, and the potential for future development. Based on the findings, the recommendations such as integrated approach to implement smart city projects, requirement of more technical support, rugged cyber security system, formulation of city data policies for better service delivery and others were made.

Keywords: sustainable development, smart city, technology, ICT, urbanization

Introduction Formulation of the theme

Over the last two decades, Internet and Communication Technology (ICT) has become central to the discourse revolving around "smart cities." Around the world, governments are harnessing the benefits of emerging technologies to build more liveable urban environments and efficiently manage the impact of rapid urbanisation, climate change, and demographic imbalance. Initially, much of the discussion around smart cities primarily focused on the technological dimensions due the catalyst role played by the corporate in innovation. However, this narrow discussion point has changed significantly over the years with the well-being of the citizens and sustainable development taking over as a major aspect of smart cities. Sustainable development of smart cities emerged with the development of five major trends. These are- globalisation of environmental problems and sustainable development, urbanisation and urban growth, sustainable urban development, and sustainable cities, information and communication technologies, and smart cities. Various reports highlight the role that technology can play to mitigate the rising sustainability challenges to improve urban and rural living conditions. International organisations such as the United Nations have also recognised the role of Big Data for sustainable development. Although various policies recommend a balanced development of smart and sustainable urban cities, the trend notices a misalignment where smart city assessment downplays the importance of environmental sustainability.

India, an emerging power in the international arena has come to recognise the challenges and opportunities of urbanisation in India. As a result, the Ministry of Housing and Urban Affairs (MoHUA), Government of India (GoI), launched the Smart Cities Mission (SCM) in June 2015. With the launch of this mission, India started paving a new path towards transforming urban development using the power of digital technologies. However, it is important that India comes up with a rigid policy that does not neglect the sustainable development of smart cities. In this view, the current research will try to cull out the significance of technology for sustainable development of smart cities in India by suggesting the best policies and practices from around the world.

Survey of literature

The survey of literature examines the various aspects of sustainable development and smart cities as a stand-alone concept and as an integrated aspect. The literature has reviewed the various discourses surrounding the concepts of sustainable development of smart cities. Further, it has assessed the international scenario concerning the theme under study by selecting certain smart cities which meet the demands of sustainable development. Finally, the survey of literature has explored India's approach to sustainable development of smart cities.

The Brundtland Commission defines sustainability as "meeting the needs of the present without compromising the ability of the future generations to meet their own needs" (United Nations, 1987). In 2015, as part of the 70th session of the United Nations General Assembly adopted Sustainable Development Goals (SDGs) which provided a shared blueprint of peace and prosperity for people and the planet (UNESCO, 2015) (United Nations, 2015). These objectives recognise different areas that call for action by all the countries. The concept of sustainable development or sustainability became significant with the passage of time and countries tried

incorporating this concept in various developmental areas. Smart cities are one of the areas where the objectives of sustainability are highly promoted. The smart city concept emerged with the revolution in the Internet and Communications Technology (ICT). The last decade has witnessed fundamental changes in the living environment of urban areas with different aspects of cities becoming closely intertwined with ICTs (Chuan Tao et al., 2015, p. 2). Digital technologies play a significant role in assisting governments to administer. For instance, governments are using Big data to improve the living conditions of their citizens at a very low cost. Big data analytics is considered as an empowering capability of smart city development as it brings sustainability in smart cities by utilising the analytics outcome for a variety of applications including home security, traffic control, resource allocation, healthcare, education, and environmental protection (Khan et al., 2021, p. 16029).

The ICTs have become a crucial component in solving issues pertaining to urbanisation. Smart cities are thus defined as a city that "infuses information into its physical infrastructure to improve conveniences, facilitate mobility, add efficiencies, conserve energy, improve the quality of air and water, identify problems and fix them quickly, recover rapidly from disasters, collect data to make better decisions, deploy resources effectively, and share data to enable collaboration across entities and domains" (Nam & Pardo, 2011). However, the definition of the term remains ambiguous due to lack of academic consensus over one definition. Smart cities as a term were introduced in the year 2011. Initially, the term focused on the significance of ICT regarding modern infrastructures within the urban areas. The continuous criticism from civil society led to the focus being shifted to governance and human-centrism (Albino et al., 2015, p. 4). A smart sustainable city is a "city that meets the needs of its present inhabitants without compromising the ability for the other people or future generations to meet their needs, and thus, does not exceed local or planetary environmental limitations, and where this is supported by ICT" (Hojer & Wangel, 2015, p. 10). This concept should be seen as an aggregate of sustainable development and smart cities.

Sustainable development of smart cities has become a significant topic for diverse stakeholders since digital technologies have become a powerful enabler in stimulating paradigmatic shifts in urban development-related visions, strategies, implementation, and learning. Most smart cities overlook sustainability as a motivating driver of smart cities and tie the smartness approach to innovation, technology, and economic entrepreneurship (Yigitcanlar et al., 2019). However, the development in globalisation of environmental problems and sustainable development, urbanisation and urban growth, sustainable urban development and sustainable cities, information and communication technologies, and smart cities gave impetus to the concept of smart sustainable cities (Hojer & Wangel, 2015). Countries have come to the realisation that deploying sustainable development practices can address diverse set of problems associated with smart cities, such as pollution and climate change adaptation, human development, natural calamity preparedness, circular economy, biodiversity, and energy consumption (Kutty et al., 2022, p. 2).

Like any other country, India has taken several initiatives to manage the complexity with growing urbanisation. The need to increase efficiency, improve the quality of life, provide a core infrastructure, and clean and sustainable environment prompted the government to apply

smart solutions in the Indian cities (India Brand Equity Foundation, 2021). The Smart Cities Mission was launched by the Government of India in 2015 with the mission to drive economic growth and improve quality of life. 200 Indian cities have been selected to be developed as smart cities through a two-stage competition (Smart City, 2021). Dehradun, the capital of the northern state of Uttarakhand has been selected to be developed as a smart city in the phase-2 of the competition. A special purpose vehicle named as Dehradun Smart City Limited (DSCL) has been initiated to develop Dehradun as a smart city (Dehradun Smart City Ltd., 2021). Although the DSCL has taken several innovative steps to incorporate smart solutions for the everyday urban challenges that the city faces, it will be interesting to research whether these steps balance the sustainability aspect of the smart city. The following chapters will elucidate more on the sustainable approach of smart cities in India with Dehradun being the case study of the research.

Research gap

The concept of smart cities has become a wide topic for discussion with countries deploying emerging technologies to combat urban problems more efficiently and effectively. Despite the growing relevance of smart cities, a holistic view to guide practitioners and researchers on this topic is missing. Ergo, an aim of this paper would be to narrow down this gap by providing more nuanced study through incorporating the aspect of sustainable development of smart cities.

The Indian government has launched the Smart City Mission in 2015 to promote core infrastructure, give a decent quality of life to its citizens and a sustainable environment using technology. However, there has been substantially less academic effort to highlight India's approach to sustainable development of smart cities. In this view, the paper will narrow down the gap by studying cases of sustainable development of Indian smart cities.

Objectives of the study

The following would be the objectives of the study:

- To understand the concepts of sustainable development of smart cities;
- To briefly explain the role of emerging technologies in sustainable development of smartcities;
- To study the current status of Dehradun smart city.

Methodology

Deductive approach would be used to conduct this research. To explore the objectives, this research will use qualitative methods extensively. This will allow for an in-depth examination of the concept in question. This will also help in evaluating and analysing the different concepts that the research poses to explain and answer. Further, the research relies on both primary and secondary sources to gather data. In order to get expert insight on various initiatives, discussion and interviews would be carried out. Furthermore, the help of secondary sources such as books, journal articles, research papers, reports published by reputed think tanks, and other online as well as offline sources would be used to substantiate the concepts and phenomenon in question. To ensure that the research is least biased and objective, triangulation method will be deployed.

Limitations of the study

The research has potential limitations. The literature used to research the concepts will largely be based on works conducted in the English language. Further, due to the evolving nature of certain concepts, the research will also face the problem of lack of literature required for analysis.

Delimitations of the study

The scope of the research is strictly limited to and restricted to August 2023. Further, smart city initiatives of certain cities would be described. Additionally, the research will dominantly focus on Dehradun smart city initiatives.

Understanding the concepts of sustainable development and smart cities

Sustainable development has gained wide popularity with countries around the world maximising their effort for a conscious development. The term involves two main components, sustainability, and development (Mitlin, 1992, p. 112). Development is an umbrella term encompassing basic needs and rights, economic growth, political stability among others, whereas, sustainability refers to the conditions necessary for a conscious holistic growth. The 'Report of the World Commission on Environment and Development: Our Common Future' is identified with introducing the word in the international political arena. The Report defines sustainable development as, "development that ensures the needs of the present without compromising the ability of the future generations to meet their own needs" (United Nations, 1987). Although this definition is most cited among scholars, there is no academic consensus when it comes to defining sustainable development. This gives the concept a constructive ambiguity which enables a strategic flexibility in terms of responses. Diverse set of actors with incompatible interests have come to join hands for sustainable development because of this strategic flexibility (Elliott, 2013, p. 19).

In 2015, the members of the United Nations adopted the Sustainable Development Goals (SDG) replacing the Millennium Development Goals (MDG). There are 17 SDGs that stress on five fundamental pillars including planet, people, prosperity, peace, and partnership (International Monetary Fund, n.d.). These 17 SDG are interconnected and are a blueprint to achieve a better and more sustainable future for all. Below is the image depicting the 17 SDG:

Figure 1: 17 Sustainable Development Goals

Source: United Nations https://www.un.org/sustainabledevelopment/blog/2015/12/sustainable-development-goals- kick-off-with-start-of-new-year/

Smart cities

Despite widespread studies worldwide centred around smart urbanism discourse, there is no universal definition for 'smart cities'. A rationale behind this lack of universal definition for such a popular concept could also arise from contextually informed definitions provided by different countries with respect to their policies and practices. The table below highlights the definition of smart city provided by governments of different countries.

Country/ international and regional organisations	Definition
Denmark	The Ministry of Transport, Building, and Housing and the Danish Business Authority consider "Smart City" as an evolving concept: "Initially, the concept was only used in a narrow and governmental context especially in relation to environmental, energy and infrastructure issues in terms of how information and communication technologies can improve urban functionality. Subsequently, virtually all other areas of welfare started working with Smart City, for example in business development, innovation, citizen involvement, culture, healthcare and social services, where the use of data and digital platforms helps smart new solutions."

Korea	The Ministry of Land, Infrastructure and Transportation defines a smart city approach as one that "makes use of opportunities from digitalisation, clean energy and technologies, as well as innovative transport technologies, thus providing options for inhabitants to make more environmentally friendly choices and boost sustainable economic growth and enabling cities to improve their service delivery". It also states: "smart cities are a tool for solving urban problems and improving the quality of life by applying ICTs and new technologies to cities."
United Kingdom	The UK Department of Business, Energy and Industrial Strategy says "The concept [of smart city] is not static: there is no absolute definition of a smart city, no end point, but rather a process, or series of steps, by which cities become more "liveable" and resilient and, hence, able to respond quicker to new challenges."
European Union	According to the European Commission, "a smart city is a place where the traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses" (European Commission, 2014).
United Nations	A smart city approach, as defined by the United Nations, "makes use of opportunities from digitalisation, clean energy and technologies, as well as innovative transport technologies, thus providing options for inhabitants to make more environmentally friendly choices and boost sustainable economic growth and enabling cities to improve their service delivery" (United Nations, 2016).
OECD	Smart cities are defined by the OECD as "initiatives or approaches that effectively leverage digitalisation to boost citizen well-being and deliver more efficient, sustainable and inclusive urban services and environments as part of a collaborative, multi-stakeholder process" (OECD, 2018).

A robust sustainable smart city will require several fundamental blocks of emerging technologies. The administration must keep a few parameters in mind when building smart cities. These include interoperability, scalability, fast deployment, robustness, eco-friendly and efficiency, and multi-modal access (Javed et al., 2022, pp. 5-6).

Interoperability- The need for seamless collaboration to establish interoperability is crucial to establishing interoperability between systems and devices. This is pivotal for unlocking the true potential of smart cities through the deployment of independent technologies which can minimise the distance to interoperability (Greer, 2021). The IoT plays a significant role in communication between the technologies which further allows the devices to become more compatible with their environment. The feature and capacity of interpretation also increases with data sharing between the devices. Moreover, it also allows for comfortable user experience by making the interaction with devices easier (Javed et al., 2022, p. 5). However, due to lack of common standards it becomes difficult to achieve interoperability among the independent technologies (Koo & Kim, 2021).

Fast deployment- Technology deployment refers to the process of "adding or updating software or hardware for one or more users or systems in an organisation" (Bocchino, 2022). The aim here is to seamlessly integrate the new technology to use immediately post-deployment. Hence,

fast deployment of technological devices becomes another crucial aspect of smart cities. The requirement of the recent times demands sustainable but portable technologies since it requires less workforce and comparatively less time in implementation (Javed et al., 2022, p. 6).

Scalability- Scalability is another important feature of emerging technologies. It ensures the versatility of any given technological device in fulfilling consumer requirements. Scalability in technology and its applications refers to making a piece of technology bigger, more expansive, and flexible enough to handle change in behavioural situations (Bridgwater, 2020). This concept denotes, "the ability of a system to accommodate an increasing number of elements or objects, to process growing volumes of work gracefully, and/or to be susceptible to enlargement" (Bondi, 2000, p. 195). Enhanced scalability also ensures less expenditure on different devices and greater consumer satisfaction.

Robustness- Technological robustness is another aspect for implementing a smart city. The term can be understood as the procedure of testing a technology's capability to overcome its limitations and errors (Javed et al., 2022, p.6).

Eco friendly and efficiency- Electricity remains the fundamental source of power for most of the critical technologies. However, with the rise of global warming, there is a conscious effort among various stakeholders to diversify their source of fuel. This has positively affected the way research and technology manufacturing companies work. These companies are trying to orient themselves to a more eco-friendly and efficient manner by taking a collective effort to reduce environmental emissions and defining a products' cost-efficient manufacturing and usage (Javed et al., 2022, p. 6).

Multi-modal access- Multimodal interaction refers to "interaction with the virtual and physical environment through natural modes of communication such as speech, body gestures, handwriting, graphics or gaze" (Bourguet, 2003, p. 717). Recent developments in AI and sensor technologies have revolutionised newer ways of recognition- based interaction by opening up myriad ways of multimodal interaction. Technology can be made more practical and versatile by increasing the channels of communications such as through texts, voice and mails.

Role of emerging technologies in sustainable development of smart cities

The Internet and its allied technologies have empowered citizenry at community and metropolitan level. The IoT devices have revolutionised human-centric interaction (HCI) by making technology more human-centric than computer-centric as in the past. Countries around the world have started incorporating innovative techniques and technologies to better administer the affairs of their cities. To transform the city into a truly sustainable smart city, countries are required to change the design level of the cities by integrating more complementary technologies. Increasing the efficiency of technologies composed of information and communication technologies (ICT) and IoT can make the cities more eco-friendly, agile, and productive (Javed et al., 2022, p. 2). The emergence of the fourth industrial revolution witnessed significant advancements in powerful miniaturised machines that can be deployed for everyday use. The state-of-the-art technologies including AI, IoT, 5G and 6G

networks, robotic systems, Big data, blockchain, electric vehicles among others are vital to the implementation of procedures required to develop holistic and sustainable smart cities.

IBM defines IoT as, “a network of physical devices, vehicles, appliances and other physical objects that are embedded with sensors, software and network connectivity that allows them to collect and share data” (IBM, n.d.). The IoT is the key driver of smart cities, it connects multiple devices and facilitates communication. The industrial IoT integrates smart homes, smart grids, automobiles, wearable devices, automobiles, waste management systems, smart factories, health applications, security, water management, and smart industries (Al-Badi et al., 2020, p. 3). IoT enables improved efficiency, reduces cost and improves profitability, data-driven decision-making and enhances customer experience by creating more personalised and engaging experiences (IBM, n.d.). The potential applications of IoT in an enterprise context are vast and varied ranging from temperature check, air quality, energy consumption, humidity to machine performance. Several technologies come together to make IoT possible. These include sensors and actuators, connectivity technologies, cloud computing, big data analytics, and security and privacy technologies.

Sensors and actuators are the building blocks of IoT devices as they allow the machines to interact with the physical world. Sensors are electronic devices used for measuring physical parameters such as thermistor for temperature, photoresistor for light fluctuation, to detect sound, movements, flames, or any other physical fluctuation in the environment (García et al., 2017, p. 7). Whereas actuators are “mechanical or electro-mechanical devices that provide controlled and sometimes limited movements or positioning that are actuated electrically, manually or by various fluids such as air, hydraulic, etc” (Mouha, 2021, p. 89). Actuators can cause physical changes in the environment, such as turning on a motor or opening or closing a valve. IoT uses several connectivity technologies to receive data. Technologies such as Wi-Fi, Bluetooth, cellular, Zigbee among others.

These data are further stored, processed, and analysed in the cloud. Big data analytics further help in extracting insights and identifying patterns from the vast amount of data that is generated through different IoT devices (IBM, n.d.). Big data projects are changing city landscapes by simplifying complicated data infrastructure efficiently. Big data can solve some of the most challenging issues that a smart city can face. These pressing issues could be related to security of the city, transportation and efficient traffic management, city-planning, sustainability, and future proofing (Chowdhury, 2021).

Artificial Intelligence is the backbone of innovation in modern computing as it enables computers to perform a variety of advanced functions. These functions include the ability to understand and translate spoken and written language, the ability to see, analyse data, and provide better recommendations among others. AI has been defined as, “the field of science concerned with building computers and machines that can reason, learn, and act in such a way that would normally require human intelligence or that involves data whose scale exceeds what humans can analyse” (Google, n.d.). AI has applications in counting vehicles, object recognition in videos and images, and licence plate reading. AI processes information generated by IoT. For devices to work smoothly, synchronisation is required between IoT, Big data and AI. The image below depicts the relationship between the three:

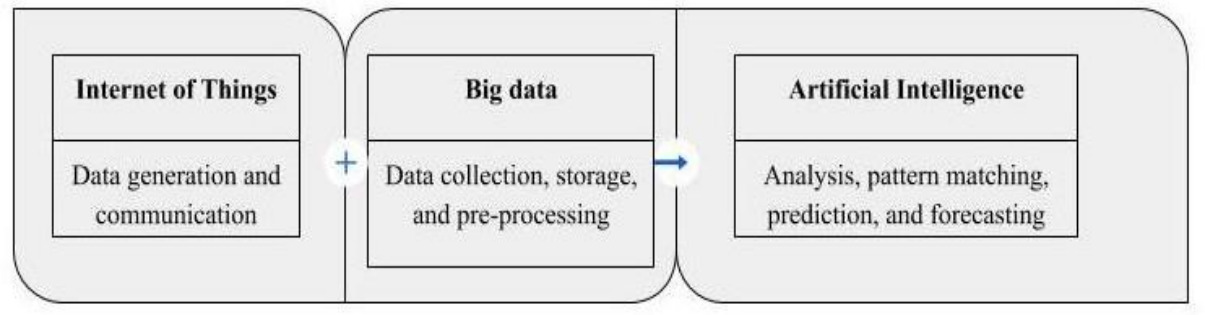


***Figure. 2**: relationship between emerging technologies in smart cities solutions*

***Source:** Al-Badi, A., Sharma, S. K., Jain, V., & Khan, A. I. (2020, December 11). Investigating Emerging Technologies Role in Smart Cities' Solutions. International Working Conference on Transfer and Diffusion of IT (TDIT), 230-241. https://link.springer.com/chapter/10.1007/978- 3-030-64861-9_21#citea*

Smart cities require absolute security of data communication since cyber-security threats are an ever-increasing threat. Blockchain solutions can provide a thrustless environment where the stored data is secured from unauthorised third-party data tampering. Smart contracts can further secure data shared between sensors. These smart contracts can only accept or release data if they satisfy a given condition (Jo et al., 2019, p. 771). The healthcare sector is a beneficiary of blockchain technologies. Blockchain is used to create a distributed system for patient health records, manage the outbreak of harmful diseases and transparent supply chains for medicines, help in diagnosing a patient through wearable diagnostic tools, and the use of telemedicine instead of in-person visit. Furthermore, blockchain technologies also assist in better waste management, increased energy savings, efficient mobility, and better education (Joshi, 2023).

Features/Components of smart cities

Smart healthcare- advancement in the healthcare system has seen revolution since early 1990 for agile treatment, delivering and monitoring healthcare services remotely, appropriate early patient serving, delivery, and handling emergency cases swiftly. Further, the challenge of delivering the best services to patients was addressed by employing IoT and evolutionary technologies (Raoof & Durai, 2022). The introduction of these technologies gave rise to the concept of smart healthcare. It has been defined as, "a healthcare system that enables patients and doctors to communicate with each other and remotely exchange information monitored, collected, and analysed from patients' daily activities via the IoT" (Annansingh, 2021). Few of the major objectives of smart healthcare include augmenting existing methods for medical research using machine learning and artificial intelligence-based approaches, identifying novel methods for early diagnosis, formulating new and existing health care devices, and creating platforms to use various electronic, mechanical and biosensors to improve remote health care facility (*IITJ-Indian Institute of Technology Jodhpur*, n.d.). Technology companies have helped create more equitable solutions to improve the performance and outcomes of healthcare. Digital transformation has particularly enhanced the healthcare industry.

Intelligent transportation system- intelligent transportation system (ITS) has become an indispensable component of smart cities. Mobility has become a key concern of citizens in a city and ITS can make the city traffic system more efficient, secure, and safer. It provides users with prior information regarding traffic congestion, real-time running information of vehicles,

seat availability among others (Choudhary, 2019). ITS include state-of-the-art electronic, wireless, and automated technologies which collectively have the capacity to integrate vehicles, system users, and traffic infrastructures. ITS, which extensively uses IoT, includes vehicle-to-vehicle and vehicle-to-infrastructure technologies. ITS technologies can be applied to varied systems such as car navigation, variable message signs, automatic number plate recognition, security CCTV systems, container management system, and weather information. Additionally, predictive methods are used to compare historical baseline data and produce more accurate information.

Smart grid- smart grids are electricity networks that efficiently manage the supply and demand of electricity in real-time and maintain the stability and reliability of the grid. Smart grids use digital technologies, sensors and software to monitor and manage the transport of electricity (Drtil et al., 2023). Some of the features of smart grid include- real time monitoring, dynamic pricing mechanism, automated outage management and faster restoration, better energy management, in-house displays, web portals and mobile apps, opportunities to reduce and conserve electricity among others (National Smart Grid Mission, 2023).

Smart waste management- smart waste management focuses on solving solid waste management problems by using intelligent monitoring systems, sensors, and mobile applications. Sensors can inform the waste management services about the fill level of bins or containers and timely update them about the same. Sensors can also alert the authorities in charge of waste management in case of any undesirable incident. Whereas, mobile applications can be used to keep in track the drivers working on the field. In this way, the internet and its allied technologies can provide the authorities with data intelligence and real-time insights. This can have several benefits including, elimination of missed pickups, reduction in the collection and unnecessary fuel consumption cost, reduction in the emission of CO2, and waste generation geo-specific data analysis (Evreka, n.d.).

Smart governance- IGI Global defines smart governance as the “use of technology and innovation to facilitate and support enhanced decision-making and planning within governing bodies” (Esses, 2022). It is very often associated with improving democratic processes, administration, and delivering services with the use of emerging technologies. It is one of the fundamentals of smart cities. As digital technologies are becoming an integrating force in the governing processes, there seems to be a rise in smart governance. And among the many technologies, social media sites have become the foremost platforms for conducting governance using technologies.

India’s approach to sustainable development of smart cities

Evolution- Pan India Schemes

India has undergone a spatial transformation as it developed. This can be better substantiated with the trend in the urbanisation curve. In the initial stage, most of the Indian population resided in rural areas and were dependent on primary sector occupation. According to the data shared by Macrotrends, the percentage of total population residing in rural areas of India in 1960 was 82.08 %, whereas in urban areas it was just 17.92 % (Macrotrends, 2023). This was followed by an accelerated stage which witnessed structural transformation of the Indian

economy that led to the population shift towards urban areas. In the year 2005, the percentage of total population residing in rural areas decreased to 70.77 % whereas in urban areas it increased to 29.24 % (Macrotrends, 2023). The pace at which India is recording the transition of its population to urban areas, it is estimated that by 2035 the percentage of total population residing in urban areas will increase to 43.2% (PTI, 2022). Scholars attribute this trend to growth in population and emergence of new towns, expansion in urban agglomerations and municipal limits.

There has been a concerted effort to standardise urban policy in India since the early 1970s. Several national level infrastructure development schemes have been implemented to accentuate the standard of urban lifestyle in India. However, the formulation and implementation of these policies were ineffective for many decades. For instance, in 1988 a policy report titled National Commission of Urbanisation was introduced to provide recommendations to the centre and the state government to carry out a balanced and sustainable development of urban centres. Both the centre and the state governments neglected the suggestions to follow up the implementation (Kundu et al., 2019).

Huge funds were allocated for the first time to cities for urban development with the launch of Jawaharlal Nehru National Urban Renewal Mission in 2005. An investment of more than INR 1,00,000 crores during 2005 to 2012 was envisaged for the mission. The rationale behind the mission was to uplift infrastructure and service availability in cities and towns that was restricted by indifferent implementation of the Constitution (74th) Amendment Act, 1992. There was also a need to make cities work more effectively and equitably for which it was essential to create regulatory frameworks, provide support and incentives to aid urban reforms at city and state level, and integrate the poor with the service delivery system (Comptroller and Auditor General of India, 2012). However, the government funds allocated were largely biased against non-mission cities and towns. Further, the mission was criticised for not considering separate cost benefit analysis for metropolitan cities and small towns.

There were certain operational issues linked to the JNNURM process. The Eleventh Planning Commission mentions how the “Projects hitherto being implemented by city level agencies have been very small in size compared to those being taken up under JNNURM. The overall institutional capacity and more specifically the project implementation capacity is clearly inadequate to deal with such large projects. This calls for immediate lateral expansion of human resources with appropriate skills, backed up by good project management systems. There is also a shortfall in the contracting capacity in the private sector. Large/organised sector players in the infrastructure industry have not yet seriously looked at municipal infrastructure because of uncertainty in the enabling environment. The project sizes have been small, with overdependence on the government funding. Poor credibility of implementing agencies is also one of the concerned areas” (Planning Commission of India, 2012, p. 399). Other issues pertaining to continuous engagement with all the cities, capacity building efforts to absorb the investment and need for an independent agency to evaluate the programme timely with appropriate remedial measures.

In 2011 Rajiv Gandhi Awas Yojana was launched with the aim to upgrade slums and provide

basic infrastructure and social amenities in the selected slums. The "Slum Free India" encouraged states/union territories to bring all existing slums under a formal system while also redressing the failures of the formal system that lie behind the creation of slums (Ministry of Housing & Urban Poverty Alleviation, 2011). However, negligible progress was achieved and soon with the change in Central government in 2015 the mission was renamed as 'Housing for All'. The mission was to be implemented from the year 2015 to 2022 to provide 'central assistance to implementing agencies through States and UTs for providing houses to all eligible families/beneficiaries by 2022' (Ministry of Housing & Urban Poverty Alleviation, 2015). The mission is further extended till 2024.

In 2015, Atal Mission for Rejuvenation and Urban Transformation (AMRUT) was also launched to provide basic infrastructure such as water supply, storm water drainage, sewerage and septage management, non-motorised urban transport, and green spaces and parks to the selected 500 cities. Till date, 134 lakh water tap connections and 102 lakh sewer connections have been provided through AMRUT & in convergence with other schemes against targeted 139 lakh water connections and 145 lakh sewer connections respectively (PIB, 2022). The mission was further subsumed as AMRUT 2.0 to promote a circular economy of water.

Smart City Mission

According to the Census of 2011, cities accommodate 31% of India's current population and contribute to 63% of its GDP. It is estimated that the total percentage of population dwelling in cities would rise to 40% and their contribution would increase by up to 75% by 2030 (National Portal of India, 2016). Hence, there arouse a need to equip cities with comprehensive infrastructural development. The central government's Smart City Mission introduced in 2015 under the Ministry of Housing and Urban Affairs, is a step in this direction. The mission is not just a dream but a way to increase the liveability index in the cities by uplifting the standards of necessities using technologies. The Mission does not define the term 'smart city' for a simple reason that the conceptualisation varies from city to city.

The objective of the mission is to provide core infrastructure to the citizens with the application of 'smart' solutions. The mission statement emphasises on the need for sustainable and inclusive development. The core infrastructure elements in a smart city would include: (i) adequate water supply, (ii) assured electricity supply, (iii) sanitation, including solid waste management, (iv) efficient urban mobility and public transport, (v) affordable housing, especially for the poor, (vi) robust IT connectivity and digitalisation, (vii) good governance, especially e-Governance and citizen participation, (viii) sustainable environment, (ix) safety and security of citizens, particularly women, children and the elderly, and (x) health and education (Ministry of Urban Development, 2015).

The Mission covers 100 cities and initially the duration to complete the projects was FY 2015-16 to FY 2019-20. However, the Mission is extended till FY 2024 after evaluations conducted by the Ministry of Urban Development (The Hindu Bureau, 2023). The Mission is a centrally sponsored scheme and the central government will provide financial support of up to Rs. 100 crore per year to the assigned cities. Further, the State/ULB will also contribute an equal amount for the projects. The Mission will have convergence with other schemes for comprehensive development. These schemes are Atal Mission for Rejuvenation and

Transformation (AMRUT), Swachh Bharat Mission, National Heritage City Development and Augmentation Yojana (HRIDAY), Digital India, Housing for All, programmes connected to social infrastructure such as Education, Health, and Culture (Ministry of Urban Development, 2015).

***Figure. 3**: 100 Smart Cities*

***Source**: Maps of India, https://www.mapsofindia.com/government-of-india/smart-cities- project.html*

The selection of the cities was concluded on an equitable criterion, where equal weightage was

given to urban population of the State/UT and towns in the State/UT. The mission strategy is divided into two broad categories, that is, Area Based Development (ABD) and Pan-City Initiative. The Area based-development comprises retrofitting, redevelopment, and greenfield developments. Whereas, in the Pan-city Smart solutions would be applied throughout the city. The retrofitting model introduces planning in an existing built-up area. More intensive infrastructure service levels and mass use of smart applications will be deployed in retrofitted smart cities. In the redevelopment model, an existing built-up environment will be replaced by a layout with enhanced infrastructure. The greenfield development model will introduce major smart solutions in a vacant area with the use of innovative planning, plan financing and plan implementation tools with provision for affordable housing. Whereas, a pan-city model envisages application of selected smart solutions to the existing city-wide infrastructure (Ministry of Urban Development, 2015).

To tackle the challenges of urban management, the government introduced Special Purpose Vehicle (SPV) as a strategic intervention. The primary responsibilities of SPVs are to plan, appraise, approve, release funds, and implement, manage, operate, monitor, and evaluate projects. The projects are implemented through public-private partnerships, joint ventures, subsidiaries, turnkey contracts among others. The members of the SPV are appointed from each hierarchy of the governance system of India (Maurya & Biswas, 2019, pp. 145-146). The Smart City Proposal was introduced by the SPVs for the challenge. These proposals by SPVs of different cities included at least one pan-city solution and either retrofitting, redevelopment or greenfield models. Further, the proposal contained a detailed financial plan for the complete lifecycle of the proposal. An interesting point to note here is that the Proposals have been citizen driven from the very beginning. The authorities have been taking consultation from citizens, including Taxpayers Associations, Senior Citizens and Slum Dwellers Associations, and Residents Welfare Association.

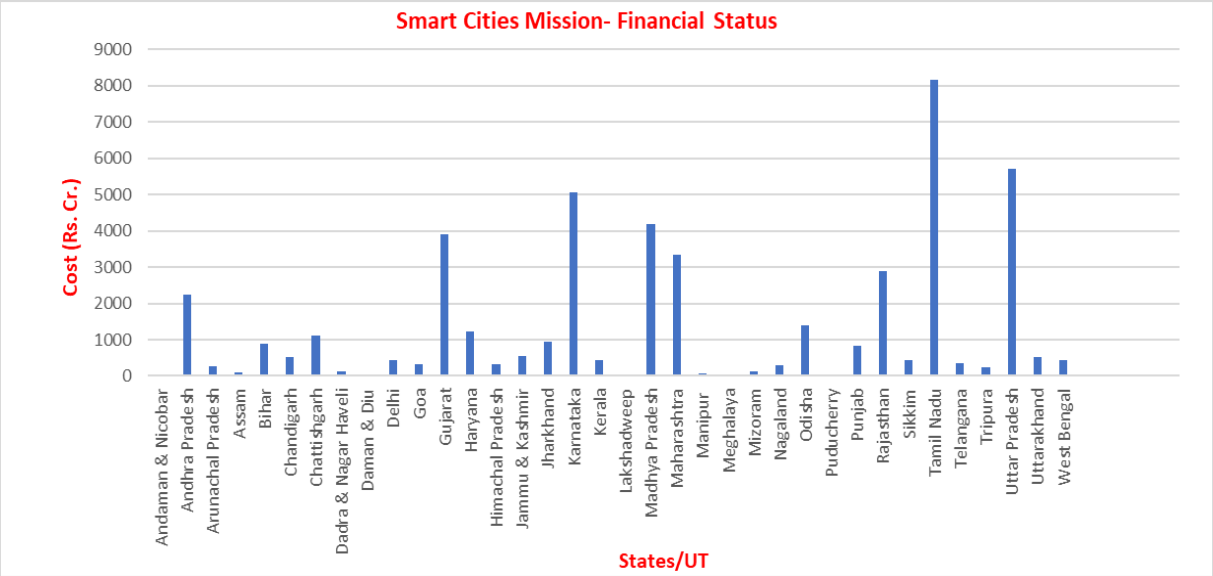
Current status: Physical and financial

The Covid-19 pandemic created a widespread disruption in economies around the world. It also affected the projects undertaken by the Smart City Mission. However, Smart Cities showed better resilience during the pandemic. In a reply to The Indian Express by the Right to Information it was revealed that out of 100 Smart Cities a dozen Smart Cities undertook projects worth Rs 70.40 crore to address the critical situation. The RTI also revealed that as of May 2023, a total of 4,382 projects costing Rs 46,374.24 crore were completed by the 100 cities selected under the Mission (Nath, 2023). A World Economic Forum report in partnership with Deloitte highlights how some of the Smart Cities such as Surat, Bengaluru, and Pimpri Chinchwad leveraged technology to coordinate between different agencies to monitor and plan their COVID-19 emergency response. Many of the smart cities effectively used their Integrated Command and Control Centre (ICCC) to analyse city-specific data, coordinate activities within various agencies and connect with citizens (World Economic Forum et al., 2020). However, the mission was extended in 2021 till June 2023 due to the delay caused by COVID-19. There were delays in implementation of the projects in some of the cities due to the late formation of SPVs.

The Mission was extended for the second time by a year till June 2024 for the completion of

the pending work. A total of 7,804 projects worth Rs 1,81,322 crore have been sanctioned and 72% of the projects worth Rs 1,07,000 crore were completed till April 30, 2023. As part of the Mission, Integrated Command and Control Centres have been introduced in all the 100 cities to improve service delivery through data-centric solutions. 53 Smart Cities have taken up 232 infrastructure development projects worth Rs 15,006. Further, 1104 smart mobility projects worth Rs 22,785 crore have been completed while 526 projects are about to get completed. Similarly, Rs 5861 crore have been used to develop 984 public spaces in cities and 343 more such spaces are going to be developed (Chitlangia, 2023).

The Smart Cities Mission released a document on 7th July 2023 indicating the list of completed projects in different States/Ut with the cost accrued by each State/UT. Among the states, Tamil Nadu, Uttar Pradesh, Karnataka, Madhya Pradesh, and Gujarat have done exceedingly well in completing the projects. Whereas, North-eastern states of Meghalaya, Manipur, Assam, Mizoram, and Tripura have had the least progress. The graph below represents the costs accrued by different states and Union Territories for the Smart City Mission.



***Graph 1**: Smart Cities Mission- Financial status of Indian States/UT*

Source: *https://smartcities.gov.in/sites/default/files/2023-08/List%20of%20Completed_Projects_SCM_7July2023_0.pdf*

Some of the recently completed and upcoming projects under the SCMs of top-most cities are highlighted below:

1. Indore- A Memorandum of Understanding was signed between the co-Founder of the Pataa Navigations and Indore Smart City Development Limited (ISCDL), making Indore the first Indian Smart city to have a fully implemented digital addressing system(CNBCTV18, 2022). The city now has over 5 lakh digital addresses, easing the problems arising out of unstructured addressing systems (IndianWeb2 Desk, 2023).

Recently, the ISDCL has been awarded a tender for the installation of a 60-megawatt capacity solar power plant worth Rs 420 crore with the aim to meet the city's electricity demands (Hall, 2023).

2. Surat- As of May 2023, Surat Smart City has completed 78 projects worth Rs 2,567 crore (ANI, 2023). The PM Awas Yojana and other city housing projects have made commendable efforts to reduce the population of slum dwellers. Slum dwellers stood 25% of the total population of the city; however, it has come down by 6% in 2023 (Press Trust of India, 2023). Additionally, the construction of Asia's biggest biodiversity park is underway in Surat. The park aims to rejuvenate the existing wasteland of Kankara Creek and transform it into a usable public space (National Institute of Urban Affairs, 2022).
3. Coimbatore- Coimbatore Smart City projects are near its completion with 43 out of the 54 projects being completed and the rest pacing up for completion (ANI, 2023). Projects that balance beautification, cultural aspects, aesthetics, and functionality of Tamil Nadusuch as the 25 ft tall statue of Thiruvalluvar, 11-metre-tall Media Tree, restoring lakes, and model roads have been appreciated by the Ministry of Urban and Housing Affairs(TNN, 2023).
4. Agra- Agra has been among one of the Smart cities to complete its projects on time. Smart Health Centres have been pivotal under the Smart Cities Mission. As of October2022, 4 out of 8 Smart Health Centres have been completed and have been opened for public use (Amit Dixit, 2022).
5. Bhubaneswar- The Bhubaneswar Smart City Limited has completed 29 projects as of 2023 and is aiming for 9 other ongoing projects (OB Bureau, 2023). The BSCL recentlyupgraded the Wi-Fi facility by providing higher speed and better download limit to its citizens (The New Indian Express, 2023).

The Ministry of Housing and Urban Affairs have initiated several programmes to enhance the impact of the Mission. The National Urban Digital Mission, launched on 23 February 2021 was introduced for enhancing digital infrastructure. Under this, initiatives like India Urban Data Exchange, Smart Cities Open Data Portal, and Smart Code have been created to ensure data availability and skill building. An India Smart Cities Awards Contest has been organised every year since 2018 to award the best performing cities. Further, internships have also been offered under The Urban Learning Internship Programme (TULIP) for experiential learning to graduates. The National Urban Learning Platform (NULP) enrols knowledge creators, to promote capacity-building (Aijaz, 2021).

Smart City Mission- A case study of Dehradun

Dehradun is situated in the north-west corner of Uttarakhand state. Nested in the mountain ranges of Himalaya, the district became the capital of Uttarakhand in 2000 and serves as the headquarters of many institutes of national importance. The total area of the district is 3088 sq. kms and it is 2100 ft above the sea level. The district has 7 tehsils, 6 blocks and 767 villages. The population of the city is 16,96,694 (Government of Uttarakhand, 2023). The population of the district has grown multi fold since it was declared as the capital of the newly formed state of Uttarakhand. This increased the pressure on the infrastructure and surrounding land and

immediately called for a proactive plan to govern the growing urban area in a sustainable way.

The Smart City Mission came as a relief to the city dwellers of Dehradun, for its objective is to improve the quality of life of city dwellers by addressing key challenges with the use of technology. Moreover, transforming Dehradun into a Smart City would only supplement its strategic location. Dehradun has good connectivity to New Delhi, it is a popular tourist destination, it has proximity to Hindu holy cities of Haridwar and Rishikesh, and it is also an educational hub. The Smart City Proposal introduced by Dehradun had a citizen centric approach. To reach out to the people of Dehradun for their suggestions and advice, various mediums were utilised including press conferences, door-to-door survey, workshops, websites, blogs, advisory committee meetings, industry experts' meetings, campaigns, online opinion poll, public meetings, and general queries (Smart City, 2016). Further, the Proposal was dovetailed with the UN Sustainable Development Goals to link the vision with sustainable development.

The SPV to implement the projects in Dehradun came to be known as the Dehradun Smart City Limited (DSCL). The SPV consists of a high-powered steering committee which includes the Board of Directors, Advisory Body, CEO and Project Management Consultant. DSCL will receive funds from the Government of India and State Government of Uttarakhand for the completion of the projects. The total projects undertaken by the DSCL are 22, out of which 14 projects have been completed and 8 projects are under development. The budget that has been released till date is INR 789 crore out of the total budget of INR 990 crore. Out of the budget that has been released, the total expenditure done till date is INR 627.46 crore.

Initiatives by the DSCL

Currently 18 out of the total 22 projects have been completed. Out of these 18 projects, 11 projects use smart solutions to meet the city's demands. The table below provides a brief overview of the completed projects.

Table 1: Projects completed by the DSCL

Project name	Cost (Rs. cr)
Digitisation of Collectorate and CDO office	0.56
Smart Waste Vehicle for Nagar Nigam and Jal Sansthan	21.28
Monumental Flag	0.09
Facade works at Paltan Bazaar	4.79
Water Supply Augmentation	26.92
Creche Building in Secretariat	1.02
Bandwidth for DICCC	32.00
Parade Ground rejuvenation	21.92
Citizen Outreach Programme	1.00
Doon Integrated Command and Control Centre	289.92

Modern Library Complex	5.75
Smart Schools	5.92
Sewerage line project along smart roads	22.15
Smart water metres	9.48
Smart water management	25.07
Paltan bazar pedestrianisation MLCP	13.81
Electric buses	33.30
Smart toilets	1.81

Source: *https://smartcities.gov.in/sites/default/files/2023-08/List%20of%20Completed_Projects_SCM_7July2023_0.pdf*

This research will only focus on technology intensive projects by reviewing the current status and challenges associated to them. The data is collected from ITDA, DSCL, DTP, and Government of Uttarakhand.

1. Doon Integrated Command and Control Centre (DICCC)

Doon Integrated Command Control Centre aims to enable ICT-based handling of various civic operations and facilitates the city administrator in the monitoring of all municipal departments for efficient service delivery. The Centre is spread across 3200 sq. feet of floor area. It consists of a war room, a discussion room, and a conference room. There is provision for 30 operators. The beneficiaries of this are ITDA, traffic police, City police and Nagar Nigam.

The functions of the DICCC are as under-

- The ICCC helps in real-time monitoring of solid waste collection services efficiently,
- It facilitates real-time monitoring and analysis of surveillance data from CCTV camerasto improve safety measures in the city
- The ICCC aids in the effective management of traffic in the city
- The ICCC has been instrumental in making the public transport more efficient
- The ICCC has helped with monitoring the vital environmental parameters in order toensure effective public health measures.
- The Emergency Call Box response system has also helped citizens immensely
- The ICCC helps in cross-departmental coordination and effective management of services

Use cases

1. Monitoring public transport system using Vehicle Tracking and Management System (VTMS)

Overview- The city administration aimed to install GPS devices in public buses to track the E-Buses for facilitating monitoring of bus location, identify the ETA for each bus stops falling within the route, and ensure trip adherence.

Implementation details- All the 10 vehicles are fitted with GPS live feed for tracking the location of Bus can be viewed in DICCC through TMS Application & ICCC Dashboard. Some key activities facilitated at ICCC using the application are as follows:

- Monitor each trip of Vehicles
- Trip Not Started: In case any vehicles do not start the trip as per schedule, informthe concerned Authority to make an alternative arrangement
- Identify the ETA for all Bus Stops
- Ensure Trip adherence
- Prepare to produce MIS reports to Officers

Outcomes achieved-

- Increased accuracy of ETA information for buses: Citizens can schedule their travel from the nearest bus stop based on ETA as the accuracy of the information has increased.
- Reduced waiting time: It is not required for citizens to wait for a long time at any busstop.
- Real-time vehicle monitoring: Real-time updates of bus arrival on any stop hasimproved the efficiency of the public bus system.

2. Electric buses

Dehradun has witnessed an exponential increase in motorisation which has subsequently impacted the air quality, noise pollution, congestion, accidents, encroachments, and deterioration of health. As a solution for this gridlock, a regular fleet of environment friendly transportation system was advised. Under the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, the Uttarakhand government deployed a fleet of 30 E-Buses. The E-buses will cover a total distance of 277 km, along 16 routes with 134 stops and pick-up points at regular frequency of 5-10 minutes.

An In-built ITS (Intelligent Transport System) application has also been developed by Dehradun Smart City Limited (DSCL) for smooth movement of the fleet buses along with their proper monitoring as in the form of services of Trip scheduling, Alert System, GPS Tracking, Estimated Time of Arrival (ETA) Service among others. As per the functionality and usability of Intelligent Transport System (ITS) team is Scheduling Trips along with Service Configuration, Vehicle Tracking for all categories namely Running, Idle, Under Maintenance, Vehicle Trip Status, ETA along with Vehicle and Trip Dashboard.

***Figure 4**: ITS*

Source: ITDA

Citizen Centric Public Transportation system have many Operational, Community and Utility benefits. Reports can be accessed for better route allocation, last mile connectivity, Alert Management, Economic benefits as well. Significant reduction in emission of Green House Gases along with other health benefits for citizen, especially children and patients with Asthma and heart related ailments.

Statistics:

- Revenue Generated (₹) =37064670(Approx 4 Crore till date)
- Total Passenger Travelled = 1730614 (Approx 18 Lakh till date)
- Total Distance covered = 4 lakh Km.
- Total Trip = 19178
- Total reduction in PM 2.5= 50-60 tonnes per year

3. Solid Waste Management

Municipal Solid Waste (MSW) management is a challenging task for cities. Increase in the population of Dehradun city has affected the disposal and management of MSW. This waste is a combination of commercial waste, industrial waste, food waste, sweeping waste, construction waste, sanitation waste and it may also contain toxic chemicals. As per Environmental Information System data, 40% of the total MSW is not collected and lied littered in the city.

Various surveys were conducted in 2018 with several stakeholders to help identify the gaps and solutions for the ongoing crisis of solid waste management. Two major concerns which were addressed way back in 2019 were Proper and effective collection of the generated Garbage and finding and allocating optimal route which results in most efficient use of labour and equipment. Smart Bins is an economical solution saving time and money by using smart waste collection bins and systems equipped with fill level sensors and integrated with command centre. As smart transport vehicles go only to the filled containers or bins. It reduces

infrastructure, operating and maintenance costs.

Analysis and close monitoring are carried out through SWM application currently hosted in Integrated Control and Command Centre (DICCC) at ITDA. Garbage Weight, GPS tracking of vehicles deployed for Door-to-Door collection, Attendance marking of field and supervisor staff through workforce Application, Bin Sensor status – are running in parallel through SWM application.

Outcomes

- Citizen friendly Grievance redressal system for prompt action to be taken by concerned department.
- Staff attendance and Location can be exactly known through workforce application.
- QR Code enabled door to door primary garbage collection ensuring full transparency and exact statistical monitoring.

Reports related to all Alerts and Complaints, Bin Status, Vehicle Trips, Total Vehicles on fields can be fetched for analytics which can be very helpful in making required administrative decisions for carrying out required operations in a more effectivemanner.

Table 2: Bin Sensors log report

Sl. No.	Month	Bin Sensors Log Report
1	15th March	1749
2	30th April	
3	May-22	295
4	Jun-22	937
5	Jul-22	557
6	Aug-22	780
7	Sep-22	475
8	Oct-22	1362
9	Nov-22	2440
10	Dec-22	382
11	Jan-23	219

Source: *ITDA*

Table 3: Zone wise household collection

Sl. No.	Month	Zone wise Household collection (In Num)
1	Apr-22	2
2	May-22	953
3	Jun-22	634
4	Jul-22	1230
5	Aug-22	745
6	Sep-22	342

7	Oct-22	318
8	Nov-22	53
9	Dec-22	2

Source: *ITDA*

Table 4: Total garbage weight- door-to-door

Sl. No.	Month	Total Garbage Weight [In Kg] [Door to Door Zone wise]
1	Apr-22	38.75
2	May-22	32865
3	Jun-22	21552.75
4	Jul-22	20865
5	Aug-22	25505.25
6	Sep-22	10822.5
7	Oct-22	10501.25
8	Nov-22	1672.5
9	Dec-22	62

Source: *ITDA*

4. Citizen Outreach Programme

Citizen engagement in Dehradun is to be promoted through virtual interaction, dialogue and discussion and is therefore centre to the urban development.

This can be done by reporting on the cleanliness of roads, parks, and public toilets, encouraging the public to use more public transport and to use apps to report incidents of corruption and malpractice. Encouraging general public to act as citizen police, taking on the responsibility of making the city safer, is a way towards a more aware doon

For instance, the Doon-1 app helps to promote cities as engines of economic growth through improvement in the quality of urban life by facilitating creation of quality urban infrastructure, with assured service levels and efficient governance and for creating economically vibrant, inclusive, efficient, and sustainable.

Table 5: Complaints lodged for SWM IN 2022

No. of SWM Complaints in 2022		
S No.	Month	No. of Calls
1	April	22
2	May	34
3	June	43
4	July	65
5	August	49
6	September	53
7	October	51
8	November	18
9	December	13
Total		348

No. of SWM Complaints in 2023		
S No.	Month	No. of Calls
1	January	55
2	February	8
3	March	7
Total		70

Source: *ITDA*

5. Smart schools

The importance of smart classes has increased in this age of technology. In the three smart schools developed under the smart city project, the students will get the latest facilities. Along with smart labs and virtual classes, various new technologies are being used for education in these smart schools. three smart schools under the Dehradun smart city project were inaugurated at the Government Inter college, Rajpur Road. The smart schools inaugurated by the CM include the GIC Rajpur Road, GIC Khudbuda and pre secondary school at Khudbuda. The schools provide with virtual classes, digital content, school management system, learning management system, library management system, CCTV surveillance, and biometric attendance.

6. Modern Doon Library

The Modern Doon Library has been built at the Lansdowne Chowk near Parade Ground. This is a joint initiative and the SCM contributed to around INR 5.75 cr while the CSR funds allocated for the same where INR 7.50 cr. The library is built in an area of 3000 sq. Mt, and has seating arrangements for 500-600 readers. The library has been equipped with high technology and facilities such as e-reading, books, newspapers, and magazines of diverse subjects are available for the readers. The low membership charges of the library make it convenient for the readers to take full advantage of the facilities. The annual membership charge of the library of the library is INR 300, while INR. 1000 is deposited in the security room. Whereas, the life membership is just INR 2000. The library is also a research centre. The library will soon inaugurate a museum where the artefacts, showcasing Uttarakhand's culture and heritage are donated by various patrons.

Features:

- Offline books- 14,000 with 2500 titles, including text books, book banks, and referencebooks
- E-journals- 6000+ and subscribed to 5 E-Databases
- E learning CD/DVDs- 1000+

7. Water ATM

The rationale to encourage this project was the problems arising from the availability of water at high costs in Dehradun. To make easy availability of portable water at reasonable cost to citizens at public places, slum areas, parks, and schools the DSCL installed water ATMs. This is directly advantageous to the public and particularly the marginalised and economically weaker section. The project was completed in 2019 and 24 Water ATMs have been installed

so far.

Features:

- Automated treated water dispensing unit at public places
- Low cost of water
  - 300 ml- INR 1
  - 300 ml with glass- INR 2
  - 1 Lt. without container- INR 3
  - 5 Lt. without container- INR 14
- Facility to display water quality and online dissemination of such reports
- Coin/RFID card-based system
- Total revenue collection till March 2023- INR 8,98,548

8. Smart Toilets

The lack of the presence of public toilets in Dehradun encouraged open defecation and littering. The DSCL, thus undertook the initiative to build seven Smart Toilets. The project was completed in 2019. The toilets have been built at public spaces. The locations for these Smart toilets are- Parade Ground-1 & 2, ISBT, Old Tehsil Compound, Niranjanpur Sabji Mandi, Doon hospital, and near Collectorate office.

Features

- Total new toilets 07 nos.
- The complex has 3 sets of toilets viz. Gents', Ladies' & Handicapped.
- The gents' toilet has 4 WC, 7 Urinal and 3 Nos wash basins.
- The ladies' unit 4 WC and one child care room and 4 nos wash basins.
- The total area of smart toilet complex is 665 Sq Ft.
- Automated features for cleaning and collection of Payments for usage.
- User Charges - INR 5 per usage of WC and Urinals are Free

9. Smart water metre

The consumption of water needs to be monitored with integrity and accuracy for water loss management. Accurate measurement of water consumption at domestic and non-domestic water connections became the need of the hour in Dehradun city. Under the Smart Water Meter project, all 5,901 nos. domestic and non-domestic water connections in selected DMA (District Metered Area) in ABD area of Dehradun Smart City has provided with smart metering. This technique offers the benefits of mobile data collection system.

This has various functions including, regulation of water consumption, enforcing water discipline, implementing volumetric tariff, smart billing, and making consumers pay for what

they consume. The grouping of data is done with the help of GPS positioning as well as the off-field methods. The IP68 water meter can be submerged up to 3 meters. The AMR is easily readable in submerged conditions which are otherwise tough to read by manual or conventional methods of meter reading.

10. Smart water management- ESCO supervisory Control and Data Acquisition (SCADA)

The ESCO model was adopted and implemented to increase pumping accuracy in Dehradun city for water supply. This model uses less energy consumption during the pumping process. An estimated of INR 35 cr. of energy will be saved over 10 years.

Features-

- Flow monitoring
- Ground water level and draw down monitoring
- Long term maintenance
- Analysis through SCADA software
- Level based operation- saves water
- Real-time monitoring through GPRS 4G communication
- Pressure monitoring
- Mobile monitoring through android app
- Smart water management

Table 6: SCADA

Item	Quantities as per BOQ	Supplied Oty (Nos.)	Installed Qts (Nos.)
Flow meter	286	293	290
Valves	296	520	479
Actuator	296	520	479
Depth sensor (only 63 available locations)	63	63	63
Observation bore well (63 available locations)	63	63	63
Actuator panel	504	504	504
Hard wire timer circuit	287	484	484
Ultrasonic level transmitter	72	72	72
Pressure transmitter	217	217	217
Chlorine analyser	278	278	278
Chlorine dozer	206	206	206
RTU panel installed for automation	206	206	206
Energy efficient pumps (Non BOQ	206	206	206

item for ESCO)			

Source: *DSCL*

Challenges with Dehradun Smart City

The Dehradun Smart City faces some potential challenges that is hindering the smooth functioning of the projects.

1. The smooth functioning of smart cities relies on the utilisation of internet connectivity to its full potential. Smart solutions used in smart cities depends on technologies such as IoT which requires robust connectivity to further provide services. Thus, quality and reliability of connectivity becomes critical to the smart city. This will transform the smart cities into vibrant socio-economic hubs that helps businesses thrive and easy to govern. However, the DSCL projects face challenges due to poor internet connections. The internet vendors are in Dehradun smart city are BSNL and UPCL. The city surveillance report by the Dehradun traffic Police of April 2023 revealed that out of 96 cameras installed at various junctions, 28 were inactive due to BSNL issue, 9 were inactive because UPCL had issue, 5 cameras were inactive because of UPCL high voltage, and 1 camera was inactive because of UPCL cable was damaged.
2. The Dehradun Smart City follows retrofitting strategy. There lie latent challenges with retrofitting strategy. The challenge lied in aligning new solutions to the existing masterplan of the city. Delay in the rapid implementation or construction of these projects can adversely impact the residents of Dehradun smart city. For instance, the 8.1 km long Smart Road project which includes utility ducts, sewer work, drain work, water supply works, and road improvement works is still incomplete. The INR 191 cr project has crossed its deadline, that is, June 2023. In order to complete the project on time, all theroads were dug up at once. This has left the residents baffled. These constructions often abrupt internet and electricity connectivity creating further problems for the residents.
3. Proper management of the Dehradun smart city needs coordination among various stakeholders. Although the implementation body is DSCL, the projects need convergence from various stakeholders including public and private sectors. However, there is lack of coordination and unity among the stakeholders. For instance, when the residents wanted to register complaint about the dug-up road in Dalanwala, instead of registering the complaint, they were made to approach different departments for the solution to the problem.
4. For the residents to understand and avail the benefits of the initiatives, there has to be good communication strategy between the stakeholders and the public. However, this is not the case. For instance, there were cases of residents burning the underground garbage fill because of their unawareness about the sensors installed in them. Since sensors are expensive devices, such incidents have attached costs to it. This incident could have been avoided if better communication strategy were deployed by the authorities.
5. Since the smart solutions makes the most of the smart cities, it is important to equip all the teams handling the projects with enough technical experts. For instance, no technical team was appointed to the Dehradun Traffic Police from the DICCC. This is a major concern when dealing with devices such as RLVD, ATCS, and Radars. Further, it is important that all the devices work efficiently since smart city relies heavily on these. For instance, the City

Surveillance Report by the Dehradun Traffic Police (April 2023) mentions that the ANPR system skipped tracking some cars, indicating that it isincompatible to track cars.

Recommendations

Challenges such as lack of coordination among stakeholders, untimely allocation of funds, and lack of technical experts can be dealt by having an integrated approach to the implementation of smart city projects. This integrated approach will need to have the Dehradun Municipal Corporation and Dehradun Smart City Ltd. working together as a single entity. Municipal Corporations have a long history and expertise of managing cities. There needs to be an authority that needs to check the working of the SPV, in this case, the Dehradun Municipal Corporation should be the concerning body.

The city needs more technical support in the form of manpower and funds to manage the projects. Lack of technical experts have created hurdles in the effective functioning of the Dehradun smart city. Further, the city needs a rugged cyber security system to deal with mishaps. A city data policy is another recommendation for Dehradun Smart City. Although there are many national policies for management of data, city governments' proximity to their constituents enables them to efficiently understand, utilise and monitor the usage of data at the city level and put it to use for better service delivery.

Conclusions

As cities grow, there is a conscious understanding among the authorities to keep it up with the global trends. In this context, smart city is a phenomenon that is technologically modern urban area deploying diverse ICT solutions to improve the operations across the cities. Cities globally are adopting technologies to effectively fasten governance models. The concept of sustainability has positively contributed to the development of smart cities. Smart sustainable city balances its priorities between technology and sustainability.

The Indian Smart City Mission launched in 2015 is a direction to sustainable growth of cities by employing technology as a means. Although the Mission does not define the term smart city, it focuses on the core infrastructural development criteria to inform the citizens about theconcept. Dehradun is one among the 100 smart cities to be chosen under the Mission. The Dehradun Smart City Ltd receives funds from the Government of India and the Government of Uttarakhand to implement its projects. Under the DSCL, the projects that have been implemented vary in nature, aiming to provide the city with a holistic growth. However, the projects face some potential challenges which is required to be overcome in order to avail the benefits to the citizens. The implementation and execution of certain projects needs to be inspected for its prompt completion.

References

- Aijaz, R. (2021, August 16). *India's Smart Cities Mission, 2015-2021: A Stocktaking | ORF*. Observer Research Foundation. Retrieved August 14, 2023, from https://www.orfonline.org/wp-content/uploads/2021/08/ORF_SpecialReport_155_SmartCitiesMission.pdf
- Al-Badi, A., Sharma, S. K., Jain, V., & Khan, A. I. (2020, December 11). Investigating Emerging Technologies Role in Smart Cities' Solutions. *International Working Conference on Transfer and Diffusion of IT(TDIT)*, 230-241. https://link.springer.com/chapter/10.1007/978-3-030-64861-9_21#citeas
- Albino, V., Berardi, U., & Dangelico, R. (2015, February 4). Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology*, *22*(1), 3-21. https://www.tandfonline.com/doi/pdf/10.1080/10630732.2014.942092?casa_token=NGNLxH2SVPUAAAAA:Fn8VoX2MehUnty6zY9PBbFBIEX44mLJmflVleFsagSSe2HRRYoeYy4zssJKSo_ZuXwgvNx7Gp-mB3DA
- Amit Dixit. (2022, October 30). *Smart City Project* के इन *8* काम ों ने बदल दी आगरा की तस्वीर पढ़ें अब तक हुए कार्यों की ललस्ट - *Smart City Project read the list of work in Agra Smart City Project*. Jagran. Retrieved August 16, 2023, from https://www.jagran.com/uttar-pradesh/agra-city-smart-city-project-read-the-list-of-work-in-agra-smart-city-project-23171058.html
- ANI. (2023, August 5). *TN: Coimbatore Smart City project work to be completed by Sept 2023, informs City Municipal Commissioner | News - Times of India Videos*. The Times of India. Retrieved August 16, 2023, from https://timesofindia.indiatimes.com/videos/news/tn-coimbatore-smart- city-project-work-to-be-completed-by-sept-2023-informs-city-municipal-commissioner/videoshow/102451077.cms
- ANI. (2023, May 2). *With Biodiversity parks, monitoring centre, DREAM city, Surat playing key role in Smart City Mission*. ANI News. Retrieved August 16, 2023, from https://www.aninews.in/news/national/general-news/with-biodiversity-parks-monitoring- centre-dream-city-surat-playing-key-role-in-smart-city-mission20230502214813/
- Annansingh, F. (Ed.). (2021). *Examining the Socio-Technical Impact of Smart Cities*. IGI Global. Bocchino, S. (2022, July 27). *Technology deployment services: what is it, and is it right for you? -*
- *Naperville, Aurora, St. Charles*. WEBIT Services. Retrieved July 31, 2023, from https://www.webitservices.com/blog/technology-deployment-services/
- Bondi, A. B. (2000). *Characteristics of Scalability and Their Impact on Performance*. Proceedings of the 2nd international workshop on Software and performance. Retrieved July 31, 2023, from https://dl.acm.org/doi/pdf/10.1145/350391.350432
- Bourguet, M. L. (2003). Designing and Prototyping Multimodal Commands. *Interact*, *3*, 717-720. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=7c236a52d7167f306e5742

b1354eedaf1bc4aa3b

- Bridgwater, A. (2020, February 19). *What Is Technology Scalability?* Forbes. Retrieved July 31, 2023,from https://www.forbes.com/sites/adrianbridgwater/2020/02/19/what-is-technology-scalability/?sh=660bcbbf4f3f
- Chitlangia, R. (2023, May 2). Smart Cities Mission gets second extension until June 2024. *Hindustan Times*. https://www.hindustantimes.com/india-news/smart-cities-mission-extended-till-june-2024-for-completion-of-pending-work-projects-worth-rs-1-81-322-crore-sanctioned- 101682995991441.html
- Choudhary, M. (2019, January 15). *What is Intelligent Transport System and how it works*. Geospatial World. Retrieved August 6, 2023, from https://www.geospatialworld.net/blogs/what-is- intelligent-transport-system-and-how-it-works/
- Chowdhury, M. (2021, October 29). *Role of Big Data Analytics in Smart City Projects*. Analytics Insight. Retrieved August 1, 2023, from https://www.analyticsinsight.net/role-of-big-data-analytics-in-smart-city-projects/
- Chuan Tao, Y., Hui, C., Yuan, W., Daven, C., & Bertrand, D. (2015, August 15). A literature survey on smart cities. *Science China, 58*, 1-18. https://www.researchgate.net/profile/Jingyuan-Wang-14/publication/281670019_A_literature_survey_on_smart_cities/links/5c0e2f0092851c39ebe1e619/A-literature-survey-on-smart-cities.pdf
- CNBCTV18. (2022, September 13). *Indore to become the country's first "Smart City" with digitaladdresses*. CNBCTV18.com. Retrieved August 16, 2023, from https://www.cnbctv18.com/technology/indore-to-become-the-countrys-first-smart-city-with-digital-addresses-14718471.htm
- Comptroller and Auditor General of India. (2012). *Performance Audit of Jawaharlal Nehru National Urban Renewal Mission, Ministry of Housing and Urban poverty Alleviation*. Comptroller and Auditor General of India. Retrieved August 10, 2023, from https://cag.gov.in/en/audit- report/details/1922
- Dehradun Smart City Ltd. (2021). *Dehradun Smart City Ltd.* Dehradun Smart City Ltd. Retrieved July 18, 2023, from https://smartcitydehradun.uk.gov.in/dscl/CitizenAboutUs.html
- Drtil, M., Pastore, A., & Evangelopoulou, S. (2023, July 11). *Smart grids - IEA*. International Energy Agency. Retrieved August 6, 2023, from https://www.iea.org/energy-system/electricity/smart-grids
- Elliott, J. A. (2013). *An Introduction to Sustainable Development*. Routledge. http://students.aiu.edu/submissions/profiles/resources/onlineBook/N8V7w2_An_Introduction
- _to_Sustainable_Development_4.pdf
- Esses, F. (2022, November 22). *Smart Governance : A Hybrid of Civic Technology IoT and Local Government*. Hello Lamp Post. Retrieved August 6, 2023, from

https://www.hlp.city/smart- governance-a-hybrid-of-civic-technology-iot-and-local-government/

- Evreka. (n.d.). *What Is Smart Waste Management? › Evreka*. Evreka. Retrieved August 6, 2023, fromhttps://evreka.co/blog/what-is-smart-waste-management/
- García, C. G., Llorián, D. M., G-Bustelo, B. C. P., & Lovelle, J. M. C. (2017). A review about SmartObjects, Sensors, and Actuators. *International Journal of Interactive Multimedia & ArtificialIntelligence*, *4*(3), 7-10. https://www.researchgate.net/profile/Cristian-Gonzalez-Garcia/publication/307638707_A_review_about_Smart_Objects_Sensors_and_Actuators/links/57ce6d8108ae582e069244e8/A-review-about-Smart-Objects-Sensors-and-Actuators.pdf?_sg%5B0%5D=started_experiment_miles
- Google. (n.d.). *What Is Artificial Intelligence (AI)?* Google Cloud. Retrieved August 1, 2023, fromhttps://cloud.google.com/learn/what-is-artificial-intelligence
- Government of Uttarakhand. (2023). *District at a glance*. District Dehradun | Government of Uttarakhand | Dehradun, Capital of Uttarakhand | India. Retrieved August 17, 2023, from https://dehradun.nic.in
- Greer, C. (2021, November 1). *Cyber-Physical Systems & the Internet of Things* [U.S. Department of Commerce]. National Institute of Standards and Technology. Retrieved July 31, 2023, from https://www.nist.gov/news-events/news/2021/11/nists-pivotal-points-interoperability-enable- smart-city-standardization
- Hall, D. (2023, August 13). *Indore Smart City Development Awards Tender for Solar Plant Installation*. Energy Portal.eu -. Retrieved August 16, 2023, from https://www.energyportal.eu/news/60mw-solar-plant-to-power-jalood-indore-news/154213/
- Hojer, M., & Wangel, J. (2015). Smart Sustainable Cities: Definition and Challenges. *ICT innovations for sustainability*, 333-349. https://www.researchgate.net/publication/310403759_Smart_Sustainable_Cities_Definition_and_Challenges
- IBM. (n.d.). *What is the internet of things?* IBM. Retrieved August 1, 2023, from https://www.ibm.com/topics/internet-of-things
- *IITJ-Indian Institute of Technology Jodhpur*. (n.d.). IITJ-Indian Institute of Technology Jodhpur. Retrieved August 5, 2023, from https://iitj.ac.in/shc/
- India Brand Equity Foundation. (2021). *Smart Cities Mission*. IBEF. Retrieved July 18, 2023, from https://www.ibef.org/government-schemes/smart-cities-mission
- IndianWeb2 Desk. (2023, June 8). *Smart City Indore with Pataa App is Now India's 1st Digital Address City with Over 5 Lakh Digital Addresses*. IndianWeb2.com. Retrieved August 16, 2023, from https://www.indianweb2.com/2023/06/smart-city-indore-with-pataa-app-is-now.html
- International Monetary Fund. (n.d.). *IMF and the Sustainable Development Goals (SDG)*.

International Monetary Fund. Retrieved August 7, 2023, from https://www.imf.org/en/About/Factsheets/Sheets/2023/IMF-Sustainable-development-goals-SDGs

- Javed, A. R., Shahzad, F., Rehman, S. u., Zikria, Y. B., Razzak, I., Jalil, Z., & Xu, G. (2022). Futuresmart cities: requirements, emerging technologies, applications, challenges, and future aspects.*The International Journal of Urban Policy and Planning*. https://www.sciencedirect.com/science/article/pii/S0264275122002335?casa_token=MWlx2QRo4dsAAAAA:m-4LYsiKkD9xMYUpgHBK_Pn_e0b1DJX1XfcGHHEGlo7ODDwjhPp_N-s6Ia1BvtCSrfkMvdBPa9g
- Jo, J. H., Sharma, P. K., Sicato, J. C. S., & Park, J. H. (2019, August). Emerging Technologies for Sustainable Smart City Network Security: Issues, Challenges, and Countermeasures. *Journal of Information Processing Systems*, *15*(4), 765-784. https://s3.ap-northeast-2.amazonaws.com/journal-home/journal/jips/fullText/265/jips_686.pdf
- Joshi, N. (2023, June 22). *6 Ways In Which Blockchain Makes Your Smart City Even Smarter*. Forbes. Retrieved August 1, 2023, from https://www.forbes.com/sites/naveenjoshi/2022/04/07/6- ways-in-which-blockchain-makes-your-smart-city-even-smarter/?sh=168d44d17f5d
- Khan, M., Siddiqui, M., Rahmani, M., & Husain, S. (2021, September 27). Investigation of Big Data Analytics for Sustainable Smart City Development: An Emerging Country. *Institute of Electrical and Electronics Engineers*, *10*, 16028-16036. https://ieeexplore.ieee.org/abstract/document/9548909/authors#authors
- Koo, J., & Kim, Y. G. (2021, April 22). *Interoperability requirements for a smart city*. Association for Computing Machinery. Retrieved July 31, 2023, from https://dl.acm.org/doi/10.1145/3412841.3441948
- Kundu, D., Pandey, A., & Sharma, P. (2019). *Making Cities Work: Policies and Programmes in India*. national Institute of Urban Affairs. Retrieved August 10, 2023, from https://niua.in/intranet/sites/default/files/1182_0.pdf
- Kutty, A. A., Kucukvar, M., Abdella, G., Bulak, M., & Onat, N. (2022, June). Sustainability Performance of European Smart Cities: A Novel DEA Approach with Double Frontiers. *Sustainable Cities and Society, 81*. https://www.sciencedirect.com/science/article/pii/S221067072200107X
- Macrotrends. (2023). *India Urban Population 1960-2023 | MacroTrends*. Macrotrends. Retrieved August 10, 2023, from https://www.macrotrends.net/countries/IND/india/urban-population
- Maurya, K. K., & Biswas, A. (2019). *The Rationale of SPV in Indian Smart City Development*. Scienceand Technology Publications, Lda 10.5220/0007726701430150
- Ministry of Housing & Urban Poverty Alleviation Government of India. (2011). *Rajiv Awas Yojana (RAY) Scheme Guidelines 2013-2022*. RAY Guidelines.

https://mohua.gov.in/upload/uploadfiles/files/RAYGuidelines.pdf

- Ministry of Housing & Urban Poverty Alleviation. (2015). *Pradhan Mantri Awas Yojana-Housing for All (Urban)*. Pradhan Mantri Awas Yojana. https://pmaymis.gov.in/PDF/HFA_Guidelines/hfa_Guidelines.pdf
- Ministry of Urban Development. (2015, June). *Smart City- Mission Statement & Guidelines*. Smart City. Retrieved August 13, 2023, from https://smartcities.gov.in/sites/default/files/SmartCityGuidelines.pdf
- Mitlin, D. (1992). Sustainable Development: a Guide to the Literature. *Environment and Urbanization, 4*(1), 111-124. https://journals.sagepub.com/doi/pdf/10.1177/095624789200400112
- Mouha, R. A. (2021). Internet of Things (IoT). *Journal of Data Analysis and Information Processing,9*(2), 77-101. 10.4236/jdaip.2021.92006
- Nam, T., & Pardo, T. (2011, June). *Conceptualizing smart city with dimensions of technology, people, and institutions* [Conference]. The Proceedings of the 12th Annual International Conference on Digital Government Research. Retrieved July 17, 2023, from https://www.researchgate.net/publication/221585167_Conceptualizing_smart_city_with_dimensions_of_technology_people_and_institutions#:~:text=The%20paper%20offers%20strategic%20principles,institutional%20improvement%20and%20citizen%20engagement.
- Nath, D. (2023, June 16). From oxygen to disinfectants: 14 cities carried out 30 projects costing Rs. 116 cr to tackle Covid using Smart City funds in 2020-'21. *The Indian Express*. https://indianexpress.com/article/india/from-oxygen-to-disinfectants-14-cities-carried-out-30-projects-costing-rs-116-cr-to-tackle-covid-using-smart-city-funds-in-2020-21-8663316/
- National Institute of Urban Affairs. (2022). *CITIIS*. CITIIS. Retrieved August 16, 2023, from https://citiis.niua.in/projects/surat
- National Portal of India. (2016, May 13). *Smart Cities Mission: A step towards Smart India*. National Portal of India. Retrieved August 13, 2023, from https://www.india.gov.in/spotlight/smart- cities-mission-step-towards-smart-india
- National Smart Grid Mission. (2023). *Smart Grid*. National Smart Grid Mission. Retrieved August 6,2023, from https://www.nsgm.gov.in/en/smart-grid
- OB Bureau. (2023, August 10). *Smart Cities Mission: 85 Projects Completed In Bhubaneswar & Rourkela With Rs 2707 Crore Released By Centre - odishabytes*. Odisha Bytes. Retrieved August 16, 2023, from https://odishabytes.com/smart-cities-mission-85-projects-completed- in-bhubaneswar-rourkela-with-rs-2707-crore-released-by-centre/
- PIB. (2022, December 22). *AMRUT Scheme*. Press Information Bureau. Retrieved August 10, 2023, from https://pib.gov.in/PressReleasePage.aspx?PRID=1885837
- Planning Commission of India. (2012). *Eleventh Five Year Plan (2007–2012) Agriculture, Rural Development, Industry, Services and Physical Infrastructure Volume III* (Vol. 3).

Oxford University Press. http://www.im4change.org/docs/11th_vol3.pdf

- Press Trust of India. (2023, April 18). *MoHUA lauds Surat model of developing recreational zones from unutilised road spaces*. Republic World. Retrieved August 16, 2023, from https://www.republicworld.com/india-news/city-news/mohua-lauds-surat-model-of-developing-recreational-zones-from-unutilised-road-spaces-articleshow.html
- PTI. (2022, June 30). India's urban population to stand at 675 million in 2035, behind China's 1 billion:
- U.N. *The Hindu*. https://www.thehindu.com/news/national/indias-urban-population-to-stand-at-675-million-in-2035-behind-chinas-1-billion-un/article65584707.ece
- Raoof, S. S., & Durai, M.A. S. (2022). *A Comprehensive Review on Smart Health Care: Applications, Paradigms, and Challenges with Case Studies*. National Library of Medicine. Retrieved August 5, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9536991/
- Smart City. (2016). *INDIA SMART CITY MISSION*. Smartnet. Retrieved August 21, 2023, from https://smartnet.niua.org/sites/default/files/resources/Smart-City-Proposal-Dheradun%20-%20UT-01-DDN.pdf
- Smart City. (2021, February 20). *About The Mission | Smartcities*. Smart Cities Mission. Retrieved July 18, 2023, from https://smartcities.gov.in/about-the-mission
- The Hindu Bureau. (2023, May 23). More than 90% of funds allocated under Smart Cities Mission utilised, says Hardeep Singh Puri. *The Hindu*. https://www.thehindu.com/news/national/more- than-90-of-funds-allocated-under-smart-cities-mission-utilised-says-hardeep-singh- puri/article66885240.ece
- The New Indian Express. (2023, July 29). Bhubaneswar Smart City Limited gets free Wi-Fi with more download limit. *The New Indian Express*. https://www.newindianexpress.com/states/odisha/2023/jul/29/bhubaneswarsmart-city-limited-gets-free-wi-fi-with-more-download-limit-2599825.html
- TNN. (2023, August 16). *Smart City: Union Ministry Lauds Smart City Projects | Coimbatore News -Times of India*. The Times of India. Retrieved August 16, 2023, from https://timesofindia.indiatimes.com/city/coimbatore/union-ministry-lauds-smart-city-projects/articleshow/102756853.cms?from=mdr
- UNESCO. (2015). *UNESCO and Sustainable Development Goals*. UNESCO. Retrieved July 17, 2023, from https://en.unesco.org/sustainabledevelopmentgoals
- United Nations. (1987). *Report of the World Commission on Environment and Development: Our Common Future*. Strategic Imperatives. Retrieved July 26, 2023, from http://www.ask-force.org/web/Sustainability/Brundtland-Our-Common-Future-1987-2008.pdf
- United Nations. (1987, October). *Report of the World Commission on Environment and Development: Our Common Future*.Sustainability- United Nations. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

- United Nations. (2015). *THE 17 GOALS | Sustainable Development*. Sustainable Development Goals. Retrieved July 17, 2023, from https://sdgs.un.org/goals
- World Economic Forum, Government of India, & Deloitte. (2020, December). *Technology and Data Governance in Cities Indian Smart Cities at the Forefront of the Fight Against COVID-19*. World Economic Forum. Retrieved August 14, 2023, from https://www3.weforum.org/docs/WEF_Technology_and_Data_Governance_in_Smart_Citie_India_2020.pdf
- Yigitcanlar, T., Han, H., & Kamruzzaman, M. (2019, November). Approaches, Advances, and Applications in the Sustainable Development of Smart Cities: A Commentary from the Guest Editors. *Energies*, *12*(23), 4554. https://www.mdpi.com/1996-1073/12/23/4554

Shreshtha Gupta

M.A. in Politics (Specialization in International Studies), University of Mumbai, Maharashtra.

Mentored by Shri Yugal Joshi, Adviser, NITI Aayog.

Domain for Internship: Public Policy & Governance

India & The Global Partnership on Artificial Intelligence-The Way Forward

India is evolving in the global landscape of artificial intelligence (AI), emphasizing its commitment to responsible AI development and inclusivity. The present research focused on multiple dimensions, including societal impact, regulatory frameworks, and India's position in global AI governance. The research objectives included a critical examination of India's AI initiatives, examining a comprehensive national AI strategy, and India’s leadership in the Global Partnership on AI (GPAI). Methodologically, the secondary research was conducted from a variety of sources, encompassing academic papers, government reports, and industry analyses. India's leadership in GPAI is a central focus, with an emphasis on its role in shaping global AI policies and addressing challenges. The inclusion of specific AI applications in healthcare, agriculture, education, and mobility underscores India's commitment to leveraging AI for social development. Findings highlighted India's emphasis on responsible AI governance, with discussions on data governance, and building AI systems aligned with societal needs. The establishment of the National AI Agenda, National Mission on Interdisciplinary Cyber-Physical Systems, and sector-specific AI applications exemplify India's comprehensive approach. The findings provide insights for policymakers, researchers, and industry leaders, emphasizing the importance of ethical considerations, global cooperation, and AI applications aligned with societal needs.

Keywords: Artificial Intelligence, GPAI, Global AI Governance, AI Applications, National AI Strategy, India

Note: This is a relatively developing topic so there is not much research on the subject available.

Introduction

Artificial Intelligence (AI) requires the machine to perform tasks in an intelligent manner in a similar fashion to humans. There are pros and cons associated with any major technological advancement so is the case with AI. While AI has the potential to bring about significant economic growth, it is anticipated that we might lose on some due to automation. Therefore, it is necessary to put in place the necessary policies and infrastructure.

"Though the field of AI has been an area of extensive research since the term was coined in 1956, it has recently only led to large-scale deployment of intelligent applications for different domains and tasks. The works in the late fifties and early sixties were in the direction of development of general techniques, which could be applied in several domains. The results were not very encouraging and it led to the first winter of the field, which started in the late sixties and continued till the late seventies. It was realized that the knowledge of the domain plays an important role and therefore, the focus of the research was on representing and using knowledge. The systems developed were called knowledge-based systems. MYCIN, a KBS using rules for representing knowledge of the experts was used successfully in the medical domain. A number of such systems were developed in other domains. As these were based on the knowledge of human experts, these were called expert systems. Several companies captured the opportunity. However, by the late eighties, it was found that the rules were often brittle and did not work in practical applications which required incorporating a large number of rules to deal with various scenarios. When several companies failed in their efforts in applying the technology, there was general disappointment in the industry. The second winter of AI started in the late eighties and continued till the mid of the first decade of the current century when high computational power machines and storage became easily available and affordable. It was fuelled by the development of certain algorithms such as deep learning. Large-scale deployment could be easily possible on mobile phones using Internet. It may be noted that the periods of the two winters mentioned above are not precise due to obvious reasons" (Sunil Kumar Srivastava 2018).

"Considering recent advances in AI and its potential impact on job opportunities, each country needs to prepare an action plan to take advantage of opportunities and face challenges. Identify priority areas for technology development investment to create AI-based solutions. At the same time, steps should also be taken to prepare workers to accept the new types of work that may arise. A country cannot be immune to impact, but it can well manage it by putting in place the necessary infrastructure and policies" (US Government, 2016).

Many countries have formulated their policy for AI (U.S. Government, 2016; House of Commons Science and Technology Committee, 2016; State Council of China, 2017; Government of South Korea, 2017; Benner, 2017). India needs to capitalise on it. It already missed to reap the benefits of first and second industrial revolutions due to certain political factors at play. We were able to reap the benefits of the revolution due to IT (Information Technology) using the country's tech talent. Fortune has not only been made by the export of software but also provided jobs to millions of educated people. This lies at risk today since

most of the companies are automating the process using AI. Therefore, the country must be prepared to seize the opportunities and face the challenges brought by AI.

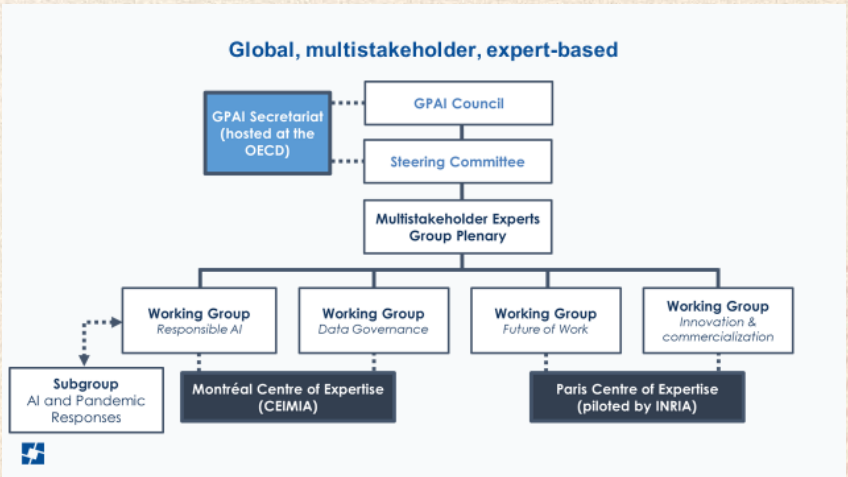
"An analysis of major economies (Purdy & Daugherty, 2016) shows that GDP growth has levelled off or declined in several developed countries over the past decades. The average GDP growth of Japan, the United States, the United Kingdom, France, Italy and Germany was 3.0 in the 1980s, 2.1 in the 1990s and 1.1 in the first decade of the current century. in. For a time, capital and labour were considered factors of production. However, studies show that the rate of capital efficiency has decreased. Furthermore, the working-age population is not growing in many developed countries. The net effect is marginal GDP growth in developed countries. Accenture analysed 12 major economies and predicted that AI adoption has the potential to double economic growth by 2035" (Sunil Kumar Srivastava 2018).

AI has the potential to drastically transform for good but at the same time it presents significant challenges if left unchecked. To ensure that AI is utilized to its full potential international collaboration and cooperation are necessary.

On the similar lines the Global Partnership on Artificial Intelligence which has been launched in 2020. It was first formally proposed Canada and France at G7 44th summit. "The purpose of the partnership is to act as a bridge and act as a point of contact for governments and world's prominent AI experts in order to promote the human- centric development and use of AI in a manner that aligns with human rights, fundamental freedom and democratic values" (GPAI).

There are currently 29 members in GPAI namely the UK, the USA, Argentina, Australia, Belgium, Brazil, Canada, Czech Republic, Denmark, France, Germany, India, Ireland, Israel, Italy, Japan, Mexico, the Netherlands, New Zealand, Poland, the Republic of Korea, Senegal, Serbia, Singapore, Slovenia, Spain, Sweden, Turkey and the European Union.

"Four pillars of GPAI are Responsible AI, Data governance, Future of Work and Innovation & Commercialization. It consists of a Council and a Steering Committee and a Secretariat hosted by Organisation for Economic Cooperation and Development (OECD). There are two centres of expertise: The International Centre of Expertise in Montreal for the advancement of Artificial Intelligence in Montreal and French National Institute for Research in Digital Science and Technology" (GPAI).



Source: GPAI, The Structure of GPAI

India assumed the chair on November 21, 2022 at the Tokyo summit by surpassing countries like USA and Canada in the vote count. “As one of the largest Global South economies leading the AI race, India nominated itself for the position of incoming council chair of GPAI. India received more than two-thirds of first-preference votes and was therefore elected as the Incoming Council Chair in November 2022. India will serve as the Incoming Chair in 2023, then subsequently Lead Chair in 2024, and Outgoing Chair in 2025.”(MeitY)
India had been one of the founding members of GPAI in 2020. Indian economy is expected to grow by 967 billion US dollars by 2035 and is also expected to add 400-500 billion US dollars by 2025 to the country’s GDP accounting for 10 percent of the country’s GDP target.

Importance of Data Governance-Case Studies

Data Governance is extremely important with the emergence of advanced technologies such as AI. These case studies show us how things can go haywire without proper data governance and what are the benefits of AI with proper guidelines on the governance of data.

Case Study No. 1: AI recruitment tools – using faulty data for the AI at hand

In many sectors women are structurally underrepresented compared to men; this is especially true for managing or other well-paid positions. Where companies automatize their hiring process, the existing bias against women may also be reflected in the AI based hiring tool. (Reuters 2018). Recruitment algorithms usually assign scores to applicants (e.g. one to five, one being the worst, five being the best). Women are particularly disadvantaged if such scores do not reflect their abilities. Even though such unfavourable scores can also result from bias within the design of the algorithm itself, in the past, the problem seemed to stem even more from the wrong data sets being used. For example, if algorithms were trained to review applicants by observing patterns in resumes submitted to the company in the past and the majority of successful applications came from men, the algorithm will teach itself that male applicants are to be preferred over female applicants. However, such technologies could also be quite promising to reduce bias in traditional hiring decisions, as they can sometimes be more objective than HR officers (Harvard Business Review 2019) “This use case provides a well-established example of how the use of prejudiced data sets can result in discriminatory outcomes by AI-based systems. Effective data governance must ensure that the data used is suitable for the intended purpose” (Data Governance Working Group A Framework Paper for GPAI’s work on Data Governance 2020).

Case Study No. 2: COVID-19 research related to public health – lack of access to data required for AI

In the course of the COVID-19 pandemic, medical research is vital to overcome global challenges. In particular, there are research projects aimed at improving our understanding of COVID-19 by reviewing scientific literature and projects focusing on the development of tools to effectively combat the spread of COVID-19 with the help of medical or other data from individuals. Even though the latter might have a more direct and ad hoc influence on decisions of health authorities, they both show difficulties related to the availability and access to data. The lack of access to COVID-19-related literature results partly from business models of major publishing houses that limit public access entirely or at least access in machine-readable

format, meaning an approach to data governance that significantly limits the use of AI in a way that hugely benefits our societies. Pressure by the WHO, individuals, and governments resulted in a commitment for publishers to provide machine-readable access to COVID-19 related publications. The resulting COVID-19 Open Research Dataset (CORD-19) consists of nearly 200,000 entries, including thousands of articles that serve as a basis for data mining exploration using ML techniques (OECD 2020, Semantic Scholar 2020). The machine-readability of data available via CORD-19 is currently being tested, e.g. with a competition by Kaggle (Kaggle 2020) and by ongoing research.

"For research on the way the virus spreads and affects the human body, medical data (e.g. also on comorbidities of a COVID-19 infection), social data (e.g. affiliation to a certain age group) or mobility data can play a vital role. For example, a hospital in France is developing a decision support tool consisting of a map of the areas where the virus is likely to reappear in the surroundings, which can help health authorities in taking preventive measures to limit the spread of the pandemic. However, the project team does not have sufficient data at their disposal. Such data exists but is quite difficult to access, e.g. due to privacy considerations, but also due to logistical barriers (data holders expect revenue for providing access to data, different procedures to gain data access, lack of interoperability). Effective governance measures, such as access to data within secure data spaces, managed by trusted parties, and under clear and transparent conditions that include appropriate safeguards for the legitimate interests of all stakeholders involved, would be vital to make important scientific progress" (Data Governance Working Group A Framework Paper for GPAI's work on Data Governance 2020).

AI Across Spectrums

AI is currently attracting the attention of IR scholars, governments, ministries, diplomats and policy makers. Areas of foreign policy include ethics, economic turmoil, and security. With the advent of AI, foreign policy is changing rapidly as countries turn more and more to algorithms to predict geopolitical and economic scenarios are used to analyze world leaders and make social and political predictions.

Countries like China, for example, are applying AI and machine learning to foreign policy and other government policies. China has launched AI tools for foreign policy and a new generation plan to become the world leader in AI by 2030. Politicians, researchers, and bureaucrats are already using AI in their daily activities. In 2019, U.S. President Donald Trump signed an executive order establishing the U.S. AI Initiative, which joins other major nations in pursuing a national strategy for AI development. American diplomats are using the potential of AI technology to make policy changes, raise awareness and increase transparency.

On a diplomatic front, linguistic barriers can be can be abridged between countries through language processing algorithm allowing them to communicate effectively with the foreign governments and ambassadors.

Data mining can be used to simplify political forecasting and improve knowledge and forecasting of political, economic and social trends. AI helps negotiate, analyses past negotiations, and predicts the outcome of ongoing conversations. AI technology can

support election monitoring and peacekeeping operations, thus enhancing international humanitarian efforts. AI anomaly detection can also protect grant transfers from inconsistencies.

Artificial intelligence can also carry out efforts to improve the quality of life in countries in need by increasing manufacturing, healthcare and other economic benefits. In situations where an earthquake, disaster, or other large-scale emergency occurs and requires international assistance, AI and related technologies can be of great help.

In India, the use of AI in diplomatic procedures such as reporting, consular services, communications and negotiations is limited. However, the potential is so great that it cannot be ignored, at least in terms of public relations and consular affairs.

So far, we have seen the positive aspects of AI in foreign policy, but that does not mean that there are no risks associated with AI. This is fraught with risks, and even at the initial stage there are differences in technological progress and adoption rates from country to country. In such cases, it becomes clear that it is important for companies, foundations and governments to engage and fund the development and implementation of AI systems in countries where technological intervention is urgently needed for humanitarian purposes.

Techno-optimism in India

Prior work in HCI and ICTD has studied the discourses around technology in India, and how it has been frequently tied with notions of development (Joyojeet Pal 2012) The last two decades, in particular, have been crucial in shaping technology as the means for prosperity in India. Digital technologies are viewed as a vehicle for progress, as a solution to societal problems in developing countries. (Eric Brewer, Michael Demmer, Bowei Du, Melissa Ho, Matthew Kam, Sergiu Nedevschi, Joyojeet Pal, Rabin Patra, Sonesh Surana, and Kevin Fall 2005).

The following is an excerpt from Prime Minister's speech in 2018 (Narendra Modi. 2018): “Can Artificial Intelligence help us detect serious health conditions before they manifest physically? Can Artificial Intelligence help our farmers make the right decisions regarding weather, crop and sowing cycle? Friends, our government is of the firm belief, that we can use this power of twenty-first century technology [AI] to eradicate poverty and disease. In doing so, we can bring prosperity to our poor and under-privileged sections. We are committed to achieving this vision.”

The Indian government's vision for technological development manifested through two major initiatives over the recent years. First, the introduction of Aadhaar— a biometric identification system for 1.3 billion citizens, which was legitimized through a promise for poverty reduction and financial inclusion (Janaki Srinivasan and Aditya Johri 2013). Secondly BHIM, an application for digital payments introduced soon after demonetization as the future for cashless payments (Joyojeet Pal, Priyank Chandra, Vaishnav Kameswaran, Aakanksha Parameshwar, Sneha Joshi, and Aditya Johri 2018) Technology played a symbolic and functional role in enabling the ‘leapfrogging’ into the modern era. Bozarth and Pal (Lia Bozarth and Joyojeet Pal 2019) examine the social media (Twitter) discourse, and find that politicians have an inclination to discuss technology in connection with development as part of their political messaging. Public discourse around technology and AI has been hyper-optimistic from the

general public, the tech industry, and the government (Joyojeet Pal 2017) with several deployments underway (Ministry of Electronics & Information Technology 2020). Sambasivan *et al.* (Nithya Sambasivan, Erin Arnesen, Ben Hutchinson, Tulsee Doshi, and Vinodkumar Prabhakaran 2021) extensively report the ways in which a straightforward porting of responsible AI tenets can be inadequate and often harmful. How might we involve users with optimistic views about AI into algorithmic audits? Certainly, their perspectives would be valuable contributions in surfacing biased outcomes. Empowering users to interrogate these systems might be an approach to calibrate AI authority towards an appropriate level. Future work might investigate how we could leverage existing capacities in users that have high confidence in AI to acknowledge bias. This could benefit platforms in two ways: visibilising bias and mitigating harm, but also through building alternative, realistic narratives about AI that are better aligned with the capabilities of the system (Shivani Kapania, Oliver Siy, Gabe Clapper Azhagu Meena SP and Nithya Sambasivan 2022).

Global Data Governance

India calls on GPAI member states to work on a common framework for AI

“The Union Minister of State for Electronics and Information Technology, Rajeev Chandrasekhar highlighted that India will act as a “significant pole” in the Artificial Intelligence universe. India has called upon the global community to work for building a common framework for data governance, building safety and ensuring trust around the arena of AI. The minister went on to highlight the present and future trajectory of India's digital leadership journey and how the government is taking AI to the masses. He also talked about the development and implementation of policies in the world of artificial intelligence. He referred to ChatGPT, which is an artificial intelligence chatbot developed by OpenAI, and stated that the world is at a nascent stage of AI. The minister said that bias constitutes as a major problem in AI, and ChatGPT proves that "occasionally." He noted that India is working on positioning its programme as one of the bias-free and diverse in the world. "We are at the beginning of the race today, we are at the starting line, but certainly we will be in the leading pact in terms of shaping the future of AI, applications, and use cases of AI that will benefit the citizens," said Chandrasekhar as he talked of India's prospects despite the United States and China being leading leaders currently” (WION News).

How can India overcome the challenges posed by AI?

Develop a clear and comprehensive regulatory framework that defines the purpose, scope, and principles of general AI regulation. This framework must strike a balance between protecting individuals from potential harm and promoting innovation and economic growth.

Develop an accurate and fair accountability framework that assigns accountability and accountability for the actions and outcomes of innovative AI systems. The framework should take into account the roles and obligations of different stakeholders, such as developers, vendors, users, and regulators. Integrate essential legal aspects such as transparency, accountability, privacy, security, ethics, and human oversight. These aspects must ensure that the general AI systems are trustworthy, trustworthy, and respectful of human rights and values.

Invest in research and development of generalized AI technologies capable of addressing India's specific needs and challenges. India is expected to leverage its strengths in data science, engineering and entrepreneurship to create innovative solutions for different industries and sectors.

Promote collaboration and cooperation between different stakeholders, such as government, industry, academia, civil society and international partners. India should engage in dialogue and exchange of best practices with other countries and regions that are at the forefront of AI development and regulation.

India's Tech Transformation

In terms of technological discourse, it has always been oxymoronic for India. The country has been able to develop advanced digital computers and highly advanced and cost-effective space programmes yet has lagged in its digital transformation and accessibility.

- **The Unique Identification Authority of India and its Aadhar programme*:** Aadhar is currently the largest biometric identification system in the world. It is a unique 12-digit identification number that Indian citizens and resident foreign nationals can receive based on their biometrics and demographics. One of its primary uses is streamlining direct benefit schemes where benefits are transferred directly to a bank account linked to Aadhaar. Today, Aadhar also serves as the primary identity proof in India.
- **The Unified Payments Interface(UPI)*:**Unified Payments Interface (UPI) is a mobile-based instant payment tool developed by Government of India to facilitate inter-bank peer-to-peer (P2P) and person-to-merchant (P2M) transactions. According to data of November 2022, UPI's monthly transactions touched 6 billion and a total value of Rs. 10 trillion among its 260 million users. [1]
- **The CoWIN Platform*:**CoWIN, or the Covid Vaccine Intelligence Network, is the official web portal of the Indian government for COVID-19 vaccination registration. It displays the available slots for the COVID-19 vaccine available in the vicinity. The users can book various time slots as available on the website and obtain vaccination certificates, which serve as "Vaccine Passports" during the COVID-19 pandemic and can be stored in Digilocker.
- **DigiLocker*:** DigiLocker is an Indian online service provided by the Ministry of Electronics and Information Technology (MeitY) under the Digital India initiative. Every Aadhaar holders are provided with a cloud storage account to store and access authentic documents/certificates such as driver's licenses, vehicle registration, and academic mark sheets in digital format from the certificates' original issuers. It also provides 1GB of storage space with each account to upload scanned copies of legacy documents.
- **UMANG*:**The Unified Mobile Application for New-age Governance (UMANG) app is yet another MeitY initiative that provides users with the access to central and state government services. The app is for Indian citizens and offers hundreds of services, including payment, registration, information search and application forms.

---

[1] **AI for All: How India is carving its own path in the global AI race** Jibu Elias OECD Policy Observatory Research & Content Head, INDIAai

Numerous forecasts suggest AI will add USD 967 billion to India's economy by 2035 and USD 450–500 billion to its GDP by 2025. This will account for 10% of the country's USD 5 trillion GDP target, making it a crucial tool for economic growth.

Building 'AI for All'

India has begun its AI journey in tandem with its core principles of social empowerment and inclusion. Given the scalability, AI can solve numerous age-old problems that have plagued the country for decades. As major global economic powers such as US and China are engaged in an "arms race" to become AI Superpower, India has scrupulously focused on inclusion and empowerment through its programme called "AI for All". (Jibu Elias 2023)

In the last couple of years, India's public and private sectors have produced AI-powered tools aimed at improving the delivery of health and safety services, affecting the lives of millions. These include:

- **The MyGov Corona Helpdesk (by MeitY)**. During the peak of the pandemic, social media was flooded with misinformation and fake news about the COVID pandemic. This is when the country's citizen engagement platform, MyGov, the Ministry of Health and the AI startup Haptik launched MyGov Corona Helpdesk chatbot. The goal of this chatbot is to bring awareness to COVID-19 and prepare India's fight against it. (Jibu Elias 2023)
- **'e-Paarvai' is an initiative by the Tamil Nadu State Government**. It has been developed to cater to the paucity of ophthalmologists. It is an intelligent AI-powered mobile application that detects cataracts. (Jibu Elias 2023)
- **"Uzhavan"** of Tamil Nadu State Government. The application "Uzhavan" helps farmers to diagnose pest infestation in their crops and provide remedial measures. Farmers can click on images of pest-infested crops even with a cheap mobile camera and upload the images to the Uzhavan app. Once the photo is uploaded, the built-in smart system analyzes and identifies the pest and sends corrective actions as a text message to the farmer's phone in the local language, Tamil. (Jibu Elias 2023)
- **Realtime Digital Authentication of Identity system by Telangana State Government**. The Telangana State Government has implemented Real-Time Digital Identity Authentication (RTDAI) to authenticate pensioners during the COVID pandemic. Recipients must take a photo and upload it to an image verification app using artificial intelligence-based viability, big data and machine learning demographics testing solutions, and comparison solutions. image comparison based on deep learning. AI, ML, and deep learning solutions quickly verify user-submitted details using information accumulated in public data systems. (Jibu Elias 2023)
- **Crowd Estimation and Management tool by Telangana State Government**. Telangana Police successfully used Crowd Estimation and Management tool for crowd management during India vs West Indies T20 match in Hyderabad in 2019 and Medaram Jatara Festival in 2020. (Jibu Elias 2023)

On similar lines, the Ministry of Electronics and IT has launched various initiatives focused on taking advantage of the "AI revolution" in the coming years:

- India AI, the national AI portal
- The YUVAi programme for skilling students from government schools
- The soon-to-be-implemented National Programme on Artificial Intelligence
- National Semiconductor Mission
- National Data Governance Framework Policy
- New Digital Personal Data Protection Bill

Table 1: AI Initiatives by different departments of Central Govt.

Department of Central Govt.	Name of Initiative	Key Objective	Field
Ministry of Electronics and Information Technology	Responsible AI for Youth	To create a young force for future which understands the basics of AI by reaching out to students at school level.	Educational, Learning training
Ministry of Housing and Urban Affairs	Monitor e-measurement book (MB)	To develop a meticulous error free fair and transparent system of tendering and management of smart cities, parks and public facilities.	Housing
Department of Space/ ISRO	Chandrayaan 2: AI- powered "Pragyan Rover"	A robotic vehicle powered with AI tools which acted as rover in the launch vehicle of Chandrayaan-2 spacecraft as part of second lunar mission.	Space, Robotics
Ministry of Commerce and Industry	MoU for India-UAE Artificial Intelligence Bridge	A joint working group to reap the benefits of new technologies like AI, blockchain, analytics for business and economic benefits.	Bilateral collaboration
Ministry of Health and Family Welfare	Use of AI for public health	The data of diseases like cancer, diabetic retinopathy is being studied using AI for early detection and drug development	Healthcare, Medical Diagnosis, Policy Paper
Ministry of Agriculture	Drones to monitor crop and soil health	A project named "SENSAGRI-Sensor Based Smart Agriculture" has been started which gathers data of farm fields using drones. This would help in assessing crops health, issues warning in	Agritech, UAV

		advance, and facilitates compensation settlement in Crop Insurance.	
Ministry of Railways	Use of AI to prevent signal failures	A system has been developed with the help of AI to protect Railway Signal system failure in advance.	Transportation, Predictive Maintenance

Table 2: Initiatives by State Governments in India

State	AI enabled Initiatives by State Government	Field / Technology
Tamil Nadu	Smart conversation assistant	Chatbot, Natural Language Processing
Uttar Pradesh	AI video surveillance platform	Video Analytics
Karnataka	Intelligent Visualization for Pollution Control	Environment
Haryana	Drones for monitoring illegal constructions	UAV Infrastructure Management Governance
Telangana	Use of AI in eye care screening	Healthcare, Medical Diagnosis
Maharashtra	MoU between Government of Maharashtra and World Economic Forum	Industry 4.0, Agriculture, Social Welfare

India's AI Startup Ecosystem

With the world witnessing rapid transformation with the emergence of AI, India too has established itself as an AI research and innovation powerhouse. "Since 2010, the country has ranked fourth largest producer of AI-relevant scholarly papers and 8th in the world regarding AI patents filed in 2020."(Jubin Elias 2023). There are several unicorns that have come up harnessing AI technology. With the use of AI, there is an increased efficiency in the performance of tasks which results in operational efficiency and a better resource allocation.

Here are just a few of the hundreds of Indian start-ups building AI tools and products to address national and global socio-economic challenges:

- **Niramai** is an AI start-up that provides affordable and fast breast cancer screening at clinics in rural India, have developed a novel artificial intelligence-based medical device to detect breast cancer at a much earlier stage than traditional methods or self-examination. The solution is a low cost, accurate, automated, portable cancer screening tool that can be operated in any clinic. The imaging method is radiation free, non-touch, not painful and works for women of all ages. The core technology of our solution has

been developed using our patented machine learning algorithms for reliable and accurate detection of breast cancer. This unique solution can be used as a cancer diagnosis test in hospitals, for regular preventive health checkups, and also for large scale screening in rural and semi-urban areas. (Niramai)

- **Cropin** is a global ag-ecosystem intelligence provider. Cropin's suite of products enables various stakeholders in the agri-ecosystem, including financial services providers, to adopt and drive digital strategy across their agricultural operations. Using cutting-edge technology like artificial intelligence, machine learning, and remote sensing, Cropin creates an intelligent, interconnected data platform. Cropin helps organizations digitize their operations from farm to fork and leverage near real-time farm data and actionable insights to make effective decisions. (CROPIN)
- **Aquaconnect** is a full-stack aquaculture inputs and outputs platform with embedded fintech, supported by a phygital distribution network. Founded in 2017, Aquaconnect works with fish farmers and shrimp farmers to improve farm productivity, financial access, and market linkage through intelligent technology solutions. Since its inception, Aquaconnect has been working to navigate the challenges in the aquaculture value chain through an integrated tech-driven approach. Aquaconnect is helping connect aquaculture farmers with stakeholders in the value chain, such as feed producers, farm equipment manufacturers, banks, insurers, importers, processors, exporters, and certifying bodies. Aquaconnect has assisted over 60,000 farmers through its unique AI & GIS-powered advisory platform. Aquaconnect's data-enabled fintech solutions aim to bring transparency for BFSI stakeholders to engage with aquaculture farming communities efficiently. (crunchbase)
- **CogniABle** is a Machine learning-driven assistive technology for early detection and affordable treatment of Autism Spectrum Disorder. Founded by researchers and Scientists from IIT-Delhi, pediatricians, Psychologists and BCBA's from India and USA, CogniAble brings affordability, accessibility and high-quality management on Autism condition on your fingertips. It is an organization that is driven by artificial intelligence which helps in early detection and treatment of autism. The staff will assess the child and prepare an individualised education plan. A child-specific education plan is made which gives you a specific plan to advance on your child's skills. Regular training sessions are held and regular updates are taken into consideration. (CogniAble)
- **Betterhalf** is India's first and only matrimonial app without the direct involvement of parents. It is the fastest-growing matrimony app in India connecting hearts through AI technology on both IOS and Android for free. Betterhalf is a revolution in the matrimony industry. It is here to break the old approach of matchmaking apps in India with its advanced compatibility algorithm powered by AI. (CXOtoday News Desk)

"Language technology is one of the critical areas where the Indian government sees AI making a breakthrough. In India, hundreds of languages are spoken, which makes knowledge sharing, skilling and access to information a considerable challenge. According to Prime Minister Narendra Modi, Natural Language Processing (NLP) will strongly impact India's educational sector as we advance AI technology. He pointed out that advancements in NLP mean that e-

courses can be developed in regional languages and dialects based on the New Educational Policy.India launched the National Language Translation Mission to make vernacular language translation systems that bring accessibility and opportunities to millions of citizens. In addition, the Ministry of Electronics and IT (MeitY) recently announced its Bhashini programme to enable easy access to the Internet, digital services and more content for all Indians in their own languages.The country's Supreme Court now translates orders and ruling into vernacular languages such as Hindi, Tamil, Punjabi, Marathi, Malayalam, Bangla, Telegu, Kannada, and Urdu with the help of the Samantar AI tool developed by the Indian Institute of Technology- Madras. AI for Bharat, which aims at creating a language corpus for machine translation, is another notable initiative in the language space. At the same time, numerous startups such as Gnaani, Reverie, and Devanagiri have made powerful strides in addressing language challenges"(Jubin Elias 2023).

NPAI-National Programme on Artificial Intelligence

It is a flagship programme under the Ministry of Electronics and Information Technology to foster inclusion, innovation and adoption for making a social impact.

NPAI includes 6 pillars:

- AI in Governance
- AI IP & Innovation
- AI Compute & Systems
- Data for AI
- Skilling in AI
- AI Ethics & Governance

Under this programme the high value datasets of Public Sector are to be identified and put under Artificial Intelligence control framework. The framework will provide access to appropriate datasets from the public sector. It is being done to ensure safety of data and its accessibility. A centre for Artificial Intelligence is being set up to tap the data into various models. The 2018 budget authorized NITI Aayog to establish the National AI Agenda to guide research and development of new and emerging technologies.

The NITI discussion paper titled "National Artificial Intelligence Strategy" identified five areas of AI application to meet societal needs: Health, agriculture, education, smart cities and infrastructure, smart transportation and mobility.

• National Mission on Inter-Disciplinary Cyber Physical Systems (NM-ICPS): This is a program run by the Union of Ministry of Science & Technology & Earth Sciences. The 2019 budget is allocated Rs. 5 cores for the task.

• The "Artificial Intelligence Task Force for India's Economic Transformation" under the leadership of V Kamakoti has explored the possibility of leveraging AI for development in various fields. Main recommendations:

- Establishment of digital databases, markets and exchanges to ensure the availability of cross-industry information.

- Data Ombudsman: to resolve data issues and complaints.

- Ensure there is enough funding for R&D.

- Establishment of the National Inter-Ministerial Delegation on Artificial Intelligence for coordinating AI-related activities in India.

National Strategy On AI

The government has chosen to use technology for inclusive growth. Consistent with the choice was to identify technology applications or interventions which create societal impact by enabling access and reaping benefits of transformative technologies. Consequently, societally impactful sectors where private capital would have been suboptimal has been chosen as playing fields for AI in India. The framework was to identify these sectors using pragmatic and rooted in developmental needs of the nation. Therefore, those five sectors have been as biggest impact areas for the country.

The framework also includes three major pillars:

- Opportunity: The Economic Impact
- Greater Good: Social Development and Inclusive Growth
- AI Garage for 40% of the world

Opportunity: The Economic Impact

What we need to recognise is that AI is fast developing as a new factor of production augmenting the classical factors like labour and capital and it has the potential to break the physical limitations of capital and labour and drive exponential growth. Therefore, AI has a discontinuous and exponential impact on economic good.

Greater Good: Social Development and Inclusive Growth

The widespread and potential impact a technology has in a sector and its transformative on billions of Indians is another very important reference frame for identifying a particular use case.

- **AI Garage for 40% of the world:** It is a bit future looking as it recognises the fact that fundamental research on AI in India is lagging and will continue to lag. NITI Aayog conceptualises India as the AI Garage of the world where certain use cases if it is solved in India can be replicated across similar nations and regions which would, therefore, make India a hotbed of activities or use cases in AI which could be mass replicated and 40% of the humanity would be benefited from these applications.
  The application of these principles led to the identification of Healthcare, Agriculture, Education, Smart Cities and Smart Mobility as potential impact areas. These areas have potential impact across the Indian population and each sector has unique challenges to be solved.
- **AI in Healthcare: Robotics and Internet of Medical Things** If we look at healthcare, developed nations around the world spend more than 11% of their GDP on healthcare. US spends approx. 16.5% of GDP, Germany 11.7% of its GDP, France & Switzerland approx. 11% of their GDP while other EU countries around 10% of GDP, China 5% of GDP,

Indonesia 3.17% of GDP on healthcare as of 2021. To set the context, the National Health Policy of 2017 has allocated a higher level of spend in terms of GDP on healthcare but still it is not enough to cater to the present problems. The endemic problems in healthcare in India is the fact that the quality of primary care is the point where we lag substantially across the world in terms of number of beds per 1000 Indians, number of doctors, nurses and other healthcare professionals per 1000 Indians. The second aspect is non-uniform care physical access continues to be a major barrier with glaring disparity between rural and urban population on primary healthcare infrastructure, affordability, inadequate health coverage with private expenditure accounting to 70% of healthcare costs. The National Health Policy aims to break it through structural changes in terms of preventive and higher allocation and investments in terms of preventive and primary care infrastructure, financial protection for secondary and tertiary care.

- **Agriculture-AI** It has got immense potential. It can bring about food revolution and match up to the increased demand for food (global need to produce 50% more and cater to an additional 2 billion population by 2050). Through real time advisory in the improvement of crop yield, advanced detection of pest attacks and prediction of crop prices to inform best sowing practices.
- **AI in Education**: School education has seen substantial gains in gross enrolment ratios which has gone as high as 97% in elementary and 80% at secondary levels. However, low retention rates and poor learning outcomes eat away the gains of gross enrolment ratio. The quality of education has a significant impact on skill and human capital of the nation. For schools in remote areas there are no separate classrooms or teachers for different grades which is one major cause of poor learning outcomes. Lack of interactive pedagogy, ineffectual remedial learning and rote learning are a major roadblock to a child's learning capacity as it does not customize as per the child's need. Through adaptive learning tools, AI can assist the teachers in managing multi-grade classrooms by judging the learning events of individual students and allowing automated development of customized educational content to each child's learning ability. Interactive and intelligent tutoring system delivering learning materials adapted to child's proficiency level and pace of learning content.
- **Smart Mobility, including Transportation and Logistics:** Potential use cases in this area include fleet of autonomous vehicles for carpooling, semi-autonomous features such as driver assistance and forecasting engine monitoring and maintenance. Other areas where AI could impact include autonomous trucking and delivery, and better traffic management.

India's Role as the Chairman of GPAI

As New Delhi gears up for the G-20 summit, its role as the chairman of GPAI is equally significant. There are several key areas which have to focused upon in order to be established as an AI superpower. It is important to note here that India has been chosen as the chairman for the GPAI by outnumbering countries like USA and Canada. This clearly underlines the trust that the members of GPAI have on India.

Impact of AI on labour force[#]

According to the International Monetary Fund, technologies such as AI and machine learning pose significant threat to the labour market in the developing economies. AI automation can possibly disrupt the labour market by replacing rather than complementing the workforce. Moreover, the development of AI in developed economies would lead to a diversion of investment from the developing economies. According to studies some professions are more vulnerable than the others especially those that require more manual labour or cognitive work. As AI has begun replacing humans in manufacturing, transportation and customer service there is a greater risk of job losses for the concerned workforce. High skilled workers particularly those that have a good technical hand might see a rise in demand and significant pay rise. On the other hand, those with low skills might face the risk of job loss or displacement with a stagnant pay and fewer future prospects.This leads to a situation of "job polarisation" wherein there is a widened pay gap between the high skilled and low skilled workforce.

The Future of Work working group has focused on the use of AI at the workplace but it has not given any clear-cut solutions for the replacement of labour with AI and how it can be resolved. India can take the charge as it is one of the world's largest economies with a massive workforce. It can formulate new labour laws and working standards to cope with the changing needs of the market. Given the rampant threat of job losses it can help by providing for safety nets for the working population that is on the verge of losing jobs.

Inclusive AI for the Global South[#]

There are only four countries of the global south in GPAI namely Argentina, Brazil, India, and Senegal of the 29 members of the GPAI. This means that Global South is underrepresented in GPAI much like the other global forums. India must take the lead by voicing the concerns of the global south nations and ensuring that these nations too get to reap the benefits of this technological shift. It needs to ensure that these countries do not fall prey to what is called "AI Colonialism". Much of the discourse on the development of AI has been centred around the west particularly the Silicon Valley in the U.S.. But the data that is being gathered to advance studies on the technology is being gathered from the countries that have less advanced data privacy regulation. They have cheaper labour and thus have to bear the brunt of massive data collection. These countries lack the resources necessary to develop their own AI and are therefore left to cope with AI not designed for them. On the other hand, countries with more power (former colonial powers) disproportionately reap the technology's economic benefits.

MIT Technology Review's new AI Colonialism examined the parallels between AI development and the colonial past. For instance, in South Africa the AI tools built on the extraction of people's behaviour and faces are reinforcing racial hierarchies and digital apartheid. In Venezuela, the AI firms have found a new way of exploiting the workers by paying less to desperate workers amid economic crisis.

Although the GPAI has expressed its interest to include more member countries from the global south by welcoming Argentina and Senegal at the 2022 Tokyo Summit. GPAI has still not taken any concrete steps in this direction. Global AI Governance is being shaped by the economically advanced nations of the Global North. Therefore, India must ensure that this does not continue to be the case in future as well.

Governance and responsible development of AI[#]

Software like ChatGPT has fuelled the discourse on the potential applications and limits of AI technology. This offers numerous benefits, but there are certain measures that need to be undertaken for digital safety. ChatGPT has been used to commit cybercrimes such as impersonation, data theft, and malware attacks. There have been several binding agreements on nuclear and space technology but when it comes to AI there is no concrete agreement on the same. India as the head of GPAI can the lead for the establishment of such an agreement to limit the exploitation of this technology and ensure its safe and inclusive development. India should collaborate with like-minded partners like the US, Canada, and the EU. It has already taken a step in this direction at the Tokyo Summit of GPAI wherein it urged all the member nations to work on a common framework of rules and guidelines on data governance in order to build trust ensure safety of both the internet and AI.

[#] Prateek Tripathi 2023-India's chairmanship of the Global Partnership on AI https://www.orfonline.org/expert-speak/indias-chairmanship-of-the-global-partnership-on-ai/

Conclusion

Artificial Intelligence has the capacity to alter the working of government of country or the entire world as a whole. It can help the governments in resource allocation, diverse data sets, shortage of experts, handling large datasets and making timely future predictions. It poses tremendous opportunities but not without caution. It has the potential to disrupt the entire global arena namely-education, jobs, healthcare, etc. It is important to note that with the advancement of AI there is a risk of job loss or fear of displacement among the workforce especially the developing world. Labour economists contend that AI development would not lead to elimination of certain jobs rather a change in the composition of jobs. New kind of cybercrimes involving the use of AI have begun to emerge. Therefore, there is an urgent need to formulate a common policy framework for AI Governance globally.

There are various challenges and opportunities for India as the chair of GPAI. How to tackle the changing landscape of the job market with the development of AI, voicing the concerns

of the global south and initiating for common rules and guidelines on AI Governance that needs to be addressed.

Many countries like USA and China have come up with an AI policy. India too has come up with a National Strategy on AI to address developmental challenges in the 5 key areas- education, healthcare, agriculture, smart mobility including transportation and logistics. India has very scrupulously begun its AI journey with a program called "AI for All" with the purpose of development and social inclusion. Various initiatives by the Government of India and various state governments have been undertaken in the field of AI.

India in the GPAI has a significant role to play and to establish itself as an AI Power at the world level. AI like any other technology comes with its pros and cons and that it can be left without any regulation. Also, the fact that AI is not accessible by the global south nations which furthers the digital divide. India can effectively touch upon the areas which have

received little or no attention by the GPAI working group. India can initiate for framing rules and regulations for the working standards in the new tech world to accommodate the development of AI, voice concerns for the AI availability to the global south, inclusion and integration of global south in GPAI and vouch for common policy framework for AI Governance to address the ethical challenges posed by AI.

This way India can help make GPAI more inclusive and cooperation driven. It can help solve the global challenges effectively paving the way for an AI ready world.

References

1.GPAI- https://gpai.ai/

2. Sunil Kumar Srivastava,Government of India- Artificial Intelligence: way forward for India

3.Purdy, Mark and Daugherty Paul. Why Artificial Intelligence is the Future of Growth. Accenture. 2016

4. U.S. Government, Executive Office of the President, NSTC Committee on Technology. Preparing for the Future of artificial Intelligence. October 2016

5.U.S. Government, Executive Office of the President. Artificial Intelligence, Automation and the Economy. December 2016

6.House of Commons Science and Technology Committee. Robotics and Artificial Intelligence. September 2016.

7.State Council of China. New Generation artificial Intelligence Development Plan. State Council Document No. 35. July 2017

8.Government of South Korea, Ministry of Science, ICT and Future Planning. Mid-to Long-Term Master Plan Preparation for the Intelligent Information Society: Managing the Fourth Industrial Revolution. Policy Document. 2016

9. Benner, Tom. Singapore: A Smart Living Laboratory. Scientific American. 2017.

10.MeitY **https://www.meity.gov.in/emerging-technologies-division**

11.https://www.reuters.com/article/us-amazon-com-jobs-automation-insight-idUSKCN1MK08G(Reuters 2018)

12.All the Ways Hiring Algorithms Can Introduce Bias-Harvard Business Review 2019 by Miranda Bogen
https://hbr.org/2019/05/all-the-ways-hiring-algorithms-can-introduce-bias

13. Global Challenges to Public Health Care Systems during the COVID-19 Pandemic: A Review of Pandemic Measures and Problems
Roxana Filip, Roxana Gheorghita Puscaselu, Liliana Anchidin-Norocel, Mihai Dimian,and Wesley K. Savage https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9409667/

14. Data Governance Working Group A Framework Paper for GPAI's work on Data Governance 2020 https://gpai.ai/projects/data-governance/gpai-data-governance-work-framework-paper.pdf

15. Why open science is critical to combatting COVID-19 OECD 2020 https://www.oecd.org/coronavirus/policy-responses/why-open-science-is-critical-to-combatting-covid-19-cd6ab2f9/

16.The COVID-19 Open Research Dataset (CORD-19)-Semantic Scholar 2020 https://github.com/allenai/cord19

17. COVID-19 Open Research Dataset Challenge (CORD-19)-Kaggle 2020 https://www.kaggle.com/datasets/allen-institute-for-ai/CORD-19-research-challenge

18. AI Across Borders: AI in Diplomacy, International Relations, and Humanitarian Efforts-INDIAai -https://indiaai.gov.in/article/ai-across-borders-ai-in-diplomacy-international-relations-and-humanitarian-efforts

19. Joyojeet Pal. 2012. The machine to aspire to: The computer in rural south India. https://doi.org/10.5210/fm.v17i2.3733

20. Eric Brewer, Michael Demmer, Bowei Du, Melissa Ho, Matthew Kam, Sergiu Nedevschi, Joyojeet Pal, Rabin Patra, Sonesh Surana, and Kevin Fall. 2005. The case for technology in developing regions. Computer 38, 6 (2005), 25–38.
21. Narendra Modi. 2018. Make Artificial Intelligence in India, Make Artificial Intelligence Work for India: PM Modi. https://www.narendramodi.in/prime-minister-narendra-modi-inaugurated-wadhwani-institute-of-artificial-intelligence-at-the-university-of-mumbai--538994. (Accessed on 09/09/2021).
22. Janaki Srinivasan and Aditya Johri. 2013. Creating Machine Readable Men: Legitimizing the 'Aadhaar' Mega e-Infrastructure Project in India. In Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers - Volume 1 (Cape Town, South Africa) (ICTD '13). Association for Computing Machinery, New York, NY, USA, 101–112. https://doi.org/10.1145/2516604.2516625
23. Joyojeet Pal, Priyank Chandra, Vaishnav Kameswaran, Aakanksha Parameshwar, Sneha Joshi, and Aditya Johri. 2018. Digital Payment and Its Discontents: Street Shops and the Indian Government's Push for Cashless Transactions. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery, New York, NY, USA, 1–13 https://doi.org/10.1145/3173574.3173803
24. Lia Bozarth and Joyojeet Pal. 2019. Twitter Discourse as a Lens into Politicians' Interest in Technology and Development. In Proceedings of the Tenth International Conference on Information and Communication Technologies and Development (Ahmedabad, India) (ICTD '19). Association for Computing Machinery, New York, NY, USA, Article 33, 5 pages https://doi.org/10.1145/3287098.3287129
25. Joyojeet Pal. 2017. The Technological Self in India: From Tech-Savvy Farmers to a Selfie-Tweeting Prime Minister. In Proceedings of the Ninth International Conference on Information and Communication Technologies and Development (Lahore, Pakistan) (ICTD '17). Association for Computing Machinery, New York, NY, USA, Article 11, 13 pages https://doi.org/10.1145/3136560.3136583
26. Ministry of Electronics & Information Technology. 2020. INDIAai. https://indiaai.gov.in/. (Accessed on 08/24/2021).
27. Nithya Sambasivan, Erin Arnesen, Ben Hutchinson, Tulsee Doshi, and Vinodkumar Prabhakaran. 2021. Re-Imagining Algorithmic Fairness in India and Beyond. In Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency (Virtual Event, Canada) (FAccT '21). Association for Computing Machinery, New York, NY, USA, 315–328 https://doi.org/10.1145/3442188.3445896
28. Shivani Kapania, Oliver Siy, Gabe Clapper Azhagu Meena SP and Nithya Sambasivan 2022 https://dl.acm.org/doi/pdf/10.1145/3491102.3517533
29. https://www.wionews.com/technology/exclusive-india-will-be-significant-pole-in-universe-of-artificial-intelligence-says-rajeev-chandrasekhar-574828
30. Jibu Elias 2023 AI for All: How India is carving its own path in the global AI race https://oecd.ai/en/wonk/india
31. Table 1 & Table 2: Poonam Mallik, Dr. Kavita and Kusum Singal- AI INITIATIVES BY INDIAN GOVERNMENT: JOURNEY TOWARDS BECOMING GLOBAL TECHNOLOGY LEADER September 2020 Journal of Critical Reviews
32. Niramai-https://www.niramai.com/

33.Cropin- https://www.cropin.com/about
34. Aquaconnect- https://www.crunchbase.com/organization/aquaconnect-india
35.CogniAble-https://www.linkedin.com/company/cogniable/?originalSubdomain=in
36. Indian Startups Are Embracing AI Technology for Unprecedented Growth https://www.cxotoday.com/specials/indian-startups-are-embracing-ai-technology-for-unprecedented-growth/
37. The National Program on AI- https://indiaai.gov.in/national-ai
38. National Program on Artificial Intelligence- https://blog.nextias.com/national-programme-on-artificial-intelligence
39. NITI Aayog. 2018. NationalStrategy-for-AI-Discussion-Paper.pdf. https://indiaai.gov.in/documents/pdf/NationalStrategy-for-AI-Discussion-Paper.pdf. (Accessed on 12/03/2021)
40.NITI Aayog. 2021. Responsible-AI-22022021.pdf. **https://www.niti.gov.in/sites/default/files/2021-02/Responsible-AI-22022021.pdf**. (Accessed on 12/03/2021).
41. Prateek Tripathi 2023-India's chairmanship of the Global Partnership on AI https://www.orfonline.org/expert-speak/indias-chairmanship-of-the-global-partnership-on-ai/
42.Shimona Mohan- Emerging technology, emerging power: India in the age of AI https://www.orfonline.org/expert-speak/emerging-technology-emerging-power/
43. Times of India-The impact of artificial intelligence on labour economics https://timesofindia.indiatimes.com/blogs/voices/the-impact-of-artificial-intelligence-on-labour-economics/
44.The Economic Times- African tech startups take aim at AI 'colonialism' https://economictimes.indiatimes.com/tech/technology/african-tech-startups-take-aim-at-ai-colonialism/articleshow/102562664.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

Soumya S Daniel

Masters in Public Health (Social Epidemiology), Tata Institute of Social Sciences, Maharashtra.

Mentored by Prof. (Dr.) Monika Arora, Vice President, Public Health Foundation of India.

Domain for Internship: Public Health

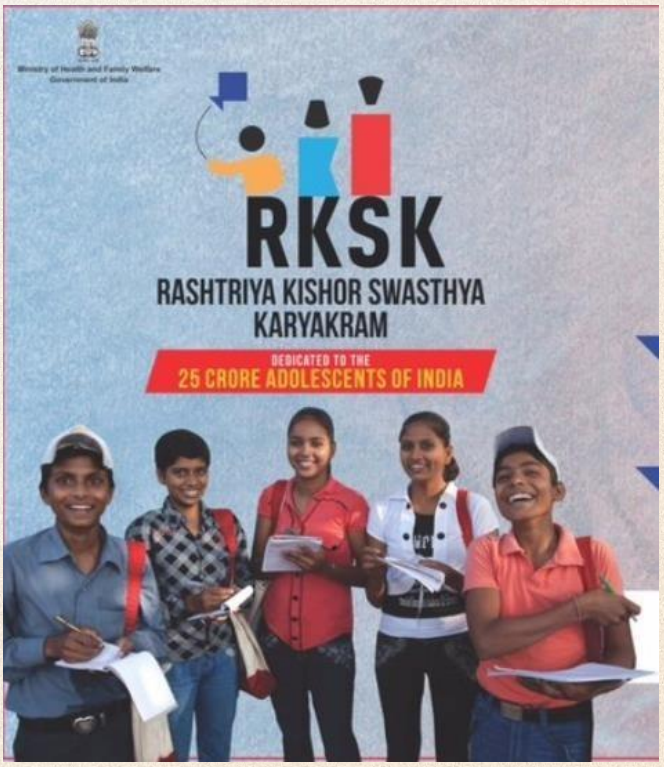
Peer Education Programme Under Rashtriya Kishor Swasthya Karyakram (RKSK)

Adolescence signifies the transition from dependence to autonomy, a phase during which young people encounter various physical and mental health transitions. The research report provided an extensive analysis of the peer education programme operating under the Rashtriya Kishor Swasthya Karyakram (RKSK) in seven states, namely Madhya Pradesh, Maharashtra, Haryana, Uttarakhand, Gujarat, Odisha and Tamil Nadu. The study aims to evaluate the effectiveness of peer education programs in promoting adolescent health and encompasses diverse implementation models employed in intervention areas to consolidate valuable insight drawn from a recent comprehensive study and field reports. Additionally, the study illuminated the crucial theoretical foundations that underpin the successful adaptation and scaling up of the Peer Education intervention. The findings of the study demonstrated that Peer Educators have demonstrated remarkable versatility and effectiveness by assuming roles as innovators and communicators, thereby bridging the crucial gap between the healthcare system and the community. The study advocated for leveraging Implementation Science (IS), Theory-Driven Evaluation (TDE), and Realist Evaluation to inform the adaptation and scaling up of the peer education intervention, aligning with best practices in scaling up complex interventions. With the fusion of empirical evidence and theoretical rigor, this report serves as a critical resource for informed policy decisions aimed at advancing adolescent health and well-being across the nation.

Keywords: RKSK, peer education, policy intervention, adolescent health

Adolescent Health: Challenges and Call to Action

Adolescents, as defined by the World Health Organization (WHO), encompass the age group between 10 to 19 years, while "young" individuals range from 10 to 24 years. This pivotal period is characterized by a multitude of physical, hormonal, physiological, psychological, and behavioral changes. Adolescence signifies the transition from dependence to autonomy, a phase during which young people encounter various physical and mental health transitions. In India, approximately one-fifth of the world's adolescents and young people reside. However, despite their demographic significance, adolescents in India face numerous challenges in terms of health and well-being. These challenges encompass high mortality rates, prevalent anemia, sexual and reproductive health (SRH) issues, as well as social and cultural factors like child marriage and early childbearing that contribute to these problems. Addressing these concerns and fostering a healthy, disease-free lifestyle among adolescents and young people is vital for harnessing a better demographic dividend for the country.



Statistical Evidence

Adolescents are integral to the achievement of numerous Sustainable Development Goals (SDGs) related to reproductive health, nutrition, sexual and intimate partner violence (IPV), child marriage, education, and employment. However, the health status of adolescents and young adults remains a matter of concern.

1. **The National Family Health Survey (NFHS)-5** conducted in **2019-2020** reveals criticalstatistics.
    a. The prevalence of pregnant women in India stands at 6.8%. Of particular concern, 32% of girls aged 10-14, and 48% of those aged 15-19 suffer from anemia.
    b. Additionally, 1.5% of young women aged 18-29 have experienced sexual

violence.

2. **The National Mental Health Survey (2015-2016)** underscores the rise in mental healthissues among this key population.
    a. There is a rise in the prevalence of psychiatric disorders, with 7% occurring among adolescents aged 13-17, regardless of gender.
    b. Depression, particularly among late adolescents aged 15-19, is significantly highat 11.7% compared to the 8.9% rate among early adolescents aged 10-14.

These statistics underscore the vulnerability of adolescents, which acts as a barrier to their growth and development.

Moreover, access to sexual and reproductive health (SRH) information and services remains a challenge, subject to social stigma and scrutiny, particularly for adolescent and young adult women. These individuals often grapple with various menstrual problems, including dysmenorrhea, premenstrual syndrome, menorrhagia, and irregular cycles. Poor dietary habits further exacerbate nutrition-related problems, which can have long-term health consequences. Compounding these issues, comprehensive health services catering specifically to adolescent and young adult women in India remain inadequate and unfocused. Access to information concerning SRH, mental health, non-communicable diseases (NCDs), and violence against this demographic is limited.

Additionally, India grapples with significant disparities in health accessibility, availability, and affordability among adolescent girls from disadvantaged socio-economic backgrounds, known as scheduled castes (SCs) and scheduled tribes (STs). Reducing this gap is imperative, necessitating the provision of health facilities tailored to the needs of adolescent and young adult women. It's noteworthy that the majority of programs targeting adolescents and young adults predominantly concentrate on reproductive and sexual health issues.

Policy Intervention

Recognizing the pressing need to address these multifaceted challenges and ensure the holistic development of adolescents and young adults, the Ministry of Health and Family Welfare, Government of India, launched the Rashtriya Kishor Swasthya Karyakram (RKSK), also referred to as the National Adolescent Health Programme (NAHP), in 2014. Initially focused on SRH, this program has since evolved to encompass non-communicable diseases (NCDs), nutrition, mental health, substance abuse, injuries, and violence. The RKSK represents a comprehensive initiative aimed at addressing the critical health needs of adolescents throughout the nation. It acknowledges the pivotal role of adolescent health in the broader context of community well-being and seeks to enhance the health and well-being of adolescents through carefully strategized interventions.

Prioritizing Adolescent Health in the light of changing Workforce Dynamics

Figure 1: *India's Ageing Workforce*

The importance of focusing on adolescent health in India has become increasingly evident due to recent data on the aging of the country's workforce. According to an analysis of employment data sourced from the Centre for Monitoring Indian Economy (CMIE), India's workforce has experienced a significant aging trend over the past seven years. This shift in demographics underscores the urgency of addressing the health and well-being of adolescents, particularly those in the age group of 15-19 years, as they represent a crucial segment of the population.

The analysis reveals a substantial decline in the share of India's youth, defined as individuals between the ages of 15 and 29, from 25 percent in 2016-17 to a mere 17 percent by the end of 2022-23. This decline is indicative of a shrinking youth population within the workforce. Furthermore, even the share of individuals falling within the subsequent 15-year age bracket, ranging from 30 to 44 years, has decreased from 38 percent to 33 percent over the same period. These statistics underscore a broader trend of workforce aging and a diminishing pool of young workers entering the job market.

It's essential to highlight that the age group of 15-19 years falls within the later adolescent period, a crucial developmental stage marked by significant physical, psychological, and social transitions. Adolescents in this age range are in the process of completing their education, entering higher education or vocational training, and preparing to embark on their careers. They are also exploring their identities, building relationships, and making decisions that will shape their futures.

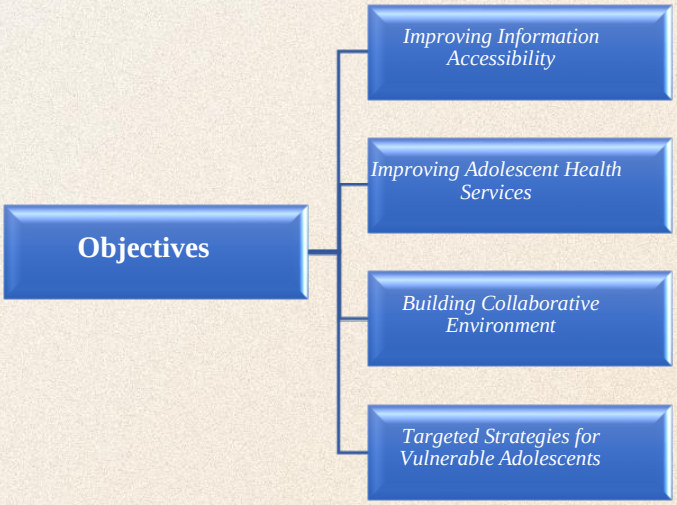
The changing dynamics of India's workforce have profound implications for adolescent health. With a shrinking youth population, it becomes even more critical to invest in the well-being and development of the existing adolescent cohort. Neglecting the health and holistic development of adolescents can have far-reaching consequences for their future prospects, as well as for the nation's socio-economic growth.

Thus, the RKSK, with its expanded scope, represents a significant step in the right direction, aiming to bridge the health gap among adolescents, particularly among marginalized groups, and promoting their holistic development. Recognizing the importance of adolescent health is not just a matter of policy but a fundamental aspect of ensuring a healthier and more prosperous future for India by leveraging the adolescents as demographic dividend.

Rashtriya Kishore Swasthya Karyakram

The National Adolescent Health programme, i.e. Rashtriya Kishore Swasthya Karyakram, launched on the on the 7th of January 2014 was developed to strengthen the adolescent component of the RMNCH+A strategy which is one of the weakest and a sub-critical programme area.

Objectives of the programme:



1. Enhance Information Accessibility: This is to expand the availability and accessibility of vital information pertaining to adolescent health. This will empower adolescents with the knowledge they need to make informed decisions about their well-being.

2. Improve Adolescent Health Services: The programme aims to enhance the accessibility and utilization of high-quality counseling and healthcare services tailored specifically to adolescents. This ensures that they receive the support and care necessary for their physical and mental health.

3. Cultivate Collaborative Networks: Through this objective, the programme aims to forge partnerships across multiple sectors and departments. These collaborations will create a nurturing and secure environment for adolescents, enabling them to thrive and reach their full potential.

4. Target Vulnerable Geographic Pockets: Certain geographic areas, such as tribal regions, conflict zones, and areas with a high population of migrant or out-of-school adolescents, pose unique health and nutrition risks. To address this, the programme will implement specialized

strategies that directly target these vulnerable groups, ensuring that they receive the attention and resources they require to lead healthy lives.

Themes Under RKSK

Key Implementation Approaches

The RKSK saw a paradigm shift from clinical to preventive and promotive aspects and realigned the clinic-based curative approaches to focus on a more holistic model, which emphasizes on community and school-based health promotion and preventive care.

Furthermore, the programme has adopted 3 major approaches to implementation, which areas follows:

Facility-based approach	***School-based approach***	***Community based approach***
• Adolescent Friendly Health Clinics (AFHC) providing counselling and clinical services • Adolescent Health Resource Centre at District Hospital	• Strengthening of school health activities • Screening of adolescents for 4 Ds (RBSK) • Weekly Iron Folic Acid Supplementation Programme (WIFS) • Deworming during National Deworming Day (NDD) • Provision of sanitary napkins (MHS) • Peer Education programme	• Weekly Iron Folic Acid Supplementation Programme (WIFS) • Deworming during National Deworming Day (NDD) • Provision of sanitary napkins • Peer Education programme for out-of-school adolescent groups • Quarterly Adolescent Health and Wellness Days (AHWDs) • Adolescent Friendly Clubs (AFCs)

The RKSK programme encompasses a diverse array of interventions that involve various stakeholders responsible for their implementation. These interventions, which are delineated in the table below, are multifaceted in nature, targeting adolescents at different levels within the ecosystem, including educational institutions (schools), local communities, and healthcare facilities.

Activities/ Services	Service Delivery	RKSK Stakeholders
1. Facility-Based Intervention		
Adolescent Friendly Health Clinic (AFHC)	A dedicated room for adolescents with the provision of clinical, counselling, and referral services. Commodities (Iron Folic Acid tablets and other medicines, pregnancy testing kits, sanitary napkins & contraceptives) are also disbursed to adolescents. AFHCs are operational at Primary Health Centers (PHCs), Community Health Centers (CHCs), and District Hospitals (DHs). AFHC at the DH level works as an Adolescent Friendly Health Resource Centre (AFHRC) responsible for capacity building of health care providers and act as a repository for RKSK IEC materials.	Medical Officers (MO), RKSK counsellors, Auxiliary Nurse Midwives (ANM), Specialists
2. Community-Based Interventions		
Adolescent Health & Wellness Days (AHWDs)	AHWD is organised quarterly at the village level to provide preventive and promotive interventions and increase awareness among adolescents, parents, families, and other community stakeholders about RKSK six thematic areas, AFHCs and helplines.	Accredited Social Health Activist (ASHA), ASHA Facilitators, Anganwadi worker (AWW), Peer Educators (PEs), ANM, MOs, Non-Governmental Organisation (NGO) Trainer/Mentor and Adolescent Health counsellors
Adolescent Friendly Club (AFC) Meetings	Meetings are organised once a month at the sub-centre (village level) under the guidance of ANM. Cover 5 villages/5000 population. Thus, 10–20 PEs from different villages are invited for these meetings. PEs clarify issues faced during their village-level PE sessions.	ANM, ASHA, ASHA Facilitators, PEs
Peer Education Programme	2 PEs (one boy and one girl) per village/1000population/ASHA habitation are selected to reach out to adolescents. Each PE forms a group of 15–20 boys or girls from the community and conducts weekly 1–2 hour participatory sessions using PE kits.	PEs, ASHA, ASHA facilitator, ANM, NGO mentor/ trainer, MO, Counsellors
Weekly Iron Folic Supplementation Programme (WIFS)	Screening of anaemia among girls and serving out-of-school adolescent girls in Anganwadi centres on a fixed day in a week to provide IFA tablets. Biannually Albendazole is provided for deworming.	ANM, ASHA, AWW
Menstrual Hygiene Scheme (MHS)	Girls are provided with knowledge and information regarding good menstrual hygiene and the safe disposal of sanitary napkins. ASHAs provide napkins at a subsidised rate of Rs. 6 per pack of 6 napkins to adolescent girls in schools and communities.	ASHAs
3. School (government, government-aided municipal schools) based [10] interventions		
School Health programme under Ayushman Bharat	The Government of India, under the Health and Wellness component of the Ayushman Bharat (Healthy India) Programme, intensified school-based health activities. These activities combine health education, promotion, disease prevention, and improved access to the health system at the school level. Two PEs/Saathiya, one boy and one girl support the health and wellness ambassador in carrying out the health promotion activities.	Trained School Teachers (Health & Wellness Ambassadors), Health and wellness messengers (2 students per section assist the health ambassadors), ANM, ASHA, AWW, Counsellors (school outreach), PEs (in-school & out of school)
Menstrual Hygiene Scheme (MHS)	Health education for adolescent girls and providing sanitary napkins and enabling other sanitation measures such as access to water and toilets in schools. Provide life skill courses to adolescents of class IX and XI.	School teachers
Weekly Iron Folic Acid Supplementation Programme (WIFS)	Screening of anaemia among adolescents and provide weekly IFA tablets to adolescents boys and girls and Albendazole biannually for deworming.	School teachers

The Peer Education Intervention

Figure 2: PE holding a session in a village in Haryana.

One of the central components of the RKSK initiative is the peer education program, which plays a crucial role in enhancing adolescents' interaction with healthcare services and enhancing their understanding, attitudes, and life skills in six key thematic areas. These thematic areas encompass the following:

The peer education program aims to empower adolescents by providing them with valuable information and skills in these critical domains to promote their overall well-being and health awareness. Peer educators are other adolescents of around the same age, belonging to the same group from a specific environment, such as a school, youth or sports clubs, or

community, who are trained and mentored to provide healthcare information, distribute educational resources, direct and support referral to healthcare services, and distribute commodities (such as condoms) to other members of the same group.

Peer education, whereby peers (‘peer educators’) teach their other peers (‘peer learners’) about aspects of health is an approach growing in popularity across school contexts, possibly due to adolescents preferring to seek help for health-related concerns from their peers rather than adults or professionals.

Role of Peer Educator/ Saathiyas

- Saathiyas, who are peer educators selected from within the community, undergo training either from healthcare workers or mentor trainers, depending on the specific implementation model. Their role is pivotal in ensuring that adolescents receive consistent and comprehensive peer education across all six thematic areas of the RKSK program.

- These peer educators work to sensitize adolescents about their health, inform them about the availability of adolescent-friendly health services, and encourage them to make the best use of these services. Additionally, they play a vital role in organizing quarterly Adolescent Health Days (AHD), which are designed to enhance the reach of preventive and promotive interventions for adolescents.

Figure 3*: An Adolescent-Friendly Health Day in Dighi, Maharashtra*

- Furthermore, Saathiyas contribute significantly to increasing awareness among adolescents, parents, families, and stakeholders regarding issues and requirements related to adolescent health. They actively participate in the activities of the Adolescent Friendly Clubs (AFC), fostering a supportive environment for adolescentsto engage with and benefit from these crucial health initiatives.

More recently, a study titled "Evaluating Implementation of a Peer Educator Programme for Improving Adolescent Health under India’s National Adolescent Health Programme (i-Saathiya)" conducted by the Publuc Health Foundation of India delved into the practical application and impact of the PE program. This study not only assessed the effectiveness of peer educators in advancing the objectives of RKSK but also highlighted their instrumental role in fostering community support, particularly evident during the challenging times of the COVID-19 pandemic.

The findings of the study demonstrate that Peer educators (PEs) have demonstrated remarkable versatility and effectiveness by assuming roles as innovators and communicators, thereby bridging the crucial gap between the healthcare system and the community.

- **Community Outreach and Support:**
  They have played an instrumental role in disseminating essential prevention messages, distributing imperative items like masks, sanitizers, groceries, and medicines directly to adolescents and communities, right at their doorsteps.

- **Community Sensitisation:**
  PEs have played a pivotal role in sensitizing the community about Covid Appropriate Behaviors (CABs) and vaccinations. Their approach has been contextually attuned to community dynamics, involving strategies such as organizing rallies, creating vibrant wall paintings, engaging in street plays (nukkad natak), incorporating folk songs, and even integrating traditional practices such as offering yellow rice.

- **Role Models:**
  In an inspiring show of leadership, these peer educators have gone on to become exemplary role models. By taking the initiative to receive their own first doses of the COVID vaccine, they have effectively motivated and encouraged other adolescents to follow suit and get vaccinated.

- **Economic Impact:**
  Remarkably, PEs have also generated opportunities for families to earn income by involving them in mask-making initiatives, thereby creating a positive impact on local economies.

- **Digital Empowerment:**
  Leveraging the power of digital tools, PEs have extended their support by aiding community members in the registration process on platforms like COWIN, contributing to enhanced access to vaccination and related resources. This digitized empowerment has not only facilitated vaccine registration but also exemplifies the dynamic role these peer educators have taken on during the pandemic.

Peer Education Interventions for Adolescent Health:

A Comprehensive Review and Analysis based on evidence generated from Implementation

This comprehensive review is based on the evidences collected from the seven states, namely Madhya Pradesh, Maharashtra, Haryana, Uttarakhand, Gujarat, Odisha and Tamil Nadu. It tries to explore the various facets of peer education interventions under the RKSK program. It examines the selection criteria and mechanisms for choosing peer educators, the training provided to equip them with the necessary knowledge and skills, the design and implementation of peer education sessions, and the overall impact of these initiatives.

Additionally, it delves into the challenges faced by peer education programs and provides evidence-based recommendations to enhance their effectiveness and sustainability.

Section A: Selection of Peer Educators

The success of peer education interventions hinges on the careful selection of peer educators who can serve as effective role models and communicators. This section discusses the selection criteria for peer educators, the mechanisms employed for their selection, and strategies to address the challenges of attrition and aging out.

I Selection Criteria for Peer Educators

Peer educators play a pivotal role in disseminating health information and fostering behavior change among their adolescent peers. To ensure their suitability for this critical role, specific selection criteria are employed. These criteria encompass:

1. Age Alignment: Peer educators are typically selected from within the adolescent age group (10-19 years), ensuring that they can relate closely to the experiences and challenges faced by their peers.

2. Personality Traits: Peer educators are chosen based on certain personality traits, including leadership, communication skills, empathy, and the ability to connect with and inspire their peers.

3. Willingness to Volunteer: A genuine commitment to volunteering and making a positive impact on their community is a fundamental criterion for peer educators.

4. Sociable Nature: Peer educators are often selected for their sociability and ability to establish rapport with their peers, creating a conducive environment for open discussions.

5. Community or Social Circle Affiliation: Ideally, peer educator candidates are sourced from the same communities or social circles as the beneficiaries. This shared background enhances trust and relatability.

II Mechanisms for Selection

The mechanisms employed for selecting peer educators can vary across states and implementation models. Four prominent selection mechanisms are as follows:

1. Government-Led Model (Haryana and Gujarat): In Haryana, Accredited Social Health Activists (ASHAs) and Auxiliary Nurse Midwives (ANMs) identify potential peer educator candidates through community mobilization efforts. Parental consent plays a pivotal role in the selection process, ensuring the support of families. In Gujarat, ASHA workers are primarily responsible for the selection of peer educators.

2. Rigorous Screening (Uttarakhand): Uttarakhand employs a rigorous process involving a quiz competition followed by selection in a meeting organized by ASHA and Village Health, Sanitation, and Nutrition Committees (VHSNC). This approach aims to identify candidates with a strong commitment to the role.

3. Collaborative Model (Odisha): Odisha adopts a collaborative approach to selecting peer educators. ASHAs, Anganwadi Workers (AWWs), and school teachers collectively nominate candidates, with the final selection occurring during Gram Kishor Samiti (GKS) meetings. This collaborative approach ensures a diverse pool of candidates.

4. 'Senior PE Selection Model' (Tamil Nadu): Tamil Nadu introduces an innovative 'Senior PE Selection Model' to address the challenge of aging out. This model allows experienced peer educators to transition into senior peer educator roles, ensuring continuity and mentorship. Newly selected peer educators join the program, benefiting from the guidance of their senior counterparts.

III Strategies to Address Challenges

Peer education programs often face challenges related to attrition and the aging out of peer educators. To mitigate these challenges, the 'Senior PE Selection Model' in Tamil Nadu serves as a notable example. By allowing experienced peer educators to transition into senior roles, the program ensures ongoing engagement and mentorship. This strategy not only addresses attrition but also leverages the expertise of experienced peer educators to guide and support new recruits. Additionally, programs can consider providing incentives, recognition, and career progression opportunities to retain peer educators and encourage their continued commitment.

Section B: Training of Peer Educators

The training of peer educators is a critical component of successful peer education interventions. This section explores the various approaches and models employed for training peer educators, including the role of trainers, curriculum and content, training duration and flexibility, the cascade training model, and the importance of refresher training.

I Trainers and Training Models

Peer educators receive training from different categories of trainers based on the implementation model in each region. Trainers can include:

- **Frontline Health Workers**: ASHA workers, ANMs, and other frontline health workers are often involved in training peer educators, leveraging their existing healthcare knowledge and community relationships.
- **School Teachers**: In some instances, school teachers are engaged as trainers, given their experience in working with adolescents and their pedagogical skills.
- **Mentors from NGOs**: Non-Governmental Organizations (NGOs) with expertise in adolescent health may provide training and guidance to peer educators.
- **Specialized Personnel**: In certain cases, specialized personnel like Block Medical Officers and counselors are engaged as trainers to ensure the quality and comprehensiveness of training.

II Curriculum and Content

Peer educator training typically includes a mix of theoretical knowledge sessions, interactive

activities, role-plays, and practical skill development. This comprehensive approach is designed to accomplish several objectives:

- Ensure that peer educators have a strong understanding of health and social topics.
- Equip peer educators with effective communication and interpersonal skills to engage with their peers.
- Enable peer educators to facilitate interactive and engaging peer education sessions.

The content of the training curriculum is informed by the specific needs of the target audience and the goals of the program. It covers a wide range of topics, including physical health, hygiene, nutrition, sexual and reproductive health, mental well-being, substance abuse prevention, non-communicable diseases, and injury and violence prevention.

III Duration and Flexibility

The duration of peer educator training can vary based on local context and logistical considerations. For example:

- In Maharashtra, a flexible training schedule spans a few days, accommodating logistical constraints and the availability of resources.
- In contrast, Madhya Pradesh follows a more structured and fixed-duration training program, taking into account the complexity of the content being delivered.

This variability in training duration reflects the need to adapt to local conditions while ensuring that peer educators receive comprehensive training.

IV Cascade Training Model

The cascade training model is employed in some regions, including Odisha. In this hierarchical model, peer educators are trained at lower administrative levels by higher-level trainers. While this approach can efficiently disseminate training to a larger number of peer educators, its effectiveness relies heavily on the quality of training provided at each level of the cascade. Ensuring that trainers at each level are well-prepared and competent is essential to maintaining the integrity of the training program.

V Refresher Training

To ensure that peer educators stay updated and proficient in their roles, some regions, such as Tamil Nadu, provide annual refresher training. Given that health information and guidelines can change over time, refresher training is critical for peer educators to deliver accurate and up-to-date information to their peers. This practice underscores the commitment to continuous learning and improvement within peer education programs.

Section C: Peer Education Sessions

Once peer educators are trained, they assume the responsibility of imparting knowledge and information to their peers through a variety of sessions. This section delves into the design and implementation of peer education sessions, covering guided facilitation, session frequency and duration, customization of content, and the use of interactive tools and materials.

- **Guided Facilitation**
  Peer education sessions are typically guided by ASHA workers or designated NGO trainer mentors. This collaborative approach combines the expertise of health professionals with the relatability of peer educators. It ensures that sessions are effective, accurate, and aligned with evidence-based information. Guided facilitationis particularly valuable when addressing sensitive topics or complex health issues.

- **Frequency and Duration**
  The frequency and duration of peer education sessions are tailored to the specific context and goals of the intervention. Variability exists, with sessions occurring weekly, monthly, or quarterly. The timing and duration of sessions are carefully considered to accommodate the availability and attention span of adolescents, maximizing engagement and retention. Sessions typically span between 45 to 90 minutes, ensuring that they are informative yet concise.

- **Customization of Content**
  The content of peer education sessions is informed by both the training received by peer educators and the unique needs of the target audience. Peer educators draw on their comprehensive training to address a wide spectrum of health topics, ranging from physical health and hygiene to psychosocial well-being and life skills. This customized approach enhances the relevance and impact of sessions, allowing peer educators to address the specific concerns and questions of their peers.

- **Interactive Tools and Materials**
  Information, Education, and Communication (IEC) materials play a crucial role in peer education sessions. These materials include resources such as comic books, flash cards, posters, and interactive tools like role plays and case studies. These aids facilitate dynamic discussions, resonate with diverse learning styles, and empower adolescents to comprehend complex concepts through relatable scenarios. The use of interactive materials fosters engagement and active participation, creating a more effective learning environment.

By structuring peer education sessions in a participatory manner, involving expert guidance, and utilizing interactive tools, peer educators become catalysts for informed health choices.

Section D: Success of Peer Education Programme

Peer education programs implemented under the Rashtriya Kishor Swasthya Karyakram have demonstrated remarkable success in multiple dimensions. This section highlights the achievements and positive outcomes of these programs, emphasizing their role as catalysts for change, empowerment, recognition, and health systems strengthening.

1. Peer Educators as 'Catalysts for Change'
The role of peer educators in their community has been that of a change agent. Their

involvement in fostering behavior change and reducing risky behaviors has proven effective. Key successes include:

- Hygienic Menstrual Product Usage:The i-Saathiya study revealed that peer education interventions effectively promoted the use of hygienic menstrual products among adolescent girls. This initiative improved menstrual hygiene management and overall health practices.
- Reduced Tobacco and Alcohol Consumption: Peer educators actively contributed to reducing tobacco and alcohol consumption among adolescents, promoting healthier lifestyles and lowering related health risks.
- Preventing Child Marriages and Teenage Pregnancies: Peer educators have played a critical role in reducing child marriages, teenage pregnancies, and supporting school dropouts in continuing their education. These efforts have significantly improved the overall well-being of these key population groups.
- Pulse Polio Immunization: Peer educators have been instrumental in ensuring 100% coverage of pulse polio immunization, making significant strides toward eradicating polio from India.

2. Empowerment

Through active participation in training and education, peer educators have significantly improved their understanding of critical health and social issues. This empowerment has equipped them with the knowledge and skills necessary to advocate for change and act as leaders within their communities. Peer educators are now better equipped to address community challenges and other developmental issues, demonstrating their capacity to drive positive transformations.

The empowerment of peer educators extends beyond their individual growth, benefiting the entire community. Within the six thematic areas outlined by the Rashtriya Kishor Swasthya Karyakram (RKSK), including Nutrition, Sexual and Reproductive Health, Mental Health, Substance Abuse, Non-Communicable Diseases, and Injuries and Violence, peer educators play a crucial role in disseminating accurate information, promoting healthy behaviors, and raising awareness. This intervention has showcased notable success in fostering a generation of young individuals capable of taking charge of their health and contributing to the betterment of their communities.

3. Recognition and Appreciation

The success of the peer education intervention under RKSK has gained recognition and appreciation from various stakeholders. In Madhya Pradesh, for example, peer educators have successfully created a distinct identity as "Green Commandos," symbolizing their commitment to environmental and social causes. Furthermore, these peer educators have carved a niche for themselves in the social impact domain and are now seen as NGO mentor trainers. Hence, it can be argued that the peer education intervention under RKSK has not only had a positive impact on the health and well-being of adolescents but has also empowered and improved their employability prospects.

4. Health Systems Strengthening

Peer educators serve as vital intermediaries, bridging the gap between the community and the healthcare system. They play a pivotal role as points of contact and support for adolescents, ensuring that this demographic group can access essential healthcare services and support. Through their presence and advocacy, peer educators facilitate adolescents' engagement with health services and provide them with information and guidance on various health issues.

Peer educators actively contribute to the successful implementation of various national health programs and campaigns. They offer valuable support to Accredited Social Health Activists (ASHAs) in executing initiatives such as the Maternal and Child Health Program, Anaemia Mukt Bharat, Pulse Polio campaign, and Deworming Day campaign. Peer educators' involvement extends beyond information dissemination; they play a role in encouraging community participation, facilitating health education, and ensuring program effectiveness at the grassroots level. Their significant contribution, especially during critical events such as the COVID-19 pandemic, underscores their essential role in maintaining and enhancing the overall health and well-being of communities.

Section E: Challenges

While peer education programs have achieved substantial success, they are not without challenges. This section explores the various obstacles and barriers faced by these programs, including issues related to conducting sessions, incentives, attrition, apprehension among parents and community members, and the inadequacy of supportive supervision.

1. Barriers to Conducting Sessions by Peer Educators

Conducting peer education sessions can be hindered by several barriers, including:

- **Lack of Information**: One notable finding is the limited awareness about peer education sessions among key stakeholders, primarily parents of both peer educators and adolescents, as well as teaching staff. This lack of awareness can impact the overall success and reach of the peer program.
- **Logistical Challenges**: Challenges such as remote training locations, inadequate access to public transportation, inappropriate weather conditions, and conflicts of training schedules with school activities often hinder the training of peer educators. These logistical challenges can negatively impact the effectiveness of peer educatorsin delivering the intervention.
- **Hesitancy to Address Sensitive Issues:** Peer educators may hesitate to conduct sessions on sensitive subjects, such as Sexual and Reproductive Health (SRH), due to their lack of complete understanding of these issues, including aspects like violence. The sensitive nature of SRH-related topics can create an environment of embarrassment and discomfort for both peer educators and adolescents, making open discussions challenging.
- **Engagement Strategies**: Challenges arise when peer educators employ fewer engaging strategies, compromising the effectiveness of their sessions. Such methods struggle tocapture and retain the attention and interest of the adolescent audience.

- **Gender Dynamics**: In contexts where gender interactions are restricted, predominantly female health workers can face challenges when engaging in peer education sessions. This dynamic can potentially hinder the delivery of effective education.
- **Timing and Parental Consent**: Inconvenient session timings and parental reluctance to permit their children's participation further obstruct the seamless execution of peer interventions.

2. Inadequacy of Incentives

Both peer educators and counselors often face insufficient incentives to maintain their engagement and commitment to the intervention. The lack of recognition and tangible rewards for their efforts can hinder their motivation and effectiveness. Without adequate incentives, peer educators may face financial constraints and time pressures, leading to attrition and reduced program impact.

3. Attrition of Peer Educators and Counselors

The absence of attractive incentives and meaningful recognition contributes to a notable attrition rate among peer educators and counselors. High turnover rates disrupt the continuity and impact of the intervention, requiring frequent training and orientation of new participants. The loss of experienced peer educators can also impact the quality and effectiveness of peer education sessions.

4. Apprehension Among Parents and Community Members

Parents and community members often lack awareness and understanding of the goals, content, and methodologies of the peer education program. This leads to apprehension and concerns about the influence and appropriateness of peer educators' interactions with adolescents. Addressing these concerns and building community support for peer education programs are crucial for their success and sustainability.

5. Inadequacy of Supportive Supervision

Frontline health workers, especially ASHAs, play a critical role in various healthcare initiatives. Their responsibilities encompass diverse tasks, including maternal and childhealth, vaccination campaigns, and health education. The sheer workload restricts their capacity to fully engage in the necessary monitoring and supportive supervision activities for peer education interventions. This limitation can impact the quality and consistency of peer education sessions.

Section F: Recommendations

To address the challenges and further enhance the effectiveness of peer education programs for adolescent health, a set of evidence-based recommendations is presented. These recommendations encompass a wide range of strategies and approaches aimed at optimizing the impact and sustainability of peer education interventions.

1. Encouraging Volunteerism and Professional Development

- **Cultivate a Culture of Volunteerism**: Organize awareness campaigns, workshops, and community engagement activities to foster a culture of volunteerism among adolescents. Highlight the personal growth and social impact that volunteering can bring.

- **Incentives for Peer Educators**: Introduce a tiered system of incentives for peer educators, ranging from certificates and recognition to connecting the program with Skill India for skill-based certification. This approach will motivate participants and provide tangible benefits.

2. Integration and Convergence

- **Holistic Approach through Convergence**: Integrate the peer education intervention with the School Health Programme and other skill-based government initiatives. This integrated approach will facilitate resource optimization, ensuring comprehensive adolescent development.
- **Strengthening Linkages**: Collaborate with occupational, health, and educational sectors to create a seamless transition for adolescents from education to employment. This linkage will contribute to their holistic growth and preparedness for the future.

3. Community Sensitization and Awareness

- **Targeted Awareness Campaigns**: Develop culturally sensitive and age-appropriate awareness videos and materials to educate communities, especially parents, about sexual and reproductive health and mental well-being. Break down barriers to discussions on sensitive topics.
- **Peer-led Community Sessions**: Empower peer educators to conduct interactive community sessions that promote open dialogue on taboo subjects. This approach ensures local relevance and bridges the gap between traditional norms and modern knowledge.

4. Investment and Capacity Building

- **Innovative IEC Materials**: Allocate resources to design engaging and digitized Information, Education, and Communication (IEC) materials, localized in various languages. These materials should resonate with adolescents and promote behavior change.
- **Mentorship and Support**: Establish mentoring agencies comprising trained professionals to guide and support peer educators. This mentoring will enhance their capacity to address complex issues and offer personalized guidance.

5. Evidence-Based Scaling Up

- **Rigorous Monitoring Framework**: Implement a robust monitoring and evaluation framework that tracks not only the quantitative reach but also the qualitative impact of the peer intervention. Real-time data will aid in timely course correction.
- **Evidence-Driven Expansion**: Base the scaling-up process on evidence generated

through monitoring and evaluation. This data-driven approach will ensure the intervention's efficacy and enable targeted expansion.

6. Inclusivity and Equity

Develop tailored strategies to reach the urban poor, a marginalized group often overlooked in health programs. Collaborate with local urban stakeholders to understand their unique challenges and needs.

7. Meticulous Planning and Analysis

Conduct a detailed costing analysis to ascertain the budget requirements for scaling up the peer intervention. This analysis should consider training, materials, mentoring, monitoring, and other essential elements.

8. Participatory Approach

Develop a transparent and participatory process for selecting peer educators, involving teachers, frontline health workers (FLHWs), and parental consent. This approach will ensure community ownership and responsible selection. Evidence from a systematic review has also suggested that if the selection of peer educators is done by peers themselves, it will garner more trust and credibility among the target audience.

Peer education interventions under the Rashtriya Kishor Swasthya Karyakram have emerged as powerful tools for addressing the unique health needs of adolescents in India. These programs, driven by dedicated peer educators, have achieved remarkable success in promoting positive health behaviors, empowering young individuals, and strengthening healthcare systems at the community level. However, they are not without challenges, including issues related to conducting sessions, incentives, attrition, and community apprehension.

To maximize the impact and sustainability of peer education initiatives, evidence-based recommendations have been presented. These recommendations encompass a range of strategies, from fostering volunteerism and professional development to enhancing community awareness and engagement. By implementing these recommendations, peer education programs can continue to play a vital role in improving the health and well-being of adolescents across India, ensuring that this critical demographic group is equipped to make informed choices and lead healthier, more empowered lives.

Evidence-Backed Scaling Up of the Peer Education Intervention

Scaling up the Peer Education (PE) intervention under the Rashtriya Kishor Swasthya Karyakram (RKSK) is a complex endeavor that requires a strategic and evidence-based approach. While PE programs have demonstrated significant success in promoting adolescent health, expanding their reach and impact necessitates careful planning, rigorous monitoring, and continuous evaluation. This section outlines a strategic and evidence-based approach for the expansion of the PE program, underpinned by the principles of Theory-Driven Evaluation (TDE) and Realist Evaluation. The significance of implementation science research (IS) as the foundation of this approach is duly emphasized.

Implementation Science:
Implementation science research is a multidisciplinary field that aims to bridge the gap between interventions and their successful deployment in the real world. It not only aims to determine if interventions are effective but also strives to optimize them by collaborating with the target population. This includes evaluating policies, programs, and individual practices, examining their impact, and understanding the intricacies of their effectiveness. Implementation science transcends the binary question of "does it work?" by delving into the nuanced aspects of "what works, for whom, how, and why," fostering a holistic understanding of interventions' real-world applicability and effectiveness.

The need to address the health and well-being of India's adolescent population is paramount. The success of the PE intervention in enhancing adolescent health outcomes in select regions necessitates its scaling up to reach a broader demographic. However, scaling up must be informed by rigorous research, evaluation, and evidence-based policy analysis.

A Synergistic Approach: Implementation Science and Theory-Driven Evaluation
Implementation science and theory-driven evaluation share a common interest in understanding the functioning of interventions in real-world settings. While implementation science primarily delves into the intricacies of the implementation process, theory-driven evaluation distinguishes itself by its emphasis on the application of theoretical frameworks to steer the evaluation of interventions. They can be complementary and can be used synergistically to conduct rigorous evaluations of interventions while also considering their real-world implementation challenges.

Theory Based Evaluation
More specifically, theory-driven evaluation is an evaluation approach that focuses on understanding the underlying theories or mechanisms that lead to specific outcomes in complex interventions, using explicitly stated models or theories, i.e. the Programme Theory. It seeks to identify the "causal mechanisms" (the reasons why and how an intervention works or doesn't work) and the contextual factors that influence these mechanisms.

Programme Theory is a conceptual understanding of the underlying assumptions and justification (which is not always explicitly stated) of how the programme is expected to work {*Action Model*} as well as the explanation of the causal processes and the intervening

contextual factors {*Change Model*}.

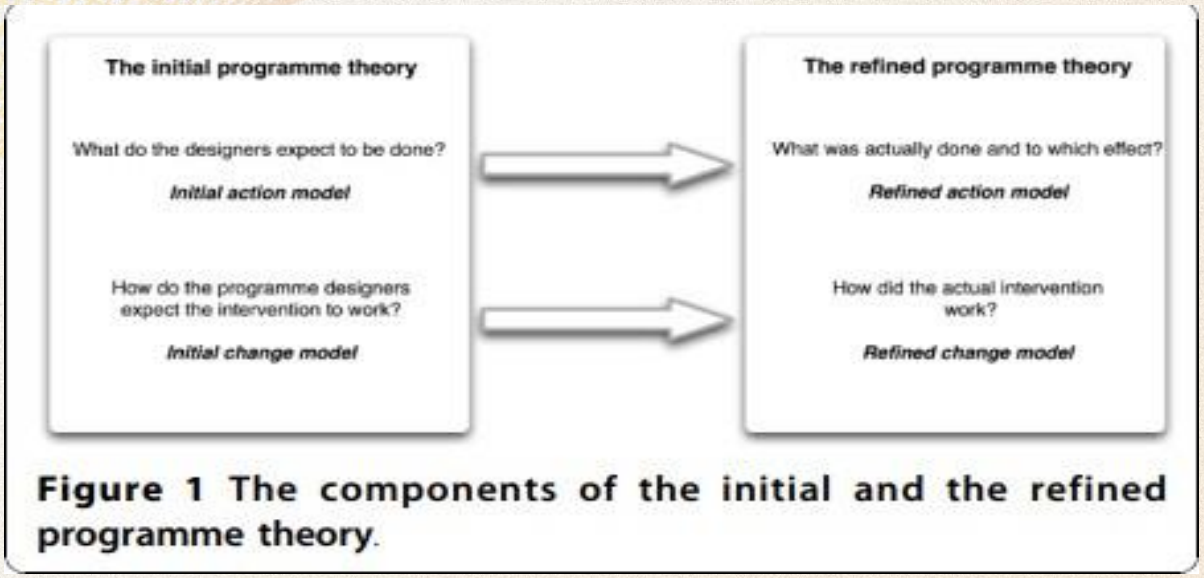
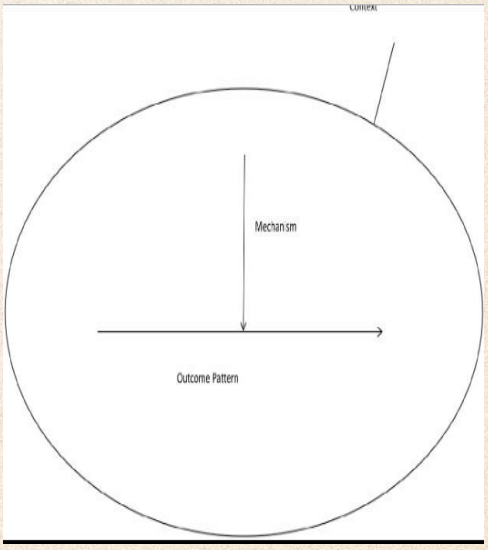


Figure 1 The components of the initial and the refined programme theory.

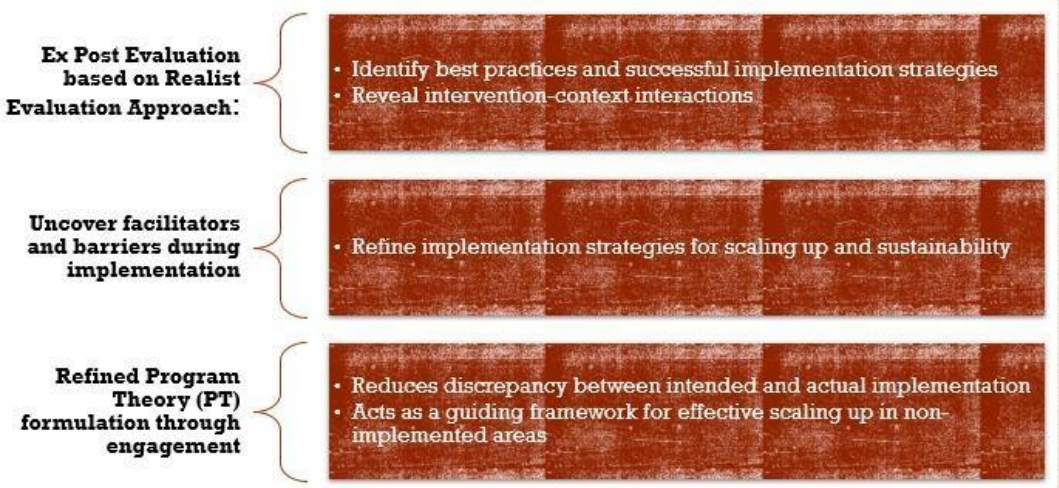
Realist evaluation approach, as a type of theory-driven evaluation, is particularly interested in exploring the interactions between context, mechanisms, and outcomes to understand how and why interventions are effective in specific situations.



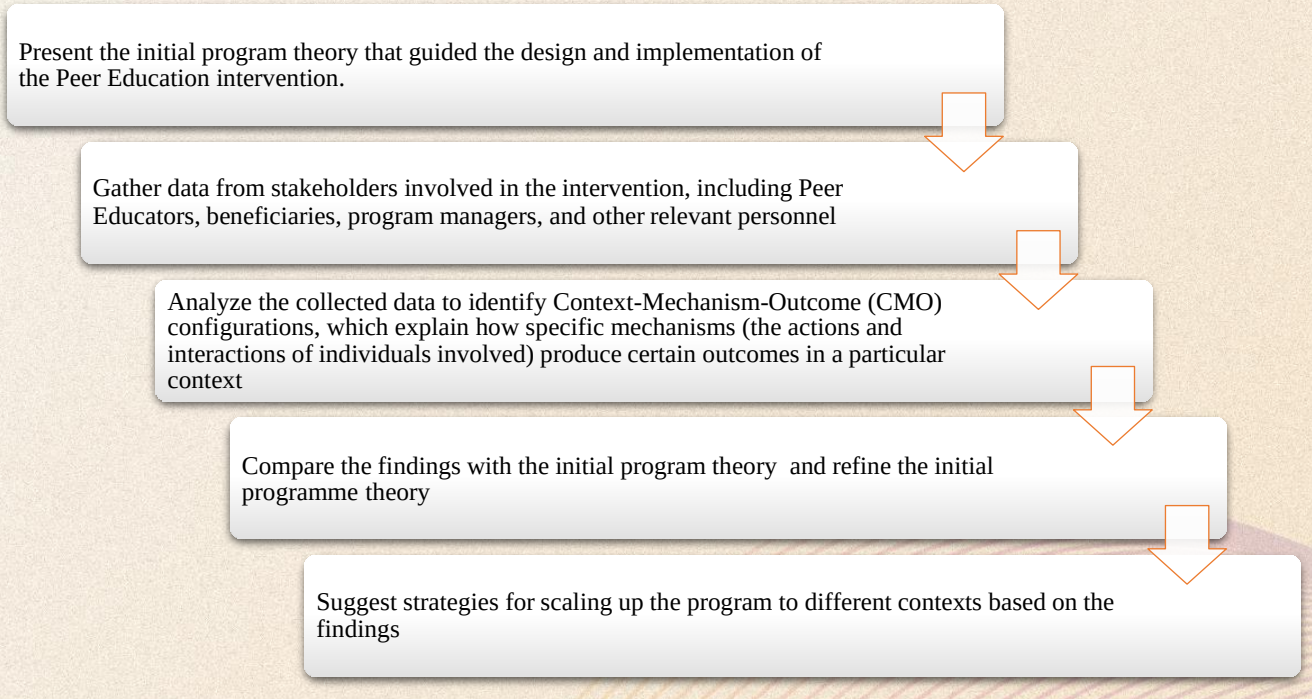
Context-Mechanism-Output (CMO)Configuration

Under the guidance of the PHFI, the study titled "Evaluating Implementation of a Peer Educator Programme for Improving Adolescent Health under India's National Adolescent Health Programme (i-Saathiya)" delved into the practical application and impact of the PE program. Findings from the study as well as the implementation process evaluation can be used as a bedrock to undertake an ex-post evaluation based on the realist evaluation approach to inform the adaptation and scaling up of the PE intervention.

How can an Ex-Post Evaluation of Peer education intervention be conducted?



The following is a proposed step-by-step method for undertaking an ex-post evaluation of the PE intervention:



Way Forward:

Scaling up the PE intervention under RKSK is a complex process that demands an evidence-based and theoretically grounded approach. Implementation Science (IS), Theory-Driven Evaluation (TDE), and Realist Evaluation collectively provide the necessary tools for this

undertaking.

- IS ensures that scaling up is based on a solid understanding of how the PE program works in practice.
- TDE, with its emphasis on program theory and process evaluation, ensures that the core model is faithfully maintained.
    - Realist Evaluation, within TDE, deepens our understanding of the intervention's mechanisms and how they interact with diverse contexts, facilitating effective tailoring.

In summary, the proposed approach aligns with best practices in scaling up complex interventions. It prioritizes a nuanced understanding of context, fosters ongoing adaptation, and places the PE intervention on a robust theoretical foundation. By leveraging IS, TDE, and Realist Evaluation, India can achieve the ambitious goal of extending the benefits of PE to all its adolescents, thereby improving their health and well-being for generations to come.

References

- Adolescent Health Division - Ministry of Health and Family Welfare, Government of India. RKSK operational framework, translating strategies into programmes. New Delhi, 2014. Available: http:// nhm.gov.in/images/pdf/programmes/RKSK/RKSKOperational_ Framework.pdf
- Agha S. An evaluation of the effectiveness of a peer sexual health intervention among secondary-school students in Zambia. AIDS Educ Prev 2002;14:269e81
- Barua A, Watson K, Plesons M, et al. Adolescent health programming in India: a rapid review. ReprodHealth 2020;17:87.
- Bastien S, Flisher AJ, Mathews C, et al. Peer education for adolescent reproductive health- an
- effective method for program delivery, a powerful empowerment strategy or neither? In: Klepp K, Flisher A, Kaaya S, eds. Promoting Adolescent Sexual and Reproductive Health in East and SouthernAfrica. Cape Town: HSRC Press; 2008.
- Bernays S, Tshuma M, Willis N, Mvududu K, Chikeya A, Mufuka J, et al. Scaling up peer-led
- community-based differentiated support for adolescents living with HIV: keeping the needs of youthpeer supporters in mind to sustain success. J Int AIDS Soc. 2020 Sep; 23(S5):e25570. https://doi.org/10.1002/ jia2.25570 PMID: 32869532
- Govender K, Cowden RG, Asante KO, et al. Sexual risk behavior: A multisystem model of risk andprotective factors in South African adolescents. Prev Sci 2019;20:1054e65.
- He J, Wang Y, Du Z, Liao J, He N, Hao Y. Peer education for HIV prevention among high-risk groups: A systematic review and meta-analysis. BMC Infect Dis. 2020 May; 20(1):1–20. https://doi.org/10.1186/ s12879-020-05003-9 PMID: 32398032
- Kim C, Free C. Recent evaluations of the peer-led approach in adolescent sexual health education: Asystematic review. Int Fam Plann Perspect 2008;34:89e96.
- Kirby D, Obasi A, Laris B. The effectiveness of sex education and HIV education interventions in schools in developing countries. In: Ross D, Dick B, Ferguson J, eds. Preventing HIV/AIDS in Young People: A Systematic Review of the Evidence from Developing Countries. Geneva: World Health Organisation; 2006.
- Knibbs S, Price N. Peer education in sexual and reproductive health programming: A Cambodian casestudy. Dev Pract 2009;19:39e50.
- Lau RR, Quadrel MJ, Hartman KA. Development and change of young adults' preventive health beliefs and behavior: influence from parents and peers. J Health Soc Behav 1990;31:240–59.
- Lehtimaki S, Schwalbe N. Adolescent health: the missing population in universal health coverage, 2019. Available: https://plan-uk.org/ sites/default/files/Adolescent Health UHC Report_FINAL May2019. Pdf
- Mason-Jones A, Flisher A, Mathews C. Who are the peer educators? HIV prevention in South Africanschools. Health Educ Res 2011;26:563e 71.
- Medley A, Kennedy C, O'Reilly K, et al. Effectiveness of peer education interventions for HIVprevention in developing countries: A systematic review and meta-analysis. AIDS Educ Prev 2009;21:181e206.
- Ministry of Health & Family Welfare Government of India. Peer education Program. Available at: https://nhm.gov.in/index1.php?lang¼1&level¼ 3&sublinkid¼1249&lid¼493. Accessed July 3, 2023.
- Ministry of Health and Family Welfare and Ministry of Human Resource Development. School healthprogramme under Ayushman Bharat, operational guidelines, New Delhi, 2018.

Available: http:// www.dnmurthy.com/go/opshp.pdf
- Ministry of Health and Family Welfare, Government of India. Scheme for promotion of menstrualhygiene among adolescent girls in rural India, 2016. Available:
- https://nhm.gov.in/WriteReadData/l892s/ 6109043369148127661 2.pdf
- National Health Mission. Peer Educator Reference Book-FAQs [Internet]. Ministry of Health and Family Welfare Government of India: 2015 [cited 2021 Feb 15]. 52. Available from: https://www.nhm.gov.in/ images/pdf/programmes/RKSK/PE_Training_Manual/PE-Reference- book_FAQ_old.pdf
- Patton GC, Sawyer SM, Santelli JS, et al. Our future: a Lancet commission on adolescent health andwellbeing. Lancet 2016;387:2423–78.
- Pollock M, Fernandes RM, Pieper D, et al. Analogue study of peer influence on risk-taking behaviorin older adolescents. Prev Sci 2014;15:842e9.
- Sharma NC. Govt launches school health programme under Ayushman Bharat, 2020. Available: https://www.livemint.com/news/ india/govt-launches-school-health-programme-under-
- ayushmanbharat-11581517583719.html
- Shiner M. Defining peer education. J Adolesc 1999;22:555e66. [4] Benton AD, Santana A, Vinklarek AJ, et al. Peer-led sexual health education: Multiple perspectives on benefits for peer health educators.Child Adolesc Soc Work J 2020;37:487e96.
- Siddiqui M, Kataria I, Watson K, et al. A systematic review of the evidence on peer education programs for promoting the sexual and reproductive health of young people in India. Sex ReprodHealth Matters 2020;28: 1741494.
- Sikander S, Lazarus A, Bangash O, Fuhr DC, Weobong B, Krishna RN, et al. The effectiveness and cost-effectiveness of the peer-delivered Thinking Healthy Programme for perinatal depression in Pakistan and India: The SHARE study protocol for randomised controlled trials. Trials. 2015 Nov; 16(1):1– 14. https://doi.org/10.1186/s13063-015-1063-9 PMID: 26604001
- Simoni JM, Franks JC, Lehavot K, et al. Peer interventions to promote health: Conceptual considerations. Am J Orthopsychiatry 2011;81:351.
- Stephenson J, Strange V, Allen E, et al. The long-term effects of a peer-led sex education program (RIPPLE): A cluster randomised trial in schools in England. PLoS Med 2008;5:1579e90.
- Sun WH, Miu HYH, Wong CKH, et al. Assessing participation and effectiveness of the peer-led
- approach in youth sexual health education: Systematic review and meta-analysis in more developedcountries. J Sex Res 2018;55:31e44.
- The Lancet Child and Adolescent Health Group. Universal health coverage and the forgotten generation. Lancet Child Adolesc Health 2019;3:749
- http://www.thelancet.com/article/S2352464219302998/ fulltext
- Tolli MV. Effectiveness of peer education interventions for HIV prevention, adolescent pregnancy prevention and sexual health promotion for young people: A systematic review of European studies.Health Educ Res 2012;27: 904e13.
- World Health Organization. Universal health coverage (UHC), 2021. Available: https://www.who.int/news-room/fact-sheets/detail/ universal-health-coverage-(uhc)
- Zodpey S, Farooqui HH. Universal health coverage in India: Progress achieved & the way forward.Indian J Med Res 2018; 147:327.

Suryakant Kumar

M.Sc. in Agriculture - Business Economics, Gokhale Institute of Politics and Economics, Maharashtra.

Mentored by Ms. Sravanthi, Asst. Advisor, CPHEEO.

Domain for Internship: Innovation & Entrepreneurship

Organic Waste Management and Energy Recovery in India with Special Focus on Gobardhan Scheme Under SBM 2.0

The ecosystems of the planet are essential to the survival of the human population, however, there has been a significant out of balance in the connection between humans and the environment. The current study emphasized the importance of sustainable waste management and clean energy production to ensure a greener future. This paper examines the prevailing policies and their effects on the production trends of Compressed Biogas (CBG), Bio-Methanation, and Fermented Organic Manure (FOM) in India. Emphasizing waste management as a global concern, the paper investigates the efficacy of the GOBARDHAN Scheme within the Swachh Bharat Mission. While traditional waste management methods such as composting and incineration have merits, the study argues for modern scientific approaches, emphasizing source segregation, recycling, waste-to-energy technologies, and waste reduction. The study also highlighted Indore's CBG Plant that illustrated an exemplary model for effective Municipal Solid Waste (MSW) management. Policy recommendations focus on strengthening the GOBARDHAN Scheme, incentivizing biofuel production, research and development, infrastructure development, public-private partnerships, and monitoring and evaluation. Policies to encourage bio-CNG fertilizer usage and reduce reliance on synthetic fertilizers are recommended to enhance marketability and achieve environmental benefits. Ultimately, the integrated waste management approach advocated in this study aims to address India's waste management challenges, reduce reliance on imported fossil fuels, enhance energy security, and contribute to environmental sustainability. The promotion of biofuels from agricultural and industrial waste is posited as a catalyst for economic growth, rural development, and employment generation.

Keywords: organic waste management, energy, GOBARDHAN scheme, sustainable development, CBG, environment, solid waste management

Acknowledgment

I would like to express my heartfelt gratitude to the National Centre for Good Governance (NCGG), Government of India, for providing me with the incredible opportunity to serve as an intern in the domain of entrepreneurship and innovation. This experience has been invaluable in shaping my understanding of organic waste management, green energy initiative, tackling environmental challenges keeping economic prosperity in mind.

I am deeply indebted to Shri Bharat Lal, former Director General of NCGG, India, for his unwavering support and encouragement throughout my internship. His valuable insights and leadership have been instrumental in shaping my understanding of the field and instilling confidence in my abilities.

I would also like to express my gratitude to Shri V Srinivas, IAS, the current Director General of NCGG, India, for his guidance and mentorship. His visionary approach and dedication to promoting innovation have inspired me to explore new horizons in the domain of entrepreneurship.

I feel privileged to express my sincere gratitude to IAS, Joint Secretary MoHUA, Miss Roopa Mishra, Her valuable and very kind attention, initiation, technical support, invaluable counsel throughout the course of the investigation, and vital suggestions, reviews during the preparation of this report. She is the one who provides top notch guideline to initiate this project. It was indeed an unforgettable experience of working under her guidance.

I am immensely thankful to Miss Sravanthi Jeevan Ma'am for her guidance, expertise, and continuous support throughout this research. Her invaluable insights and constructive feedback have been instrumental in shaping the direction and quality of this work. I sincerely thank Miss Sravanthi for their intellectual enlightenment throughout the project.

Special thanks to Dr. Ghazala Hassan for providing me with valuable guidelines and mentorship during my internship. Her expertise and valuable guideline help us a lot. I would also like to acknowledge the immense support and knowledge shared by Mr. Aakash Sir and Sachin Sir.

Lastly, I want to express my appreciation to all the staff and colleagues at NCGG for creating a nurturing and collaborative environment that facilitated my growth as an intern. Once again, thank you to NCGG, Government of India, for this enriching opportunity.

Abstract

The paper emphasizes the importance of sustainable waste management and clean energy production to ensure a greener future. The GOBARDHAN Scheme aims to convert organic waste into valuable resources like biogas and bio- methane. The study explores the potential of biofuels, waste management practices, and government policies. Policies to encourage bio-CNG fertilizer usage and reduce reliance on synthetic fertilizers are recommended to enhance marketability and achieve environmental benefits. Solid waste management is a critical issue for India's national security and sustainable development. The country's heavy reliance on imported fossil fuels and increasing concerns over energy security make biofuels a vital component of itsstrategy. By reducing dependence on imported oil, biofuels enhance energy security, promote rural development, and contribute to poverty alleviation.

Additionally, biofuels align with India's climate change commitments, reducing greenhouse gas emissions. Agricultural and dairy industries generate significant organic waste, providing opportunities for biogas production and organic fertilizer. Transitioning from traditional waste management to modern scientific techniques, such as recycling and waste-to-energy, offers sustainable solutions to waste-related challenges. India's efforts in promoting Compressed Bio Gas (CBG) plants demonstrate progress towards a cleaner and renewable energy future. This paper examines the prevailing policies and their effects on the production trends of Compressed Biogas (CBG), Bio-Methanation, and Fermented Organic Manure (FOM) in India. The government's initiatives and policies promoting renewable energy and waste management have led to significant growth in the CBG sector. The study analyses the distribution of biogas plants in different states and highlights the major determinants that can impact the achievement of desired outputs. A case study of Indore city showcases successful waste management practices through the Indore CBG Plant, setting a benchmark for other cities. Policy recommendations focus on strengthening the GOBARDHAN Scheme, incentivizing biofuel production, research and development, infrastructure development, public-private partnerships, and monitoring and evaluation. Implementing an integrated waste management approach can lead to sustainable energy production, rural development, and environmental conservation.

Literature Review

In "Bio-renewable Resources-Engineering New Products from Agriculture," R.C. Brown explores the utilization of Bio-renewable resources, specifically agricultural products, to engineer novel products. The focus is on renewable energy and waste management in the context of Compressed Biogas (CBG), Bio-Methanation, and Fermented Organic Manure (FOM) production in India. The paper analyses prevailing policies' effects on these sectors and presents a case study of Indore city as a successful model for waste management through the Indore CBG Plant. It also offers policy recommendations to strengthen the GOBARDHAN Scheme, incentivize biofuel production, and implement an integrated waste management approach for sustainable development.

"A Review of Poultry Waste-to-Wealth: Technological Progress, Modelling and Simulation Studies, and Economic-Environmental and Social Sustainability" provides a comprehensive overview of converting poultry waste into valuable resources. The review covers technological advancements, modelling, and simulation studies related to poultry waste management. It also explores the economic, environmental, and social sustainability aspects of utilizing poultry waste. The paper highlights the potential of transforming waste into wealth, contributing to sustainable practices, and addressing environmental challenges associated with poultry farming.

The report titled "Resource Assessment for Livestock and Agro-Industrial Wastes - India" was prepared for The Global Methane Initiative. It presents a comprehensive assessment of the potential resources available from livestock and agro-industrial waste in India. The study evaluates the quantity and characteristics of waste generated from various sources in the country. It also analyses the feasibility of converting these wastes into valuable resources like biogas and bio-methane through anaerobic digestion. The report aims to promote sustainable waste management practices, reduce greenhouse gas emissions, and enhance energy production from organic waste in India.

The "Swachh Bharat Mission Municipal Solid Waste Management Manual" is a comprehensive guide that forms part of the Swachh Bharat Mission in India.

This manual focuses on managing municipal solid waste effectively. It provides detailed guidelines and strategies for waste management, including waste collection, transportation, segregation, processing, and disposal. The manual emphasizes the importance of source segregation and recycling to reduce the amount of waste sent to landfills. It serves as a crucial resource for municipalities and local authorities in India to implement sustainable and efficient waste management practices, aligning with the broader goal of achieving a cleaner and healthier environment under the Swachh Bharat Mission.

The "Gobardhan Manual" released by the Department of Drinking Water and Sanitation (DDWS) is a comprehensive guide that outlines the implementation and execution of the Gobardhan Scheme in India. The scheme is part of the Swachh Bharat Mission and focuses on converting organic waste into valuable resources like biogas and bio-methane, as well as producing fermented organic manure. The manual provides detailed guidelines and best practices for setting up and operating biogas plants, waste collection and segregation, the

anaerobic digestion process, and the utilization of biogas and bio-methane. It aims to promote sustainable waste management practices and renewable energy production, contributing to India's environmental conservation and energy security objectives.

Introduction

Shaking Hand with Waste

Rising temperature, polluted planet such as Air, Water, Land etc. are the main issues for the survival of living being on the earth. Since global population is increasing every time now, the population of the world today is about 215,000 people larger than yesterday. The development will put enormous pressure on Earth's resources and we'll need to find more sustainable ways of living. And fast! Since the beginning of history, population increase has always been accompanied with economic growth, typically with per capita growth as well.

In the 46 years from 1971 to 2017, when the world's population doubled, the global economy more than quadrupled from $19.9 to $80.1 trillion (in constantprices). The number of natural resources that humans consumed on Earth tripled between 1970 and 2010 (or roughly the same period).

The ecosystems of the planet are essential to the survival of the human population. But there has been a significant out of balance in the connection between man and environment. The ability of ecosystems to sustain human existence is presently 75 percent exceeded by humanity. Such a scenario is unsustainable. In essence, the global population is "taking a loan from nature" that must be repaid by later generations. Of course, It is not simply the number of people that determines the impact of the planet. It is how much we consume and how much waste we produce.

Waste management is the biggest global challenge as well as for India also. Themanagement of different types of waste in efficient way is very crucial for reaching the sustainable development goals for any economy of the world.

India produces around 62 million tonnes of waste each year About 43 million tonnes (70%) are collected, of which about 12 million tonnes are treated, and 31 million tonnes are dumped into land fill sites. With land fill ranking 3rd in top countries who dump their waste into ground. According to the press information bureau, India 2016 in the total composition of generated waste divided in three different categories Organic (all types of bio-degradable waste), Dry waste (or recyclable) and Bio-medical (sanitary and hazardous waste).

As shown in Figure 1, nearly 50% of the total waste is organic with the volumes of recyclables and biomedical/hazardous waste growing each year as India becomes more urbanized (McKinsey Global Institute 2010).

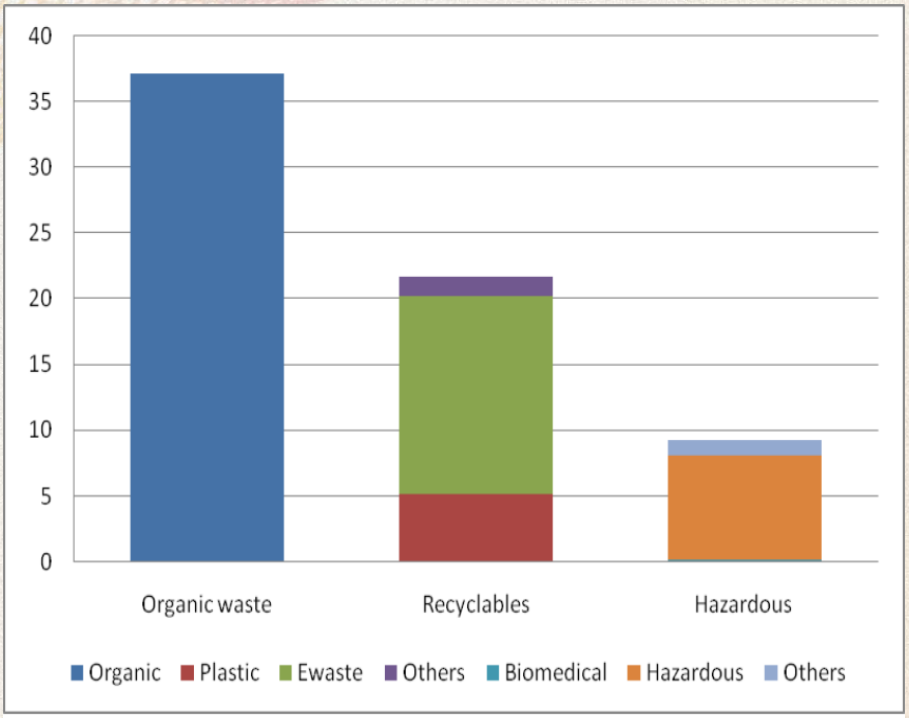


Figure 1: Waste Composition of India, in Million Metric Tonnes per annum.

Source: *PIB2016*

Potential of Organic Waste

Modern societies and economies produce increasing amounts of organic waste such as agricultural residues, food waste and animal manure, that can be used to produce biogas and Bio-methane, clean energy sources with multiple potential benefits for sustainable development. Biogas offers a local source of power and heat for communities, and a clean cooking fuel for households.

Processing and upgrading of bio gas turns into bio methane which yield less carbon emission helps in sustainable development. Organic waste has good untapped potential to provide the clean energy to the world. The world bio methane and bio gas potential could facilitate a great fraction of around 20%of total fuel demand from organic wastes.

Organic waste has significant potential and benefits when managed effectively. Some of the key potentials of organic waste include:

BIO-GAS PRODUCTION: Organic waste, including food waste and agricultural residues, can be used in anaerobic digesters to produce biogas. Biogas is a renewable energy source that can be utilized for cooking, heating, electricity generation, and even as a vehicle fuel. This process helps in waste management while contributing to the transition towards cleaner energy alternatives.

BIOCHAR PRODUCTION: It is an alternative of bio-fuel and way of efficient management of agro waste residue and solid waste. Biochar is a charred by- product of biomass pyrolysis produced from biological wastes, crop residues, animal poultry manure, or any type of organic waste material. Pyrolysis is the chemical breakdown of a substance under high temperatures in the absence of oxygen (Lehman et al., 2003). Biochar application has

been promoted in agricultural practice that creates a win-win situation by improving soil quality and enhancing agricultural sustainability concomitant with mitigating greenhouse gases (GHG) emissions.

REDUCING LANDFILL WASTE: Organic waste makes up a substantial portion of municipal solid waste, and when disposed of in landfills, it generates methane, a potent greenhouse gas. By diverting organic waste from landfills through composting, anaerobic digestion, or other means, we can significantly reduce methane emissions and cater climate change.

SOIL HEALTH IMPROVEMENT: The derivative of organic waste such as composts, FOM (Fermented Organic Manure), Bio- fertilizers helps to enhance soil health, moisture retention capacity, nutrient content. This leads to improve crop yield, reduces the dependency on chemical fertilizers and promote sustainable agriculture methods and practices.

JOB CREATION: The organic waste industry has great potential to provide job in this sector, particularly in waste collection, waste separation, recycling, CBG industries. This can support local economies and helps towards the way of sustainable development.

Policies of Government of India

India's path towards reducing carbon emission and efficient waste management is imperative. Government of India launches several schemes and programmes for effective management of waste taking environment into consideration. The government of India has undertaken multiple large-scale national initiatives such as 'Swachh Bharat Mission, 'National Water Mission' and 'Waste to

Wealth Mission" as a part of its commitment to effective waste & pollution management in India. Emphasis has also been laid on the approach of setting up Decentralised Waste processing sites within Cities to cater to problems of fresh MSW and legacy waste management.

SWACHH BHARAT MISSION: A nationwide initiative to clean INDIA was launched in 2nd October 2014. The primary goal of this mission to make India open defecation free, achieve 100% scientific method in waste management and promote hygienic and cleanliness practices, behavioural changes, public health. The mission operates under two sub operation (i) Swachh Bharat Mission (Gramin) SBM G focused on rural areas, SBM-G aims to achieve an open defecation-free India by promoting the construction of individual and community toilets and encouraging behaviour change in rural communities. (ii) Swachh Bharat Mission (Urban) SBM U Concentrating on urban areas, SBM-U seeks to create open defecation-free cities, improve solid waste management, and encourage the use of public and community toilets. The Swachh Bharat Mission has seen significant progress since its launch, with millions of toilets constructed, increased sanitation coverage, and greater awareness about cleanliness and hygiene. However, it is an ongoing effort that requires sustained engagement from the government, citizens, and various stakeholders to achieve the desired objectives of a cleaner and healthier India.

NATIONAL WATER MISSION: The National Water Mission (NWM) is one of the eight missions under India's National Action Plan on Climate Change (NAPCC), launched by the

Government of India in 2008. The NWM aims to address water-related challenges in the country and promote sustainable water management practices to ensure the availability and equitable distribution of water resources. The key features of national water mission, sustainable ground water management, improving water use efficiency, developing a sense of ownership, strengthening water governance. The National Water Mission plays a crucial role in guiding India's endeavours to ensure sustainable management of water resources, particularly amidst increasing water scarcity and the impacts of climate change. Its primary objective is to attain water security and fair access to water resources for everyone, thereby contributing to the nation's overall socio-economic and environmental welfare.

WASTE TO WEALTH MISSION: The Waste to Wealth Mission, initiated by the Indian government, aims to transform waste into valuable assets, promote sustainable waste management practices, and encourage a circular economy. As a component of India's National Bioenergy Mission, this endeavour specifically targets the increasing waste generation challenges by identifying ways to harness waste as a valuable resource, rather than viewing it as a burden. The major objectives of this mission was waste management and recycling, Bio energy generation as it aims to generate fuels from waste through scientific procedures like anaerobic digestion it helps in producing renewable energy from wastes, resource recovery and circular economy as themission aims to recover valuable materials and resources from waste through recycling and upcycling processes. By promoting a circular economy, it seeks to reduce the demand for new raw materials and minimize waste generation, waste to value, innovation and research as it supports research and innovation in waste management technologies and processes, encouraging the development of sustainable and cost-effective solutions. Job creation and economic growth the aim of this is to create employment through waste to wealth mission. Through the implementation of the Waste to Wealth Mission, India strives to attain effective waste management, mitigate the environmental consequences of waste, and encourage the sustainable utilization of resources. This mission is in line with the principles of sustainable development, reflecting India's dedication to creating a more environmentally friendly Bio energy.

GOBARDHAN – Galvanizing Bio Agro Resources Dhan

GOBARDHAN scheme is an umbrella initiative of government of India under Swachh Bharat Mission (Gramin), was launched in APRIL 2018, focusing on converting waste into wealth. The aim of this scheme is to build a robust eco- system for setting up Biogas/CBG/CND plants. The major objective of this scheme is to driving a sustainable economic growth and promoting a circular economy and generating waste and energy by utilising organic waste. The GOBARDHAN Scheme aims to create a sustainable and circular economy approach towards cattle dung management, supporting rural development, and environmental conservation. It provides an opportunity to convert waste into wealth, benefiting both farmers and the environment while contributing to India's clean energy and waste management goals.

GOBARDHAN was launched to ensure cleanliness in villages by converting bio- waste including cattle waste, kitchen leftovers, crop residue and market waste to improve the lives of villagers. This will provide economic and resource benefits to farmers and households.

The major objective of GOBARDHAN scheme is to generating waste and energy by utilising organic waste.

GOBARDHAN will be executed as a community-driven effort to utilize animal dung in rural areas. The community will take charge of planning, implementing, and managing the GOBARDHAN scheme. This initiative aims to address the urgent requirement for safe management of cattle dung and other organic waste, and the State, District, and Block administrations will actively promote its adoption among the rural population to raise awareness about the significance of GOBARDHAN scheme.

The GOBARDHAN Scheme can be implemented through various models, each involving different approaches and funding sources. These models include:

Individual Household Model: In this model, Gram Panchayats (GPs) will identify eligible households for setting up GOBARDHAN units and provide technical and financial support to construct biogas plants. Households will beencouraged through Information, Education, and Communication (IEC) activities to construct biogas plants using their resources or support obtainedfrom Corporate Social Responsibility (CSR) initiatives.

Source of fund: Funds for individual model can be sponsored from various avenues such as the New National Biogas and Organic Manure Programme (NNBOMP) of MNRE, 15th Finance Commission, MPLAD, and other State schemes.

Cluster Model: Under this approach, GPs will identify clusters of households for the installation of household-level biogas plants. Biogas generated will be used by the households, and the slurry will be collected and processed centrally. GPs will ensure that households use the biogas and sell the slurry to agencies for further processing into bio-fertilizers/organic manure.

Source of fund: Funding can be obtained from sources like NNBOMP, SBM-G,15th Finance Commission, MPLAD, MLALAD, and other State schemes.

Community Model: This model involves constructing community-level biogas plants to serve a group of 5-10 households. Waste will be collected from households and transported to the biogas plants. Biogas generated will be supplied to households, restaurants, institutions, etc., and the slurry can be used in agriculture or sold to farmers for conversion to bio-fertilizers/organicmanure.

Source of fund: Funding can be sourced from various avenues such as NNBOMP, SBM-G, 15th Finance Commission, MPLAD, MLALAD, and other Stateschemes.

Commercial Model: In this model, large biogas/compressed biogas (CBG) plants are set up by Entrepreneurs/Cooperatives/Gaushalas/Dairies on a commercial scale to generate a high volume of raw biogas. The biogas is converted into CBG and can be sold to industries, Oil Marketing Companies (OMCs), or directly through fuel dispensing units. State and District administrations will promote the construction of commercial units and create enabling policy provisions, provide support to entrepreneurs and businesses to avail loans and financial assistance from various departments/institutions, and create awareness of the business potential of such plants.

Source of fund: Funding for large CBG plants can come through self-financing, as well as schemes such as Waste to Energy Programme of MNRE, Sustainable Alternative Towards Affordable Transportation (SATAT) of MoPNG, and Commercial loans under Agriculture Infrastructure Fund of DACFW.

Ultimately, the GOBARDHAN Scheme offers multiple models that can be adopted based on the community's needs, financial support available, and objectives to promote biogas generation, organic waste management, andentrepreneurship in rural areas.

Objective:

The objective of this paper is to highlight the pressing environmental challenges facing the planet, particularly the issues related to rising temperatures, pollution, and the unsustainable consumption of natural resources due to population growth and economic development. It emphasizesthe need for urgent and sustainable solutions, focusing on waste management as a critical global challenge, and specifically in the context of India. The introduction also aims to introduce the GOBARDHAN Scheme as a crucial initiative by the Government of India under the Swachh Bharat Mission (Gramin), which seeks to address waste management and promote a circular economy approach by converting organic waste into valuable resources like biogas and bio-methane. The ultimate goal of this introduction is to provide a comprehensive understanding of the importance of waste management, the potential of organic waste, and the policies and schemes undertaken by the Indian government to tackle this pressing issue and drive sustainable development keeping cleanliness and economic wellbeing in mind. And to assess the significance of biofuels in India's national security strategy, focusing on their potential to reduce reliance on imported fossil fuels and enhance energy security. Additionally, the study aims to analyse the socioeconomic impacts of biofuel adoption, including opportunities for rural development and employment generation. The research will quantify the amount of agricultural industry waste generated in India and identify the major sources of agro- residue. By understanding the quantum of agricultural waste, the study seeks to highlight the potential for converting these residues into biofuels, contributing to India's energy security and sustainable development goals. This in turn, aims to quantify and analyse the quantum of waste generated by the dairy and poultry industries in India. It explores the potential for utilizing this waste for biofuel production, focusing on cow dung and poultry manure as feedstock. The study seeks to assess the feasibility and economic benefits of converting these by-products into bio-gas. This study aims to analyse the data related to small-scale cattle farmers (5 to 20 cattle) in a village that is for GOBARDHAN scheme. It investigates the relationship between the amount of cow dung used for biofuel production and the actual biofuel produced.

Additionally, the study explores the potential benefits of using cow dung, such as biogas production and bio-fertilizer generation. It also examines the energy recovery potential and challenges in utilizing poultry industry and abattoir waste for valuable products. This study aims to compare traditional waste management practices with modern scientific approaches for efficient solid waste management. It examines the effectiveness, cost-effectiveness, and environmental impact of each method, highlighting the benefits and challenges associated with transitioning from traditional to scientific waste management practices. This also aims to

analyse the production trends of Compressed Biogas (CBG), Bio-Methanation, and Fermented Organic Manure (FOM) in India, examining the impact of government policies and initiatives.

The study focuses on the major determinants affecting the achievement of optimum output in the CBG industry and Municipal Solid Waste (MSW) management. The case study of Indore showcases a successful model for efficient MSW management through the utilization of CBG plants, highlightingits environmental and socio-economic benefits.

Solid waste management

Bio-fuel and National Security

In 1974, A severe economic crisis developed in many parts of the world, resulting in disruption in supply of petroleum to the world market from major producers. Energy crisis arises from dwindling reserve of petroleum resources,and the prediction of oil price from few Dollars to 100 $ per barrel in international market start gaining focus and plunging the world into economiccrisis.

Biofuels have emerged as a crucial component of India's national security strategy, particularly in the context of its heavy reliance on imported fossil fuels and the growing concerns over energy security. As a nation with a rapidly expanding economy and a massive population, India faces formidable challenges in meeting its energy demands while safeguarding its national security interests. The reliance on imported fossil fuels exposes the country to geopolitical vulnerabilities, price fluctuations, and supply disruptions, which could have severe implications on its economic stability and strategic autonomy. Biofuels, derived from renewable biomass sources such as agricultural residues, non-edible oils, and animal waste, offer a sustainable anddomestically sourced alternative to conventional fossil fuels. By reducing dependency on imported oil, biofuels enhance India's energy security and contribute to mitigating the risks associated with fluctuations in global oil prices and geopolitical tensions. the cultivation of feedstock for biofuels presents an opportunity for rural development and employment generation.

India's vast agricultural sector can play a pivotal role in the production of biofuels, providing farmers with an additional source of income and bolstering rural economies. This, in turn, contributes to poverty alleviation and fosters inclusive growth, thereby enhancing the country's overall socio-economic resilience.

Moreover, the promotion of biofuels aligns with India's commitments to combat climate change and reduce greenhouse gas emissions. By transitioning from fossil fuels to biofuels, the country can significantly lower its carbon footprint and contribute to global efforts in addressing climate-related challenges. This also enhances India's standing in international climate negotiations and demonstrates its proactive role in promoting sustainable energy solutions. biofuels offer a viable and sustainable pathway towards enhancing India's energy security and achieving its national security objectives. By reducing dependence on imported fossil fuels, promoting rural development, and mitigating climate change impacts, the adoption of biofuels presents a win-win proposition for India's national security, economy, and environment. As the nation continues to pursue its energy goals, the sustainedsupport and

further development of biofuels will play a pivotal role in securinga resilient and self-reliant energy future for India.

Quantum of Agriculture Industry Waste

Agricultural industry waste typically includes various types of organic waste materials, such as crop residues, fruit and vegetable waste, straw, husks, shells, and other by-products generated during agricultural activities and food processing. These wastes can be significant, particularly in a large agricultural country like India. The amount of agricultural waste generated can vary significantly from year to year and across different regions in India due to factors like crop yields, weather conditions, and farming practices.

The maximum amount of agricultural waste comes from few major crops. We try to figure out the quantum of agro-residue from production data available on various state government websites. For more clarification we plot the amount of residue generation from different crops in vertical axis of figure 2 and different types of crops in horizontal axis.

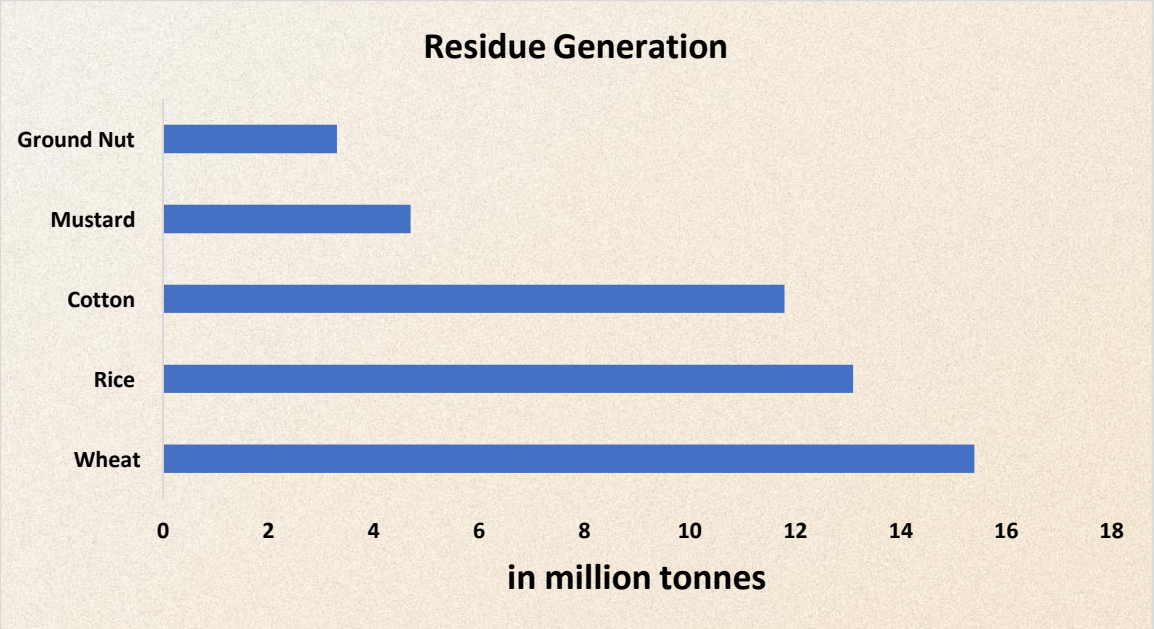


Figure-2 *Crop wise contribution of waste*

Wheat contributes largest fraction in total waste generation 15.4 million tonnes, followed by Rice 13.1, Cotton 11.8, Mustard 4.5, Ground Nut 3.8 million tonnes. These are the major crops that contributes great part of agro –residue.

In figure 3, This shows state wise generation of agricultural waste in million tonnes, Maharashtra securing the top position in generating agriculture waste,there various reason for producing large amount of agro residue such as Maharashtra has significant amount of agricultural land, large no. of farmers, scale of land holding is much larger than any other state. West Bengal is the 2nd most agro residue generator in India, west Bengal generate paddy straws atlarge scale.

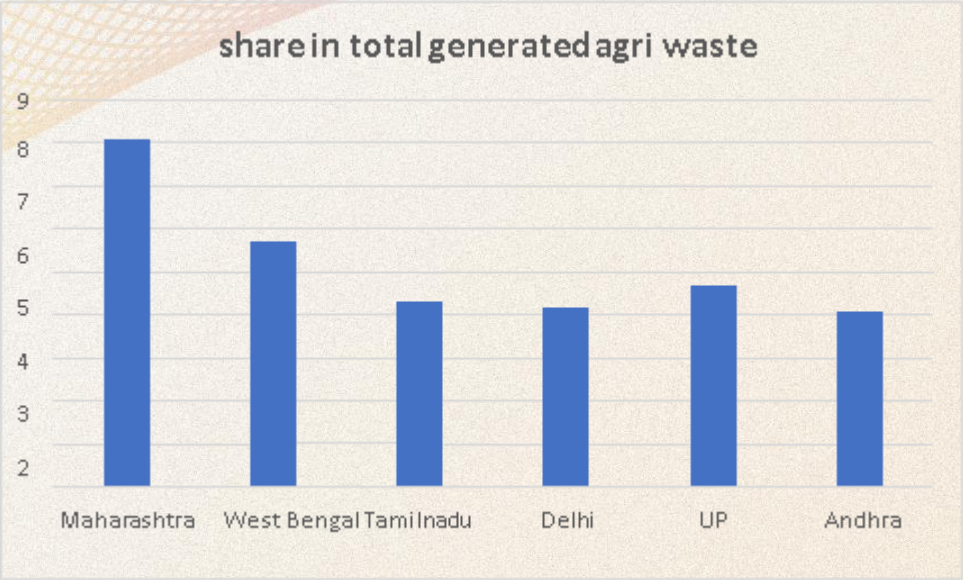


Figure 3: *State wise share in total generated agro waste*

The potential derivatives and capacities of organic agricultural waste depend on the scale of waste generation, the efficiency of waste collection and processing systems, and the market demand for the derived products.

Appropriate technologies and policies that support the sustainable management and utilization of organic agricultural waste can play a crucial role in maximizing the potential benefits and reducing the environmental impact of waste disposal.

Quantum of Dairy and Poultry Industry Waste

The amount of waste produced by these industries can vary based on factors such as the scale of operations, the number of dairy cows or poultry birds, and the efficiency of waste management practices. Both the dairy and poultry industries generate significant amounts of waste, including manure, bedding material, and other by-products. Dairy industry waste primarily consists of cow dung and urine, while poultry industry waste includes chicken manure and bedding material, meat industry, slaughter house waste.

Since India's poultry and dairy industry growing significantly in past 10 – 15 years, from production of milk and eggs to export of frozen meat, domestic demand for milk and meat also rises significantly in past few years. India has agreat potential to processed and use litter and by products of this industry. A cow weighing 450 kgs can produce up to 30kg of cow dung every day.

Numerous studies conducted on the potential of cow dung as an economic source have indicated that cow dung can be utilized as an organic fertilizer instead of chemical fertilizer in agriculture. Conversion of cow dung into vermin-compost will be an additional source of income for the farmer but will also replace chemical fertilizer and will enrich the environment. The sale of organic fertilizers increased at 4.8 percent CAGR between 2017 and 2021, withstates such as Madhya Pradesh, Maharashtra, Karnataka, Rajasthan, Uttar Pradesh, and Orissa accounting for a substantial portion of the Indian market. The organic fertilizers market in India is projected to expand, by value, at 7 percent CAGR during the forecast

period of 2022 to 2032.

For better understanding of relationship between animal by-product and production of bio-fuel, we have taken an example of a small village where 12household has small bio-gas plant under GOBARDHAN scheme as shown in table 1, Our model shows that the relationship between number of cows, to cow dung per day and their production capacity. Here we have assumed that feeding capacity of an animal is 100% and an average cow weigh range between 400-450 kg excrete around 18 kg of dung per day. The production potential of Bio-Fuel from 1 kg of cow dung is 0.04 m^3 that means for producing 3 m^3 of bio-gas we need 75 kg of cow dung. The quality of bio gas generated from cow dung is good, it contains 60% of CH4 (Methane).

Table 1. Relationship between cow dung and bio-fuel production

Sample	Number of Cows	Cow Dung Production (in kg) /Day	Cow Dung used in production /Day	Remaining Cow Dung	Bio-fuel production from used Cow Dung/Day	Feeding capacity of an animal
S1	15	270	216	54	8.64	100%
S2	18	324	259	65	10.36	100%
S3	12	216	173	43	6.92	100%
S4	8	144	115	29	4.6	100%
S5	17	306	244	62	9.76	100%
S6	9	162	131	31	5.24	100%
S7	10	180	136	44	5.44	100%
S8	8	144	115	29	4.6	100%
S9	13	234	187	47	7.48	100%
S10	17	306	244	62	9.76	100%
S11	16	288	232	56	9.28	100%
S12	15	270	216	54	8.64	100%
SUM	**158**	**2844**	**2268**	**576**	**90.72**	

The random collection of data that supports our model and given sample is sufficient to present a model of small village because information is related with small farmer of cattle ranging between 5 to 20 number of cattle. This table depicts that around 20 percent of cow dung is used for other purpose get wasted, that were not used as feed stock for bio- fuel plant. So, we subtracted that from total volume of cattle dung and left over actual volume of used cow dung that used in production process.

Now, for robustness of our model we set

X= Independent variable (amount of cow dung used in production process)

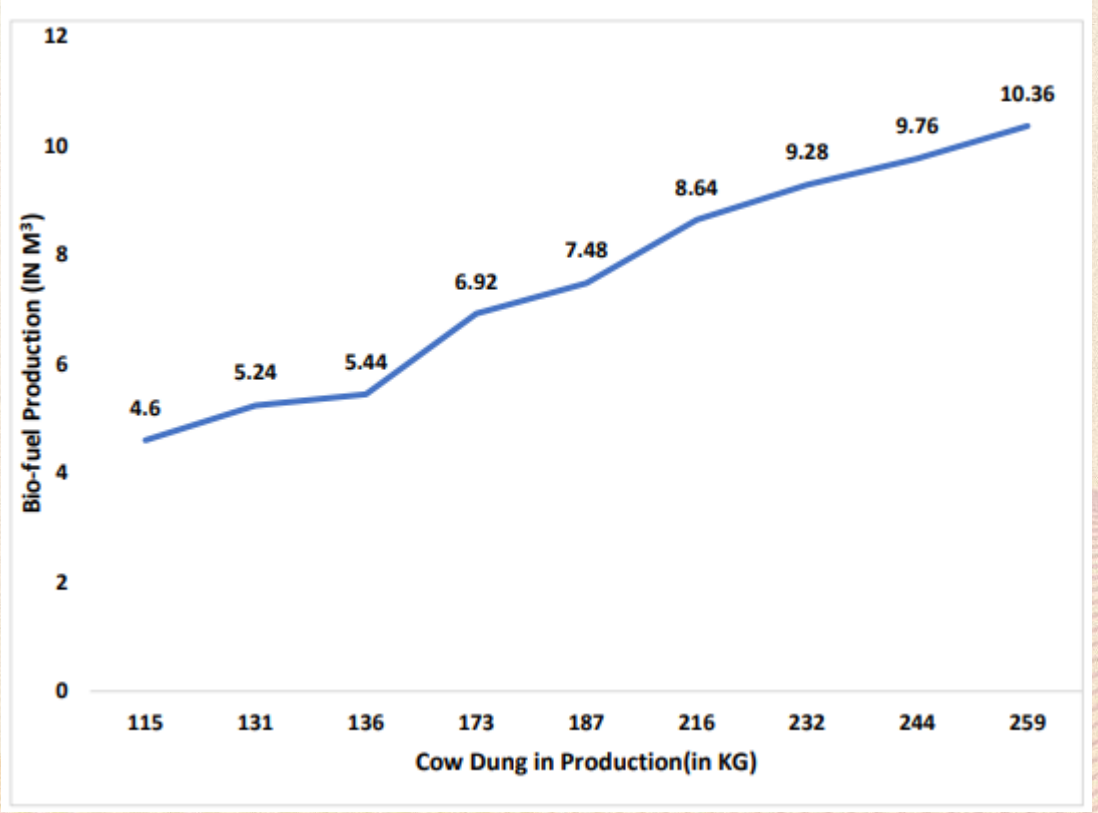
Y= Dependent variable (Bio- fuel produced from used cow dung)

After regressing X on Y we get value of R2 = 1, that means our model is best fit and it accurately explain the relationship between dependent and independent variable. So we can easily interpret the strong positive correlation between number of cows and the amount of cow dung produced. Similarly, it also signifies that number of cows is directly proportion to household income andHouse hold income strongly correlates with no. of cows and cow dung production.

Summary Output

Regression Statistics	
Multiple R	1
R Square	1
Adjusted R Square	1
Standard Error	4.81097E-16
Observations	11

This result shows that used cow dung can give multiple benefits such as (i) production of Bio-gas, (ii)Improvement in physical environment, cleanliness and (iii) Residue left after anaerobic digestion as Bio-fertilizer, helps in betteryield, better soil health.



The organic waste generated by poultry industry and abattoir shops holds significant potential for energy recovery and the production of valuable products such as protein hydrolysates, enzymes, and lipids. However, to fullyharness this potential, proper collection and treatment

of these wastes are essential. Also, Poultry litter and manure appear to possess a greater energy density compared to other types of animal manure. Poultry manure consist of 65% of CH_4 (methane). Nonetheless, a major drawback of this technology is the elevated nitrogen content in poultry waste, which can result in undigested proteins converting into total ammonia nitrogen. Moreover, the efficiency of biogas production through anaerobic digestion is influenced by various factors such as temperature, carbon-nitrogen ratio, organic load, and pH value, presenting further challenges in its utilization.

Traditional Ways to Manage the Waste

Throughout history, traditional methods of organic waste management have been utilized for generations, adapting to diverse cultural, geographical, and socioeconomic conditions. These approaches are typically uncomplicated, cost-effective, and have been inherited through the ages. Several customary ways to handle organic waste include:

Composting, an ancient and widely practiced technique of organic waste management, involves collecting kitchen scraps, crop residues, and animal manure in a designated area. Over time, these materials decompose and transform into nutrient-rich compost, beneficial for agriculture and gardening. Incineration waste management is a waste treatment method that involves the controlled combustion of solid waste at high temperatures. This process is designed to reduce the volume of waste and convert it into inert ash and gases, which can then be safely disposed of or used for energy generation.

During incineration, the waste is burned in specially designed incinerators that provide optimal conditions for combustion. The high temperatures (typically between 800°C to 1000°C) ensure the complete destruction of organic matter and pathogens, minimizing the risk of pollution and the spread of diseases.

Another traditional approach is utilizing organic waste as animal feed, which reduces pressure on other feed sources and converts waste into valuable products like milk and meat. In certain traditional systems, organic waste undergoes anaerobic digestion in pits or containers with limited oxygen, generating biogas for cooking and lighting. Vermicomposting, employing earthworms to break down organic waste into nutrient-rich vermi-compost, supports soil fertility. In agriculture, mulching involves spreading straw, leaves, and crop residues on soil surfaces, benefiting moisture retention, weed suppression, and soil health. While some traditional practices involve burning organic waste for disposal and pest control, this method releases harmful pollutants and is not environmentally friendly. Certain cultures use fermentation to produce traditional alcoholic beverages or pickled food products from organic waste. Burial or trenching allows organic waste to naturally decompose, returning nutrients to the soil.

Despite the merits of traditional methods, they may not always be efficient or eco-friendly, especially with increasing waste volumes and urbanization. Modern waste management practices, like centralized composting, anaerobic digesters, and recycling programs, offer more sophisticated and sustainable solutions to address organic waste management challenges in an ever- changing world.

The long-standing traditional approaches to solid waste management encounter numerous

difficulties and issues in today's context of rising waste production and urban development. Some of the primary challenges and problems associated with these conventional methods are as follows: Inefficient Waste Collection, the traditional methods often rely on manual waste collection, which can be inefficient and time-consuming, leading to irregular waste collection and accumulation of waste in public spaces. Lack of Segregation: Proper waste segregation is essential for effective waste management, but traditional methods may not prioritize or enforce waste segregation, leading to the mixing of different types of waste and making recycling and composting difficult. Open Dumping and Burning: In many traditional waste management practices, waste is openly dumped or burned, causing environmental pollution, greenhouse gas emissions, and health hazards due to the release of toxic fumes and pollutants. Urbanization Challenges: As urban areas grow, traditional waste management methods maystruggle to cope with the increasing volume of waste generated, leading to the overflow of waste in public spaces and inadequate waste disposal.

In conclusion, while traditional methods of solid waste management have been part of communities for a long time, they often face various challenges in meeting the demands of modern waste generation. Adopting more advanced and sustainable waste management practices, such as recycling, composting, and waste-to-energy technologies, can help address these challenges and promote more efficient and environmentally friendly waste management systems.

Transition from Traditional to More Scientific Ways

In response to the rising challenges of escalating waste generation, urbanization, and environmental issues, modern scientific techniques for solidwaste management have come to the forefront. These advanced methods prioritize effective waste collection, segregation, recycling, and resource recovery, all while minimizing the negative impacts on the environment and public health. The following are the major methods and techniques that are different from the traditional methods. These methods are cost effective, environment friendly, public health oriented and based on the concept of waste to wealth.

Source Segregation, modern waste management begins with source segregation, where households and businesses are encouraged to separate their waste into different categories, such as organic, recyclable, and non- recyclable materials. This practice facilitates easier handling and processing of waste streams, enabling better resource recovery. Recycling is a cornerstone of modern waste management. It involves the collection, processing, and conversion of recyclable materials like paper, plastic, glass, and metal into new products. Recycling reduces the demand for raw materials, conserves energy, and minimizes landfill waste. Waste-to-energy technologies involve the conversion of non-recyclable waste into energy sources, such as electricity andheat. Processes like incineration and gasification use the heat generated from burning waste to produce energy, which can be utilized for power generation or district heating.

Anaerobic digestion is a biological process that converts organic waste, such as food waste and sewage sludge, into biogas and nutrient-rich digestate. Biogas, primarily composed of methane, can be used as a renewable energy source, while digestate can serve as a biofertilizer. This gains more importance and effect in past few decades and one of the best

ways to proper management of waste.

Waste Reduction and Minimization: Modern waste management strategies emphasize waste reduction and minimization through initiatives like product redesign, extended producer responsibility (EPR), and waste prevention campaigns. By reducing waste at the source, the burden on waste management systems is alleviated. If waste generation should be minimized at the initial phase of waste generation that would be the best way to utilize waste management concept. It needs to be more focused. With the increasing proliferation of electronic devices, the management of electronic waste (e- waste) has become a significant concern. Modern methods involve proper dismantling, recycling, and safe disposal of e-waste to prevent hazardous materials from entering the environment. Effective waste management requires active public participation and awareness. Modern approaches involve public education campaigns to promote responsible waste disposal and the importance of recycling. Technological Innovations: Ongoing research and technological advancements continually enhance waste management practices. Innovations in waste sorting, automated collection systems, and data analytics optimize waste management operations and resource allocation.

Advanced scientific approaches to solid waste management provide all- encompassing and sustainable solutions to the issues arising from escalating waste generation. These methods prioritize the recovery of valuable resources, safeguarding the environment, and conserving energy, thus paving the path towards a cleaner and more sustainable future. Ongoing research and active involvement of the public will play a pivotal role in continuously enhancing waste management practices and effectively tackling new waste-related challenges.

In order to give momentum to clean India initiative/ Swachh Bharat Mission, Indian government starts promoting modern Compressed Bio Gas plants to major cities in every state of the country. Government pledged to provide proper financial assistance for private players in this industry. State sponsored plants also gaining highlight in many parts of the county after this scheme has started. Table 2 depicts the same.

Table 2: year wise status of bio-gas completed and functional

Year	Functional	Completed
2023-2024	3	**64**
2022-2023	4	**176**
2021-2022	5	**97**
2020-2021	6	**191**
2019-2020	7	**100**
2018-2019	8	**14**
2017-2018	9	**0**
2016-2017	10	**0**
2015-2016	11	**0**

2014-2015	12	**0**
2013-2014	13	**0**
2012-2013	14	**0**
Prior to 2012-2013	15	**0**
Total	**16**	**642**

Source - DDWS

As we can see from table 2 after the 2017-2018 CBG plants in India taking shape in significant numbers and in nearby year it will be effective up to some extent. CBG plant are equipped with latest technological advancements. The mechanism of a CBG plant involves a well-coordinated process that efficiently converts organic waste into a clean and renewable energy resource. Through this mechanism, CBG plants contribute to waste management, renewable energy generation, and environmental sustainability. Compressed Bio Gas (CBG) primarily consists of methane, with a methane content exceeding 90%, along with other gases such as carbon dioxide, which constitutes less than 4% of the composition. CBG is generated through the anaerobic digestion process, utilizing biomass and waste materials such as agricultural residue, cattle dung, sugarcane press mud, municipal solid waste, and sewage treatment plant waste. The biogas produced is further purified to eliminate hydrogen sulphide (H2S), carbon dioxide (CO2), and water vapour. Subsequently, the purified biogas, with a methane content of more than 90%, is compressed to a maximum pressure of 250 bar and stored in groups of high-pressure cylindrical vessels known as cascades, thereby forming Compressed Bio Gas or CBG. Thereare multiple chemical reactions occurs during the whole process CBG production. One of the major reactions is hydrolysis. The hydrolysis reaction breaks down organic molecules like carbohydrates, proteins, and fats into glucose, amino acids, and fatty acids, respectively. Acidogenesis follows, where bacteria help convert these small organic molecules into volatile organic acids.

In the Acetogenesis process, bacteria in the acetic group digest volatile organic acids and produce acetic acid. Finally, anaerobic bacteria in the methanogenic group complete the Methanogenesis process by converting acetic acid into methane gas, along with other gases like carbon dioxide and hydrogen sulphide.

Anaerobic Digestion technology, it is one of the important phases in making CBG. An Anaerobic Digester is a device designed to enhance the anaerobic digestion process of biomass and produce biogas for energy production. These digesters can be constructed using various materials such as concrete, steel, brick, or plastic and come in different shapes like silos, troughs, basins, or ponds. They can be installed either underground or on the surface. Despite the different designs, all anaerobic digesters consist of essential components, including a pre-mixing area or tank, a digester vessel(s), a system for utilizing the biogas, and a system for distributing or spreading the remaining digested material, known as effluent.

In order to improve the calorific value and energy content, methane concentration shall be increased and in turn CO2 & hydrogen sulphide (H2S) shall be removed. Some of the available technologies for removal of H2S are Iron chloride dosing, Water scrubbing,

Activated Carbon and Amine Process. Few scientific methods are adopted in that process such as PSA (Pressure Swing Technology), VSA (Vacuum Swing Adsorption), Water scrubbing, Membrane Separation etc. After cleaning the fuel, it is transferred for bottling, CBG bottling unit will consist of High-Pressure compressor and Cascade of storage cylinders. Dried and purified form of biogas goes into the suction of High-Pressure Compressor, where it compresses the gas to desired working pressure (~250 Bar). The compressed biogas will be stored in a cluster of high- pressure cylindrical vessels known as cascades. These cascades can hold 3000 litres of CBG or can have even larger capacities, and they will be used for the delivery of CBG.

Compilation of Prevailing Policies and their Effect

Production Trend of CBG, Bio-Methanation, FOM

The production trend of Compressed Biogas (CBG), Bio-Methanation, and Fermented Organic Manure (FOM) in India has been witnessing significant growth in recent years. The Indian government's initiatives and policies promoting renewable energy, waste management, and sustainable agriculture have contributed to this upward trajectory. The CBG sector in India received significant impetus with the launch of the Sustainable Alternative towards Affordable Transportation (SATAT) initiative by the Ministry of Petroleum and Natural Gas in 2018. As of March 2023, there are 58 operational CBG plants in India, and 3,694 potential investors have been issued letters of intent to establish similar plants.

Table 3 State-Wise Distribution of Bio-Gas Plants

Sl. No.	State Name	Total Installed Capacity of Bio-Gas (in m3)	Total Installed Capacity of commercial CBG Plants (in kg)
1	A & N Islands	0	0
2	Andhra Pradesh	0	9780
3	Arunachal Pradesh	0	0
4	Assam	163	0
5	Bihar	620	0
6	Chhattisgarh	4513	1425
7	D & N Haveli and Daman & Diu	0	0
8	Goa	0	0
9	Gujarat	10800	86866
10	Haryana	1090	38450
11	Himachal Pradesh	765	0
12	Jammu & Kashmir	150	0

13	Jharkhand	113	0
14	Karnataka	1456	33321
15	Kerala	844	0
16	Ladakh	0	0
17	Lakshadweep	0	0
18	Madhya Pradesh	843	42100
19	Maharashtra	330	107523
20	Manipur	0	0
21	Meghalaya	0	0
22	Mizoram	0	0
23	Nagaland	0	0
24	Odisha	0	0
25	Puducherry	50	0
26	Punjab	750	74847
27	Rajasthan	40	4000
28	Sikkim	0	0
29	Tamil Nadu	346	59800
30	Telangana	0	16200
31	Tripura	745	0
32	Uttar Pradesh	2785	73444
33	Uttarakhand	109	8880
34	West Bengal	103	16000
Total		**26615**	**572636**

Table 3 shows the expansionary pattern of bio gas plants in India in terms of production capacity in different states. We can clearly interpret that still there are many states where need of promoting the bio gas plants are necessary, they are lagging behind many leading states hence waste generation rate and quantity is significant in those state as well. India Bio-gas potential is very large, currently more than 5 million small and large Bio-gas plant is operationalin India. Maharashtra, Gujarat, Karnataka, Uttar Pradesh and Madhya Pradesh are the leading states that have most of the bio gas plants.

India Bio-gas market size is valued at 1.40 billion USD. The expected growth of Bio-Fuel industry from 1.42 billion USD to 2.25 billion USD in 2029 at a CAGR of 6.3% in 2022-29 per year. The expected growth of this industry is still very less as compared to other sector,

industry growth rate forecast.

The growth of this sector is directly proportional to population awareness of environmental protection and desirable for renewable energy. India Bio-gas potential is very large, currently we can generate more than 1800 MW of power each year and tonnes of bio- fertilizer. But currently actual production is very less than its potential, between 29 to 48 billion m^3. It is steadily grown over year.

Major Determinant to Achieve Desired Optimum Output

The achievement of desired optimum output for India in the Compressed Biogas (CBG) industry and Municipal Solid Waste (MSW) management depends on several key determinants such as high capital expenditure required by industry player to build a production unit and well managed waste acquisition.

The reliable availability of high-quality raw materials is a crucial factor that affects the profitability and efficiency of a bio-CNG facility. However, the limited window of 30-40 days for gathering agricultural feedstock and the uncertainty of feedstock prices present challenges in sustaining the financial viability of the plant. Farm machinery such as tractors, rakers, balers, loaders, and trailers are used for harvesting agricultural residue. However, there is a shortage of such machinery on the ground for harvesting and transporting the feedstock to biogas plants.

Costly financing/lack of robust finance chain. Establishing a bio-CNG plant requires a significant amount of capital investment. Despite being categorized as a priority sector for lending by the Reserve Bank of India, banks offer high- interest rates for loans related to bio-CNG. Additionally, only a limited numberof private-sector banks are willing to provide loans for these projects.

Inefficiency in source segregation of feedstock, Inefficient source segregation of municipal solid waste is a problem for biogas plants because it can lead to the contamination of the feedstock used in the biogas production process.

When waste is not properly sorted, it may contain non-biodegradable materials, such as plastics and metals, which can damage the equipment usedin the biogas plant and reduce the efficiency of the biogas production process.In addition, organic waste that is mixed with non-organic waste may not be able to produce high-quality biogas, which can affect the overall output of thebiogas plant.

Lack of indigenous equipment availability, a significant portion of the equipment and machinery needed for bio-CNG plants, including digester fabrics, biogas upgrading units, storage tanks, compressors, dispensers, and monitoring and control systems or software, is commonly sourced from overseas and may have restricted availability. This can present a hurdle for setting up and running bio-CNG plants, especially in regions like India where the local manufacturing industry for such equipment is not well-established. Importing these components may result in higher costs, longer lead times, and potential disruptions in the supply chain.

Lack of single window clearance, the establishment of a bio-CNG plant is influenced by the

requirement of a comprehensive set of regulatory approvals involving various ministries such as the Ministry of Environment, Forest and Climate Change, Ministry of New and Renewable Energy, Ministry of Petroleum and Natural Gas, Ministry of Agriculture, and state-level pollution control boards, among others. This can lead to a lengthier and more intricate process of obtaining the necessary permits and clearances for setting up and operating a bio-CNG plant. Seeking approvals from multiple agencies poses challenges for investors and operators of bio-CNG plants, including delays and heightened costs associated with compliance and coordination with regulatoryauthorities.

Lack of consumer of CNG in rural areas, one of the obstacles to the widespread adoption of bio-CNG in rural regions is the scarcity of CNG consumers. Unlike urban areas where there is a substantial demand for CNG as a transportation fuel, rural areas may not have enough demand for CNG due to lower population density and limited availability of CNG vehicles. As a result, the economic feasibility of bio-CNG plants in rural areas may be constrained, as the expenses associated with producing and distributing CNG might not be adequately balanced by the revenue generated from sales, low procurement of Bio-fertilizer is also an issue to achieve our targeted goal.

By addressing these key determinants, India can enhance the performance of the CBG industry and MSW management, contributing to sustainable development, environmental conservation, and energy security.

Case Study of an Ideal City in Waste Management – Indore (MP)

Indore, a vibrant city in the state of Madhya Pradesh, India, has earned recognition as a model city for its innovative and effective Municipal Solid Waste (MSW) management practices. At the forefront of this transformation is the Indore Compressed Biogas (CBG) Plant, which showcases a remarkable example of utilizing MSW to produce clean energy while reducing the environmental impact. This case study delves into the Indore CBG Plant and how the city has successfully harnessed its MSW to create a sustainable and eco-friendly solution. Indore faced significant challenges in MSW management due to its rapid urbanization and population growth. The traditional methods of waste disposal were inefficient, leading to the accumulation of waste in landfills, polluting the environment, and posing health hazards. In 2018, Indore took a major stride towards sustainability with the establishment of the IndoreCBG Plant. The plant, designed and operated by a public-private partnership, focuses on anaerobic digestion to convert organic waste into biogas. The process utilizes cutting-edge technology, including large-scale digesters and advanced waste segregation techniques, to maximize biogas production.

Indore introduced a robust waste collection system that emphasizes source segregation at the household level. Residents are educated and encouraged to separate organic waste from non-biodegradable materials, ensuring a high- quality feedstock for the CBG plant. An efficient waste collection network ensures regular pickups and the transportation of segregated waste to the plant. The CBG plant employs a multi-stage anaerobic digestion process to break down organic waste, such as kitchen scraps, agricultural residues, and municipal solid waste, into biogas. High-pressure digesters provide the ideal conditions for bacterial decomposition, converting the organic matter into methane-rich biogas. The produced biogas is purified to

remove impurities like hydrogen sulphide and carbon dioxide, resulting in high-purity methane. This compressed biogas (CBG) is then utilized as a clean and eco-friendly alternative to traditional fossil fuels. The CBG powers vehicles, public transportation, and other industrial applications, contributing to reduced greenhouse gas emissions and promoting a greener environment. Indore Municipal Corporation (IMC) utilizes a fleet of 600 vehicles for waste collection, and their efforts have been fruitful, resulting in a low production cost of bio-CNG, estimated at Rs 35-40 per kilogram. The plant employs rooftop solar panels to generate 20% of its power needs, while the remainder is sourced from the power grid. Furthermore, the company sells manure at a net rate of Rs 1,800 per tonne. To maintain a steady supply of segregated waste, IMC provides 90% of the waste to the plant, and in return, EverEnviro, the plant operator, pays them an annual royalty of Rs 2.5 crore.

The Indore CBG Plant has brought about remarkable environmental and socio- economic changes in the city. By diverting organic waste from landfills, the plant has reduced the emission of harmful methane gases, contributing to improved air quality and reduced pollution. Additionally, the CBG plant has created employment opportunities and promoted local entrepreneurship in the biogas sector.

The Indore CBG Plant serves as an inspiration for other cities facing difficulties in managing municipal solid waste. With its streamlined waste collection, separation, and anaerobic digestion techniques, Indore has established a remarkable benchmark for efficient MSW management. The city's achievements highlight the significant opportunities in utilizing MSW to generate clean energy, paving the way for a sustainable and eco-friendly future in urban areas, not only in India but also worldwide.

Conclusion

The introduction highlights the urgent environmental challenges posed by rising temperatures and pollution due to the increasing global population and economic growth. Waste management is a critical global issue, especially in India, which produces substantial amounts of waste. The GOBARDHAN Scheme, part of the Swachh Bharat Mission, aims to address this challenge by converting organic waste into valuable resources like biogas and bio-methane, fermented organic manure. The paper aims to assess the significance of biofuels in India's energy security strategy and analyses the potential of agricultural and industry waste for biofuel production. The study also examinesmodern waste management practices and the production trends of CBG, Bio- Methanation, and FOM in India, considering the impact of government policies. biofuels play a crucial role in India's national security strategy by reducing dependence on imported fossil fuels, enhancing energy security, and mitigating geopolitical risks. Agricultural industry waste, primarily from major crops like wheat and rice, offers significant potential for biofuel production.

Additionally, the dairy and poultry industries generate substantial waste, such as cow dung and poultry manure, which can be utilized for biofuel production, contributing to rural development and employment generation.

The traditional methods of solid waste management have been practiced for generations and include techniques like composting, incineration, and using organic waste as animal feed.

While these methods have their merits, they face challenges with increasing waste volumes and urbanization. Modern scientific approaches to waste management prioritize source segregation, recycling, waste-to-energy technologies, and waste reduction. These advanced methods offer more sustainable solutions to manage organic waste and promote environmental protection. The production trend of Compressed Biogas (CBG) and other bio-fuel technologies in India has seen significant growth, driven by government initiatives like the Sustainable Alternative towards Affordable Transportation (SATAT). However, there are challenges to achieve desired outputs, such as high capital expenditure, lack of indigenous equipment availability, and inefficiency in source segregation of feedstock.

Addressing these determinants can enhance the performance of the CBG industry and MSW management in the country. The city of Indore in Madhya Pradesh has become a model for effective MSW management with its innovative Indore CBG Plant. The plant uses anaerobic digestion to convert organic waste into biogas, which is then purified and used as a clean and eco-friendly fuel for vehicles and industrial applications. Indore's success demonstrates the potential of using MSW to produce clean energy and promote sustainable waste management practices in urban areas.

Policy Recommendation

To address the urgent environmental challenges posed by waste management and to harness the potential of biofuels for India's energy security strategy, a comprehensive and integrated waste management approach is recommended.This approach should encompass the following key policies and measures,

1. **Strengthening the GOBARDHAN Scheme:** The government should continue to support and promote the GOBARDHAN Scheme as part of the Swachh Bharat Mission. This scheme aims to convert organic waste into valuable resources like biogas and bio-methane, fermented organic manure. The government should allocate sufficient funds and resources to ensure the successful implementation of the scheme in both urban and rural areas.
2. **Incentives for Biofuel Production:** The government should provide financial incentives and subsidies to encourage the production of biofuels from agricultural and industry waste. This could include tax benefits, grants, and low-interest loans for setting up biofuel production units. Additionally, the government should create a supportive policy framework to attract private investments in the biofuel sector.
3. **Research and Development:** The government should invest in research and development in the biofuel sector to explore new and advanced technologies for efficient biofuel production. This could include funding for research institutions, universities, and private companies to developinnovative biofuel technologies.
4. **Infrastructure Development:** The government should invest in developing the necessary infrastructure for the biofuel sector, including biogas plants, waste collection and transportation systems, and distribution networks for biofuels. This will facilitate the smooth and efficient production and distribution of biofuels.

5. **Collaboration and Public-Private Partnerships:** The government should encourage collaboration between the public and private sectors to drive innovation and investment in the biofuel and waste management sectors. Public-Private Partnerships (PPPs) can help leverage expertise and resources from both sectors for sustainable waste management practices.
6. **Monitoring and Evaluation:** The government should establish a robust monitoring and evaluation mechanism to assess the impact and effectiveness of waste management policies and biofuel production initiatives. Regular audits and performance evaluations will help identify areas for improvement and ensure accountability.

The growth and integration of city gas distribution (CGD) networks with bio- CNG plants present significant advantages. This synergy would create a dependable market for CBG producers, ensuring effective utilization of their product, minimizing transportation losses, and reducing the expenses associated with unsold inventory. There is a necessity to implement a policy that mandates fertilizer companies to procure bio-CNG fertilizer at a set price, similar to the SATAT program for CBG procurement. Additionally, initiatives should be introduced to encourage the adoption of bio-fertilizers over synthetic options like urea. These steps would substantially improve the market value and demand for bio-CNG fertilizer while reducing dependency onchemical fertilizers, leading to numerous environmental advantages.

By implementing this integrated waste management approach, India can effectively address its waste management challenges, reduce dependence on imported fossil fuels, enhance energy security, and contribute to environmental sustainability. The promotion of biofuels from agricultural and industry waste will not only drive economic growth but also support rural development and employment generation.

References:

1. Kübler, Hans, and Cosima Schertler. "Three-phase anaerobic digestion of organic wastes." Water Science and Technology 30, no. 12 (December 1, 1994): 367–74. http://dx.doi.org/10.2166/wst.1994.063
2. Baynosa, Marjorie, Gladys Anne Bondoc, Leandro Angelo Miguel Sanchez, and Analiza Rollon. "Methane Generation via Two-Phase Anaerobic Digestion of Organic Fraction of Municipal Solid Wastes." Advanced Materials Research 1051 (October 2014): 317–21. http://dx.doi.org/10.4028/www.scientific.net/amr.1051.317.B
3. Bolzonella, D., P. Pavan, S. Mace, and F. Cecchi. "Dry anaerobic digestion of differently sorted organic municipal solid waste: a full-scale experience." Water Science and Technology 53, no. 8 (April 1, 2006): 23–32. http://dx.doi.org/10.2166/wst.2006.232.
4. Singh ghanshyam siddarth, Jawed kaiffee. “GOBAR-Dhan: scheme announced in budget a welcome step, but challenges ahead” https://www.downtoearth.org.in/blog/waste/gobar-dhan-scheme- announced-in-budget-a-welcome-step-but-challenges-ahead-8
5. https://www.deccanherald.com/business/union-budget/gobardhan- scheme-to-promote-circular-economy-with-investment-of-rs-10000- crore-fm-1186768.html
6. Jain, Rahul, “GREENING INDIA’S ENERGY MIX WITH COMPRESSED BIOGAS (CBG)” http_____cdn.cseindia.org_attachments_0.64106100_1681453616_greening-indias-new-energy-mix-low-res
7. Outlook for biogas and Prospects for organic growth World Energy Outlook Special Report biomethane.
8. Cedigaz (2019). Global biomethane market: Green gas goes global (press release, 20 March). https://www.cedigaz.org/global biomethane- market-green-gas-goes-global/ Global biomethane market: green gas goes global - Cedigaz
9. World Bank. (2014). Clean and improved cooking in sub -Saharan Africa: A landscape report. http://documents.worldbank.org/curated/en/1642414681787574 64/Clean -and -improved -cooking -in -Sub -Saharan -Africa-a landscape-report
10. Joris Koornneef, Pieter van Breevoort, Paul Noothout, Chris Hendriks, uchien Luning, Ameena Camps, Global Potential for Biomethane Production with Carbon Capture, Transport and Storage up to 2050,Energy Procedia, Volume 37,
11. IEA (International Energy Agency). (2019a). Renewables 2019. https://www.iea.org/reports/renewables-2019.
12. GMI (Global Methane Institute) (2019). https://www.globalmethane.org/partners/partner.aspx?c=india,(accessed 1 July 2019).
13. Giuntoli J. et al. (2015). Solid and Gaseous Bioenergy Pathways: Input Values and GHG Emissions. Italy: European Commission Joint Research Centre, Institute for Energy and

Transport, Ispra. https://ec.europa.eu/energy/sites/ener/files/documents/Solid%20and%20gaseous%20bioenergy%20pathways.pdf.

14. Waste to Energy Programme “Programme on Energy from Urban, Industrial and Agricultural Wastes/Residues” Government of India.

Tanisha Gupta

M.A. in Public Administration, Jamia Millia Islamia, New Delhi.

Mentored by Dr. Rajiv Kumar, Former Vice Chairman, NITI Aayog.

Domain for Internship: Public Policy & Governance

Cultivating Prosperity: Transforming the Agriculture Sector for Productivity and Profit

Despite agriculture being the country's backbone, only 5% of the youth engage in agricultural activities. This research study explores the challenges faced by the agricultural sector in India, particularly in attracting and retaining youth involvement. The study identifies key factors contributing to this disinterest, including low profitability, drudgery of farm operations, poor quality of life in the rural area and diminishing land holdings. Urban allure further diminishes interest unless economic opportunities are available. Further, research delved into organic farming government initiatives, and precision farming's impact on productivity. Noteworthy models like the Sahyadri Model of Aggregation, Attracting and Retaining Youth in Agriculture (ARYA), and Small Farmers Agribusiness Consortium (SFAC) are discussed. Emphasis is placed on the role of rural youth in global food security, noting a concerning trend where few envision a viable future in agriculture. The study advocates for initiatives like ARYA, strengthening FPOs, and integrating advanced technologies (AI, IoT, machine learning, and big data analytics) for evidence-based actions recommending collaboration with industry experts to academicians, fostering specialized service providers and startups, tailored skill development programs, data-driven decision-making tools, and overcoming technology barriers to revolutionize agriculture and enhance the appeal of rural livelihoods for the youth.

Keywords: organic farming, precision farming, stakeholders, youth, agriculture, India.

Seeds of Prosperity: Innovative Strategies for Boosting Productivity and Profitability in Agriculture"

In the countryside, it's common to see farmers working hard to produce food, which is a very important job. However, if you look closer and talk to farmers, you'll notice that there aren't many young people working on farms anymore. There has been integration of young people in the manufacturing sector, in the service sector but not in the agricultural sector yet. The laborious nature and lack of prestige associated with agricultural work, coupled with the allure of alternative opportunities in urban settings, often prompt young individuals to migrate away from rural regions. Farmers in India are predominantly over the age of 40, which highlights a significant challenge faced by the agriculture sector and the population relying on their produce. The average age of Indian farmers was 50.1 years in 2016, and this trend is concerning as the younger generation is increasingly abandoning farming as a profession. This situation poses a potential future where India, a major consumer of food, will have a scarcity of farmers. Presently, both middle-aged and young individuals are turning away from agriculture, indicating a potential absence of the next generation of farmers. In 2011, 70% of Indian youths resided in rural areas where agriculture served as the primary livelihood. However, the 2011 Census reveals that 2,000 farmers abandon farming each day. Furthermore, farmers' incomes are approximately one-fifth of those in non-farming occupations.

Facts: In India, agriculture is crucial to the economy, involving 54.6% of the workforce (Census 2011) and contributing 17.8% to the Gross Value Added in 2019-20 (current prices). In India, a significant majority, specifically 58%, of rural households rely on agriculture as their primary source of income. According to the Ministry of Statistics and Programme Implementation, during the 2017-18 period at current prices, the agricultural and allied sectors contributed 16.4% to the Gross Value Added. Farmers' households earn an average monthly income of Rs. 6426, with cultivation contributing to 47.9% of this income.

Historically, the agricultural sector concentrated on enhancing farm productivity. Nowadays, the emphasis has shifted from simply increasing farm output to generating higher returns on investments. Nonetheless, the agricultural landscape in India confronts several obstacles that hinder the acceleration of agricultural growth. These challenges encompass issues such as subpar farm productivity, restricted access to inputs and markets, land fragmentation, depletion of natural resources, the impact of climate change, unprofitable pricing, and limited potential for value addition.

In light of these circumstances, the Centre for Study of Developing Societies, headquartered in Delhi, discovered that a significant majority of farmers in the country would opt for alternative employment if given the opportunity. Based on a survey conducted across 18 states involving 5,000 farming households, the results indicate that 76% of farmers would choose a profession other than farming, and within this group, 61% prefer urban employment. This phenomenon leads to a trend known as "feminizing agriculture," wherein women

become increasingly engaged in agricultural and related activities. Census data from 2011 demonstrates a 24% rise in the number of female agricultural laborers between 2001 and 2011, marking an increase from 49.5 million to 61.6 million.

Consequently, a dual challenge arises. On one hand, there exists a necessity to diversify agriculture to enhance its profitability through a focus on value addition and processing. On the other hand, rural youth are progressively distancing themselves from the agricultural sector.

Youth

The pivotal role in the anticipated transformation of agriculture in India is expected to be played by the younger generation. As defined by the national youth policy, individuals falling within the age bracket of 15 to 35 are categorized as young. Currently, 35% of the overall population belongs to this age group, with 75% of them residing in rural regions. The migration rate of rural youth to urban centers stands at approximately 45% nationwide, and it is estimated that merely 5% of the youth are involved in agricultural activities. In developed nations, the proportion of skilled workforce ranges from 60% to 90% of the total labor force; in stark contrast, India's skilled workforce is a mere 5% within the age group of 20 to 24.

Empowering the youth to enhance their skills and encouraging their continued engagement in agriculture within rural settings presents a set of challenges. The establishment of successful economic models within villages is of paramount importance to inspire and motivate young individuals to take up entrepreneurial roles in rural areas and serve as guides to others in their vicinity.

Though instilling interest and fostering confidence among rural youth towards agriculture is a complex task, it is by no means unattainable. Numerous instances of profitable agricultural ventures have been demonstrated across various circumstances, serving as tangible evidence. The retention of youth within the realm of agriculture is thus intrinsically tied to the sector itself. A conspicuous upsurge in the migration of rural youth to urban locales is observable, driven by the perceived disparities in fundamental amenities, communication, healthcare, and educational facilities between rural and urban environments.

The reasons for the youth’s lack of interest in agriculture are low profitability ofagriculture, drudgery of farm operations, poor quality of life in the rural area and rapidly shrinking size of land holdings are the most significant among them. Dr. Singh also applauded that ecological balances are of paramount importance and need to be addressed. He expressed that reduction of migration of youth from rural areas to urban areas can be done, if sufficient employment opportunities are available in the village.

The Alarming Decline in Agricultural Interest among Indian Youth

Introduction:

A significant trend has emerged in India's agricultural sector, indicating a growing disinterest among the youth towards farming. This phenomenon, commonly referred to as the "Great Indian Agro Brain Drain," highlights the declining inclination of students graduating from agricultural universities to pursue careers in agriculture. Moreover, even those involved in

family farming or other agricultural activities do so out of compulsion rather than genuine interest.

Youth Perspective:

A study conducted by the non-profit organization Pratham revealed that a mere 1.2% of the surveyed rural youth aspired to become farmers, out of a total of 30,000 participants. Notably, 18% of boys expressed a preference for joining the military, while 12% aspired to become engineers. Similarly, 25% of girls, who play a crucial role in traditional farming, expressed a desire to become teachers instead.

Limited Enrolment:

The number of students enrolling in agricultural or veterinary courses across India accounts for less than half a percent of all undergraduate admissions. This statistic, shared by Madhav Chavan, the founder of Pratham, highlights the scarcity of educated and trained individuals within the agricultural workforce. Given that agricultural productivity lags significantly behind leading nations worldwide, there is an urgent need for a skilled and knowledgeable workforce in this sector.

Global Trend:

The issue of an aging farming population is not unique to India. Farmers worldwide are reaching retirement age without adequate successors in place. In the United States, the average age of farmers is 58, while in Japan, it is 67. Moreover, every third European farmer is over 65 years old. Similar to India, farmers across the globe are abandoning agriculture. For instance, in Japan, 40% of farmers plan to quit farming in the next six to eight years. The Japanese government has therefore initiated a large-scale plan to encourage individuals under 45 to take up farming.

The Importance of Reviving Indian Agriculture:

Revitalizing India's agriculture sector is undeniably one of the country's most critical agendas. The need to meet the growing food demand presents an unprecedented challenge. By 2050, when India's estimated population reaches 1.9 billion, more than two-thirds of the population will fall into the middle-income group, resulting in a doubling of food demand.

Implications:

The advancing age of farmers poses uncertain and unpredictable consequences for agricultural growth. However, this demand surge can be transformed into a significant income opportunity if India possesses a well-equipped workforce of farmers and appropriate technological support provided by its extensive educational institutions. The decline in interest among Indian youth towards agriculture, known as the "Great Indian Agro Brain Drain," calls for urgent attention. To ensure food security and meet future demands, it is crucial to revive the agricultural sector by encouraging young people to pursue careers in farming. This requires investments in education and training, as well as the development and dissemination of innovative technologies, thereby creating a sustainable future for Indian agriculture.

The TIGR2ESS Flagship Project 1 team at ICRISAT conducted a field survey in Warangal district, engaging with farmers, farm women, and rural youth through Focus Group Discussions (FGDs) and key informant interviews. The survey aimed to understand the aspirations of rural youth regarding their involvement in agriculture and their parents' aspirations for their children.

The study included three villages in Warangal, where agriculture serves as the primary source of livelihood for over 98% of households. In recent years, agriculture in the district has undergone significant transformations, including a shift from subsistence to intensive farming, water scarcity issues, rural-urban migration, and declining interest among youth in pursuing agriculture.

India's agricultural sector is of great economic importance, employing approximately 50% of the population and contributing around 17% to the country's gross domestic product (GDP). However, fewer young individuals are opting for careers in agriculture, and rural-to-urban migration among youth seeking employment opportunities is increasing. According to the World Bank, by 2050, half of India's population is projected to be urban, while the percentage of agricultural workers in the total workforce is expected to decline from 58.2% in 2001 to 25.7% by 2050. This demographic shift and the declining interest of rural youth in agriculture are raising concerns.

During the survey, it was found that most of the youth in the villages were graduates, primarily in arts and commerce subjects. Despite farming being the main family occupation, many of the youth were unemployed and expressed a desire to leave the villages in search of jobs. They considered agriculture a risky career option due to water scarcity and uncertainty regarding crop yields and market prospects. They expressed a preference for small jobs in nearby cities rather than following in their parents' footsteps as farmers.

Conversations with parents from farming families revealed similar sentiments. They did not want their children to pursue agriculture due to the hardships and challenges they had experienced. Parents expressed concerns about expenses, low profitability, high investment requirements, and frequent crop failures and losses. The aspirations of rural youth are vital to understand, as they contribute to overall well-being. High aspirations lead to forward-looking behavior and efforts to achieve a prosperous future, while low aspirations result in reduced efforts.

There is a need for more empirical studies on rural aspirations, particularly in developing countries like India, where agriculture is a significant livelihood activity. Understanding and nurturing these aspirations is crucial for improving the well-being of the rural poor, including youth. Rural youth migration exacerbates the challenges faced by the aging farming population and creates economic burdens in urban areas. Addressing these challenges requires efforts to upskill rural youth and involve them in agricultural activities, supported by comprehensive studies and assessments of their aspirations and training needs at the state and district levels.

The TIGR2ESS program conducted this research in Telangana's rural, peri-urban, and tribal areas to better understand rural youth aspirations. The findings aim to provide evidence-based

policy recommendations to government and development agencies for designing programs that enhance the well-being of rural youth.

$$Y = C + I + G + NX$$

"When youth can't find viable jobs in their communities, they begin to migrate from rural areas in search of opportunities in bigger cities or different countries"

A significant number of young individuals residing in developing and transition nations hold unfavorable views regarding agriculture. This lack of interest can be attributed to their perception of farming as outdated and financially unviable. Historically, the agricultural sector has been associated with subsistence farming, where individuals cultivate crops solely for their own sustenance rather than as a commercial enterprise. As a result, the youth fail to perceive agriculture as a profitable business opportunity.

Women in Agriculture in India

The intentional decision to focus on young women emphasises their significant role in agricultural transformation. Their contributions to the value chain have been observed in various countries, where they have demonstrated great potential and provided valuable opportunities. It is believed that young women are crucial to the future of small holder farmers, and therefore, efforts should be made to support and empower them.

Is Agriculture not profitable for everyone?

1. Small scale and Marginal Farmers

According to the report conducted by the National Sample Survey Office (NSO) under the Ministry of Statistics and Programme Implementation (MoSPI), a Situation Assessment Survey (SAS) was conducted during the 77th round of the NSS (January 2019- December 2019) in the rural areas of the country. The survey focused on Agricultural Households and referred to the agricultural year from July 2018 to June 2019. The findings of the survey indicate that approximately 89.4% of agricultural households in the rural areas of the country own less than two hectares of land.

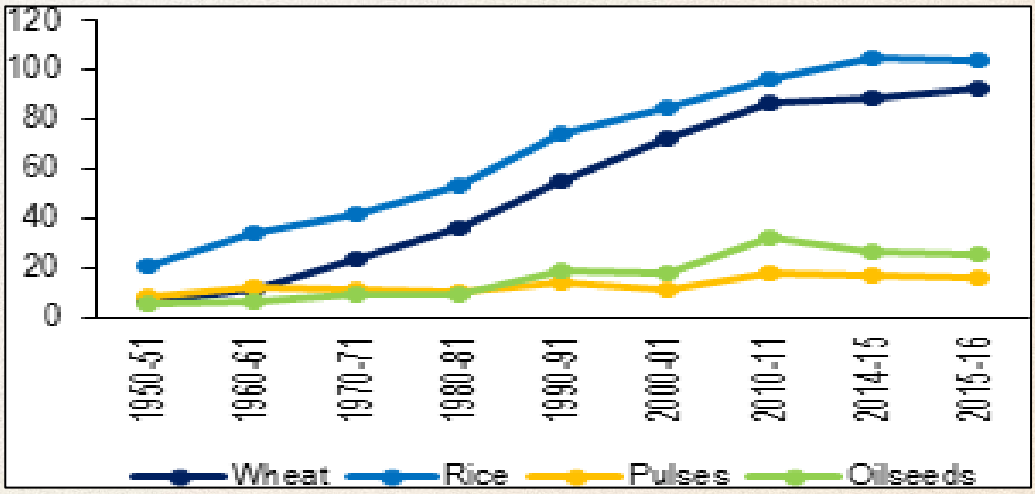
Based on the recently published report "Situation Assessment of Agricultural Households and Land and Livestock Holdings of Households in Rural India, 2019" by the Ministry of Statistics and Programme Implementation, a significant shift has been observed in the livelihood patterns of small and marginal agricultural households in rural India. The report highlights that a majority of these households now rely heavily on wage work for their income.

According to the findings, approximately 49.7% of the income for these agricultural households is derived from farming activities, including crop cultivation and animal husbandry. However, a closer examination of the data reveals a noteworthy trend among small and marginal agricultural households with land holdings of less than 1 hectare. These households have predominantly transitioned into wage earners, implying that their primary source of income is no longer farming but rather employment in other sectors.

2. Large scale Farmers

The appeal of substantial investments in industrial agriculture is linked to the benefits of scale

and variety. Advanced production methods enable larger farming operations to realize anticipated profits more quickly than smaller counterparts. Through amalgamation and streamlined coordination, not only have expenditures been lowered, but the array of available food items has also increased while mitigating informational challenges. Large, coordinated agricultural ventures offer year-round financial security by diversifying product offerings, thereby providing a safety net during market downturns for specific items.



Sources: Ministry of Agriculture

In a recent update from the Ministry of Agriculture, it's projected that the yield for food grains will reach 272 million tonnes for the fiscal year 2016-17. The significant increase in wheat and rice production, initially sparked by the Green Revolution of the 1960s, has led these crops to constitute 78% of the country's total food grain output as of 2015-16. Looking ahead, India will need an estimated 300 million tonnes of food grains by 2025 to sustain its growing population. This means that the annual growth rate for crop production should hover around 2%—a rate which aligns closely with current trends. However, it's worth noting that, even with high production numbers, India's agricultural yield still lags behind that of other major crop-producing nations.

Natural Farming/ Chemical Free Farming/ Organic Farming

“Health for ecosystems and communities, Ecology's balance with nature, Fairness in human relationships, and Care for the environment's future."

In contemporary times, certain individuals have been endangering their well-being by employing hazardous pesticides and fertilisers. The issue of population growth is particularly serious in India, resulting in escalated food requirements. Consequently, the prevalent approach to addressing the demand for food production involves the utilisation of chemical fertilisers, toxic pesticides, and hybrid crops. Regrettably, this has had detrimental effects on human health and the environment. An effective solution to mitigate these concerns lies in the adoption of organic farming practices.

Organic farming, although not a new concept, serves as an agricultural method in India that prioritises nurturing live and healthy soil. Achieving this goal involves utilising organic waste, discarded crops, animal and farm residues, aquatic waste, and other similar organic

materials. Remarkably, there is a growing awareness of organic agriculture among farmers in India, signifying a positive trend towards safer and environmentally friendly farming practices.

Organic farming in India is a way of growing crops using natural methods to control pests and fertilise the soil. It began as a response to the harm caused by chemical pesticides and synthetic fertilisers on the environment. Key elements of organic farming include the utilisation of organic inputs, green manures, and cow dung, among others, to promote sustainable agriculture.

Status of Organic Farming in India:

India has approximately 2.78 million hectares of land dedicated to organic agriculture. The country produces a variety of organic products, including oilseeds, tea, coffee, dried fruits, millets, cereals, and spices. These products are not only abundant within India but also exported to other countries. The states leading in organic farming are Sikkim, Uttarakhand, and Tripura, while other significant contributors include Madhya Pradesh, Rajasthan, and Maharashtra. In the realm of organic farming, Sikkim stands as the pioneering or the first state, being fully engaged in this agricultural practice. Additionally, Tripura and Uttarakhand have also ventured into the domain of organic farming. Madhya Pradesh holds the position of being the leading producer of organic products in India. It achieves this distinction by cultivating organic crops on an extensive area of 0.76 million hectares.

Organic agricultural products are low in the early years. Farmers find it difficult to accommodate mass production.

The main disadvantage of organic farming is the lack of marketing of the products and Inadequate infrastructure.

How to address these 3 problems?

According to the National Centre for Organic and Natural farming research findings indicate that ecological production fields host approximately 30% more wildlife and plants compared to conventional farming areas. This difference can be attributed to the absence of pesticides and reduced usage of fertilisers in ecological farming practices. Furthermore, the Covid-19 pandemic has significantly influenced people's views on organic food, shifting attention towards its safety, nutritional value, and its potential to support a robust immune system.

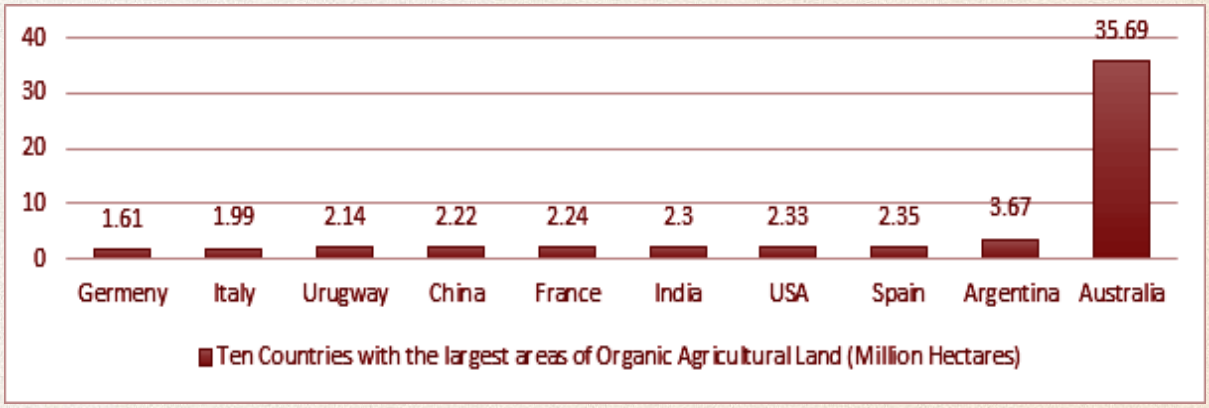
As per the FiBL survey conducted in 2021, India stands out as a distinctive country among 187 nations practising organic agriculture. It holds a remarkable position with 30% of the world's organic producers and a vast cultivation area covering 2.30 million hectares. This area is managed by a total of 27,59,660 farmers, including 11,60,650 under PGS (Participatory Guarantee System) and 15,99,010 under India Organic certification. Additionally, there are 1703 organic processors and 745 traders involved in this sector. Notably, India has experienced a significant increase in organic agricultural land across the entire country in recent times.

World Scenario of Organic Agriculture

The practice of organic agriculture is widespread, with 187 countries adopting it. Around

72.3 million hectares of agricultural land are being managed organically, benefiting at least 3.1 million farmers. Among the countries with the largest organic agricultural land, Australia takes the lead with 35.69 million hectares, followed by Argentina with 3.63 million hectares, and Spain with 2.35 million hectares.

Across all regions, there has been a noticeable increase in organic agricultural land. In 2019, the global sales of organic food and drinks surpassed 106 billion euros. According to the latest survey by FiBL on organic agriculture worldwide, the organic farmland expanded by million hectares, and organic retail sales continued to experience growth.



Source: FiBL Survey 2021

According to the FiBL Survey 2021, the number of organic producers worldwide is on the rise. In 2019, the reported count reached 3.1 million. Among the countries with the highest number of organic producers, India leads with 1,366,000 producers, followed by Uganda with 210,000, and Ethiopia with 204,000. Most small-scale producers are certified in groups based on an internal control system. (FiBL Survey 2021).

Present Scenario of Organic farming in India:

The current status of organic farming in India is at an early stage. As of March 2019, approximately 2.30 million hectares of farmland were being used for organic cultivation, which is only two percent of the country's total net sown area of 140.1 million hectares. A few states are leading the way in promoting organic farming, with a major portion of the organic cultivation area concentrated in these states. Madhya Pradesh stands out at the top with 0.76 million hectares of land under organic cultivation, which is more than 27 percent of India's total organic farming area. The top three states, namely Madhya Pradesh, Rajasthan, and Maharashtra, account for around half of the area under organic cultivation. Moreover, the top 10 states together cover about 80 percent of the total area dedicated to organic farming in the country.

To meet the growing demand for organic agricultural products, the government launched two key schemes in 2015-16:

1. **Paramparagat Krishi Vikas Yojana (PKVY)**
2. **Mission Organic Value Chain Development for North Eastern Region**

(MOVCDNER).

These schemes assist organic farmers from production to marketing, including certification, processing, and packaging. Specific details on areas and farmers under PKVY in states like Uttar Pradesh and Rajasthan. The Bhartiya Prakritik Krishi Padhati (BPKP), introduced in 2020-21 as a part of PKVY, focuses on promoting traditional farming practices. The scheme emphasizes the exclusion of synthetic chemicals, promotes biomass recycling, and stresses the use of organic materials like cow dung and plant-based formulations. Till date, 4.09 lakh ha has been covered with a fund release of Rs. 4980.99 lakh across 8 states. Organic farming improves soil fertility and crop productivity. Research from ICAR suggests yields comparable to conventional methods are achievable in 2-3 years for certain crops, with stabilization in 5 years for others.

Under PKVY & MOVCDNER:

1. Financial assistance: Rs. 31000/ha/3 years and Rs. 32500/ha/3 years respectively.
2. Funds are allocated for organic inputs, farmer organization formation, training, certification, and organic produce marketing.
3. BPKP offers Rs. 12200/ha over 3 years for various organic farming support activities including certification and analysis.

Participatory Gurantee System will be the key approach for quality assurance. Under the PKY scheme cluster formation, training, certification and marketing are supported. The central focus of both PKVY and MOVCDNER is the comprehensive support for organic farmers, covering the entire process from cultivation to post-harvest activities, inclusive of certification and marketing. While PKVY extends its reach across India excluding the North Eastern states, the MOVCDNER is tailored specifically for these states.

Financial aid is provided to organic farmers through both schemes. Specifically, the PKVY allots up to Rs 50,000/ha for three years. In contrast, the MOVCDNER offers Rs. 46,575/ha over a three-year period. This aid encompasses FPO creation, premium seeds, organic inputs, and training, coupled with certification.

Historical data indicates that from 2015-16, the PKVY scheme has incorporated 11.85 lakh ha under organic farming. Furthermore, there's an aspiration to integrate an additional 6.00 lakh ha into the scheme between 2022-23 to 2025-26. Under PKVY, farmers of various states of the country are provided financial assistance of Rs 50000/ha for 3 years out of which, Rs 31000/ ha / 3 years is provided directly to farmers through DBT for on-farm and off-farm organic inputs. Financial assistance of Rs 20 lakh/ cluster of 1000 ha for 3 years are provided for value addition and infrastructure creation. Under the scheme assistance is provided @ Rs 7500/ha for 3 years for training and capacity building whereas, Apart from this, Rs 2700/ha for 3 years is provided for certification and residual analysis.

Under MOVCDNER, there is provision of financial assistance of Rs 10000/ha for 3 years for training, handholding and ICS documentation and farmers are provided assistance @ Rs 32500/ ha for 3 years for off farm /on –farm organic inputs. Under the scheme need based assistance is provided for various component namely Integrated Processing unit @ Rs. 600

lakh, Collection, aggregation and grading unit @ Rs. 10.00 lakh, Integrated Pack house @ Rs 37.50 lakh, Refrigerated vehicle @ Rs 18.75 lakh, Pre-cooling, cold stores, ripening chambers @ 18.75 lakh and Transportation / 4 wheeler @ Rs 6.00 lakh.

State-wise and year-wise details of area added to organic farming through PKVY scheme since 2015-16

Sl. No.	State	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
1	Andaman & Nicobar	1360	1360	1360	1360	1360	1360	1360
2	Andhra Pradesh	8660	8660	26000	106000	106000	206000	206000
3	Arunachal Pradesh	380	380	380	380	380	380	380
4	Assam	4400	4400	4400	4400	4400	4400	4400
5	Bihar	6540	6540	10600	10600	10600	24600	24600
6	Chhattisgarh	3760	3760	4000	24000	24000	109000	109000
7	Goa	80	80	80	10080	10080	10080	10080
8	Gujarat	2000	2000	2000	2000	2000	2000	2000
9	Haryana	400	400	400	400	400	400	400
10	Himachal Pradesh	2200	2200	4200	4200	5700	17700	17700
11	J & K	560	560	560	560	560	560	560
12	Jharkhand	2000	2000	5540	5540	5540	8940	23940
13	Karnataka	10900	10900	10900	10900	20900	20900	20900
14	Kerala	2380	2380	12380	12380	12380	96380	96380
15	Lakshadweep	0	0	0	2700	2700	2700	2700
16	Madhya P	17600	17600	27600	76560	76560	175560	175560
17	Maharashtra	18640	18640	25160	25160	25160	25160	32160
18	Manipur	600	600	600	600	600	600	600
19	Meghalaya	900	900	900	900	900	900	900
20	Mizoram	680	680	680	680	680	680	680
21	Nagaland	480	480	480	480	480	480	480
22	Delhi	0	0	10000	10000	10000	10000	10000
23	Odisha	6400	6400	6400	20800	20800	44800	44800
24	Pondicherry	0	0	160	160	160	160	160
25	Punjab	1000	1000	5000	5000	5000	5000	7000
26	Rajasthan	15100	15100	23000	123000	123000	123000	123000
27	Sikkim	3000	3000	3000	3000	3000	3000	3000
28	Tamil Nadu	2240	2240	2240	6240	6240	8240	8240
29	Telangana	6000	6000	13800	13800	13800	13800	13800
30	Tripura	1000	1000	1000	1000	1000	1000	1000
31	Uttar P	11500	11500	18800	32800	42800	78580	78580
32	Uttarakhand	11000	11000	12540	90540	90540	140540	140540
33	West Bengal	2400	2400	2400	2400	2400	2400	2400
34	Daman & Diu	0	0	1100	1100	1100	1100	1100
35	Dadar Nagar	0	0	10000	10000	10000	10000	10000
36	Chandigarh	0	0	0	1300	1300	1300	1300
37	Ladakh	0	0	0	0	0	0	10000
	Total	**144160**	**144160**	**247660**	**621020**	**642520**	**1151700**	**1185700**

Cumulative state-wise year under PKVY since 2015-16

Post Harvest Management & Value Addition- Another Problem

Based on recent reports, Indian farmers experienced significant post-harvest losses totaling Rs 93,000 crores in 2019. These losses have been identified as one of the major factors limiting India's share in global agricultural exports. Despite the presence of established postharvest institutions backed by the government and private sector, many farmers remain unaware of the correct methods for food handling and storage. This lack of awareness leads to mechanical losses like bruising, cracking, cuts, and contamination by fungi and bacteria. Additionally, there are physiological losses that affect respiration, transpiration, pigments, and flavors of the produce. As a consequence, market prices are reduced, and consumer acceptance of agricultural produce is compromised. In various parts of India, agriculture is not heavily reliant on agro-chemicals, particularly in mountainous and tribal areas. This low usage of chemicals makes it easier for these regions to transition to organic farming methods.

Natural Farming is an agricultural methodology that aligns with Indian tradition while incorporating contemporary knowledge of ecology, resource recycling, and optimising on-farm resources. This approach is recognized as an agroecology-based farming system that integrates crops, trees, and livestock with functional biodiversity. Its foundation lies in on-farm biomass recycling, emphasising the use of biomass mulching, on-farm cow dung-urine formulations, soil aeration, and the exclusion of synthetic chemical inputs. By reducing reliance on purchased inputs, Natural Farming aims to be a cost-effective practice that also presents opportunities for increased employment and rural development. Several states, including Andhra Pradesh, Karnataka, Himachal Pradesh, Gujarat, Uttar Pradesh, and Kerala, have successfully implemented and established natural farming models. These states are recognized as leaders in this field. Presently, the acceptance and implementation of natural farming practices are in their initial stages but are gradually gaining popularity within the farming community.

Natural farming is an agricultural approach that aims to restore soil health, maintain biodiversity, ensure animal welfare, emphasize the efficient use of natural and local resources, and promote ecological fairness. It is a farming system that works in harmony with natural biodiversity, encouraging the biological activity of the soil and managing the complex interactions between various living organisms, including plants and animals, to promote thriving food production. The adoption of natural farming requires the following important practices:

- Elimination of external inputs.
- Utilization of local seeds, specifically local varieties.
- Use of on-farm microbial formulations, such as bijamrita, for seed treatment. Creation of on-farm microbial inoculants (Jivamrita) to enrich the soil.
- Implementation of cover crops and mulching with organic matter, both green and dry, to recycle nutrients and create a suitable microclimate for beneficial microbial activity in the soil.
- Adoption of mixed cropping techniques.
- Management of diversity on the farm through the integration of trees.
- Pest control through the use of diverse methods and on-farm botanical concoctions,

such asneemastra, agniastra, neem ark, dashparni ark, etc.

- Integration of livestock, particularly native breeds, to utilize cow dung and cow urine asessential inputs for various practices.
- Implementation of water and moisture conservation measures.

The Hon'ble Prime Minister, in his address to the nation on Independence Day in 2019 from the Red Fort, expressed concerns regarding the detrimental effects of chemical fertilizers and pesticides on the soil's health. Recognizing the responsibility as a farmer and a custodian of the land, he emphasized the need to refrain from causing harm to the nation and its soil. The Prime Minister urged a reduction of 10%, 20%, or 25% in the use of chemical fertilizers in agricultural fields and proposed the launch of a campaign called **Muktikar Abhiyan** to achieve this objective. Such measures were seen as crucial for the betterment of the nation and the preservation of Mother Earth.

Over the past decade, a significant increase in input costs, particularly the prices of urea, DAP, and potash, has resulted in a decline in crop income. These essential farming resources have experienced price hikes ranging from 60% to 600%. Although the real value of crop output per hectare has witnessed some growth in recent years, the rise in input costs has far exceeded it, leading to a decrease in overall farm income. Furthermore, it is believed that the prevailing green revolution technology has contributed to the degradation of the agro-ecosystem and diminished economic returns for farmers.

Numerous studies have demonstrated the adverse impact of chemical fertilizers and pesticides on soil health, including the destruction of millions of vital soil microorganisms necessary for sustaining plant life. In contrast, natural farming, an agro-ecology based diversified farming system, is gaining recognition as an alternative approach. This method integrates crops, trees, and livestock, fostering functional diversity while reducing production costs through the use of homegrown alternatives such as Jeevamrit, Beejamrit, Neemastra, as well as adopting intercropping and mulching practices.

In the context of declining fertilizer response and farm income, the Economic Survey of India highlights the significance of natural farming as one of the alternative farming practices that can potentially improve farmers' income.

Success story:

Name: Ajay Rattan Address: Village Niun, Block Ghumarwin

Crops: Sugarcane, Gram, Wheat, Pea, Soybean, Moong, Taro Root, Ginger, Capsicum, Gourd and Ridge Gourd Total land:25 bigha Land under Natural farming :25 bigha Chemical farming expenditure: Rs 30,000 Chemical farming income: Rs 65,000 Natural farming expenditure: Rs 20,000 Natural farming income: Rs 3,00,000.

Precision Agriculture

The transformation of agriculture through precision farming is comparable in impact to the invention of the John Deere steel plow in the 19th century. Utilizing contemporary technologies such as the Internet of Things (IoT), GPS, GIS, and satellite imagery, farmers are greatly enhancing their decision-making processes. According to a 2021 report by the

Association of Equipment Manufacturers (AEM), the adoption of these precision agriculture tools has led to a 4% increase in crop yields, a 7% reduction in fertilizer use, a 9% decrease in herbicide application, a 6% cut in fossil fuel consumption, and a 4% conservation of water. Adopting advanced technological solutions often necessitates a significant financial investment, posing a challenge for farms operating on slim margins. Additionally, the influx of data generated by these technologies can overwhelm farmers, who may lack the requisite expertise or time to effectively interpret and apply this information.

Way Forward

To effectively scale Precision Farming, there will be a substantial need for specialized service providers and startups proficient in this area. Skill development, particularly in drone operations, should be emphasized as part of the overall training strategy, including data collection capabilities for decision-making tools.

Academic institutions focused on agriculture should prioritize human resource development (HRD) by creating tailored training programs and curricula to equip professionals for teaching, training, and research in precision agriculture. Collaboration is key: stakeholders ranging from industry experts to academics must unite to design Decision Support Systems that enable farmers to make real-time, informed choices. This will necessitate the integration of advanced technologies such as AI, IoT, machine learning, and big data analytics, transitioning from traditional experiential decision-making to real-time, evidence-based actions. The Indian Council of Agricultural Research (ICAR) has recently launched a project focused on Precision Agriculture. To enhance its effectiveness, the project requires expansion to include a broader range of institutions and target additional agricultural domains, such as swine, poultry, goats, and aquaculture. After a period of successful operation, the network has the potential to evolve into a nationwide coordinated research initiative. This would ensure that research in Precision Agriculture becomes a formalized endeavor, producing groundbreaking technologies and methodologies.

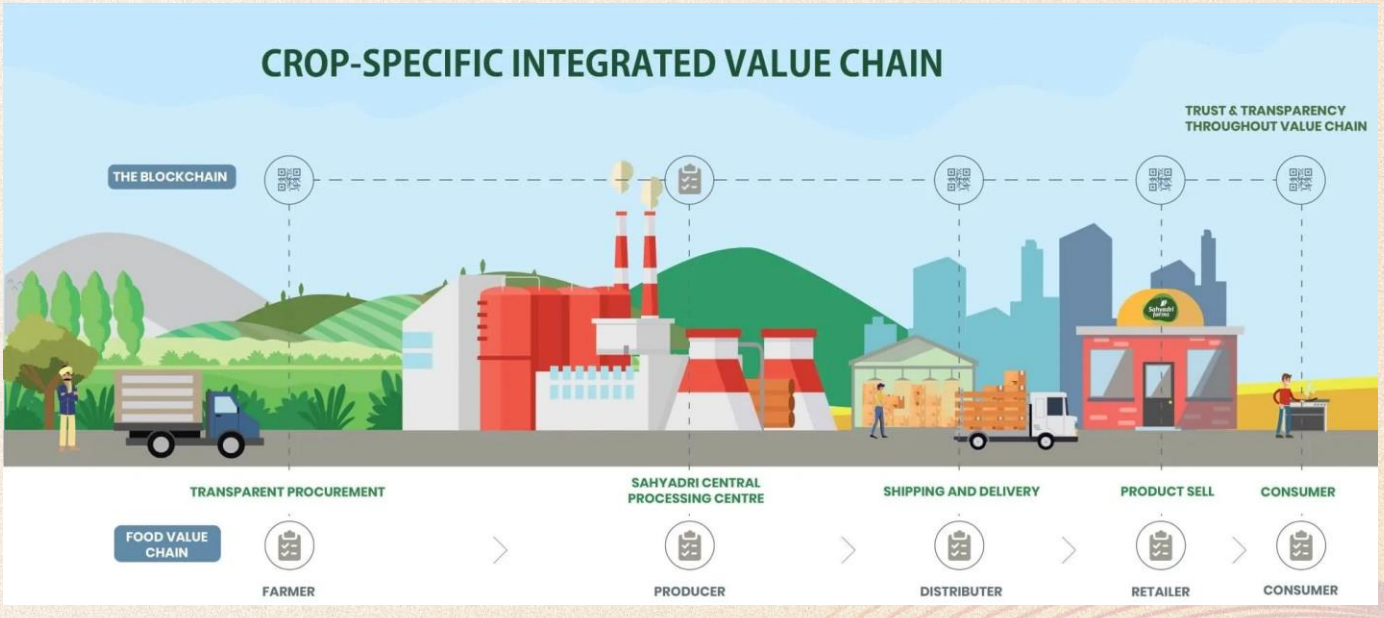
Sahyadri: Adopting the Model of Aggregation

"Sahyadri's unwavering vision: Cultivate a foundation of people, processes, and practices, fostering the growth and empowerment of smallholder Indian farmers."

In order to tackle various longstanding challenges in the agriculture sector, it has been recognized that bringing farmers together, particularly those who are small or have limited resources, through producer organisations can be an effective solution. It is evident that providing small-scale farmers with access to technology, resources, and markets is essential for the overall development and progress of the sector. Founded in 2011 in Nashik, Maharashtra, Sahyadri Farmers Producer Company Ltd. (SFPCL) has evolved into India's largest cooperative of farmers within just ten years. Initially envisioned by Vilas Shinde as a platform for "farmer-entrepreneurs," the company transitioned into a full-blown Farmers Producer Company (FPC) due to market demands. It offers over 8,000 registered farmers across 15,789 acres a robust agricultural value chain that elevates small-scale farming into a large-scale operation.

Sahyadri Farms is not just a business but a farmer-driven movement with a strong ethical

backbone. The company exported approximately 22,000 tonnes of grapes during the 2018-2019 season, showcasing its global reach and established trust with international partners. The company's structure is divided into three layers: the top-level organization, specialized FPCs for various crops, and the farmers. While crop-specific FPCs focus on technical support and initial processing, the apex organization takes care of post-harvest management, further processing, and both domestic and international marketing.VSahyadri Farms has created a comprehensive 65-acre facility equipped with advanced technologies for sorting, cooling, and storing produce supplied by its network of farmers. The company uses geo-tagging to monitor crops in real-time, enabling precise harvest planning. Alongside this, they have established an in-house IT platform for end-to-end traceability of produce. With a focus on quality and sustainability, Sahyadri Farms has formed a subsidiary, Sahyadri Agro Retail Ltd (SARL), to offer a range of processed food items. These products are available in nearly 10,000 retail stores in Maharashtra. Additionally, they have 13 owned retail stores withplans to expand further. They have garnered international recognition with a €7.50 million loan from FMO, the Netherlands' development finance company. To tackle the issue of skilled labor shortage, Sahyadri launched a skill development program, resulting in employment for over 150 young people within a year. Moreover, the company collaborates with various organizations for rural development, affirming its commitment to empowering small farmers and fostering community growth.



Farmer Producer organizations (FPO’s)

Empowering Farmers with FPOs (A Step Towards Atmnirbhar Krishi)

A Farmer Producer Organization (FPO) is a group of farmers who come together to improve their agricultural and allied sector activities through collective efforts. They are registered under specific laws and aim to benefit from economies of scale in production and marketing. To help farmers create these organizations, the Small Farmers’ Agribusiness Consortium (SFAC) is supporting state governments in the formation of FPOs.

The Government of India has launched a scheme called "Formation and Promotion of 10,000

Farmer Producer Organizations (FPOs)" to create and promote 10,000 new FPOs by 2027-28. The scheme focuses on two approaches: the Produce Cluster Area approach and the specialized commodity-based approach. The cluster-based approach aims to develop product specialization in each district by promoting "One District One Product." So far, 4465 FPO clusters have been assigned for creation by various implementing agencies, with 632 of them already registered. A study by PricewaterhouseCoopers on the scheme's impact indicates that sales through these FPOs have led to a 22% increase in price realization for members, 31% reduced marketing costs, and net savings of Rs. 1384 per acre for 28% of members who purchased inputs through these organizations.

In Andhra Pradesh, 852 FPOs have been established as of 2020. The scheme also provisions financial assistance up to Rs. 18 lakhs per FPO over a three-year period to cover management costs. To date, Rs. 249.08 crore has been disbursed to implementing agencies, and an Equity Grant of Rs. 31.22 lakh was provided to four FPOs in Andhra Pradesh for the fiscal year 2020-21.

SFAC- Small Farmers Agriculture Consortium Implementation

It is recommended that the SFAC should enhance its ground staff. However, this doesn't imply expanding its bureaucratic structure. Instead, considering third-party collaborations with skilled agencies could be a viable solution. Furthermore, maintaining regular communication with clients, especially those who are smaller or new to the platform, is essential for providing extra guidance and resolving issues.

While the pathway to profitability is fraught with obstacles for Farmer Producer Organizations (FPOs), only a handful successfully navigate these challenges to achieve commercial success. Confronted by various issues such as limited access to credit and inadequate infrastructure, the importance of highlighting successful models, novel strategies, and insights from prospering FPOs cannot be overstated. Collaborative efforts can play a key role in attaining this objective.

In a cooperative effort, public authorities and private businesses can work together to grant agricultural producers guaranteed avenues for selling their goods, thereby minimizing market uncertainties. Furthermore, by utilizing farm produce for the creation of enhanced-value items like tofu, powdered soya milk, and frozen soya-based desserts, companies have the opportunity to offer more competitive rates to farmers.

Way Forward

In summary, the key function of Community-Based Business Organizations (CBBOs) is to empower Farmer Producer Organizations (FPOs), turning them into attractive options for agricultural workers. Rather than acting simply as businesses, FPOs function as farmer collectives. With the landscape of Indian agriculture primarily made up of small and marginal farmers—owning less than 1.1 hectares of land and making up over 86% of all land holdings—it's crucial to address the unique challenges they face in both production and post-production phases. Forming FPOs can be a strategic way to tackle these issues and boost farmers' income.

This report emphasizes the significance of rural youth in ensuring global food security.

However, it highlights a concerning trend where few young individuals perceive a viable future in agriculture or rural regions. The obstacles faced by rural youth in pursuing livelihoods are numerous, including limited access to arable land, credit, and essential resources for agriculture.

Moreover, the appeal of urban life often surpasses that of rural areas, unless adequate economic opportunities are available. This predicament is particularly prevalent in developing countries, leaving rural youth in a difficult position.

The majority of the world's food supply is currently produced by aging smallholder farmers in developing nations. Unfortunately, these farmers are less likely to adopt modern technologies necessary for sustainable agricultural productivity growth, hindering the ability to feed a growing global population while safeguarding the environment. To address this issue, it is imperative to re-engage youth in agriculture.

Despite the agricultural sector's ample potential to provide income-generating opportunities for rural youth, challenges related specifically to youth participation in this sector – and, more importantly, options for overcoming them – are not extensively documented.

Furthermore, statistics on rural youth are often lacking, as data are rarely disaggregated by important factors such as age, sex and geographical location.

ARYA- Attracting and Retaining Youth in Agriculture

India currently holds the largest youth population in the world, with approximately 356 million individuals aged between 10 and 24 years. Nearly half of this youth population, around 200 million young people, reside in rural areas. Recognizing the significance of rural youth in agricultural development, particularly concerning livelihood security and stable income streams, the Indian Council of Agricultural Research has been implementing the "Attracting and Retaining Youth in Agriculture (ARYA)" project since the fiscal year 2015-16, under its Agricultural Extension Division.

The ARYA project is active in 25 states, operating through Krishi Vigyan Kendras, with the participation of one district from each state. The primary objective of the project is to attract and empower rural youth to engage in various agricultural and allied sector enterprises, ensuring sustainable income and gainful employment in the selected districts.

Within the framework of the ARYA project, rural youth are identified and provided with orientation and training in entrepreneurial skill development. They are encouraged to establish micro-enterprise units in sectors such as apiary, mushroom cultivation, seed processing, poultry, dairy, goatry, carp-hatchery, and vermicompost production. In India, agricultural management has seen a notable shift towards rural women and elderly farmers, with rural youth moving to urban areas in search of employment opportunities. This trend places undue strain on urban centers and depletes the potential human resource pool in rural regions. Nonetheless, there exists substantial potential to transform agriculture into a lucrative source of income and employment. According to Arya's report, the income generated from approximately 17 significant enterprises, such as Apiary, Mushroom, Seed Processing, Poultry, Dairy, Goatry, Carp-hatchery, Vermi-compost, etc., has the potential to yield an average monthly income ranging from Rs. 10,000 to Rs. 12,000. This income

projection is based on the economy of scale associated with each enterprise. This initiative aims to specifically target rural individuals below the age of 35 under a specialized program. The goal is to encourage their involvement in the agricultural sector, providing avenues for income generation and active participation in farming.These motivated youth groups serve as exemplary models, showcasing the potential of agriculture-based ventures and offering guidance through training. The enhancement of skills among rural youth not only boosts their confidence in pursuing farming as a profession but also generates additional employment prospects. This helps address the issue of underemployment and unemployment among rural youth by involving them in secondary agriculture and related services within rural areas. As part of this project, a total of 4280 young individuals, organized into various groups, have received orientation. The orientation is aimed at enabling them to establish small-scale entrepreneurial endeavors across 25 districts.

It remains necessary to emphasize the exploration of the District's capabilities, the recording of indicators related to livelihoods, facilitation of communication among farmers, and the establishment of a baseline for income assessment prior to and following the implementation of the ARYA project. The technology barriers should be tackled first as involving more people does not going to affect productivity.

References:

1) https://icar.org.in/content/7th-zonal-committee-meeting-arya-project-organized
2) Why are rural youth leaving farming?
3) https://pib.gov.in/PressReleasePage.aspx?PRID=1796561
4) https://www.agrifarming.in/government-schemes-for-organic-farming-in-india
5) https://www.downtoearth.org.in/blog/agriculture/farmers-ageing-new-generation-disinterested-who-will-grow-our-food--65800
6) https://tigr2ess.globalfood.cam.ac.uk/news/rural-youth-aspirations-can-indian-agriculture-regain-interest-rural-youth
7) Improving Condition of Small and Marginal Farmers.
8) http://naturalfarming.dac.gov.in/NaturalFarming/Concept
9) What is Organic Farming in India - Types, Methods & Advantages.
10) https://ncof.dacnet.nic.in/StatusOrganicFarming
11) https://www.manage.gov.in/publications/reports/Sahyadri-report.pdf
12) https://allfoodonline.com/en/our-ultimate-goal-is-to-make-small-farmers-agriculture-profitable-sahyadri-farms/
13) https://pib.gov.in/Pressreleaseshare.aspx?PRID=1696547
14) http://sfacindia.com/FPOS.aspx
15) https://www.mofpi.gov.in/sites/default/files/fpo_policy_process_guidelines_1_april_2013.pdf
16) https://prsindia.org/policy/analytical-reports/state-agriculture-india
17) https://www.worldbank.org/en/news/feature/2012/05/17/india-agriculture-issues-priorities
18) https://www.fao.org/india/fao-in-india/india-at-a-glance/en/
19) https://www.niti.gov.in/verticals/agriculture
20) https://pib.gov.in/PressReleasePage.aspx?PRID=1886630
21) https://yourstory.com/2023/08/collaborative-efforts-sustainability-indias-agricultural-sector
22) https://www.gatesfoundation.org/our-work/programs/global-growth-and-opportunity/agricultural-development
23) https://www.jstor.org/stable/24110255
24) https://www.researchgate.net/profile/Ramesh-Sahni/publication/341039824_Farm_mechanization_-_trends_and_policy_for_its_promotion_in_India/links/5eaa3ed9a6fdcc70509b0989/Farm-mechanization-trends-and-policy-for-its-promotion-in-India.pdf
25) https://www.mdpi.com/2073-4395/10/2/207
26) https://www.tandfonline.com/doi/abs/10.1080/13600818.2017.1283010
27) https://demo.dspacedirect.org/items/a94ef210-25e1-4399-b93e-54930f2ba37f

28) https://www.sciencedirect.com/science/article/abs/pii/S0959652621022915

29) https://www.researchgate.net/profile/Suraj-Singh-8/publication/351026185_Mainstreaming_adaptation_strategies_in_relevant_flagship_schemes_to_overcome_vulnerabilities_of_Climate_Change_to_Agriculture_Sector/links/613c36de4e1df271062ae259/Mainstreaming-adaptation-strategies-in-relevant-flagship-schemes-to-overcome-vulnerabilities-of-Climate-Change-to-Agriculture-Sector.pdf?_sg%5B0%5D=started_experiment_milestone&origin=journalDetail

30) https://journals.sagepub.com/doi/abs/10.1177/09730052221107730

31) https://www.indianjournals.com/ijor.aspx?target=ijor:ah&volume=13&issue=1&article=014

32) https://www.researchgate.net/profile/Alok-Sahoo-8/publication/350859334_The_Role_of_Krishi_Vigyan_Kendras_KVK_in_Strengthening_National_Agricultural_Research_Extension_System_in_India/links/607a4fb28ea909241e0536c3/The-Role-of-Krishi-Vigyan-Kendras-KVK-in-Strengthening-National-Agricultural-Research-Extension-System-in-India.pdf

33) http://sifisheriessciences.com/journal/index.php/journal/article/view/2304

34) https://www.emerald.com/insight/content/doi/10.1108/20440831111131505/full/html

35) https://pib.gov.in/PressReleasePage.aspx?PRID=1739593

36) https://www.sciencedirect.com/science/article/abs/pii/S221204162030125X

37) https://books.google.co.in/books?hl=en&lr=&id=JNSiChnCangC&oi=fnd&pg=PR5&dq=government+RESERACH+PAPERS+ON+AGRICULTURAL+marketing+IN+INDIA+LATEST+ONES&ots=d0pQiVkKOM&sig=20XCZCNg0-2qj3zpDqGk9shom84&redir_esc=y#v=onepage&q=government%20RESERACH%20PAPERS%20ON%20AGRICULTURAL%20marketing%20IN%20INDIA%20LATEST%20ONES&f=false

38) https://onlinelibrary.wiley.com/doi/abs/10.1111/0002-9092.00101

39) https://www.researchgate.net/profile/Kadambini-Katke/publication/332318856_Precision_Agriculture_Adoption_Challenges_of_Indian_Agriculture/links/5cad831b299bf193bc2daf05/Precision-Agriculture-Adoption-Challenges-of-Indian-Agriculture.pdf

40) https://www.researchgate.net/profile/Evs-Prakasa-Rao/publication/359938430_Digital_Agriculture_-A_Future_Disruption_in_India/links/6257cd31a279ec5dd7f58d97/Digital-Agriculture-A-Future-Disruption-in-India.pdf

41) https://www.ncpahindia.com/pfdc-mandate

42) http://naas.org.in/News/NN22032022.pdf

Tarun Sharma

LL.M., Hidayatullah National Law University, Bhopal, Madhya Pradesh.

Mentored by Dr. Amit Dubey, Scientist 'D', Certified Control Systems Technician (CCST).

Domain for Internship: Public Policy & Governance

Assessing the Effectiveness of Geographical Indications in Chhattisgarh and Safeguarding Traditional Knowledge: A Hybrid Study

Traditional Knowledge (TK), its protection, the rights of the holders and its relation with Intellectual Property Rights has become the critical issue of global concern. The present research study explored the significance of TK and its protection under Geographical Indications (GI), with a specific focus on the Indian state of Chhattisgarh. The study also shed light on the potential benefits and challenges of using GIs for safeguarding TK particularly in domains such as traditional art, handicraft, agriculture, and food and beverages. Emphasizing the cultural, social, and economic importance of traditional knowledge in Chhattisgarh, the research highlights its role in sustainable development, community resilience, and cultural identity preservation. Through a mixed-methods approach involving interviews, and document analysis, primary data is collected from Artisans, Government Organisation, and relevant Stakeholders. Furthermore, the research identified the gaps in the existing six GIs, including lack of awareness regarding GI, quality control mechanisms, and authorized users of the GIs. The study recommended opting for the APEDA style model as a quality control mechanism and entrusting local IP cells to make GI proprietors aware. Further, the study proposed strategies to enhance recognition, preservation, and sustainable use of traditional knowledge through effective GI protection mechanisms in Chhattisgarh.

Keywords: geographical indications, traditional knowledge, awareness, government organizations, policy makers and stockholders

Assessing the Effectiveness of Geographical Indications in Chhattisgarh and Safeguarding Traditional Knowledge: A Hybrid Study

This research study explores the significance of traditional and indigenous knowledge in the Indian state of Chhattisgarh and its protection under geographical indications (GI). The research aims to assess the level of awareness and utilization of traditional knowledge among local communities and examine the challenges faced in safeguarding such knowledge under the GI framework. Through a mixed-methods approach involving interviews, and document analysis, primary data is collected from artisans, Government Organization, and relevant stakeholders. Furthermore, the research identifies the gaps in the existing six GIs in the state and triesto propose a policy framework for the same. The researcher has also tried to propose various Traditional Knowledge for the protection under the current GI framework with the proper way forward. The study concludes by providing recommendations for policy-makers and stakeholders to enhance the recognition, preservation, and sustainable use of traditional knowledge through effective GI protection mechanisms in Chhattisgarh. Overall, this research contributes to the ongoing discourse on Traditional & indigenous knowledge protection by means of Geographical Indication and informs future strategies for promoting culturalheritage and economic development in the region.

General Introduction

Traditional and indigenous knowledge systems are invaluable cultural treasures that have been passed down through generations in various regions across the world. Chhattisgarh, a state in central India, is renowned for its rich cultural heritage and diverse traditional knowledge practices. These practices, deeply rooted in the state's history and indigenous communities, encompass a wide range of areas such as agriculture, handicrafts, herbal medicine, and folklore. However, in today's globalized and rapidly changing world, traditional knowledge faces numerous challenges. One significant concern is the potential misappropriation and unauthorized use of traditional knowledge, often leading to the exploitation of indigenous communities and their resources. Protecting traditional knowledge and ensuring fair recognition and benefit-sharing for local communities have become pressing issues. One potential avenue for safeguarding traditional and indigenous knowledge lies in the realm of Geographical Indications (GIs). GIs are legal tools that identify and protect products originating from specific geographical regions. GIs focus on the unique qualities, characteristics, and reputation associated with a product's origin, offering legal recognition and economic benefits to the local communities involved. This research aims to explore the possibility of utilizing GIs as a means to protect and promote the traditional and indigenous knowledge of Chhattisgarh.

By examining the existing traditional knowledge practices in the region and analyzing the current 6 GIs given to agricultural and handicraft products of Chhattisgarh, this study seeks to shed light on the potential benefits and challenges of using GIs for safeguarding Chhattisgarh's traditional knowledge. The research will delve into the cultural, social, and economic significance of traditional knowledge in Chhattisgarh, highlighting its contribution to sustainable development, community resilience, and the preservation of cultural identity. Furthermore, it will critically analyze the effectiveness and suitability of GIs as a mechanism

for protecting traditional knowledge, taking into account the specific context and challenges faced in Chhattisgarh. By identifying potential areas of overlap and synergy between traditional knowledge and GIs, this research aims to provide valuable insights and recommendations for policymakers, indigenous communities, and other stakeholders involved in the preservation and protection of Chhattisgarh's traditional knowledge systems.

Literature Review

Teshager W. Dagne and Graham Dutfield[1] edited this book which is a collection of essays that examine the complex relationship between IP laws and TK. The book provides a comprehensive analysis of the legal, social, cultural, and economic issues surrounding the protection of TK in the context of IPRs. The book is divided into three parts. The first part provides an overview of the legal and policy frameworks for protecting TK, including the international treaties, national laws, and customary laws that govern TK. The second part explores the diverse perspectives of different stakeholders, including indigenous communities, governments, researchers, and corporations, on the protection of TK. The third part examines the challenges and opportunities of integrating TK into IP law, and the potential of alternative forms of protection, such as community-based models and ethical frameworks. The essays are written by a range of experts in the fields of law, anthropology, economics, and indigenous studies, providing diverse and nuanced perspectives on the topic. The book draws on case studies from around the world, including Africa, Asia, the Americas, and the Pacific, highlighting the diversity and complexity of TK systems and their relationship with IP law.

Daniel F. Robinson and Ahmed Abdel-Latif[2] in their book took an in-depth exploration of the international legal framework for protecting TK through the lens of the WIPO IGC on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore. The book begins by providing an overview of the historical and cultural significance of TK and the challenges it faces in a globalized world. It then delves into the IGC's work on TK, which began in 2000, and the various international legal instruments that have been developed, including the Draft Articles on the Protection of TK and Traditional Cultural Expressions. The authors explore the complex issues surrounding the protection of TK and how it intersects with various areas of IP law, including copyright, patents, and trademarks. They also examine the diverse perspectives of indigenous communities, governments, and other stakeholders, and the challenges of achieving a balanced and effective legal framework. The book provides a detailed analysis of the debates, negotiations, and outcomes of the IGC's meetings over the years, as well as the broader political and economic context in which the discussions took place. It also highlights the contributions of various actors, including indigenous peoples and civil society organizations, to the IGC's work and the evolving discourse around traditional knowledge protection.

[1] Teshager Worku Dagne, Intellectual Property, Traditional Knowledge and Biodiversity in the Global Economy: The potential of GI for protecting Traditional Knowledge-based Agricultural Products (Dalhousie University, 2012)

[2] Daniel F. Robinson, Ahmed Abdel-Latif, Pedro Roffe, Protecting Traditional Knowledge, The WIPO Intergovernmetnal Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (Routledge, 2019)

Ajeet Mathur's[3] in his research paper explores the complex issue of ownership of traditional knowledge (TK) and the challenges it poses for IP law. The article argues that the traditional dichotomy between private property and public domain is inadequate for understanding the ownership of TK, which is often collective, communal, and embedded in cultural and spiritual traditions. The article begins with a brief overview of the cultural, social, and economic significance of TK and the challenges it faces in a globalized world. It then examines the legal frameworks for the protection of TK, including international treaties, national laws, and customary laws. The article argues that the current legal frameworks are inadequate for protecting TK, as they often fail to recognize the collective and communal nature of TK and the rights and interests of indigenous communities.

Research Objectives

The main objectives of this Hybrid Research are as follows: -

1. To define Traditional Knowledge, identify its scope and mode of its protection
2. To analyze the GIs of Chhattisgarh, and
3. To identify any improvement in the existing GI
4. To propose relevant Traditional & Indigenous Knowledge for the protection undertheGI regime
5. To propose an efficient policy or model for the protectable Traditional & Indigenous Knowledge to get its GIs registered.

Research Questions

1. What is Traditional Knowledge and how it is protected under the current IPR regime?
2. What factors contribute to the analysis of the GIs in Chhattisgarh?
3. How can the status and utilization of GIs in Chhattisgarh be evaluated effectively?
4. Why are fewer or comparatively no authorized users for certain GIs in Chhattisgarh?
5. What potential improvements can be identified for the existing GI system in Chhattisgarh?
6. How can Traditional & Indigenous Knowledge be integrated into the GI regime toensure its protection?
7. What policies or models can be proposed to facilitate the registration of Traditional &Indigenous Knowledge as GIs effectively?

[3] Ajeet Mathur, Who Owns Traditional Knowledge, Economic and Political Weekly, Vol. 38, No. 42 (2003)

Chapter 1. Introduction

Introduction

Knowledge is a fundamental aspect of human life that has played a significant role in shaping the development and progress of mankind. It is the driving force behind human achievements in various fields, such as science, technology, medicine, and many others. Through knowledge, humans have been able to innovate, create, and discover new things that have improved the quality of life for all. Cambridge Dictionary has defined knowledge as "understanding of or information about a subject that you get by experience or study, either known by one person or by people generally"[4], Merriam defined it as "the fact or condition of knowing something with familiarity gained through experience or association"[5]. Knowledge enhances our understanding of the world and our place in it. It allows us to make sense of the complexities of life and provides us with a framework to analyze and interpret information. With knowledge, we can evaluate evidence, make informed decisions, and draw conclusions based on facts rather than opinions.

Furthermore, knowledge is essential for personal growth and development. It helps individuals to expand their minds, learn new skills, and gain new perspectives. As a result, individuals can become more adaptable, flexible, and better equipped to face challenges and make positive changes in their lives. Knowledge promotes critical thinking, which is a valuable skill for navigating the complexities of modern society. It enables individuals to evaluate information critically, analyze situations, and make informed decisions. With this skill, individuals can assess the validity of information and avoid being misled by fake news or misinformation.

The evolution of knowledge in the perspective of mankind is a complex topic that can be traced back to the ancient civilizations. The ancient civilizations, such as the Egyptians, Greeks, Romans, Indian and Chinese, made significant contributions to the development of knowledge in various fields. Indian civilization has made significant contributions to the world's knowledge base in various fields, including mathematics, astronomy, philosophy, science, medicine, and spirituality. Mathematics is one of the fields in which Indian civilization has made significant contributions. Ancient Indian mathematicians developed the decimal system and the concept of zero[6], which revolutionized mathematics and had a profound impact on the development of science and technology. They also developed the concept of infinity and made significant contributions to algebra and geometry. In astronomy, Indian civilization developed sophisticated systems for predicting eclipses, calculating the movements of celestial bodies, and measuring time. They also developed a vast knowledge of the universe and its workings, which influenced the development of astronomy in other parts of the world. Indian philosophyhas also had a profound impact on the world's knowledge base. The ancient Indian texts, such as the Vedas, Upanishads, and Bhagavad Gita, contain profound

[4]Knowledge, Cambridge Dictionary. Available at:https://dictionary.cambridge.org/dictionary/english/knowledge (Accessed: July,7, 2023).
[5]Knowledge definition & meaning, Merriam-Webster. Merriam-Webster. Available at: https://www.merriam-webster.com/dictionary/knowledge (Accessed: July, 7, 2023).
[6]New Indian Xpress, How science & tech flourished in Ancient India, The New Indian Express. The New Indian Express. Available at: https://www.newindianexpress.com/opinions/2022/jan/14/how-science-tech- flourished-in-ancient-india-2406610.html (Accessed: July 7, 2023).

philosophical ideas and concepts that have influenced the development of Eastern philosophy and spirituality. In the field of science, ancient Indian scholars made significant contributions to medicine, with Ayurveda being one of the earliest medical systems in the world[7]. Ayurveda emphasizes the holistic approach to healing, which includes the use of herbs, diet, and lifestyle changes. Indiancivilization also developed sophisticated surgical techniques and developed a vast knowledge of anatomy and physiology.

The knowledge acquired by these civilizations becomes TK through a process of transmission and preservation over time. One of the ways that knowledge becomes TK is through oral traditions. In many cultures, knowledge is transmitted through stories, songs, and other forms of oral communication. This allows the knowledge to be preserved and passed down through generations, even when there is no written language. Another way that knowledge becomes TK is through written records. Many ancient civilizations developed sophisticated writing systems, which allowed them to record their knowledge and achievements. This written knowledge could then be passed down to future generations, becoming part of the cultural heritage of the community. In some cases, TK is also developed through trial and error. Ancient civilizations would experiment with different materials, techniques, and practices until they found a method that worked best for their needs. This knowledge would then be passed down through generations, becoming part of the cultural heritage of the community, TK is often tied to specific cultural practices, and beliefs like TK about herbal remedies may be closely tied to a particular religious or spiritual belief system. This connection to cultural practices and beliefs helps to preserve TK and ensure that it is passed down through generations.

TK, its protection, the rights of the holders and its relation with the IPR has become the critical issue of the global concern. Knowledge has proved to be one of the most coveted possessions of the man kind since ages. After the world war, the industrial boom actually recognizes and highlighted the importance of the intellectual knowledge. The International and national debate for the protection mechanism of the TK is whether the adequate protection is provided through the conventional IPR systems or there is a need for additional law to be incorporated or an additional protection with the amendments need to be done into the Intellectual property law. The moralistic arguments that advocate for the protection of TK mainly focus on the western impression that every person has a moral right to control the product of his or her labor or creativity[8]. The developing countries argue that their TK has been the basis for the research leading to high-priced inventions, the benefit of which is reaped by developed nations.[9] The increasing demand from the holder of the intellectual property with respect to the TK has gained momentum, either through the means of enacting new system or through the application of traditional conventional form of IPR.

Defining Traditional Knowledge: A Dilemma

Defining TK can be a complex and nuanced issue, as it encompasses a wide range of knowledge systems that have been developed and transmitted through generations of

[7]Id.
[8]Srividhya Ragavan, Protection of Traditional Knowledge, Minnesota Intellectual Property Law Review, Vol. 2, No. 2, (2001)
[9]Craig D. Jacoby & Charles Weiss, Recognizing Property Rights in Traditional Biocultural Contribution, STAN. ENVTL. L.J .Vol. 16, p. 85 (1997)

indigenous and local communities. One dilemma in defining TK is that it is often seen as being inextricably linked to culture and identity, and as such, there may be resistance to defining it in a way that could be seen as limiting or reducing its significance.[10] Another dilemma in defining TK is that it is often context-specific and may not fit neatly into Western scientific categories or frameworks.[11] TK may include knowledge about the environment, spirituality, social organization, and other aspects of life that are interconnected and holistic, rather than being narrowly defined and compartmentalized. Furthermore, TK is often transmitted through oral traditions and practices, rather than through written texts, which can make it difficult to document and preserve.[12] This can create challenges in defining TK in a way that is accessible and understandable to people outside of the community in which it originated.

Here are some definitions of TK from various organizations and legislations:

1. **Convention on Biological Diversity (CBD)**
   The CBD defines traditional knowledge as "knowledge, innovations, and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity"[13]
2. **World Intellectual Property Organization (WIPO)**
   WIPO defines traditional knowledge as "it is the knowledge, know-how, skills and practices that are developed, sustained and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity. "[14]
3. **United Nations Educational, Scientific and Cultural Organization (UNESCO)**
   UNESCO defines traditional knowledge as "Knowledge, innovations and practices of indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation."[15]

Nature and Characteristics Of Traditional Knowledge

TK is not static but is constantly evolving and adapting to changing circumstances, and it is often deeply embedded in cultural practices and customs.[16] It is an important source of information and guidance for indigenous and local communities in their daily lives, and can also be valuable for scientific research and sustainable development. However, TK is also at risk of being lost or undermined due to factors such as colonization, globalization, modernization, and the erosion of traditional cultures and languages.[17] Not the vintage nature

[10] Fitzmaurice, M. (2008). The Dilemma of Traditional Knowledge: Indigenous Peoples and Traditional Knowledge. International Community Law Review 10, 3, 255-278, Available at Brill https://doi.org/10.1163/187197308X346805 (Accessed July, 7, 2023)
[11] *Id.*
[12] Fikret Berkers, Sacred Ecology, Routledge (2018)
[13] Preamble, Convention on Biological Diversity, 1760 U.N.T.S. 79 (Jun 5, 1992)
[14] Traditional knowledge, WIPO Available at: https://www.wipo.int/tk/en/tk/#:~:text=Traditional%20knowledge%20(TK)%20is%20knowledge,its%20cultural%20or%20spiritual%20identity. (Accessed: July 8, 2023).
[15] Traditional knowledge (2023) UNESCO UIS. Available at: https://uis.unesco.org/en/glossary-term/traditional-knowledge (Accessed: July 8, 2023).
[16] Customary law and traditional knowledge – WIPO. Available at: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_tk_7.pdf (Accessed: July 8, 2023).
[17] Stephen Allen, The Consequences of Modernity for Indigenous Peoples: An International Appraisal, IJMGR,

of the TK itself, but the method through which it is learned and used, is what makes it traditional. The essential essence of traditionalism is the social act of sharing information that is specific to each indigenous and local culture. Even if TK isn't ancient, it nevertheless has special cultural significance. Because of its shared character, traditional wisdom is typically not viewed as the intellectual property of any one person but rather of the entire community. Often only a small subset of the population has access to this information since it is passed down the generations verbally from experts in the field (breeders, healers, etc.).[18]

Here are some general characteristics of traditional knowledge taking in account the varying notion of TK across the world:

- Holistic: TK takes a holistic approach to understanding the world, recognizing the interconnectedness of different aspects of life and the environment.
- Embedded in culture: TK is often deeply embedded in cultural practices and customs,and is shaped by the history and beliefs of the community that holds it.
- Oral transmission: TK is typically transmitted orally from one generation to the next, although some forms of TK may also be recorded in written or visual form.
- Observational: TK is often based on long-term observations and interactions with the natural world, including local ecosystems and biodiversity.
- Experiential: TK is experiential and grounded in practical experience, rather than abstract or theoretical concepts.
- Adaptive: TK is constantly evolving and adapting to changing circumstances, as communities learn from new experiences and respond to new challenges.
- Context-specific: TK is often specific to a particular place, culture, and
- Respectful of nature: TK often involves a deep respect for nature and the environment, recognizing the interconnectedness of humans and the natural world.

Scope of Traditional Knowledge

The scope of TK is vast and encompasses a wide range of areas, including agriculture, medicine, ecology, forestry, spirituality, and cultural practices. TK has been recognized across various fields like:

Agricultural traditional knowledge: Agricultural TK refers to the knowledge, skills, and practices related to agricultural production that have been developed and passed down over generations within a particular community or culture. It includes knowledge about crop cultivation, soil fertility management, irrigation, seed saving, pest and disease management, and animal husbandry, among others.

Medicinal traditional knowledge: Refers to the knowledge, skills, and practices relatedto the

---

Vol. 13, pp. 315-340 (2006)

[18]Narel Paniagua-Zambrana, Rodrigo Cámara-Leret, Rainer W. Bussmann, Manuel J. Macía, Understanding transmission of traditional knowledge across north-western South America: a cross-cultural study in palms (Arecaceae), Botanical Journal of the Linnean Society, Volume 182, Issue 2, pp480–504 (2016)

use of medicinal plants and other natural remedies for the prevention and treatment of illnesses and diseases. This knowledge has been developed and passed down over generations within a particular community or culture, and it plays an important role in many traditional healthcare systems around the world.

Religious Traditional Knowledge: Religious TK refers to the knowledge, practices, beliefs, and values associated with various religions and spiritual traditions that have been developed, preserved, and passed down over generations. This knowledge encompasses a broad range of cultural and spiritual practices, including rituals, ceremonies, meditation, prayer, moral and ethical teachings, and sacred texts, among others.[19] Religious traditional knowledge is a fundamental aspect of many cultures and plays a central role in shaping individual and collective identities, providing guidance for ethical and moral behavior, and promoting spiritual well-being.

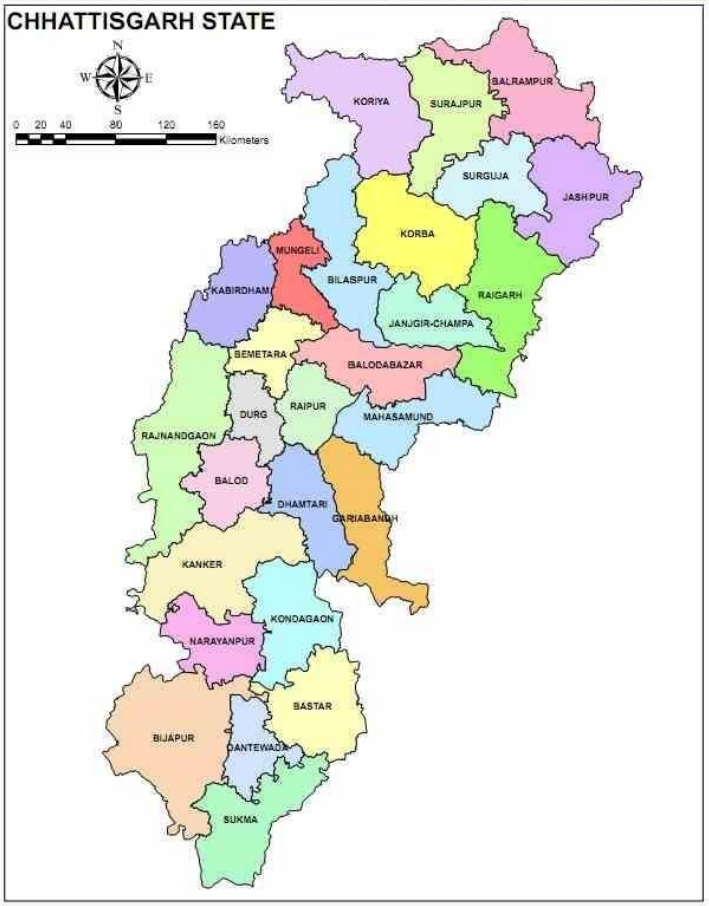
Folklore traditional knowledge: Folklore TK refers to the body of knowledge, beliefs, customs, and practices that are passed down through generations within a particular culture or community. It includes oral traditions such as folktales, myths, legends, songs, proverbs, and rituals that are transmitted through word of mouth rather than through written or formal education.[20] Folklore TK is often deeply rooted in the cultural, social, and historical context of a community and can serve as a means of preserving and sharing that community's unique heritage and identity.[21] It can also provide insight into the values, beliefs, and worldviews of a culture, as well as its relationship with the natural environment and spiritual realms.

Artistic traditional knowledge: Artistic TK refers to the knowledge, skills, techniques, and practices related to the creation and performance of art forms that are passed down through generations within a particular culture or community. It encompasses a wide range of artistic expressions, including visual arts, music, dance, theater, storytelling, and other forms of creative expression that are rooted in cultural traditions and heritage. Artistic traditional knowledge is often deeply connected to the social, cultural, and historical context of a community and is an important means of expressing and preserving that community's identityand values. It reflects the unique artistic styles, aesthetics, and techniques of a culture, and canalso serve as a vehicle for transmitting cultural knowledge, history, and values from one generation to the next.[22]

Culinary traditional knowledge: encompasses the practices, techniques, and knowledge related to the preparation, preservation, and consumption of food that are rooted in cultural traditions and heritage. This knowledge includes traditional recipes, cooking techniques, and food preservation methods that have been developed over centuries by different communities around the world.

[19]Gowda and Ushasi Khan, Sacred But Vulnerable: A Critical Examination of the Adequacy of the Current Legal Framework for Protection of Tribal Sacred Traditional Knowledge, 1 NUJS L Rev 109 (2008)
[20]Balavanth S. Kalaskar, Role of international Forums in Protecting Traditional Knowledge, PL May 41 (2012)
[21]*Id.*
[22]Lush, E. (2022) 60+ incredible world rituals and ceremonies (part 2), Wander. Wander-Lush. Available at: https://wander-lush.org/world-rituals-part-two/ (Accessed: July 8, 2023)

Preserving Chhattisgarh's Rich Tapestry: Embracing and Safeguarding Traditional Knowledge



CAPITAL	**RAIPUR**
AREA	Approximately 135,191 square kilometres[23] (52,198 square miles)
POPULATION	32,199, 722[24]
LANGUAGE	93 languages spoken; Hindi most prominent

DISTICTS	33
GOEGRAPHY	Chhattisgarh is known for its rich mineral resources and is a significantcontributor to India's industrial sector. It has abundant reserves of coal, iron ore, limestone, and other minerals.

[23]India Census, Chhattisgarh population. Available at: https://www.indiacensus.net/states/chhattisgarh (Accessed: 10 July 2023).
[24]*Id.*

ECONOMY	Agriculture is a crucial part of the state's economy, with rice, wheat, pulses, and oilseeds being the major crops grown in the region. Apart from agriculture, industries like steel, cement, power generation, and mining play a significant role in the state's economy.
CULTURE	Chhattisgarh is known for its vibrant tribal culture, with numerous indigenous communities residing in the state, each having their distinct traditions, customs, and art forms. The state is also famous for its folk music, dance, and handicrafts.
TOURISM	Chhattisgarh boasts several tourist attractions, including ancient temples, wildlife sanctuaries, waterfalls, and historical sites. Some notable places to visit are Chitrakote Falls, Bastar Dussehra Festival, Kanger Valley National Park, and the ancient temples of Sirpur.

INTRODUCTION

Chhattisgarh, located in east-central part of India, is a state brimming with rich cultural heritage, breathtaking landscapes, and a history that dates back to ancient times. Formed on November 1, 2000, through the reorganization of the state of Madhya Pradesh[25], Chhattisgarh emerged as the country's 26th state, and since then, it has been making significant strides in various sectors. One of the state's most defining features is its diverse and vibrant culture. Chhattisgarh is home to numerous indigenous tribes, each with its distinct customs, rituals, and art forms. The state's folk music, dance, and traditional crafts are a testament to the region's artistic prowess, with the 'Pandwani' and 'Raut Nacha' being among the most famous art forms[26].

Apart from its cultural heritage, Chhattisgarh boasts an abundance of natural beauty. The state is adorned with lush forests, picturesque waterfalls, and the enchanting Maikal Hills. The prominent national parks and wildlife sanctuaries, such as Indravati National Park and Barnawapara Wildlife Sanctuary, are havens for various flora and fauna, making it a delight for nature enthusiasts and wildlife photographers[27]. Chhattisgarh's economy thrives on its vast mineral resources, including coal, iron ore, and bauxite, which play a crucial role in contributing to the nation's industrial growth. Additionally, the state has been making strides in the agricultural sector, with rice, pulses, and oilseeds being the primary crops cultivated by the farmers.

TK in the state of Chhattisgarh, India, is deeply rooted in its rich cultural heritage and diverse indigenous communities. The state is known for its vibrant traditions, customs, and practices

[25]Chhattisgarh, Encyclopædia Britannica. Available at: https://www.britannica.com/place/Chhattisgarh (Accessed: 09 July 2023).
[26]Pandey, V. (2023) Folk dance of chhattisgarh. Raut Nacha, Panthi, and many more., CgPsc.info. Available at: https://www.cgpsc.info/folk-dance-of-chhattisgarh.html/ (Accessed: 09 July 2023).
[27] Welcome to CGG Tourism - Official Website of Department of Tourism, Government of CGG, cgg Tourism. Available at: https://www.chhattisgarhtourism.in/nationalpark/ (Accessed: 09 July 2023).

that have been passed down through generations, encompassing various aspects of life, including agriculture, medicine, handicrafts, dance, music, and spirituality. One of the prominent features of traditional knowledge in Chhattisgarh is its agricultural practices. The state's agricultural techniques have been developed and refined over centuries, perfectly attuned to the region's ecological conditions. Indigenous farmers have a profound understanding of the land, weather patterns, and soil fertility, enabling them to cultivate a wide variety of crops like paddy, millets, pulses, and oilseeds. Their traditional knowledge includes organic farming practices, crop rotation, and water management techniques, which not only ensure a sustainable livelihood but also contribute to the preservation of biodiversity.

Traditional medicine and healing systems hold a significant place in Chhattisgarh's culture. The state's tribal communities have their distinct systems of healthcare that rely on the use of medicinal plants, roots, herbs, and minerals. These traditional healers possess a wealth of knowledge about the medicinal properties of various plants and their applications to cure ailments. Their remedies often incorporate age-old wisdom and spiritual beliefs, making their practices holistic and deeply rooted in cultural significance.

Chhattisgarh's handicrafts and artistic expressions showcase another facet of its traditional knowledge. The state is renowned for its exquisite tribal art forms, such as Gond paintings, Bastar Dhokra craft, and Kosa silk weaving. These art forms are not just a means of livelihood for the artisans but also a way to preserve their cultural identity and pass on their heritage to the next generations. The intricate designs and motifs found in these handicrafts often draw inspiration from nature, folklore, and religious beliefs, making them culturally significant and unique. Dance and music play a vital role in Chhattisgarh's cultural fabric, with numerous traditional dance forms and musical styles practiced across the state. Performances like Raut Nacha, Panthi, Pandwani, and Karma dance are deeply rooted in the local folklore and religious rituals[28]. They celebrate the triumph of good over evil, depict stories from epics like the Mahabharata and Ramayana, or honor natural phenomena like the changing seasons. These art forms are a reflection of the people's spiritual connection with their land and ancestors, and they continue to be cherished and performed during festivals and other auspicious occasions.

Spirituality and religious practices in Chhattisgarh are diverse and often rooted in tribal customs and beliefs. The state is home to several ancient temples, sacred groves, and pilgrimage sites that hold immense cultural and spiritual significance. The worship of natural elements, spirits, and deities reflects the close bond between the people and their surroundings. Many tribal communities celebrate festivals dedicated to nature and agriculture, which are marked by elaborate rituals and traditional practices that celebrate the harmony between humans and their environment.

Why the protection of traditional knowledge of Chhattisgarh is imperative?

Protecting the TK of Chhattisgarh through IPRs is essential to safeguard the cultural heritage and interests of its indigenous communities. TK, passed down through generations, holds valuable insights into sustainable practices, medicinal remedies, artistic expressions, and

[28]Pandey, V. (2023) Folk dance of chhattisgarh. Raut Nacha, Panthi, and many more., CgPsc.info. Available at: https://www.cgpsc.info/folk-dance-of-chhattisgarh.html/ (Accessed: 09 July 2023).

spiritual beliefs unique to the region. However, the lack of legal protection exposes this knowledge to misappropriation, exploitation, and erosion due to globalization and modernization.

Implementing IPR protection can offer several benefits. Firstly, it provides recognition and acknowledgment to the custodians of TK, the indigenous communities themselves. By legally attributing ownership, IPRs empower these communities to protect their knowledge from unauthorized use and commercial exploitation by external entities[29]. Secondly, IPRs can foster the conservation and preservation of TK. When communities know that their knowledge is protected, they are more likely to continue practicing and transmitting it to future generations. This preservation is crucial to maintain the cultural identity and heritage of Chhattisgarh's indigenous communities, which face the risk of losing their traditional practices in the face of modernization.

Thirdly, IPRs can stimulate innovation and creativity within the communities. By protecting TK, communities are encouraged to build upon their heritage, developing new products, and enhancing existing ones. This process can lead to economic opportunities for the communities, creating sustainable livelihoods based on their traditional expertise. Fourthly, IPRs can prevent bio-piracy and unfair exploitation of TK by external entities[30]. Chhattisgarh's traditional knowledge of medicinal plants, agriculture, and handicrafts, for example, has immense commercial potential. By obtaining IPRs, communities can control how their knowledge is utilized, ensuring that any commercial benefits derived from it are shared equitably and ethically.

IPRs can promote collaboration and mutual respect between indigenous communities, researchers, and businesses. Establishing clear guidelines on the use of TK fosters partnerships that are built on trust and respect for the cultural heritage of Chhattisgarh. Implementing IPR to protect the TK of Chhattisgarh is crucial for preserving its rich cultural heritage, empowering indigenous communities, promoting innovation, and ensuring equitable benefits from its commercial use. By taking proactive steps to safeguard TK, the state can strike a balance between preserving its past and embracing the future.

Possible Intellectual Property Protection for the Holders of Tk

Introduction

One of today's most pressing challenges of justice is the recognition and vindication of indigenous peoples' rights under municipal and international law, as well as the preservation of their culture and lifestyles, and intellectual property. Hence, IPR has an important role in protecting indigenous people's cultural legacy, and this includes protecting TK.

IPR can be an effective way to protect TK for several reasons:

1. Preventing Misappropriation

[29]Ouma, D.M. >WTO: Intellectual property (TRIPS) - gateway, Protection of Traditional Knowledge and Traditional Cultural Expression in Kenya . Available at: https://www.wto.org/english/tratop_e/trips_e/trips_e.htm (Accessed: 28 July 2023).
[30]Hamilton, C. Intellectual property rights, the bioeconomy and the challenge of biopiracy. Life Sci Soc Policy 4, 26 (2008). Available at: https://doi.org/10.1186/1746-5354-4-3-26

2. Encouraging Preservation
3. Promoting Innovation
4. Strengthening Cultural Identity
5. Ensuring Fair Compensation

TRADE SECRETS PROTECTION

WIPO has defined Trade Secrets (TS) as "Intellectual Property rights on confidential information which may be sold or licensed."[31] TS can include formulas, processes, designs, patterns, techniques, customer lists, and other valuable information that is kept confidential.[32] Confidential information is recognized as an IPR under Article 9 of TRIPS[33].

What qualifies as a trade secret?

There are some important elements required in order to be a trade secret and that is the knowledge:

- having a commercial value
- must not be made available to the general public
- And that knowledge in itself subject to the reasonable efforts in order to maintain the secrecy or there needs to be sufficient evidence available to show that efforts were made inline to maintain that secrecy for the respective information.

Trade Secrets found to be best possible branch of law in order to protect the TK in the current convention forms of intellectual property right mechanism.

Patent Protection to the Tk

WIPO defines Patent as "an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem"[34].

Requirement of Novelty vis-à-vis TK

Novelty is regarded as the most important prerequisite for granting a patent for an invention. An idea can be seen coming by:

a. prior publication or

b. prior use.

Section 13 of the Act requires the patent examiners to conduct search for anticipation.[35] If a

[31]Trade secrets– Everything you need to know. Available at: https://www.wipo.int/tradesecrets/en/ (Accessed: July 28, 2023).
[32]What is the definition of trade secret? Winston & Strawn Legal glossary , Winston & Strawn. Available at: https://www.winston.com/en/legal-glossary/trade-secret.html (Accessed July 29, 2023).
[33]Agreement on Trade-Related Aspects of Intellectual Property Rights, Marrakesh Agreement Establishing the World Trade Organization, Annex 1C, 1869 U.N.T.S. 299 (Apr. 15, 1994)
[34]World Intellectual Property Organization, Patentscope, https://www.wipo.int/patentscope/en/ (Accessed: July 29, 2023).
[35]Patent Act, 1970, No. 39, § 13, No. 13, Acts of Parliament, 1970 (India)

product or procedure based on the invention is already on the market or being used in the production of a product, then the invention is considered to be in use.[36]

Requirement of Non-obviousness or Inventive step vis-à-vis TK

This is the second most important requirement in order to get a patent protection. The inventive step was substituted from the place of non-obviousness.

Requirement of Industrial Applicability vis-à-vis TK

Only inventions that are frivolous or injurious to the society are considered as not useful to the society.[37] Now, according to Section 3(p)[38] the TK and its duplication or its known properties are not patentable. Also, Section 3(a)[39] lays down that inventions that are contrary to well-designed natural laws cannot be patented.

Impediment created by Patent Laws on TK

The requirement which is discussed above act as an impediment to the protection of TK by the Patent regime. Holders of TK face Evidentiary, Substantive, Administrative, and Cultural hurdles under the patent regimes[40].

Evidentiary Impediment

Patent law's evidentiary hurdles are the most significant challenge to TK. The holder of the TK is not eligible for patent protection if they are unaware of this fact. Prior art is another source of evidential difficulty for TK.

Substantive Impediment

Inventiveness is currently seen as the "isolated, individual achievement of a known inventor." In contrast, TK is often owned and made by the natives of a certain territory as a group.

Administrative Impediment

The administrative barrier to TK is created by the patenting process itself[41]. In the first place, owners of TK typically lack the financial means to file for patent protection. Second, the patents must be written in patent terms, which TK holders find challenging to communicate since they lack the linguistic skills to articulate the "language of chemistry" or "language of molecular biology"[42]. This puts corporations at an edge over local populations.

Hence from the above requirement, the researcher can make an observation that Patenting TK can have both positive and negative outcomes.

Positive outcomes of patenting TK:

- Protection of TK

[36]Indian vacuum Brake Co. Ltd. v. E. S. Laurd, AIR 1926 Cal. 152.
[37]Bedford v. Hunt, 3 F. Cas. 37 and Reliance Novelty Corp. v. Dworzek, 80 F. 902 (N.D. Cal. 1897).
[38]Patent Act, 1970, No. 39, No. 13, Acts of Parliament, 1970 (India)
[39]*Id.*
[40]Sumathi Subbiah, Reaping What they Sow: The Basmati Rice Controversy and Strategies for Protecting TK, 27 Boston College International and Comparative Law Review, 542 (2004)
[41]*Id.*
[42]Graham Dutfield, TRIPS Related Aspected of TK, Case Western Reserve Journal of International Law, 233 (2001)

- Economic benefits

Negative outcomes of patenting TK:

- Exploitation
- Limited access
- Disruptive to traditional practices

Analysis of Existing Geographical Indications (GIS) In Chhattisgarh: Evaluating Their Impact and Effectiveness

Introduction

Geographical Indications (GIs) play a pivotal role in protecting and promoting unique products and TK that are deeply rooted in specific regions. In the state of Chhattisgarh, India, in total 6 products and crafts have been bestowed with GI status, although less as compared to other states, it recognizes their distinct origin and cultural significance. These GIs have been instrumental in not only safeguarding the rich heritage of the state but also in providing economic opportunities for local communities. As the importance of GIs grows, it becomes imperative to assess their impact and effectiveness in preserving traditional practices, fostering innovation, and promoting sustainable development. This chapter delves into the existing GIs in Chhattisgarh, examining the tangible and intangible benefits they have brought to the region and its people. By evaluating the outcomes of GI recognition, this section aims to shed light on the role of IP protection in preserving cultural heritage, encouraging rural livelihoods, and fostering a sense of identity among the communities of Chhattisgarh. Moreover, it seeks to identify areas where further support and enhancement can be provided to fully harness the potential of GIs as powerful tools for sustainable development and the preservation of TK in the state as well as benefitting the tribal and indigenous population using the GI.

Existing GIS and its Specification

In the diverse cultural landscape of Chhattisgarh, six distinctive products and crafts have earned prestigious recognition and protection under the GI status. These GIs symbolize the region's rich heritage, unique traditions, and skilled craftsmanship. Each GI represents a remarkable blend of art, culture, and indigenous knowledge, deeply rooted in the communities that have nurtured these age-old practices for generations.

Here is the list of all the registered GIs of the state of Chhattisgarh:

S No.	Name	Classification	Good	Registration Authority	Certificate Date	No. of Authorized users	No. of Registered authorized users
1.	Bastar Iron Craft	6 & 21	Handicraft	Chhattisgah Hastshilp Vikas Board	10/07/2008	26	1

2.	Bastar Dhokra	6 & 21	Handicraft	Chhattisgah Hastshilp Vikas Board	22/04/2008	103	103
3.	Bastar Wooden Craft	20	Handicraft	Chhattisgah Hastshilp Vikas Board	22/04/2008	27	1
4.	Champa Silk Saree and Fabrics	23, 24, 25 & 26	Handicraft	Champa Raigarh Hathkargha Kosa Bunkar Kalyan Samiti	04/10/2010	2	0
5.	Jeeraphol	30	Agriculture	Jaivik Krishi Utpadak Sahkari Samiti Maryadit	14/03/2019	1	0
6.	Nagri Dubraj	30	Agriculture	Maa Durga Swayam Sahayata Samooh	31/01/2023	0	0

Bastar Iron Craft

Bastar Iron Craft

APPLICANT'S NAME	Chhattisgarh Hastshilp Vikas Board
CERTIFICATION DATE	10/07/2008
CLASSIFICATION	6 & 21 (Handicraft)
NO. OF AUTHORISED USERS (AU)	26
NO. OF REGISTERED AUs	1
PRACTICING POPULATION	3000 Artisans
TECHNIQUE USED	Wax Thread casting method
ALLOY USED	Bronze with high Tin content
TURNOVER	3 Cr.

Introduction

Bastar Wrought Iron Craft is a revered art form and a proud holder of the Geographical Indication (GI) tag, originating from the culturally rich state of Chhattisgarh, India. It showcases the exquisite craftsmanship and artistic finesse of the tribal communities residing in the Bastar region. What sets Bastar Wrought Craft apart is its raw and rustic appeal. The artisans draw inspiration from nature, tribal folklore, and mythological narratives, infusing their creations with symbolism and cultural significance. From figurines depicting tribal deities and animals to tribal jewelry and household items, each piece of Bastar Wrought Craft tells a story, reflecting the tribal heritage and traditions of Chhattisgarh.

It has the most symbiotic relation of the tribals with nature allowing them to draw raw material from the ore-rich mines in Chirandonigiri region or by prudently recycling with a firm touch of the blacksmith. Blacksmith uses his rudimentary tools of hammer and tongs to skillfully forge the item in such a way that no joints are created. A final varnish provides the bedrock ofthe craft but most objects also embody strong ritualistic significance. Lamp Candle stands, Musicians joyfully playing a variety of instruments, figurines of deities, etc. typify the product range. A Unique beauty pervades the entire art form and creates an ageless appeal. Crafted extensively in the Nagamar, Jondrapadar & Kondagaon village of Chhattisgarh[43], the blacksmith skillfully forges the items. Some of the commonly made objects include adivasi musician playing the Muhri (Trumpet). Dhapra (Daphil), Tudbudi (Nagada) with Peacocks, Monkeys Lions, Deers, which are dedicated to wedding and the jhaari of the bundi goddess[44]. The laman diya is one of the most popular items in wrought iron[45].

Impact, Effectiveness & Advantages

[43]Chandrashekhar, P. author B.M. et al. Chhattisgarh's timeless tradition: Bastar iron craft, The Cultural Heritage of India. Available at: https://cultureandheritage.org/2023/07/bastar-iron-craft-of-chatthisgarh.html (Accessed: 20 July 2023).
[44]*Id.*
[45]Neeru (2015) Products, D'Source. Available at: https://www.dsource.in/resource/wrought-iron-craft-bastar/products (Accessed: 20 July 2023)

The GI status granted to the Bastar iron craft has had a profound impact on the traditional craft and the local artisans of Chhattisgarh. With its recognition as a GI product, the craft has gained increased visibility and reputation both within India and on the international stage. The GI status has served as a valuable marketing tool, allowing the artisans to distinguish their products from imitations and establish a unique identity in the market. The effectiveness of the GI tag lies in its ability to protect the craft from unauthorized replication and mass production. By registering the Bastar iron craft as a GI, it ensures that only the artisans from the designated geographical area, specifically the Bastar district, can produce and market the craft under the protected name. This safeguards the craft from being exploited by commercial interests and preserves the TK and craftsmanship of the local artisans.

One of the significant advantages of the GI status is the economic upliftment it brings to the artisans and their communities. The increased market demand and premium pricing for genuine Bastar iron craft products enable the artisans to earn better incomes. This, in turn, contributes to poverty alleviation and enhances the overall socio-economic conditions of the region. Moreover, the GI status promotes the transmission of TK and skills from one generation to the next. As the younger artisans see the value and recognition associated with the GI tag, they are encouraged to learn and continue the craft, preventing its decline and ensuring its continuity for the future. The GI recognition also fosters a sense of pride and cultural identity among the artisans and the local community. It highlights the unique heritage and artistic expression of the Bastar region, contributing to a heightened sense of cultural preservation and promotion.

Additionally, the GI status attracts tourism and cultural enthusiasts who wish to experience and purchase authentic Bastar iron craft products. This influx of tourists not only boosts the local economy but also creates opportunities for cultural exchange and appreciation.

However, despite its protected status, many artisans in the region face significant disadvantages and a lack of adequate support. The challenges include limited market access, exploitation by middlemen, and insufficient government assistance[46]. Additionally, the younger generation's dwindling interest in continuing the traditional craft poses a threat to its sustainability. The lack of proper training, modern design integration, and marketing assistance further hinder the growth and development of the Bastar iron craft industry. Addressing these issues is crucial to ensure the long-term survival and prosperity of skilled artisans and their invaluable cultural heritage.

Challenges Identified

The Bastar Iron craft got its GI certification in the year 2008[47], but after 15 years of its registration, it still has only 20 named users and among them, no one has the status of registered Authorized user except TRIFED, a governmental organization. The researcher has identified following gap and challenges after interacting with the relevant organizations, GI's proprietor and artisans which has to be acknowledged, ratified and worked upon:

[46]Bastar art goes global, but artisans battle for survival (2010) The Hindu. Available at: https://www.thehindu.com/arts/crafts/Bastar-art-goes-global-but-artisans-battle-for-survival/article16364328.ece (Accessed: 29 July 2023).

[47]'Geographical Indications Journal' (2008) Supplementary 24, pp. 32–54. Available at: https://search.ipindia.gov.in/GIRPublic/Application/ViewDocument

1. **Limited direct market access provided to the Artisans**

   After having a telephone conversation with State awardee in the craft Shri. Bhagye Lal[48], the major difficulty identified by him was the market access available for them. As most of the artisans live in remote areas and in villages, it becomes difficult for them to reach out to the wider group of consumers to sell their craft. The government has published brochures and conducted various exhibitions for the craft where they can sell their product, but it is only a temporary solution to this problem. The artisans do not have regular market access.

2. **Economic effects of Intermediaries on the artisans**

   Most of the craft sold is through people who work as middlemen or intermediaries[49]. These middlemen buy craft in large numbers from the artisans at a standard price and then brandand sell them in various markets across India and abroad at higher rates.

   Due lack of market access provided to the artisans, middleman take advantage of it, and this leads to low economic returns for artisans.

3. **Pricing Method**

   Most of the Bastar Iron Craft is priced on the basis of the Weight to Price ratio. It simply means that the weight of the craft plays the most important role in deciding the price of the craft made. Due to this pattern, motifs and intricate details of the craft doesn't play a relevant role. Due to this, the authenticity of the craft is getting diluted and the quality of the craft is also getting affected. The artisans also do not get the desired remuneration for the craft.

4. **Lack of Monetary Support**

   Most of the artisans have a humble background and also do farming to support their familyand craft. No, proper mechanism is there to provide the artisans with monetary support, except for the rewards given by the government. This has led to artisans resorting to local moneylenders for loans which are at very high interest rate.

5. **Inadequate Infrastructure and equipment.**

   Shri Bhagye Lal pointed out that lack of proper infrastructure and modern equipment posesa significant challenge for Bastar iron craft artisans. Inadequate access to tools and technology hampers the efficiency of production, limiting their ability to meet growing demands and compete in the market.

6. **Lack of supply chain mechanism**

   The lack of a well-defined supply chain mechanism for Bastar iron craft creates hurdles in its market reach and growth. Absence of organized channels for raw material sourcing, production, and distribution impedes artisans from accessing wider markets and potential customers, limiting the craft's expansion and economic opportunities.

[48]Telephonic Interview
[49]*Id.*

7. **Lack of Awareness of GI among artisans.**

8. **Diminishing Interest and Skill Gap**
   The younger generation's waning interest in learningtraditional crafts and skills poses a significant challenge to the continuity of Bastar iron craft. As the older generation of artisans retires or passes away, there is a risk of losing the intricate knowledge and techniques associated with this craft.

Proposed Policy and Solutions

This proposal aims to address the challenges faced by the Bastar iron craft, a cherished traditional art form in Chhattisgarh, and is formulated after due discussion with relevant organizations and Artisans:

1. To resolve the direct access to market and middleman problem, the researcher proposes:
   a. Increased participation of CHSB, in the exhibition and selling of the artisan'sproducts
   b. Formulation of a web-based site and a mobile-based e-commerce application thatwill have a direct artisans-to-consumer connection
2. A loan-giving mechanism should be set up and with the help of the local Gramin Bank which will provide easy loans for artisans with very low interest rates.
3. Organizations like TRIFED and CCoST should be appointed for helping artisans and proprietors of the GI to set up a supply chain that will be in consonance with the web-basedand software application.
4. Local NGOs and CCoST can launch and awareness drive, which will help the local artisansto understand the important and significance of GI and how they can take benefit from it.

Bastar Dhokra

APPLICANT'S NAME	Chhattisgarh Hastshilp Vikas Board
CERTIFICATION DATE	22/04/2008
CLASSIFICATION	6 & 21 (Handicraft)
NO. OF AUTHORISED USERS (AU)	103
NO. OF REGISTERED AUs	103
PRACTICING POPULATION	6000 artisans
TECHNIQUE USED	Dhokra wax casting
ALLOY USED	Brass or Bronze
TURNOVER	6 Cr.

Dhokra art popularly known as Bell Metal art is derived from the "Dhokra damar" tribe, almost 4000 years old,[50] one of the earliest of this technique is the famous "Dancing Girl" figurine excavated from Mohenjo Daro. Exquisite dull gold figurines and objects de art are crafted in the Bastar & Raigarh districts of Chhattisgarh[51] out of Bell Metal, brass, and bronze. The gadwa's of Bastar and Jharas of Raigarh practice the Dhokra art with lost wax technique or hollow casting[52].

Inspiration is available to the craftsperson from his abundant environment, be it the village Ghotul. A myriad of trees, birds and animals, mythology or rituals, and utilitarian pieces such as combs. lamps, bowls, and cups[53] are created for daily use just as mythological icons like Budha Deo, Karma Jharr, and Mata Jhula[54] are crafted for their spiritual relevance. Each piece is characterized by intricate attention to detail, visible in the jewelry that depicts the maria-muria heads, the elephant's hounda, or even in the pot's geometric lines, nowhere else in the country craft pay such obeisance to nature, as in the Dhokra art.

Casting Process

The Dhokra craft process is a labor of love, skillfully combining the use of beeswax, clay, and scrap metal to create stunning and detailed figurines. The artisans start by sculpting the desired form using beeswax, which is then coated with a layer of clay. The intricate details are carefully etched on the clay coating, capturing the essence of tribal life, mythology, nature, and folklore. Once the clay mold is ready, it is heated in a pit furnace, causing the beeswax to melt and flow out, leaving a hollow cavity. Molten metal, typically a combination of brass and bronze, is then poured into the cavity, taking the shape of the original wax sculpture. The mold is allowed to cool, and once solidified, the clay coating is broken to reveal the magnificent metal artwork within.

[50]'Geographical Indications Journal' (2008) No. 24, pp. 34-52. Available at: https://search.ipindia.gov.in/GIRPublic/Application/ViewDocument
[51]*Id.*
[52]*Id.*
[53]*Id.*
[54]*Id.*

The significance of Dhokra craft goes beyond its artistic appeal. It serves as a vital source of livelihood for the tribal communities of Bastar, providing economic empowerment and preserving their traditional way of life. Additionally, the GI tag bestowed upon Bastar DhokraCraft protects its authenticity, ensuring that this unique art form remains exclusive to the region.

Challenges Identified

The Bastar Dhokra got its GI certification in the year 2008. For identifying the existing gaps the researcher had an interaction with The researcher has identified following gaps and challenges after interacting with the relevant organizations, GI's proprietor, and artisans which have to be acknowledged, ratified, and worked upon:

1. **Stock hoarding by Middleman and intermediaries**

   The researcher had a telephonic interview with state awardee Shri. Jitendra Kumar[55], S/o of president award winner Shri. Banu Ram Vaidya[56], and one of the major problems facedby them was the hoarding by businessmen, certain businessmen who have good connections with the artisans, buy their craft in large quantities and after due touch-ups andtagging sell them at much higher prices. As they buy craft in bulk, it is more profitable forthe businessmen, but at the same time it is not much beneficial for the artisans and due to lack of direct market access and shortage of supply chain they are compelled to sell their craft to them.

2. **Barriers created by Businessman**

   Among the few artisans, the researcher had telephonic interviews with, almost all of thementioned the problems of barriers created by local businessmen in selling their craft directly to the market. Artisans are able to sell their craft in local exhibitions conducted bythe state government but due to a lack of connection and knowledge, they are compelled to sell their craft only to certain businessmen. Also, due to a lack of economic viability, mostof them take minimal loans from these businessmen and in exchange they sell their craft only to them.

3. **Weight to Price System**

   Weight to Price system is the same as discussed before, and the artisans of this craft face the same problem as that of the artisans of Bastar Iron Craft.

   a. As stated by Shri. Jitendra Kumar, they usually get 5000 rupees for a craft made by them which weighs around 5 kgs, not paying much relevance to the craft itself and pattern and motifs in them.

4. **Lack of Monetary Support**

   The situation of artisans of this craft is not different than the artisans as discussed for othercrafts. They also are in need of proper monetary support.

[55]Annexure 2
[56]Telephonic Interview

5. **Supply Chain**
6. **Lack of Direct Market Access**
7. **Lack of awareness of GI**
8. **Dilution of quality of the craft by Authorized Users**

   The Bastar Dhokra which is also known as Bell metal craft is mainly made from non-ferrous metal alloys of Brass and Bronze, but due to increasing prices of these metals and the fact that the price of the craft depends on its weight itself, some of the registered authorized users have stated mixing ferrous metals to cut the cost of making and increase the weight of the craft. This had led to the dilution of the craft and it becomes disadvantageous to other artisans who are making it with proper, non-ferrous metals.

Proposed Policy and Suggestions

This proposal aims to address the challenges faced by the Bastar Dokhra artisans, a cherished traditional art form in Chhattisgarh, and is formulated after due discussion with relevant organizations and Artisans:

1. Increased participation of CHSB, in the exhibition and selling of the artisan's products.
2. Formulation of a web-based site and a mobile-based e-commerce application that will have a direct artisans-to-consumer connection.
3. A loan-giving mechanism should be set up and with the help of the local Gramin Bank which will provide easy loans for artisans with very low interest rates.
4. Organisations like TRIFED and CCoST should be appointed to help artisans and proprietors of the GI to set up a supply chain that will be in consonance with the web-based and software application.
5. Local NGOs and CCoST can launch an awareness drive, which will help the local artisansto understand the importance and significance of GI and how they can take benefit from it.
6. Government and local organizations can help artisans acquire the required raw material for the craft and can implement a quality control mechanism for the craft.
7. Shri. Jitendra Kumar has proposed that with the help of other artisans in his village, the local government can request the state government to identify his village as a craft village which will help them to promote their craft in India.
8. Recognized artisans can be given opportunities to teach in the art and craft colleges, which will help them to advertise their craft and support them economically.

Bastar Wooden Craft

APPLICANT'S NAME	**Chhattisgarh Hastshilp Vikas Board**
CERTIFICATION DATE	**22/04/2008**
CLASSIFICATION	**20 (Handicraft)**
NO. OF AUTHORISED USERS (AU)	**27**
NO. OF REGISTERED AUs	**1**
PRACTICING POPULATION	**3000 artisans**
TECHNIQUE USED	
MATERIAL USED	**Sheshum & Shivna**
TURNOVER	**3 Cr.**

Introduction

Bastar is a region with extensive land cover, with large forests of "Sheshum" and "Shivna" thriving in the area[57]. Initially, the tribals used the forests as a source of wood for basic needs like firewood and building shelters. Over a period of time, they began to use wood for carving objects and other forms of carpentry, precipitating in the emergence of a community of people skilled in this craft, called the "Badais"[58]. The Badais then diversified into two groups-one making agricultural instruments and others making decorative and totemic pillars, Simple tools made of wood or bamboo used by them.

[57]Geographical Indications Journal' (2008) No. 24, pp. 55-71. Available at: https://search.ipindia.gov.in/GIRPublic/Application/ViewDocument
[58]Manikanta (2018) Ghothuls of different tribes, Bastariya.com - Bastar Chhattisgarh. Available at: https://bastariya.com/ghothuls-different-tribes/ (Accessed: 01 August 2023).

Making Process

One of the distinctive features of Bastar Wooden Craft is the use of traditional tools, passed down through generations, to shape and sculpt the wood. The artists employ simple implements like chisels, hammers, and saws, relying on their honed skills and inherent creativity to bring their visions to life.

The Kaas is employed to remove the bark of the trees and scrape the wood surface. When carving scraping and shaping has to be done, the chisel and the smaller tools are used. One of the places where the Badais's skills can be seen is the ghotul[59]. The youth dormitories of the muria once stored dancing stills, carved wooden head gear or kutul, and large drums used during the dances[60]. Reflecting the mood of ghotul, are doors and pillars carved with elaborate images of amorous couples indulging in merry-making motifs such as combs, sun and moon, floral and geometric designs also appear alongside.

Challenges Identified

The Bastar Wooden craft got its GI certification in the year 2008. For identifying the existing gaps, the researcher had an interaction and identified following gaps and challenges after interacting with the relevant organizations, GI's proprietor, and artisans which have to be acknowledged, ratified, and worked upon:

1. **Lack of Direct market access**
2. **Economic effects of Intermediaries on the artisans:** Most of the craft sold is through people who work as middlemen or intermediaries. Thesemiddlemen buy craft in large numbers from the artisans at a standard price and then brandand sell them in various markets across India and abroad at higher rates. Due lack of market access provided to the artisans, middleman take advantage of it, and this leads to low economic returns for artisans.
3. **Lack of Monetary Support:** Most of the artisans have a humble background and also do farming to support their familyand craft. No, proper mechanism is there to provide the artisans with monetary support, except for the rewards given by the government. This has led to artisans resorting to local moneylenders for loans which are at a very high-interest rate.
4. **Lack of awareness of GI**

Proposed Policy and Suggestions

The proposed policy and suggestion for this GI is no different than the suggestions given by the researcher for the above two GIs.

[59] *Id. 57*
[60] *Id. 57*

Champa Silk Saree and Fabrics

APPLICANT'S NAME	Champa Raigarh Hathkargha Kosa Bunkar Kalyan Samiti
CERTIFICATION DATE	04/10/2010
CLASSIFICATION	23, 24, 25 & 26 (Handicraft)
NO. OF AUTHORISED USERS (AU)	2
NO. OF REGISTERED AUs	0
PRACTICING POPULATION	50, 000 women
TECHNIQUE USED	Spinning and Weaving
MATERIAL USED	Kosa Silk
TURNOVER	

Introduction

Champa Silk Saree and Fabrics is a treasured craft that holds the prestigious GI tag of Chhattisgarh, India. Rooted in the ancient textile traditions of the region, Champa Silk Sarees and Fabrics are a testament to the artistic brilliance and cultural heritage of the state. Champa Silk is a fine and lustrous silk that is native to Chhattisgarh[61], specifically cultivated in the town of Champa, from which it derives its name[62]. The silk is carefully sourced from silk-producing worms, and the entire process of transforming the raw silk into gorgeous sarees and fabrics is a labor of love and skill.

The Champa Silk Sarees are known for their exquisite craftsmanship, intricate designs, and vibrant colors. Artisans weave magic into each saree, adorning them with traditional motifs, intricate borders, and artistic pallus that reflect the rich cultural tapestry of Chhattisgarh[63]. The luxurious feel of the silk, combined with the timeless elegance of the designs, make Champa Silk Sarees a sought-after choice for special occasions and celebrations. Apart from sarees, Champa Silk is also used to create a wide range of fabrics, such as dress materials, stoles, scarves, and dupattas. Each piece of fabric is a testament to the dedication and mastery of the

[61]Geographical Indications Journal' (2008) No. 34, pp. 57-74. Available at: https://search.ipindia.gov.in/GIRPublic/Application/ViewDocument
[62]*Id.*
[63]*Id.*

weavers, showcasing the richness and diversity of Chhattisgarh's textile heritage.

A few varieties of Champa Silk Saree and Fabrics products are:

1. Kosa silk plain. Saree
2. Kosa silk sarees with Extra Warp border and Extra Weft designs made of pure Kosa silkeither with natural colours or with different dyed materials.
3. Kosa silk Sarees with Pallow heading, using with additional attachments namely, dobby,jacquard and jala Systems.
4. Kosa silk sarees with the embroidery works
5. Kosa silk dyed sarees with or without extra warp and extra weft designs.
6. Kosa silk dress materials made of the natural colours.
7. Kosa silk dyed dress materials
8. Kosa silk printed dress materials
9. Kosa silk woven designs with or without the help of the dobby, jacquard, and jalatechniques.
10. Kosa silk shawl.

The Geographical Indication (GI) status of Champa Silk Saree and Fabrics has undoubtedly provided recognition and protection to this exquisite traditional craft from Chhattisgarh. However, several challenges have been identified in its implementation. One of the main hurdles is the competition from cheaper mass-produced synthetic fabrics, which can impact the demand for authentic Champa Silk products. Additionally, limited market access and inadequate marketing efforts pose barriers to reaching wider audiences. Furthermore, the lack of modern design integration and innovation may hinder its appeal to younger consumers. To preserve and promote this valuable craft, it is crucial to address these challenges and provide appropriate support to the artisans and weavers involved in the production of Champa Silk sarees and fabrics.

Proposed Policy and Suggestions

The proposed policy and suggestions for the GI Champa Silk Saree and Fabrics aim to bolster the recognition and preservation of this exquisite traditional craft from Chhattisgarh.

1. Establishment of specialized training centers to impart intricate weaving techniques to anew generation of weavers.
2. creating market linkages and providing financial support
3. Provide financial support to weavers through the same mechanism discussed above.
4. Web-based and Application based market access for weavers.

Jeeraphool

APPLICANT'S NAME	**Jaivik Krishi Utpadak Sahkari Samiti Maryadit**
CERTIFICATION DATE	**14/03/2019**
CLASSIFICATION	**30 (Agriculture)**
NO. OF AUTHORISED USERS (AU)	**1**
NO. OF REGISTERED AUs	**0**
TOTAL PRODUCTION	
CULITVATION REGION & AREA	**Sarguja Region, 2232 ha.**
TURNOVER PER YEAR	
AVERAGE PRICE	**Rs. 155 per Kg**

Introduction

"Jeeraphool" is an ancient rice variety of Surguja district of Chhattisgarh state[64]. It is an aromatic and very soft grain after cooking and, very fine and short slender variety looks like cumin. The rice variety is organically cultivated as per their traditions and supplemented by comparative ideology in specially prepared paddy fields of Surguja district bottom hills low lying areas with extra care to maintain its purity. The Cropping situation and weather conditions of Surguja (Northern hills ecological condition of Chhattisgarh) contributed greatly to its strong aroma with softness in cooking and other quality attributes. It is an aromatic short grain premium rice variety looks like cumin. Jeeraphool rice is especially famous for its taste, aroma

[64]Geographical Indications Journal' () No. 163, pp. 28-41. Available at: https://search.ipindia.gov.in/GIRPublic/Application/ViewDocument

and softness after cooking. Jeeraphool rice is white in colour with short grain size, it is strongly scented and very soft when cooked. This rice is preferred because it remains flaky and soften even after cooling. (Due to its medium Amylose content and other quality traits).

Description

It is an indigenous aromatic short grain cereal plant of Chhattisgarh. The Jeeraphool or "Oryza sativa" is widely used in eating purpose as Kheer (pudding) and Pulao. Its rice looks like a Jeera (cumin) shape that's why its name is Jeeraphool. It has an excellent eating quality due to high aroma, special softness and unique taste after cooking. Duration of the variety is 140-145 days.

Rice is looks like a Jeera (cumin) shape that's why its name is coined as Jeeraphool, its L:B ration is 2.13[65] and its grain chalkiness is very low and very occasionally present, its panicle size is very long i.e. 33 cm[66]. Jeeraphool rice plant is tall around 135-140 cm. in height the milling percentage is 67.2% also the head rice recovery percentage is 62.5%[67].

Aroma of this variety is excellent when cooked, this rice is preferred due to its softness and flakiness hence it is widely used in eating purpose as Kheer (pudding) and Pulao. The Kernel size is elongated length wise after cooking and its resistant to Blast disease.

Goegraphical Area of Production

Sl. No.	BLOCK NAME	VILLAGE NAME
1.	Ambikapur	Podikhurd, Sohga, Kanthi, Libra, Kareya, Chindkali,Amadhraha, Podika, Navapara Khurd, Khairbar, Parsa, Bhakhura, Bhakauli, Karmaha, Karanji, Bardohi, Parsodi
2.	Lakhanpur	Jamgala, Kunwarpur, Andhala, Argoti, Jaipur, Kanchanpur
3.	Udaipur	Mohanpur, Manpur, Khamhariya
4.	Sitapur	Girhuldih, Bharatpur, Sarga, Gerasa, Dhodagaon, Banshipur
5.	Lundra	Udari, Semardih, Dhakila, Sakoli, Kalpodi, Nagam, Pasena,Gujwar, Kakni, Devari, Kachgand
6.	Batauli	Kunkuri, Sedam, Basen, Govindpur, Chirga, Umapur, Kalipur, Manjha, Poprega, Samastipur, Nakna, Bansajhal, Chirga, Bonda, Jarhadih, Bilaspur, Ghoghra, Birhuli, Saliyadih, Kudkel, Kachardih, Chawarpani.
7.	Mainpat	Pet, Pediya, Kunkuri, Kot, Vandna, Udumkela, Rachketa, Kotchhal

65
66
67

Uniqueness:

Geographical significance

- Soil: Soil type usually depends on the type of bedrock, climate and weathering patterns. Two types of soils are found in the batauli block viz., Matasi and Kanhar (medium to heavysoil)
- Climate: Temperature: Average temperature of night is cooler of Batauli block. Average rainfall of Batauli block is 1150 mm.

Uniqueness of Jeeraphool Rice

- Jeeraphool rice is strongly scented. The aromatic compound is 2 acetyl 1 pyrrolene (2AP) content is present. Value of 2AP against the standard method with 2,4.6 trimethylpyridine(TMP) as a reference solution is 1.351
- Organoleptic taste is very good and taste of this rice variety is very unique
- Leaf weight of Jeeraphool is very high i.e. 24.2 mg cm2. It is one of the highest scorersamong the aromatics short grain rice of India
- Weight of 1000 rice grain (test weight) is 16.001 g.
- Head Rice Recovery 62.50 %
- Milling percentage 67.20 %
- Cooking time is less because it has alkaline spreading value score 5.
- Amylose content is 23.221 % and Its Gel consistency is medium i.e. 57 mm (Intermediate)
- Kernel length is 4.15mm while its kernel length after cooking is 9.4 mm. Elongation Ratiois 2.26mm.
- Volume Expansion Ratio is 4.8mm.

Nagri Dubraj

Introduction

Nagri Dubraj is a traditional special variety of rice in the Dhamtari district of Chhattisgarh[68]. It is an aromatic, medium slender grain rice variety. Nagri Dubraj rice is especially famous for its taste and aroma. It has premium grain quality. It is white in colour with strong aroma. "Nagri Dubraj" as plant variety originates and is confined to Nagri block of Dhamtari district in Chhattisgarh plane state ecology. This rice has a special grain quality and quality characteristics based upon the unique production technique and unique characteristics to the said geographical condition.

APPLICANT'S NAME	Maa Durga Swayam Sahayata Samooh
CERTIFICATION DATE	31/01/2023
CLASSIFICATION	30 (Agriculture)
NO. OF AUTHORISED USERS (AU)	0
NO. OF REGISTERED AUs	0
TOTAL PRODUCTION	24-30 quintal per ha.
CULITVATION AREA	250 to 300 ha. In Dhamtari
TURNOVER PER YEAR	
AVERAGE PRICE	Rs. 140 per Kg

Geographical area of production

The rice variety is organically cultivated as per their traditions and supplemented by comparative ideology in specially prepared paddy fields of Nagri areas with extra care to maintain its purity.

The cropping situation and weather conditions of Nagri (Chhattisgarh plane region) contributed greatly to its high aroma in cooking and other quality attributes. Dhamtari district is situated in the fertile plains of the Chhattisgarh Region. It is located in the southern part of the Chhattisgarh state and is bounded by East longitudes 81°24"43" & 82°10"29" and by North latitudes, 20°02"45" & 21°01"33" falling in the Survey of India topo-sheets nos 64G, 64H and 64L. It covers an area of 4082 sq. km. Dhamtari town is the district headquarters of the district[69]. The District is surrounded by District Raipur in North & East, District Durg in North-West, Kanker as well as Bastar in the South-West. The district is divided into 3 no. of tehsils, 4 no. of Community Development blocks, and 554 no. of revenue villages. The block headquarters are Dhamtari, Kurud, Magarlod and Nagri. The district is known mainly for its rice production and forest produce.

[68]Geographical Indications Journal' (2008) No. 163, pp. 28-41. Available at: https://search.ipindia.gov.in/GIRPublic/Application/ViewDocument
[69]*Id.*

Uniqueness Of Nagri Dubraj Rice[70]

- Nagri Dubraj rice is white in colour.
- Grain size is medium slender aromatic Rice
- 2-AP (2 Acetyl 1 Pyrrolene) content (1.39 %)
- Kernel paddy length 5.94 mm
- Kernel paddy breadth 1.78 mm
- Kernel L:B ratio is 3.33
- Brown Rice length 5.17 mm
- Brown Rice breadth 1.6 mm
- Milled Rice length 5.02 mm
- Milled Rice breadth 1.4 mm
- The milling percentage is 62.88 %
- The hulling percentage is 81.1 %
- The head rice recovery (HRR) is 51.10 %
- Cooked Rice length 8.59 mm
- Cooked Rice breadth 1.80 mm
- Elongation Ratio 1.69
- Test weight (1000 grain weight) 16.2
- The cultivation period is 140-145 days.
- Grain yield 35.79 Quintal/ha. Taste of this rice variety is very unique
- Cooking time is less because it has alkaline spreading value score 6.1.
- Iron content is 4.90 mg/kg milled rice.
- Zinc content 35.11 mg/kg miller rice.
- GI Journal No. 163 38 September 30, 2022
- Carbohydrate 76 % in Brown Rice.
- Amylose content is 17.83 %
- Kernel size is increase length wise after cooking.
- Elongation Ration is 1.87
- Volume Expansion Ratio is 3.20

[70] *Id.*

- Milling percentage is 77.68 %
- The hulling percentage is 81.1 %
- The head rice recovery is 47.2 %
- Nagri Dubraj recorded desirable quality parameters such as intermediate value for alkali spreading value, gel consistency, amylose content and superior performance for elongationratio and kernel length after cooking. Nagri Dubraj acceptable for cooking quality traits.
- significantly higher value of milling percentage was recorded for Dubraj (7.68%)

Identified common gap and its suggested policy framework

Following are the major gap identified:

1. lack of awareness regarding GI among the proprietors of the GI.
2. Lack of quality control mechanism
3. Lack of Authorized Users of the GIs

Recommended Policy:

1. During the interview with the Manager of the CHVB, the researcher was able to identify that there is a need to conduct awareness campaigns among the government organizations and proprietors so as to make them aware of the legal aspects of the GI and channelize the process of registration of the Authorized Users by the proprietors.
    - Local IP cells of the state can be entrusted with this responsibility.
2. Most of the GIs in India lack a proper quality control mechanism due to the fact that the proprietors are the one which has the power to check the quality of the GIs. This led to situation which happened with Alphanso mangoes whose consignment to EU was rejected due to not meeting defined standards.[71] APEDA style model can be recommended as a quality control mechanism.
    - Additionally, a common certification organization for quality can be created which will certify all the GIs for its meeting the quality and control standards.
3. The resolution of the first gap will lead to the effective eradication of the third issue, whichis lack of AU. This is due to the process of registration and the socio-economic status of the artisans. The researcher suggest that local IP awareness cells should be entrusted with the task of assisting the proprietors of the GIs to fill for the application for AU. And the fee of 500 rupees and the task of fill the documentation shall be bear by the government with proper consultation with the proprietors of the GI.

71

Unearthing the Rich Traditional and Indigenous Knowledge of Chhattisgarh and its Protection Under Geographical Indication

Introduction

Chhattisgarh, a state in central India, is a treasure trove of diverse cultures and traditions that have been nurtured and passed down through generations. Within its boundaries lie numerous indigenous communities, each contributing a unique and invaluable wealth of traditional knowledge. These age-old practices encompass various domains such as agriculture, handicrafts, herbal medicine, music, dance, and spirituality. The traditional knowledge of Chhattisgarh's indigenous people is not only deeply ingrained in their way of life but also reflects their profound connection with the land and its resources.

In recent years, the concept of GI has emerged as a means to protect and promote traditional knowledge and products associated with specific regions. The GI tag is granted to products or crafts that possess specific characteristics or qualities attributable to their geographical origin. For Chhattisgarh, this legal recognition has offered a glimmer of hope in safeguarding its rich traditional knowledge from misappropriation, commercial exploitation, and the threat of vanishing in the face of modernization. This chapter will delve into the discussion of some selected traditional knowledge identified by the researcher which has properties to be protected as geographical indication.

Here is a proposed list of traditional and indigenous knowledge which the researcher tends to propose:

Sl.No.	Proposed	Classification	Goods	Location
1.	TUMBA/TUMA ART	20,21	Handicraft	Bastar
2.	GODNA TATTOO	8,10,16		
3.	GODNA ART	24, 25	Handicraft	
4.	BHITTI CHIRTA ART	27	Handicraft	
5.	SALFI	32	Beers (Beverage)	
6.	HANDIA	32	Rice Beer	
7.	ANT CHATTNI / CHAPDA	29,30	Food Stuffs	Bastar
8.	POORAN/ JHEET LADOOS	30	Food Stuffs	
9.	KODO KUTKI Millet	31	Agriculture	20/33 Districts Dindori
10.	BODA	31	Agriculture	Bastar

	MUSHROOM			
11.	TIKHUR	31	Agriculture	Dhamtari
12.	WILD HONEY	30	Natural Goods	
13.	BASTAR TAMARIND (Imli)	30	Agriculture	

Ant Chutney or Chapda

REGION	Bastar, Chhattisgarh
TYPE	Food
PROPOSED GI CLASSIFICATION	29, 30 (Food Stuff)
UNIQUENESS	Red Ant (Oecophylla smaragdina)[72]

Introduction

In Chhattisgarh's Bastar region, this chutney is called chaprah (meaning "leaf basket," a reference to the nests that the ants make using the leaves of the sal tree)[73]. Chapda chutney or red ant chutney is a traditional Indian chutney originating from Chhattisgarh, although it's also popular in Odisha and Jharkhand. The chutney is made with a combination of crushed and dried red ants and their eggs, coriander, garlic, ginger, tomatoes, hot peppers, sugar, and salt. It is sometimes cooked with chopped onions in hot oil. Once prepared, the chutney is traditionally sold in local markets and wrapped in Sal leaves[74]. The flavors of this chutney are very spicy and hot.

Multi-Michelin start chief Gordon Ramsay, while visiting Bastar termed Chapda chutney as "the world's best chutney and called the dishes as healthy"[75]. Due to him, now it has been

[72]Oecophylla Smaragdina (2023) Wikipedia. Available at: https://en.wikipedia.org/wiki/Oecophylla_smaragdina (Accessed: 01 August 2023).
[73]Ugc (2018) This spicy chutney is made from Red Ants, Atlas Obscura. Available at: https://www.atlasobscura.com/foods/red-ant-chutney-chaprah-india (Accessed: 01 August 2023).
[74]TasteAtlas (2022) Chapda chutney: Traditional spread from Chhattisgarh: Tasteatlas, World Food Atlas: Discover 16778 Local Dishes & Ingredients. Available at: https://www.tasteatlas.com/chapda-chutney (Accessed: 01 August 2023).
[75]Singh, S. (2018) These tribal Chhattisgarh dishes go international. thanks to Gordon Ramsay, English.

widely known among the culinary community across the globe.

Recipe/ Cooking Method

To make the chutney, villagers first crush and dry all the ants and eggs, then grind them with a mortar and pestle. Then add tomatoes, coriander, garlic, ginger, chili, salt, and a bit of sugar to create a smooth, orange paste. Sometimes, they cook the paste further with oil and chopped onions. The ants used in the chutney has high levels of formic acid[76].

Unique properties

This chutney is considered as good source of Formic acid, Iron, Calcium, Zinc, Vitamin B-12 and keeps the heart and eyes healthy. It is also found to be effective in preventing the tribals from cold, cough, flu, and other seasonal diseases and has proved to be a preventive medicine for malaria[77].

Relevance to the Region

The reasoning behind why this chutney is indigenous to Chhattisgarh is because red ants are found in abundance in the jungles of Bastar. Chapda in native language means leaf basket which is also in the reference to the nest of red ants. Red ants are found in abundance in sal wood / mango forests of Chhattisgarh during summer. The red ant builds the nest by joining small leaves or by folding bigger leave high on the tree inside the forest region[78]. They lag the eggs inside those clusters. They are more aggressive than most native species, so have pushed many species away from their local habitat.

Bhitti Chitra
Introduction

Available at: https://www.indiatvnews.com/buzz/news-these-tribal-chhattisgarh-dishes-go-international-thanks-to-gordon-ramsay-432351 (Accessed: 01 August 2023).
[76]Oecophylla Smaragdina (2023) Wikipedia. Available at: https://en.wikipedia.org/wiki/Oecophylla_smaragdina (Accessed: 01 August 2023).
[77]Baghel tastes Bastar Available at: https://www.dailypioneer.com/2022/state-editions/baghel-tastes-bastar---s-chapda-chu
[78]Tribal Chapada Chutney, Royal Bee Brothers. Available at: https://www.royalbeebrothers.com/pages/chapdachutney (Accessed: 01 August 2023)

REGION	Chhattisgarh
TYPE	Handicraft
PROPOSED GI CLASSIFICATION	27
UNIQUENESS	
POPULATION INVOLVED	
TURNOVER	
AVERAGE PRICE	

Bhitti Chitra, also known as Wall Art or Wall Paintings, is a traditional art form that has its roots in the culturally rich state of Chhattisgarh, India. This exquisite form of art holds a significant place in the cultural heritage of the region and has been practiced for centuries by skilled artisans. Bhitti Chitra literally translates to "paintings on the wall" in Hindi. It involves the meticulous process of creating intricate and colorful designs directly on the walls of houses, temples, and public spaces. The art form primarily utilizes natural pigments derived from minerals, plants, and other organic sources.

The subjects of Bhitti Chitra often depict mythological stories, religious symbols, and elements of nature. These paintings are known for their vibrant colors, intricate detailing, and the use of traditional motifs that are passed down through generations. The artists, known as Bhitti Chitrakars, possess remarkable skills in freehand drawing and possess a deep understanding of the cultural and religious significance behind the artworks. Bhitti Chitra is not just a form of visual expression but also serves various purposes within the community. It has been used as a means to preserve and convey cultural and historical narratives, as well as to beautify public spaces and bring a sense of joy and harmony to the surroundings.

Over time, Bhitti Chitra has evolved and adapted to modern techniques and materials while still retaining its traditional essence. Today, it is not only cherished within the state of Chhattisgarh but has also gained recognition and admiration at national and international levels. The art form continues to thrive, with artists and enthusiasts working tirelessly to preserve and promote this unique artistic heritage. Bhitti Chitra stands as a testament to the rich cultural traditions of Chhattisgarh, capturing the essence of the region's history, spirituality, and artistic prowess.

Unique properties

Bhitti Chitra art, also known as wall painting or mural art, is a distinctive and ancient art form that hails from the region of Chhattisgarh, India. It holds several unique properties that set it apart from other art styles and make it a remarkable cultural heritage:

- **Earthy and Natural Pigments**: Bhitti Chitra art primarily employs natural pigments derived from locally available materials such as soil, stones, minerals, and vegetable dyes. These earthy hues create a rustic and organic color palette, reflecting a deep connection with nature.
- **Indigenous Techniques**: The art form relies on indigenous techniques, where the artists use fingers, twigs, or brushes made from animal hair to apply the pigments

directly onto walls or mud surfaces. This hands-on approach adds a raw and soulful charm to the paintings.

- **Site-Specific Art**: Bhitti Chitra art is site-specific, meaning it is painted directly on walls, floors, or other surfaces of buildings, temples, and public spaces. This unique characteristic blends the artwork seamlessly into the architectural landscape, creating an immersive experience for viewers.
- **Folk and Mythological Themes**: The themes of Bhitti Chitra art often revolve around folktales, mythological narratives, and local folklore. The paintings narrate stories of gods,goddesses, heroes, and events from ancient scriptures, making them an essential part of cultural storytelling.
- **Communal Art Tradition**: Historically, Bhitti Chitra art was a communal endeavor, with entire villages coming together to paint important occasions and rituals. This collaborativespirit fosters a sense of community and cultural continuity.
- **Preservation of Local Traditions**: Bhitti Chitra art serves as a visual repository of local traditions, customs, and rituals. It reflects the cultural practices and beliefs of the community, making it an invaluable record of their history.
- **Spiritual and Ritualistic Significance**: The art form often adorns places of worship and religious festivals, adding a sacred dimension to the paintings. The motifs and symbols used in Bhitti Chitra art are believed to bring prosperity, protection, and blessings.
- **Environmental Friendliness**: Bhitti Chitra art uses natural pigments, which are eco-friendly and biodegradable. This aspect aligns with sustainable art practices, making it an environmentally conscious form of expression.
- **Cultural Identity**: Bhitti Chitra art is a source of pride and identity for the people of Chhattisgarh, representing their distinct cultural heritage and traditional artistry.

Telephone Interview of Mrs. Pritima, State Awardee of Bhitti Chitra Art

Mrs. Pritima is a famous Bhitti Chitra artist and is popular for taking this craft of the walls and using it to produce different types of products like Portraits, pictures and other decoration arts in hotels and public places. She has recently worked with Tata Cultural Society to make doors using a combination of Bhitti chitra and Motifs of Godna art.

She has also taught her art in the Indira Gandhi Tribal University, and is of the opinion that training should be provided to local bhitti artists to produce more minute and intricate designs. She mentioned during the interview that her fellow bhitti artists are more than willing to form a trust under the supervision of relevant organization and to apply for the protection of their art under GI. She sells her craft at the rate of 12.5 rupees per square inch, and is optimistic that GI protection will give her and her fellow artisans with the opportunity to show their craft across and outside India.

Rajwar Bhitti Chitra is a local style of Bhitti Chitra which is produced by Mrs Pritima and her fellow villagers, which includes some designs which are locally used in the Godna art.

Tuma/ Tumbha

REGION	Bastar, Chhattisgarh
TYPE	Handicraft
PROPOSED GI CLASSIFICATION	20, 21
UNIQUENESS	Gourd (Lagenaria siceraria)
POPULATION INVOLVED	
TURNOVER	
AVERAGE PRICE	

Introduction

Chhattisgarh, a state in central India, is known for its rich cultural heritage and vibrant art forms. Among its numerous traditional art forms, Tuma or Tumbha art holds a significant place. Tuma art, deeply rooted in the history and traditions of Chhattisgarh, is a form of tribal art that showcases the artistic prowess and unique cultural identity of the region. Tuma or decorative gourd craft is a unique handicraft from Bastar district of Chhattisgarh which takes gourds beyond mere utilitarian use, to create truly innovative artwork.

It is a recently developed craft that brings out the hidden beauty of gourds. Derived from the term "Tumhi" meaning "gourd" in the local dialect[79], Tuma craft is made of the bottle gourd vegetable (Lagenaria siceraria), also known as calabash, opo squash, long lemon and lauki (in Hindi). Tuma craft originates from the people who used gourd shells as containers to store water and salfi (local drinks)[80]. Gradually, they began to decorate their vessels, and tuma craft, or decorative gourd craft, became popular within the state. Today, tuma products include a wide range of lampshades, wall hangings, utensils and masks.

[79]Telephonic Interview
[80]Isha.sadhguru.org. Available at: https://isha.sadhguru.org/in/en/blog/article/decorative-gourd-craft (Accessed: 01 August 2023)

Process of Making

Firstly, gourds with appropriate natural shapes are selected and dried in the sun, sometimes for as long as six months. As a result, they turn brown in color. The darkness of the color depends on how old the gourd is. Once they are dry enough, they are thoroughly washed using mud, which acts as a scrubber. After the mud wash, the gourds are once again dried under the sun and kept in water for about five to six hours. This makes the upper layer loose, allowing it to be scraped of with a knife. The rear portion of the gourd is then cut using a hot iron knife, and the contents inside removed, making it completely hollow. Designs are then sketched on the gourd with a pencil and etched with a hot knife. This process burns the surface and makesthe pattern permanent. If bowls and food utensils are made, they are boiled first to remove thegourd's bitterness. Finally, the gourd is varnished.

In recent years, Tuma art has gained recognition not just within India but also on a global scale. The intricate craftsmanship and artistic finesse displayed in these gourd artworks have captivated art enthusiasts and collectors alike. Tuma art has found its way into exhibitions, galleries, and homes, spreading the beauty of Chhattisgarh's cultural heritage far and wide.

Unique properties

Lagenaria siceraria type is used. This specific use of Gourd is done only in Bastar and its nearby region of Chhattisgarh, which makes its geographic-specific and eligible for GI protection.

Salfi/ Salphi Drink

REGION	Chhattisgarh
TYPE	Beer Beverage
PROPOSED GI CLASSIFICATION	32
UNIQUENESS	Caryota urens, member of Areaceae Family Rich in Carbohydrate
POPULATION INVOLVED	
PRODUCTION AREA	Bastar, Dantewada, Kondagaon, Kanker and Bijapur
TURNOVER	
AVERAGE PRICE	40 to 60 rupees per liters

Introduction

Originating from the heartland of Chhattisgarh, Salfi is a cool and invigorating drink that offers respite from the scorching heat of the region[81]. It is commonly collected from the Salfi tree bymaking a cut on the top of the tree and collecting the liquid coming out in an earthen pot. It isusually fermented overnight and then served[82]. Traditionally, Salfi is served chilled, making itthe perfect companion on hot summer days. Its soothing properties and ability to quench yourthirst make it a popular choice among locals and visitors alike. Salfi stands as a symbol of hospitality in Chhattisgarh, where it is often offered to guests as a gesture of warmth and welcome.

Beyond its delightful taste, Salfi holds cultural significance in Chhattisgarh. It is deeply rooted in the culinary traditions of the region and showcases the local ingredients and flavors that make Chhattisgarhi cuisine unique. Salfi represents the rich heritage and culinary expertise of the state, passed down through generations.

Handia Drink

81

82

REGION	Chhattisgarh
TYPE	Rice Beverage
PROPOSED GI CLASSIFICATION	32
UNIQUENESS	
POPULATION INVOLVED	
PRODUCTION AREA	
TURNOVER	
AVERAGE PRICE	

Introduction

It is a traditional fermented rice drink that originates from the culturally rich state of Chhattisgarh, India. Handia, also known as Hadiya or Laungi, holds a significant place in the vibrant festivities and social gatherings of the region. Handia is a unique and mildly alcoholic beverage that has been cherished by the people of Chhattisgarh for centuries. It is crafted through an age-old fermentation process, using locally sourced ingredients and traditional techniques, which give it a distinct taste and character.

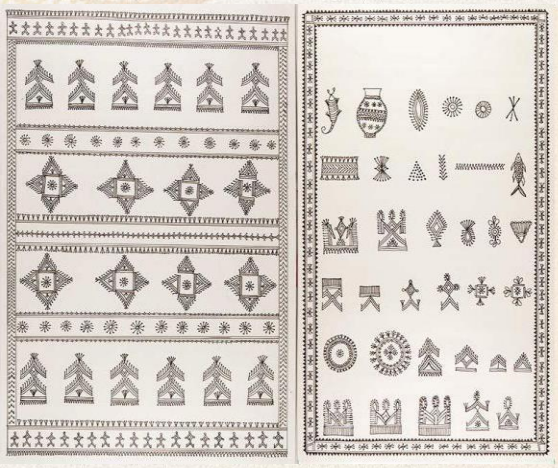
Handia holds deep cultural significance in Chhattisgarh, where it is often offered to deities during religious ceremonies and festivals. It is also an integral part of weddings and other auspicious occasions, symbolizing joy, prosperity, and togetherness.

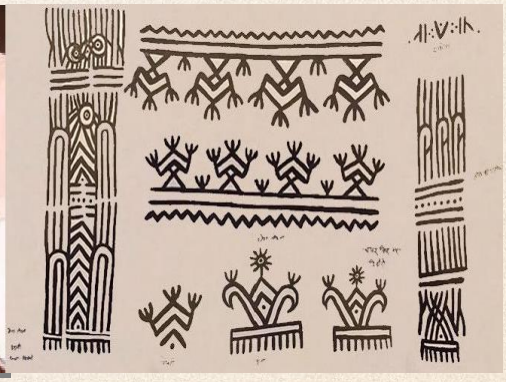
Process of Making

The main ingredient in Handia is rice, which is soaked, partially cooked, and allowed to cool. The cooled rice is then mixed with a special indigenous starter culture called “Dhaura” or “Phut” obtained from the previous batch of Handia. This starter culture initiates the fermentation process by introducing beneficial microorganisms, primarily yeast and lactobacilli, to the mixture. After the rice and starter culture are combined, the mixture is traditionally stored in large earthenware pots called “Handias” or “Matkas.” These pots are made from clay and are porous, allowing for natural aeration and fermentation. The Handias are typically covered with banana leaves or cloth to protect the contents while still allowing air to circulate.

Over the course of several days, the mixture undergoes fermentation, transforming the rice starches into alcohol and carbon dioxide. The Handia is periodically stirred or shaken to aid in the fermentation process. The duration of fermentation can vary, typically ranging from a few days to a couple of weeks, depending on factors like temperature and desired alcohol content. The end result is a slightly sour, mildly alcoholic beverage with a smooth and tangy flavor profile. Handia is usually served chilled and enjoyed on special occasions, cultural celebrations, or as a part of social gatherings. It is known for its ability to bring people together, fostering a sense of camaraderie and festivity.

Godna Art





REGION	Chhattisgarh
TYPE	Rice Beverage
PROPOSED GI CLASSIFICATION	32
UNIQUENESS	Motifs and Patterns used by Indigenous Women.
POPULATION INVOLVED	Locals of Surguja and Raigarh districts
AVERAGE PRICE	Rs. 500- 2000 per piece

Godna Tattoo

The general meaning of Godna is to Pick or to Poke, in Devanagari it means "to scribble" or "to draw"[83]. Godna art is a traditional art form practiced in Northern and Central India. It is a form of tattooing or body art that has been practiced by the indigenous communities of Chhattisgarh for centuries. The word "Godna" means "to tattoo" in the local language. Godna art involves creating intricate designs and patterns on the skin using natural dyes and pigments. The artists, known as "Godna artists," use a needle and thread to create the tattoos.

[83]Godna and the gonds: From tradition to innovation (the politics of art, body, and identity) (2023) Economic and Political Weekly. Available at: https://www.epw.in/engage/article/godna-and-gonds-tradition-innovation-politics-art (Accessed: 02 August 2023).

They dip the needle into the dye and then puncture the skin to create the desired design. The thread is passed through the needle, which is then pulled out, leaving behind the dye in the punctured skin.

There are traces of Godna tattoos which can be dated back to 200 BCE. Female figures excavated in Bharhut, Madhya Pradesh were found to have Godna on their hands and faces.[84] Traditionally, Godna tattoo are of various types and each carriers different significance and meanings. Some tattoos are there which are imprinted on special occasions such as weddings, festivals, and other significant events. It was believed to bring good luck, protection, and enhance beauty[85]. The designs often incorporate geometric patterns, floral motifs, and elements inspired by nature and daily life. Godna art is not limited to tattoos on the body alone. It has expanded to other art forms such as painting, fabric printing, and pottery. Artists incorporate the traditional motifs and patterns into these art forms, preserving and promoting the cultural heritage of Chhattisgarh.

The women of the Oraon tribe, living in Surguja and Raigarh districts, get three lines tattooed on their foreheads[86]. The Bhil women use this Godna art to get a tattoo on the sides of their eyes in a bird form so as to make an appearance of long eye lashes[87]. It has a historical and religious significance as in the Mahabharata period, Shri Krishna took the form of Godnaharin and went to tattoo Radha[88]. It is believed among the communities that the Godna have some curing abilities and can prevent various diseases, it is an ancient and traditional form of Acupuncture[89]. The people of Surguja region accept the fact that tattooing gives beauty as well as relief from rheumatism, pain of injury or any other kind of pain[90].

Technique of Godna:

- **Needle or piercing stick:** It is mainly made up of bamboo sticks or thorns.
- **Ink:** The ink is made from a combination of herbs, cow bile and pig fat. Sometimes the extract of beetroot and grapes seeds are burned and its ash is used as ink. To get variation in colour natural products like Leaves, flowers, seeds, bark trees and plants and its roots are used[91].

[84]DN Singh, "Godna (Body Tattooing) Tradition of Awadh from Mythology to Modernity," International Journal of English Language, Literature and Humanities, Vol 3, No 4, pp 15-27 2015

[85]Godna: A typeface made from tribal tattoos (2016) Godna: a typeface made from tribal tattoos | Ishan Khosla Design. Available at: https://www.ishankhosla.com/work/godna-typeface-made-tribal-tattoos (Accessed: 03 August 2023).

[86]Godna paintings, INDIAN CULTURE. Available at: https://indianculture.gov.in/paintings/godna-paintings (Accessed: 03 August 2023).

[87]*Id.*

[88]by, P. (2022) Tattoo art of Surguja District Chhattisgarh – free PDF download, StudyIQ. Available at: https://www.studyiq.com/articles/tattoo-art-surguja-district-chhattisgarh-free-pdf/ (Accessed: 03 August 2023).

[89]Acupuncture in Godna: The India Post the India Post (2011a) The India Post | Breaking News from India. Available at: https://www.theindiapost.com/nation/madhya-pardesh/acupuncture-godna/ (Accessed: 03 August 2023).

[90]

[91]1Chaki, D. (2022) Godna painting, Buy Indian Arts, Crafts and Traditional Products | ARTSofINDIA.in. Available at: https://www.artsofindia.in/arts-of-india-blog/post/indian-arts-and-crafts/godna-painting-the-incredible-story-of-tattoo-art.html (Accessed: 03 August 2023).

Use of Godna Tattoo by Ramarmiha caste of Chhattisgarh

People belonging to this Scheduled Caste live near the bank of Mahanadi, and both men and women of this community get a Ram-Rama tattoo in every part of their body. This tattoo is of quit different motif then that of other Godna tattoo found in the state of Chhattisgarh.

Godna painting

Godna paintings are Devar Godna of Rajanandgaon district of Chhattisgarh, Godi godna of Surguja district of Chhattisgarh, Badi Godna of Dindori district of Madhya Pradesh and Madhubani Godna of Mithila region of Bihar, done by Brahmins and Kayasthas to picturize the sacred Hindu Mythological texts Paswans design animals, minerals and vegetables on their huts rather than divinities Madhubani Godna artists use natural colours derived from bark, leaf, flowers, seeds of plants and trees, clay and cow dung[92].

This is a recently developed art form, derived from the Godna Tattoo, practiced mainly by the women of Jamgala Village, Bilaspur District, and communities of Lakhanpur and Udaipur region of Surguja district, Chhattisgarh. This art form got its inception from the decline of the Godna Tattoo, as the young generation of the region does not want to get this tattoo, due to which there is a considerable decline in the Godna tattoo practices. To preserve and keep this tradition alive, the local found a way of using the designs and motifs of the tattoo on the textile and clothing accessories. The painted Godna work has been sold in the form of stoles, Sarees, Blouses, Ghagras and Handkerchiefs.

Proposed Policy for Application for GI Protection

1. **Identification and Documentation of Traditional Knowledge**: The policy should begin with a comprehensive survey and documentation of traditional knowledge related to various products, crafts, and practices of Chhattisgarh. This involves identifying the communities and individuals holding the knowledge and understanding of the traditional methods and techniques used in the production of goods**.**
2. **Creation of an Indigenous Knowledge Bank** for Documentation and Validation with Scientific data signifying geographical relevance and uniqueness.
    a. Regional Science and Technology Council can be given the task of formulation of the bank.
3. **Conducting an awareness drive** for the promotion and education of GI among the local population.
    a. The regional IP cell of the state with the help of local NGOs can organization these types of awareness camps.
4. **Creation of centralized Laboratories and State Nodal Agency** for sample analysis and quality and safety checks for TK related to food and beverages.

[92] *Id. 88*

a. These laboratories can be established under the supervision of the relevant ministry and state Science and technology council.

5. **Creation of trust** by encouraging the population holding the TK.

6. Local IP cell of the state can play a significant role in the creation of trusts.

7. **Establishment of common quality control authority in the state for all the GIs**

    a. A certification system can be introduced which will allow only the GIs which has taken due certification from the authority to sell their Geographical Indicated products.

8. **Establishment of a web-based and application-based e-commerce portal for all the GIs.**

References

Primary source

- Telephonic Interview
- ANNEXURE 1.
- ANNEXURE 2.
- ANNEXURE 3.

Secondary source

Books

- Fikret Berkers, Sacred Ecology, Routledge (2018)

Legislations, Treaties, And Conventions

- Preamble, Convention on Biological Diversity, 1760 U.N.T.S. 79 (Jun 5, 1992)
- Patent Act, 1970, No. 39, § 13, No. 13, Acts of Parliament, 1970 (India)

Research papers

- Teshager Worku Dagne, Intellectual Property, Traditional Knowledge and Biodiversity in the Global Economy: The potential of GI for protecting Traditional Knowledge-based Agricultural Products (Dalhousie University, 2012)
- Daniel F. Robinson, Ahmed Abdel-Latif, Pedro Roffe, Protecting Traditional Knowledge, The WIPO Intergovernmetnal Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (Routledge, 2019)
- Ajeet Mathur, Who Owns Traditional Knowledge, Economic and Political Weekly, Vol. 38, No. 42 (2003)
- Srividhya Ragavan, Protection of Traditional Knowledge, Minnesota Intellectual Property Law Review, Vol. 2, No. 2, (2001)
- Craig D. Jacoby & Charles Weiss, Recognizing Property Rights in Traditional Biocultural Contribution, STAN. ENVTL. L.J .Vol. 16, p. 85 (1997)
- Fitzmaurice, M. (2008). The Dilemma of Traditional Knowledge: Indigenous Peoples and Traditional Knowledge. International Community Law Review 10, 3, 255-278
- Stephen Allen, The Consequences of Modernity for Indigenous Peoples: An International Appraisal, IJMGR, Vol. 13, pp. 315-340 (2006)

Articles

- Balavanth S. Kalaskar, Role of international Forums in Protecting Traditional Knowledge, PL May 41 (2012)
- Pandey, V. (2023) Folk dance of chhattisgarh. Raut Nacha, Panthi, and many more., CgPsc.info. Available at: https://www.cgpsc.info/folk-dance-of-chhattisgarh.html/

Web sites

- https://dictionary.cambridge.org/dictionary/english/knowledge
- https://www.merriam-webster.com/dictionary/knowledge
- https://www.newindianexpress.com/opinions/2022/jan/14/how-science-tech-flourished-in-ancient-india-2406610.html
- https://www.wipo.int/tk/en/tk/#:~:text=Traditional%20knowledge%20(TK)%20is%20knowledge,its%20cultural%20or%20spiritual%20identity
- https://uis.unesco.org/en/glossary-term/traditional-knowledge
- https://www.wipo.int/edocs/pubdocs/en/wipo_pub_tk_7.pdf
- https://wander-lush.org/world-rituals-part-two/
- https://www.britannica.com/place/Chhattisgarh
- https://www.wto.org/english/tratop_e/trips_e/trips_e.htm
- https://www.thehindu.com/arts/crafts/Bastar-art-goes-global-but-artisans-battle-for-survival/article16364328.ece
- https://en.wikipedia.org/wiki/Oecophylla_smaragdina
- https://www.atlasobscura.com/foods/red-ant-chutney-chaprah-india
- https://www.tasteatlas.com/chapda-chutney
- https://www.indiatvnews.com/buzz/news-these-tribal-chhattisgarh-dishes-go-international-thanks-to-gordon-ramsay-432351
- https://www.dailypioneer.com/2022/state-editions/baghel-tastes-bastar---s-chapda-chutney.html
- https://www.epw.in/engage/article/godna-and-gonds-tradition-innovation-politics-art
- https://www.ishankhosla.com/work/godna-typeface-made-tribal-tattoos
- https://indianculture.gov.in/paintings/godna-paintings
- https://www.studyiq.com/articles/tattoo-art-surguja-district-chhattisgarh-free-pdf/
- https://www.theindiapost.com/nation/madhya-pardesh/acupuncture-godna/
- https://www.serialsjournals.com/abstract/50434_4.pdf
- https://www.artsofindia.in/arts-of-india-blog/post/indian-arts-and-crafts/godna-painting-the-incredible-story-of-tattoo-art.html

Documents

- India Census, Chhattisgarh population. Available at: https://www.indiacensus.net/states/chhattisgarh
- Welcome to CGG Tourism - Official Website of Department of Tourism, Government

of CGG , cgg Tourism. Available at: https://www.chhattisgarhtourism.in/nationalpark/

- ‘Geographical Indications Journal’ No. 24. Available at : https://search.ipindia.gov.in/GIRPublic/Application/ViewDocument
- ‘Geographical Indications Journal’ No. 34. Available at : https://search.ipindia.gov.in/GIRPublic/Application/ViewDocument
- ‘Geographical Indications Journal’ No. 163. Available at : https://search.ipindia.gov.in/GIRPublic/Application/ViewDocument
- ‘Geographical Indications Journal’ No. 114. Available at : https://search.ipindia.gov.in/GIRPublic/Application/ViewDocument

Unnati Sharad

PGP in Public Policy, Design & Management, Indian School of Public Policy, New Delhi.
Mentored by Mr. Ankit Jain, Asst. Advisor, CPHEEO.

Domain for Internship: Climate Change

Countering the Plastic Governance Challenge in New Delhi

Delhi has set a target of June 2024 to increase its waste recycling and managing capacity. This study investigates Delhi's waste recycling and management goals considering the challenges posed by current waste composition and plastic generation rates due to rapid urbanization and population growth. Examining economic, environmental, and social costs of plastic pollution, the research explores the potential of Waste to Energy (WtE) plants in managing escalating waste volumes. Utilizing the WasteAware Indicator method, indicators were derived from field studies, consultations with a Municipal Corporation of Delhi (MCD) official, and Swachh Survekshan data. Critical insights emerged from an examination of government initiatives and case studies, exemplified by the Ghazipur landfill, unveiled Extended Producer's Responsibility (EPR) governance challenges, emphasizing geographic, financial, and informal recycling sector disparities. Key findings advocated the economic incentives for low-income households, understanding plastic recyclability and integrating informal waste pickers into formal systems. Additionally, the benefits of a decentralized waste management system with a focus on Public-Private Partnerships proposing strategies to overcome information asymmetry and promote household recycling. The study recommendations included incentivizing recycling, creating a market for recycled products, fostering sustainable innovation in plastic packaging, and mainstreaming recycling through public awareness and behavioral change initiatives. Other recommendations underscore the importance of transparency, community incentivization, and policy alignment with India's economic objectives.

Keywords: Extended Producer's Responsibility (EPR), plastic waste management, governance challenges and initiatives, MCD, recycling, Waste to Energy (WtE)

Acknowledgements

I would like to sincerely express my gratitude to the National Centre for Good Governance (NCGG) Team for this opportunity to develop a paper on the plastic waste management challenge in Delhi. My sincerest gratitude to Shri V. Srinivas Sir, Director General of NCGG, for his guidance and mentorship. It has been an utmost privilege to participate in this project, and this learning experience would not have been possible without Shri Bharat Lal Sir, Former Director General of NCGG, who took the initiative tostart this internship programme, providing me with a wonderful opportunity to use my research to bring about impact. I would like to thank Ministry of Housing & Urban Affairs (MoHUA) Joint Secretary Shri Roopa Mishra Ma'am for her invaluable mentorship and support.

I would also like to thank Mr. Ankit Jain, CPHEEO, for his brilliant advice and suggestions that provedto be really helpful for the project's completion.

I would like to also thank Gazala Ma'am, Akash Sikdar Sir, Dr. Yashu, and the team at NCGG for their unwavering support and help.

I would like to mention my sincerest appreciation for the following stakeholders/personnel whoanswered all my questions and helped me develop this paper:

Mr. Shailesh Kumar, Municipal Corporation of Delhi (MCD)

Mr. Jai Kumar Gaurav, GIZ (German Agency for International Cooperation)

Ms. Ekta Gupta, Municipal Corporation of Delhi

Mr. Devinder Chawla, Trashonomy

Mr. Siddharth Singh Ghanshyam, Centre for Science and Environment (CSE)

Nehaal Rao, Recykal

The Association for Social Justice and Research (ASOJ) Team in Ghazipur, New Delhi Mr. Sourabh Manuja, GIZ India

Green Polymers in Kirti Nagar

Thank you, sincerely, for all your inputs, suggestions, and advise.

Introduction

"The economics of recycling is not able to catch up with the volume of plastic wastebeing produced in Delhi."

Delhi's population is estimated to be 30 million by 2023. By 2028, New Delhi, is projected to become the most populous city on the planet (UN News, United Nations Department of Economic and Social Affairs (DESA), n.d.). Although India's per capita plastic consumption in 2014-15 – at 11 kg – wasmuch below global average of 28 kg and just about 10% of per capita consumption in the US, by 2031, plastic waste generation in India is expected to grow by more than 3 times from current levels, amounting to 31.4 million tons per annum (GIZ India, 2022). Plastic waste in India is projected to jump 10 times by 2030. What role will Delhi, the highest plastic polluting city in India, play in this?

In terms of waste composition, dry waste is 60% and wet waste is 40% in Delhi (Kumar). In every state except Delhi and Goa, the opposite would be true. For example, in Pune, wet waste composition is 76%(Ghanshyam, 2023). Delhi's plastic waste generation is predicted to be around 15%, out of which a major fraction is single use plastics (nearly 5%) (Gupta, 2023). The estimated amount of plastic waste generated in Delhi is approx. 2,30,525 tons per annum, which is 7% of total amount of plastic waste generated in India. The per capita plastic waste generation rate in Delhi is 13.5 kg per year, which is second highest among all states in India (Indian Pollution Control Association, Delhi Pollution Control Committee, Government of NCT, 2022). As per a DPCC report, only 2.4% or 271 TPD (out of a total of11,500 TPD of Solid Waste generation per day) of is recycled per day through MRFs in Delhi (Status Report on Behalf of Government of NCT of DELHI, Delhi Pollution Control Committee, 2023). There are at present no plans to increase the recycling infrastructure and value chain in the city, due to the implementation of the Extended Producer's Responsibility Rules, 2016 (amended 2022), which puts theonus of the management of plastic waste on the producers, importers, and brand owners of the plastic products.

Plastic minimization comes at an economic cost. Plastic pollution comes at an environmental, social, and economic cost. India is projected to become a global economic superpower. The growth rate of the Indian plastics industry is one of the highest in the world, with plastics consumption growing at 16% perannum. India also has one of the highest plastics recycling rates in the world. With the introduction of Extended Producers Responsibility Rules, India is making a shift to the circularisation of plastic wastein the Indian economy.

60-80% of plastic is recycled in the informal sector. Plastic waste has a thriving market – literally. With fluctuating rates based on demand and supply, and a well-organised supply chain in the "unorganized" waste picking sector, Delhi's plastic market recycles and diverts waste from landfills.

With three operational plants, one expansion being planned (Okhla plant), and 2 being set up to be completed by the year 2027, Delhi's waste-to-energy plants will be able to account for the volume of waste being produced in the city as of 2023 production (Status Report on Behalf of Government of NCT of DELHI, Delhi Pollution Control Committee, 2023). However, with the predicted population growth comes an increase in consumption and then

waste. More affluent a city is, the more waste is produced.

Without a recycling chain being created in the capital city with decentralized recycling infrastructure,both in the formal and informal capacity, Delhi will not be able to keep up with the volume of waste being produced.

Waste Management in metropolitan cities is increasingly attracting the attention of large-scale institutional investors, due to the increasing volume of generated waste, its metabolic density, and proportion of recyclable materials. Waste to Energy (WtE) appears as an attractive option, with the processing capacity in Delhi being close to 7500 MT/day (Ghanshyam, 2023). Delhi produces 11,500 MT of waste per day. Out of which, it is unclear how much remains to be plastic waste. It is roughly estimated that plastic waste generated per day lies between 690 MT to 2000 MT (according to waste management experts consulted for this research project). Waste to Energy (WtE) plants are required to recover and process recyclable content (South Delhi Municipal Corporation, 2017) according to MSW Rules, but not only are no provisions arranged to do so, but the ragpickers who engage in this occupation are not allowed authorisation to collect such plastic waste from dumpsites.

There exist unanticipated gaps in plastic waste management in Delhi that must be addressed. There is a gap in processing of solid waste management of 6462 TPD, which is planned to be addressed through 11 Proposed Waste Processing & Disposal Facilities (Status Report on Behalf of Government of NCT of Delhi, Delhi Pollution Control Committee, 2023).

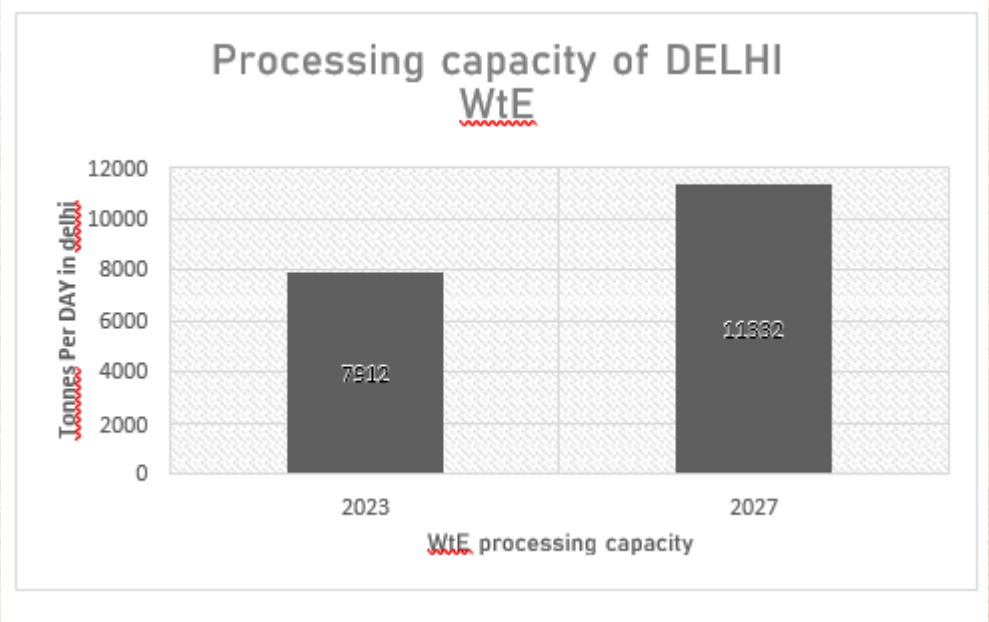


Figure 1 SWM processing capacity of WtE plants in Delhi (Actual and Projected)

In 5 years, the processing capacity of the Waste to Energy plants will be sufficient to meet the needs of Delhi's current population, and not its growing population.

This can be changed through certain measures. The first and the most important is that waste can make wealth. The market for recycling plastic has saved Delhi from choking under the weight of its waste.

However, some plastics like LDPE and MLP are tough to recycle. The cost of recovery of

these plastics is more than the benefit received by recycling it. However, MLP like plastics are indispensable in the production of certain consumer goods. These plastics are littered across the city, ruining its aesthetic design and leading to public health effects. The second is that recycling majorly takes place in the informal sector. Not only does it go unaccounted for, but can lead to devastating health effects due to theuse of unscientific methods. Thirdly, the rules for plastic waste management formulated in 2016 clearly lays down the guidelines for proper channelization and recycling of plastic waste. However, lack of adequate enforcement and monitoring mechanisms, capability, motivation, and technology lead to it remaining an on-paper aspiration and vision.

Ultimately, plastic waste management in Delhi is a shared responsibility, and must be viewed as such.

Channel of Plastic Waste Management in Cities

Delhi, the national capital, contains 5 administration zones – Delhi Cantonment Board, New Delhi Municipal Corporation, South Delhi Municipal Corporation, North Delhi Municipal Corporation, andEast Delhi Municipal Corporation. With the introduction of the Plastic Waste Management Rules, producers are responsible for the collection and recycling of plastic waste generated by them, andmunicipal bodies are required to set down guidelines for plastic waste management in the city.

As per a report submitted by the National Green Tribunal, 1,100 tons of plastic is generated in Delhi daily, of which 755 tonnes are co-processed in the three WtE plants (Times of India, 2022). There are noplans to increase MRFs in the city, according to MCD officials.

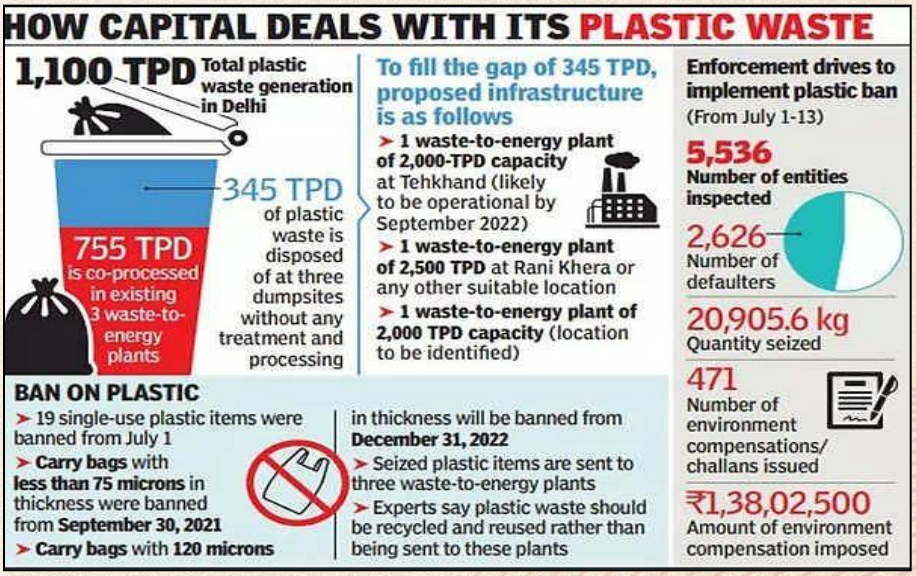


Figure 2 Times of India, Delhi: Why recycling, not waste plants, is key to tackling plastic waste

The municipal corporation of Delhi is not responsible for recycling of any plastic waste. There are currently no revenue streams for the MCD from Solid Waste Management activities in the city. There is just cost, but no profit. Since the Extended Producer's Responsibility Rules was recently implemented as of 2022, the system has not been streamlined yet. Bulk Waste generators and households have to segregate their waste into three separate streams – wet waste, dry waste, and domestic hazardous waste. Bulk Waste Generators means and

includes buildings owned and operated by State or Central Government institutions, Hospitals, Commercial establishments, Markets, etc. having an average waste generation rate exceeding 100 kg per day.

Municipal bodies collect the plastic from the declared storage containers using human resources and machines like tipping trucks, and transport the segregated waste from source in a closed vehicle to the final disposal point. The comprehensive operation of street cleaning, waste transportation, and waste disposal is done by the MCD. The secondary collection and transportation of MSW from dhalaos (secondary storage points) is done through private concessionaires in 7 zones.

Delhi has 4 WtE plants located in Okhla, Ghazipur, Tehkhand and Narela. They process nearly 7500 tons of waste per day (Ghanshyam, 2023). It produces 52MW of electricity. Segregated high-calorific non-recyclable value plastics is supposed to be incinerated in WtE plants. However, it is found that low-value plastic content and content with high moisture (mixed waste that is wet) is incinerated in these plants, leading to anaerobic combustion. The good news here is that high-value recyclable waste rarely ends up in landfills (Kumar). This valued waste finds itself in a leaked channel, ending up in the hands of informal workers.

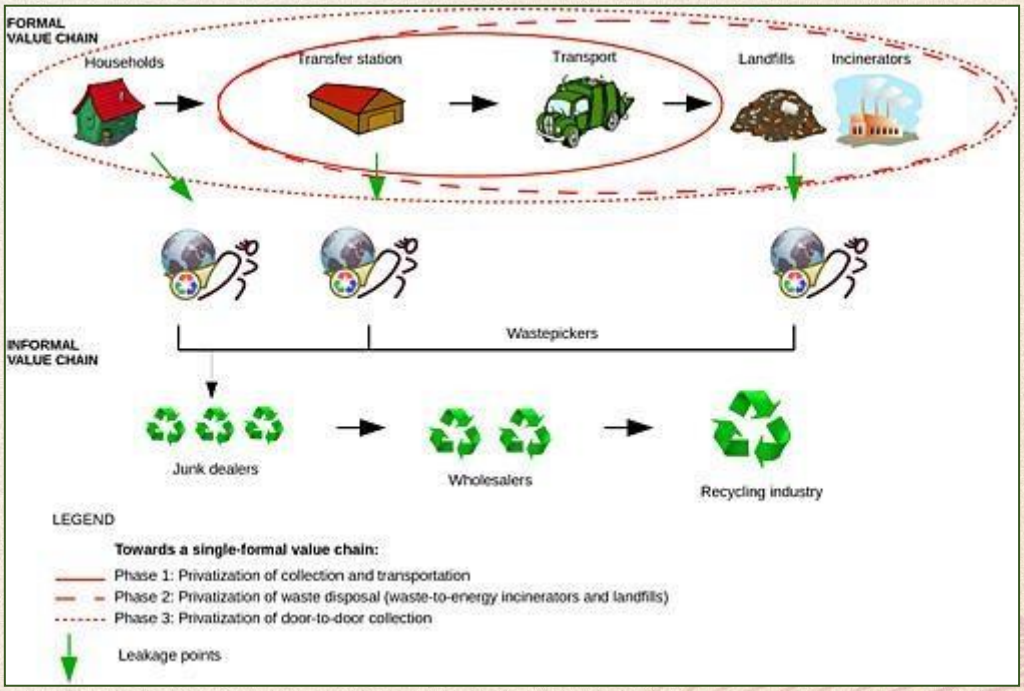


Figure 3 Federico Demaria, Contesting Urban Metabolism: Struggles Over Waste-to-Energy in Delhi, India

From primary collection (from households and BWGs) and secondary collection (from common collection points located in public spaces), waste is transported in one vehicle with segregated compartments with wet waste, dry waste, and mixed waste to a secondary storage facility, or directly dumped in the landfills. A senior official in Delhi stated that all waste is mainly being dumped in landfills. However, one saving grace has been valuable plastic leaking out into the informal chain, where it is recycled.

Wastepickers in the informal channel are of two types-

1. Wastepickers who pick high value recyclable waste from households and bulk waste

generators,otherwise known as “kabadiwallahs”

2. Ragpickers who scour through waste in landfills for recyclable waste to sell.

They collect the waste and sell it to a small-scale trader, who in turn sells it to a big recycler/large aggregator. Large aggregators sell the segregated plastic waste to recyclers. Small scale traders and wastepickers do not have the capacity to store the waste. However, recycling is a lucrative business, and it is also an industry that deals in specialisation. Recyclers deal in specialised types of plastic – PVC (polyvinyl chloride), PP (polypropylene), PET (Polyethylene terephthalate), LDPE (Low density polyethylene), PS (polysterene), and others.

Recycling is, as mentioned, lucrative. 60-80% of plastic recycling happens in the informal sector. These represent leakages in the waste channel, as the recycling has environmental benefits but goes unmonitored. Monitoring and accounting for the quantities of waste that are recycled is necessary:

a) To better calculate and address the plastic footprint of households and industries

b) Ensure unscientific methods of recycling is not carried out, which causes more environmentalharm than good

c) To make certain that rejected unrecyclable waste is not littered in public spaces.

Plastic waste leakage is a governance challenge, and addressing it requires policy interventions at thehouseholds, market/bazaar, and government level.

Waste aware Indicator for the City of Delhi

To assess the governance challenges in the city, the WasteAware Indicator method has been adapted from to present a visual understanding of the gaps that need to be addressed for proper plastic waste management. The Wasteaware ISWM (integrated sustainable waste management) benchmark indicatorsare a tool to assess the performance of the municipal solid waste management and recycling system in a city. The focus here will not be on the performance of SWM services in Delhi, but rather it is a framework of indicators intended to dig out the weak points in the recycling framework in the city. TheWasteaware indicator has been used as it has been designed by the University of Leeds, UK, for developed and developing countries. Each indicator has 6 subpoints that need to be calculated to arrive at a number. The Wasteaware indicators have been prepared through

a) Field studies

b) A consultative session with a MCD official.

c) Data from Swacch Survekshan[i] indicators for MCD (2022-23)

Disclaimer: The attempt and focus of the theoretical model is not on the performance of the municipality, but on the governance challenges and gaps in the recycling framework. It has been looselyadapted from the Wasteaware Indicators, and is based on strong judgements of a few stakeholders, and should not be cited in other research papers without permission from the author.

	City	New Delhi			
	Country	India			
B1	Country income category	World Bank income category			
		Lower-middle income	GNI per capita		
B2	Population	Total population	$2380		
B3	Waste Generation	Total municipal solid waste generation (tonnes/year)	3,29,41,000		
			11,332		
No	Category	Data/ Benchmark Indicator			
Key Waste-related data	Data			Results	
W1		Waste per capita	MSW per capita		
			kg per year		
W2	Waste composition	Summary composition of MSW for 3 key Fractions	kg per day		
W2.1	Organic	Organics (food and green wastes)			
W2.2	Paper	Paper/Glass/Textiles	40		
W2.3	Plastics	Plastic	25		
W2.4	Metals	Metals	15		
	Others	17	3		
Physical Components					
		Public health - waste collection			
		1.2 Waste captured by system		HIGH	
		Quality of waste collection service		MEDIUM/HIGH	
		Controlled treatment and disposal		LOW/MEDIUM	
		Quality of environmental protection of waste treatment and disposal		MEDIUM	
		Recycling rate of plastics			
		Quality of 3Rs			
Governance Factors					

4U		Inclusitivity	User	
4P		Provider		
5F	Financial Stability	Financial Stability		MEDIUM/HIGH
6N	Sound institutions, proactive policies	Adequacy of national solid waste management framework		LOW/MEDIUM
6L		Local institutional coherence		MEDIUM

A background of the city – The 5 ULBs in Delhi were unified recently. The MCD alone manage almost 95 % of the total area of the city. The above authorities are supported by a number of other agencies.

The Delhi Development Authority (DDA) is responsible for siting and allotment of land to MCD for sanitary land filling. Delhi Energy Development Agency (DEDA) under Delhi Administration (DA) is responsible for solid waste utilization projects aiming at bio-gas or energy generation in consultation with the Department of Non-Conventional Energy Sources (DNES), and Ministry of Environment and Forests, Climate Change (MoEFCC). There are other important agents who play their part in the overallscheme of solid waste management in the city. They are 575,000 private sweepers and garbage collectors employed by the people for cleaning privately owned premises, waste pickers, waste dealers and recycling industries, which consume recyclable waste to produce recycled products. Most of the plastic recycling happens in the informal sector through unorganised wastepickers. The current population of Delhi is 3 crores, and 11,500 Tonnes Per Day (TPD) of SWM is produced, out of which 15% (estimated) is said to be plastics. 5% out of this is single use plastic.

Recycling Rate in the city (Formal & Informal)

(A) 3R Principles

This indicator assessed the MCD's efforts to reduce waste generated by households/commercial establishments.

3R initiatives have been introduced in more than 45% wards in 2022 in Delhi, according to Swacch Survekshan Data. One indicator of 3R speaks of the integration of the community and/or informal recycling sector (IRS) with the formal solid waste management system. There is a high focus by theMCD administration on this front. IEC campaigns are consistently and committedly administered tomultiple wards, and RWAs are encouraged and incentivized to take up solid waste management activities by themselves. Nearly 300 colonies have composting pits, and 100 have been named zero waste colonies. The NDMC has integrated the IRS into sorting of recyclables in two MRF plants, incollaboration with the civil society organization – Chintan Environmental Research Action Group.

In terms of environmental protection in recycling, another sub-indicator, the field visit to the UNDP MRF showed high compliance to PPE kits, but however, sorting at a primary level happens out of mixed waste. The truth is that the recyclables that land up in MRFs are more than often mixed waste. Tosort and clean it takes a lot of time, effort, and water.

Women are primarily in-charge for this part of the recycling process. 18 of the workers interviewed didnot know a word of Hindi, so it was tough to communicate the importance of wearing gloves.

Moreover, 80% of the recycling that happens in the informal sector, especially in Tikri Kalan, happensin a scientifically-unsound manner.

(B) For the benchmark indicators for Governance Aspects:

There is implementation of comprehensive, culturally appropriate public awareness raising programmes, in more than 45% of wards of the MCD, and this number has increased to 60% in 2023. There has been a high level of involvement of the public in SWM planning and implementation. Resident Welfare Associations are active in the planning processes. The MCD also has a helplinenumber for public feedback.

However, one indicator under "User Inclusivity" speaks of effectiveness in achieving behavior change through IEC activities. However, there has been very low segregation at source. This is because the users of SWM believe that all the waste they painstakingly make efforts to segregate clean and dry recyclables and minimise mixed waste ultimately gets dumped in the landfills itself.

In terms of Provider Inclusivity, the formal channel of SWM services, which is based on a PPP model (Public-Private Partnership) has ensured high compliance with the sanitary guidelines of MoHUA. Waste services are mutually beneficial, with the MCD handling transportation and collection, while theresponsibility of disposal lies with the private sector (WtE plant operators).

However, except for one ULB, there is no evidence of acknowledgement and recognition of the role of the organised informal sector within or alongside the formal solid waste management system. However, this must be addressed as the reality in many developing country cities is that the informal sector is providing services for waste collection, recycling, and reuse.

Key Takeaways from Delhi's Wasteaware Indicators:

1. The Informal Recycling Sector is missing from the overall solid waste management system.
2. Recyclables that land up in MRFs are more than often mixed waste.
3. There is a lot of potential for PPP in not only disposal, but also processing functions, likerecycling plants.

Challenges For Plastic Waste Management in Delhi

1. Increase in volume of plastic waste, decrease in standard of living for Delhi'sresidents

Rapid urbanization → More money to spend due to increased incomes → Money spent onproducts that have plastic → Annual increment in plastic waste generation → More volume means more waste to be picked up from trash dumps by informal sector → more employment → Increase in migration → Major shortage of land which is now occupied by the scattered illegal settlements → Increase in spread of diseases due to unhygienic and

dangerous nature of wastepicking occupation in unsanitary conditions → An unemployable, sick, depraved, and dependent section of society that renders the informalsector unproductive, thereby reducing the rate of recycling from 80% to 20%.

2. Lack of recognition of informal wastepickers in official channels.

There are 2 lakh informal wastepickers in Delhi. Informal wastepickers face constant challenges to their livelihood. From privatisation of doorstep collection to Waste to Energy plants to health hazards, this section of society remains marginalised and socially ostracised due to the nature of their work. Except for the North Delhi region, who has partnered up with an NGO (Chintan), ragpickers have been bribed by caretakers of dumpsites, landfills, and dhalaos before they can enter these places to collect plastic waste.

They cannot gain formal recognition due to the lack of legal documentation, nor do they understand how to gain access to rights and benefits as they are uneducated and poor.

Prices for the plastic they collect fluctuates, and they are frequently taken advantage of by small aggregators who sell their trade for a way larger margin to recyclers. Lack of business acumen and low awareness of the market for recyclables leads them in an impoverished and insecure state.

3. Low segregation of plastic at source

A study shows that only 29% of households in Delhi segregated at source (Kaveri Kala et al, 2022). This leads to inefficient recovery of valuable plastics from mixed waste. Why?Citizens in Delhi see it as a cumbersome effort to undertake as they believe their efforts would go waste as even if they segregate it, it will be transported in one truck and dumped in the same place. They are not wrong to think this because that is what is happening currently in Delhi.

However, a field study showed that if the information asymmetry is addressed by reverting back to the beneficiaries of SWM services, and they are made aware of how their efforts contribute towards the beautification of the city they live in, there will be a perceived change in their behaviour and increase in segregation efficiency at source(Shivani Wadehra, 2017).

4. Implementation of EPR in starting stages, exclusion of MSMEs

The Extended Producer's Responsibility that puts the onus of plastic waste recycling on plastic producers, importers and brand owners (PIBOs) recently got implemented, and while there has been a compliance to the rules, the ambitious targets and goals set by the policy have clear gaps in governance – starting with inadequate guidelines surrounding monitoring and implementation. The MSME-dominated plastic industry, both in terms of plastic production and plastic recycling, are exempted from the policy for now.

5. Low Value plastics have a higher cost for recovery and recycling, and end up in the environment

As per a source in the Municipal Corporation, a recent study conducted shows that 10% of SWM is plastic waste, out of which 5% is single-use plastic.

6. Lack of shared responsibility

Plastic waste management requires a multi-stakeholder effort. However, it is currentlyseen as the problem of the PIBOs, with the introduction of EPR.

7. Single-use plastic dominates plastic use in Delhi

Single use continues being used in the city, even after several bans and guidelines being implemented. Single use production takes place underground, and it is hard to monitor and penalise those producing it. Plastic use is a supply-driven market. No consumer would actually prefer to use single use plastics over its alternatives. But lack of an inexpensive alternative and the ready availability of these plastics makes it a convenient source for packaging. It is difficult to monitor and ban the complete use of these packages. The main reason is due to the fact that the production of these bags happens covertly, as the size of the operation is small and well-hidden. Information, Education & Communication (IEC) campaigns in communities and schools can bring about change inusing these plastics.

8. No single-window clearance for recycling businesses.

Recycling businesses require multiple clearances thus delaying the set-up whileunorganized sector continue to run their businesses without any clearances.

An Inside View: Plastic Circularity

Figure 4 Shakti Plastics - Factsheet

Plastics are broadly of 7 types. The ones most commonly recycled are PET, HDPE, and PP. PS and PVC are difficult to recycle and therefore are collected less. LDPE is recyclable, but loses value in therecycling process.

Under Extended Producer's Responsibility, there is another classification of these plastic-

Category-I: Rigid plastic packaging.

Category-II: Flexible plastic packaging of single or multi-layer plastic sheets, covers, and the likes.

Category-III: Multi-layered plastic packaging.

Category-IV: Plastic sheet and similar material used for packaging purposes as well as carry bags madeof compostable plastics

Multilayered plastics are difficult to recycle, along with low-value plastics. It is difficult to recycle theseproducts due to its heterogenous materials. The cost of recovery is more than the benefits from recycling. These are often the plastics found littered in roads, forests, beaches, hilly areas, and otherpublic areas.

To complementarily align with India's ambitious economic goals, it is necessary that plastic circularity is streamlined and implemented. Plastic needs to retain its true value. An analysis by MoHUA identifies significant potential for resource recovery from these waste categories through circular economy. For example, dry waste recycling has a potential to generate approximately 11,836 crores per annum (Ministry of Housing and Urban Affairs, 2021).

A circular economy approach entails creating incentives for businesses to innovate models to reduce theplastic quantity or enhance the recyclable/reusable quality of their product, thereby addressing the wastechallenge (Ministry of Housing and Urban Affairs, 2021). The design of the Extended Producer's Responsibility Rules is such that it aims to incentivize recycling at the product design stage itself, by leveraging high fees based on the "polluter pays principle".

EPR – Foreseen Governance Challenges

In terms of environmental law, the polluter pays principle aims to make the party responsible for producing pollution also pay for the damage done to the natural environment. The EPR targets for recycling is set to start from 2024. As of now, PIBOs are required to collect and dispose of their plastics. However, there are anticipated problems that may arise with this policy –

i. EPR Rules are not geographically specific. PIBOs aim to fulfil their obligations by handling waste in metropolitan cities, whereas their products are pan-India. Plastic thrown in hills and beaches will now have a low probability of being collected and disposed of.

ii. The plastic credit model does not require producers to recycle their own packaging, but toensure an equivalent amount of packaging waste is recycled and recovered.

iii. The financial exchange of plastic credits takes place without being traced on the EPR portal.

iv. The EPR mechanism does not incentivise a shift to cleaner plastic production. The firm will continue producing plastics which have little to no value, and they will only have to pick up acertain portion of it. The long-term environmental impact the left-out plastic will go unaccounted for.

v. The concept of Producer's Responsibility Organisations has been removed from the EPRpolicy. However, it is instrumental to have competing recycling organisations to create amarket for recycled goods.

vi. High regulatory costs are imposed on Central Pollution Control Board and its subsequentstate committees.

vii. EPR will also take away valuable waste from the informal recycling segments, such as theragpickers. They are dependent on this waste.

viii. Though the EPR regimes intend for reduction of government involvement, governments have to involved because EPR systems require not only sound policy design, but also effective governance to operate effectively.

Sources say that as of 2023, the EPR mechanism has been operating smoothly. Plastic is being collected; certificates are being brought. Time will tell. For now, infrastructure capacities must be increased and policy interventions targeting waste generators (like households and BWGs) and wastepickers must be implemented and adhered to. EPR is meant to account for rising population growth, but will it be able to recycle and collect back how much is being disposed of, without plastic waste management being viewed as a collective responsibility of the public, the PIBOs, and the municipal authorities?

Current Government Initiatives to Manage Plastic Waste

Delhi currently has 7 Semiautomatic Material Resource Facility overseen by the Municipal Corporationof the city.

- Under CSR initiative of SBI Card IPCA has established 4 Material Recovery Facilities in DelhiNCR, with a cumulative plastic processing capacity of 9 TPD
- UNDP plant in collaboration with waste economy start-up Trashonomy with a plastic processingcapacity of 5 TPD.
- 2 MRFs managed by Chintan Environmental Research Action Group, in New Delhi RailwayStation and IIT-Delhi campus which processes 8 TPD a day.
- One MRF in Raghubir Nagar, managed by ITC.

Additionally, the Union Territory has 150 dhalaos being converted to FCTS (Fixed Compactor TransferStations), to increase the segregation rate in the city by following the 3Rs concept i.e., 'Reduce, Reuse,and Recycle'.

In terms of EPR Rules, only in Delhi, the ULBs are not responsible for monitoring and implementation. The responsibility lies with the Delhi Pollution Control Committee. Delhi bye-laws for plastic waste management are currently under process of being implemented. A fewnotable rules in the bye-laws include

i. Segregated plastic waste will be put in the bins with the colour blue

ii. Waste generators will be responsible for depositing their segregated waste, which shall not betransported along with MSW to the designated landfill site.

iii. The primary responsibility for collection of used multi-layered plastic sachet or

pouches or packaging is of Producers, Importers and Brand Owners who introduce the products in the market. They need to establish a system for collecting back the plastic waste generated due to their products. This plan of collection to be submitted to the DPCC while applying for Consentto Establish or Operate or Renewal.

iv. Concerned Local Bodies (LBs) shall facilitate construction, operation and maintenance of Material Recovery Facility (MRF), plastic waste processing facilities and associated infrastructure on their own or through any agency for optimum utilisation of various componentsof plastic waste.

v. Concerned LBs shall endeavour to create a market for consumption of Refuse Drive Fuel (RDF).

And, most importantly

vi. Concerned Local Bodies (LBs) shall make efforts to streamline and formalize plastic waste management systems and endeavour that the informal sector workers in waste management (waste pickers) are given priority to upgrade their work conditions and are enumerated andintegrated into the formal system of plastic waste management

The MCD spends lakhs and crores on IEC activities for proper segregation at source, hoping for a behavioural change to take place. Recently, close to 100 residential colonies in Delhi declared themselves as 'zero waste colonies', with women community leaders leading the initiative for 100% segregation at source. The Municipal Corporation of Delhi is also offering an incentive of 5 per cent of the property tax paid to zero waste colonies recognised as participatory colonies (The Print, 2023).

The initiatives taken by the Municipal Corporation is definite step towards managing growing waste in the city in a sustainable manner. There still remains a problem of plastic litter that originates from a market system that continues to be dependent on plastic products.

Case Story 1 UNDP MRF Plant in Dwarka, Delhi

Trashonomy is a for-profit enterprise working towards providing professional waste servicesto households and BWGs. They ae the operating partners for the UNDP and MCD funded MRF in Dwarka, New Delhi. They process 10 metric tonnes of waste dry waste per day, of which 5 TPD is plastic. The cost of setting up the MRF was 2 crores, and in terms of O&M, Mr. Chawla (CEO of Trashonomy) states, “It is a self-sustainable, or even profitable model for us.” Wealth out of waste is created not only for Trashonomy, but also for the 300 workers from the informal sector being trained and employed in the plant.

Primary sorting is done by women.

The semi-automatic plant produces black pellets out of plastic waste, which is then transported to recyclers outside of Delhi. Two challenges were brought up by Mr. Chawla. First, MLP is hard to recycle. To recover MLPs costs more than the benefits of recycling it. Secondly, even seemingly easy to recycle products like PET bottles pose challenges for recycling technologies. Plastic products are commonly made out of more than one plastic type. The bottles may be made out of PP plastic, and the labels out of HDPE. When the plastic bottle is shredded, what comes out is a mixed product with several types of plastic, now indistinguishable. When water is run through to separate the products so that it may be sent to different recyclers, it is found that PP and HDPE settle on the top, and PET on the bottom. This complicates the process of separating plastics to be sent to recyclers.

Altering Our Perspective on Plastics

As seen from Case Story 1, it becomes important to incentivise the producers and brand owners todesign sustainably, design for recycling. Recycling must be made an easier process, to lead to a circularity in the lifecycle of a plastic product.

Reusing is higher up on the waste hierarchy, and brand owners are aware of this fact. However, it is expensive to manufacture reusable products. Additionally, people in urbanising cities look for convenience, which is why markets and shops are alternatively called convenience stores. Sustainable packaging is available for people of a higher income level, while majority of the population belongs to lower-income levels, thereby consuming more products with less sustainable packaging. Behaviour economics speaks extensively about the rational consumer. Brand owners and Producers must be directed to bear the responsibility under EPR guidelines to devise plastic minimisation efforts by using pricing mechanisms to incentivise consumers to choose a more sustainable lifestyle (LiFE – Lifestyle for Environment). Low cost, low effort (Figure 5) means products that are cheap also tend to have MLP and low recyclable material packaging. The common person in India cares about how much they spend. So, alternatively, brands can incentivise consumers by offering discounts to induce environmentally sustainable behaviours in their everyday consumption and lifestyle.

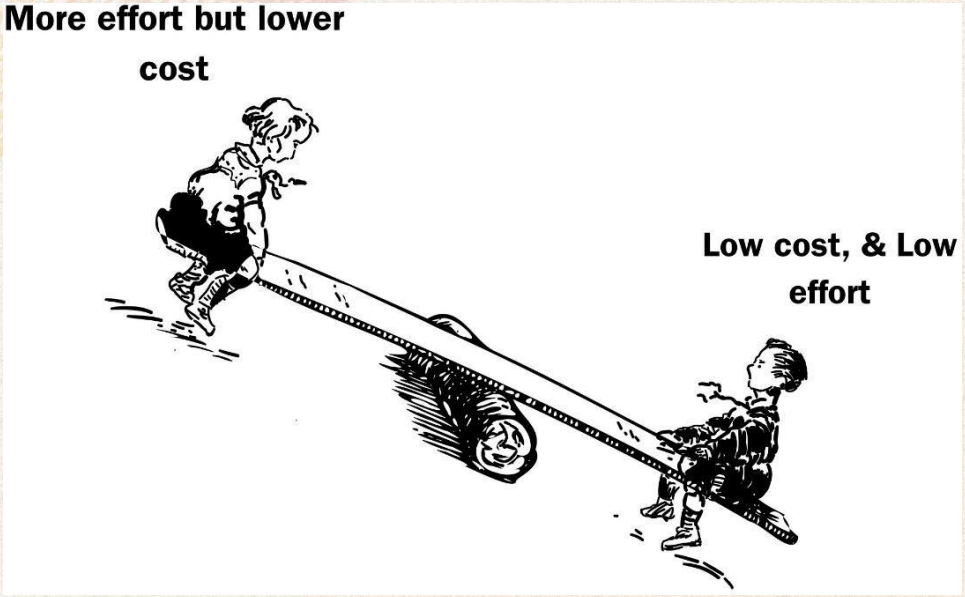


Figure 5 Principles for incentivising green consumer behaviour

By incentivising the industries by way of constantly holding EPR Monitoring Consultative Workshops and inculcating recycling into the mainstream by encouraging the firms to trust that their consumers would be rational and adopt sustainable ways. For example, instead of buying milk packets, Mother Dairy installed 900 token milk dispensing booths that has saved 850 tonnes of plastic per day (ETInsights, 2023).

A Pune-based startup called Ashaya has created what it claims to be the "world's first recycled sunglasses" made from discarded packets of chips. These glasses are highly functional as they are UV-polarized, durable, bendy and comfortable. Customers can also scan a QR code on the side of the sunglasses to see how many packets were used to manufacture them, which waste pickers collected thepackets etc (ASHAYA, 2023).

Recommendations For Plastic Waste Management and Governance

1. Scaling up of the decentralised waste management system through setting up digitally monitored MRFs via innovative Public Private Partnerships.
2. Incentivising recycling for households, bulk waste generators, PIBOs, and wastepickers.
3. Planning ahead for the city's growing population (and predicted future generation of plastic waste) by integrating the informal sector into the plastic recycling framework of Delhi.

The implications of the three suggestions to improve plastic waste management and governance are:

IMPLICATION 1: Scaling up of the decentralised waste management system through setting up digitally monitored MRFs via innovative Public Private Partnerships.

Good governance is future-proofness, inclusive, and participatory. The wasteaware indicators show that it is not enough just to "manage" plastic waste in Delhi, but rather increase the recycling rate in the highest polluting city to promote a circular economy. This can be done

by integrating the informal sector into a new decentralised and adequately monitored plastic waste management system.

There is huge potential of Public-Private Partnership in this venture. As observed with the case study ofTrashonomy (Refer. Case Story 1). The MCD partnered with the UNDP to build the facility, and transferred the management to Trashonomy. Plastic recycling makes the MRF plant situated in Dwarkanot only a self-sustainable venture, but also a profitable one. There are profits in plastic. Along with creating stable employment for nearly 2 lakh wasteworkers in the informal sector, this will enhance the recycling process due to the indigenous expertise they hold.

Delhi is planning to shut down its dhalaos and instead institute MRFs. This can be a transformativeopportunity for two reasons –

a) It provides a closed a contained space for dry waste to be segregated and sent to recyclers.

b) Allows the monitoring of plastic waste being generated and processed in these facilities via the Sansaadan app (developed by the Ministry of Housing and Urban Affairs)

c) The top 50 plastic waste generating PIBOs can be invited to the bid auction and set up MRFs to collect back their waste and streamline the EPR Process in the highest plastic waste generating city.

It is an opportunity for bazaar, samaaj, and sarkar to recycle plastic waste in the city using a streamlinedprocess-driven and profit-seeking model.

A space for waste makes all the difference. Thus, this participative decentralised waste model will make recycling mainstream and visible in the city, without ruining the aesthetics. Collection and transportation cost sometime outweighs the intrinsic value of the dry waste item. Decentralized collection infrastructure needs to be developed to reduce logistics cost and enhance collection by informal sector.

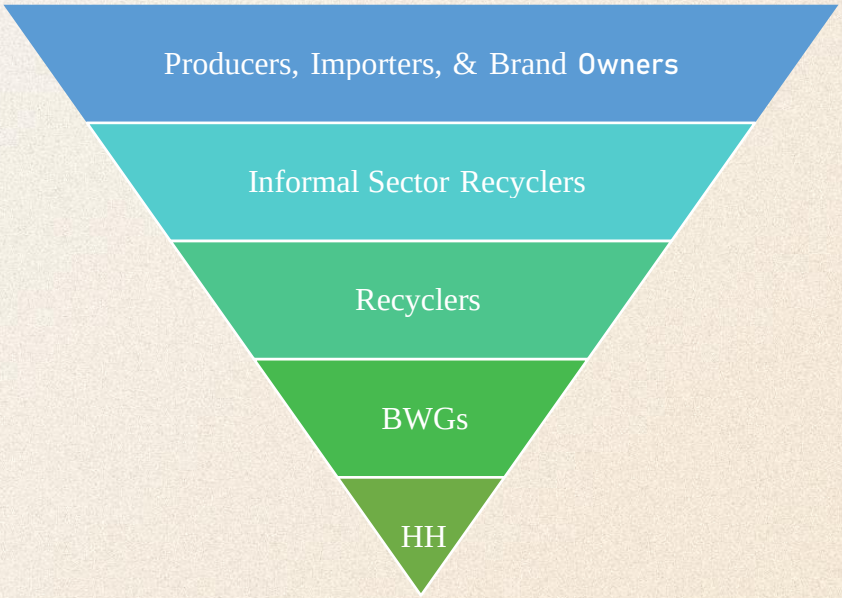
It can be created as an inclusive model that generates employment for nearly 30 people/10 TPD. The current MRF capacity in Delhi is between 257 to 317 TPD. Unlike waste to energy plants, the work at the Material Resource Facilities does not get impacted by rain. It can generate employment, especially for the 1000-2000 unemployed women in Seemapuri and Ghazipur. This gender-inclusive model of plastic waste segregation and recycling can enhance the livelihoods of slum communities, who can nowenhance their children's nutrition and education with their increased income, in double-earning families. This enhances future choices for these young school-going children, who may now dream a better life for themselves.

These MRFs represent a future-proof model, as Delhi's waste-to-energy plants capacity is currently 7550. It is projected to be 11,550 by 2027. Delhi is the highest-growing city in terms of population growth. There is massive land constraint in the city, which is burdened by a growing population unable to afford even low-cost housing. This section of society takes up land near waste landfills, and fall ill due to the toxic chemicals and general unhygienic

conditions. WtE plants will not be able to keep up with the growing demand for foods with cheap plastic packaging that is disposed off in the environment. This decentralised MRF system is cheaper and easier to scale up than the complex technological WtE model. Material recycling facilities can help improve recovery from ₹5,187 crores/annum to ₹17,023 crores/annum by 2025 thus adding ₹11,836 crores to economy per annum (Ministry of Housing and Urban Affairs, 2021). This makes it a future-proof innovation that creates jobs not only in O&M functions but also in construction. Each MRF handling 10 TPD of plastic waste can generate employment for nearly 31- 50 people (Chawla, 2023).

Recycling of plastic creates value, and generates socio-economic development. EPR obligations willlead to plastic becoming a profit-making market.

IMPLICATION 2: Recycling at all levels



At Household Level (HH)

In Delhi, there is a belief that efforts to segregate go wasted, as the waste is ultimately dumped in landfills rather than reused or recycled (Shivani Wadehra, 2017). While this is true, the MCD plans on changing the status quo to incentivise recycling. Overcoming the information symmetry in plastic waste management will make a significant change in the plastic that ends up in landfills.

With the introduction of Sansaadan app by MoHUA and Technical Partner GIZ India, MRF's will berequired to report the daily tonnes of plastic received[ii]. Making this accessible to the public, and alsoincluding information of the plastic diverted from landfills per day from MRF closest to a particular neighbourhood will drastically increase the probability of people committing to achieving 100% segregation at source in their homes.

Even in low-income households, recycling can be incentivised by making them aware of the economic gain they would receive by selling their recyclable plastics to authorised wastepickers connected to a private company.

Incentivise households to segregate waste at source by making it a community and collective action commitment. MCD has offered a rebate of 5% of Property Tax for Delhi zero waste colonies, to be usedin developmental projects for the neighbourhood and its people. Common interest would signify a collective organisation that aims to convert their living space into a zero-waste colony. By instituting a neighbourhood mechanism that rewards households that segregate well, and have them be recognised on the MCD website will positively incentivise all households to segregate responsibly for a chance to be rewarded by their RWA and Municipal body.

For Bulk Waste Generators (BWGs)

Bulk Waste generators need strict guidelines for segregation of plastics. Delhi as an urban metropolitanand urbanising city Is divided into clusters/regions. Strategically placing Depots for recycling specifically for industrial, commercial, and office complexes will not only generate employment but will also ensure an increased rate in recycling of plastic waste.

75 percent of plastic waste generated from bulk generators is MLP, 7 percent is PET, 8 percent is LDPE, 9 percent is Polystyrene while HDPE is a lowly 1 percent. Installing garbage bins by conducting a study in each of these areas and accordingly installing waste management facilities to fit the needs of the waste generator will facilitate better plastic waste management.

For Recyclers

Research by CSE in 2019 showed that PP was partially recyclable. PP is used primarily in food packaging and beverage containers. Of the types of plastics recycled in India, PVC (polyvinyl chloride)accounts for 45 per cent, LDPE (low density polyethylene) for 25 per cent, HDPE (high density polyethylene) for 20 per cent, PP (polypropylene) for 7.6 per cent and other polymers such as PS (polystyrene) for 2.4 per cent.

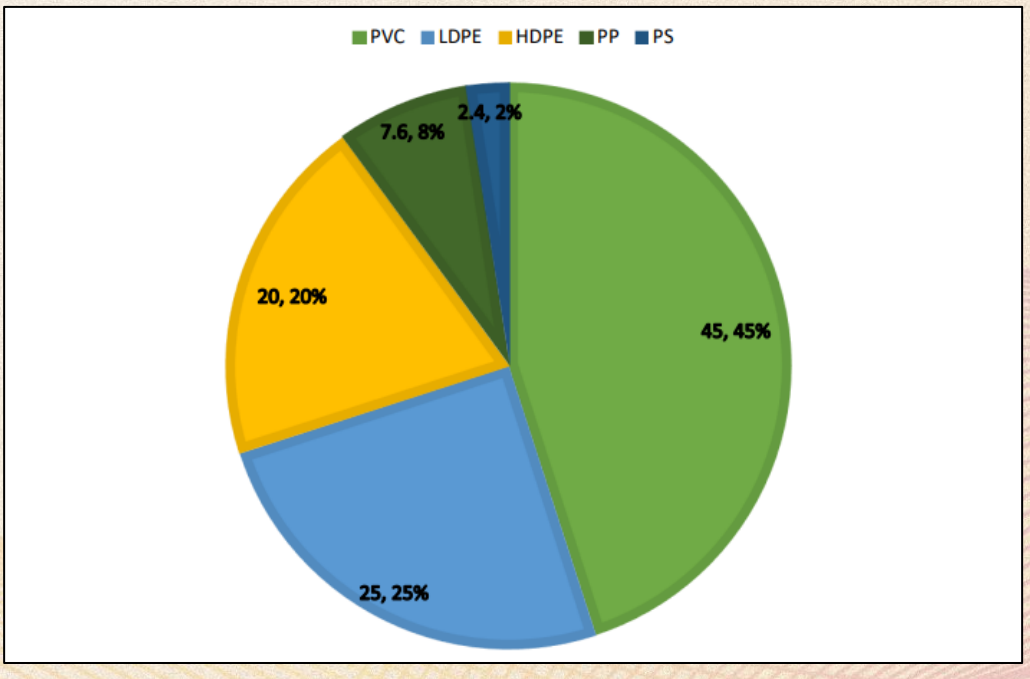


Figure 6 CSE Plastic Datasheet

However, a study by GIZ India shows that PET, PP and LDPE recycling rate is over 40 percent. The lowest recycling rate is that of PVC. HDPE and Polystyrene enjoy recycling rates of close to 30 percent from the waste that is generated and collected in Delhi. Data collected from recyclers of materials shows that PP does not reach recyclers while small aggregators were making a huge margin.

Recyclability potential of plastic in Delhi is influenced by 3 factors (GIZ India, 2022):

1. Presence of a recycler
2. Market for the recycled material
3. Materials covered under EPR

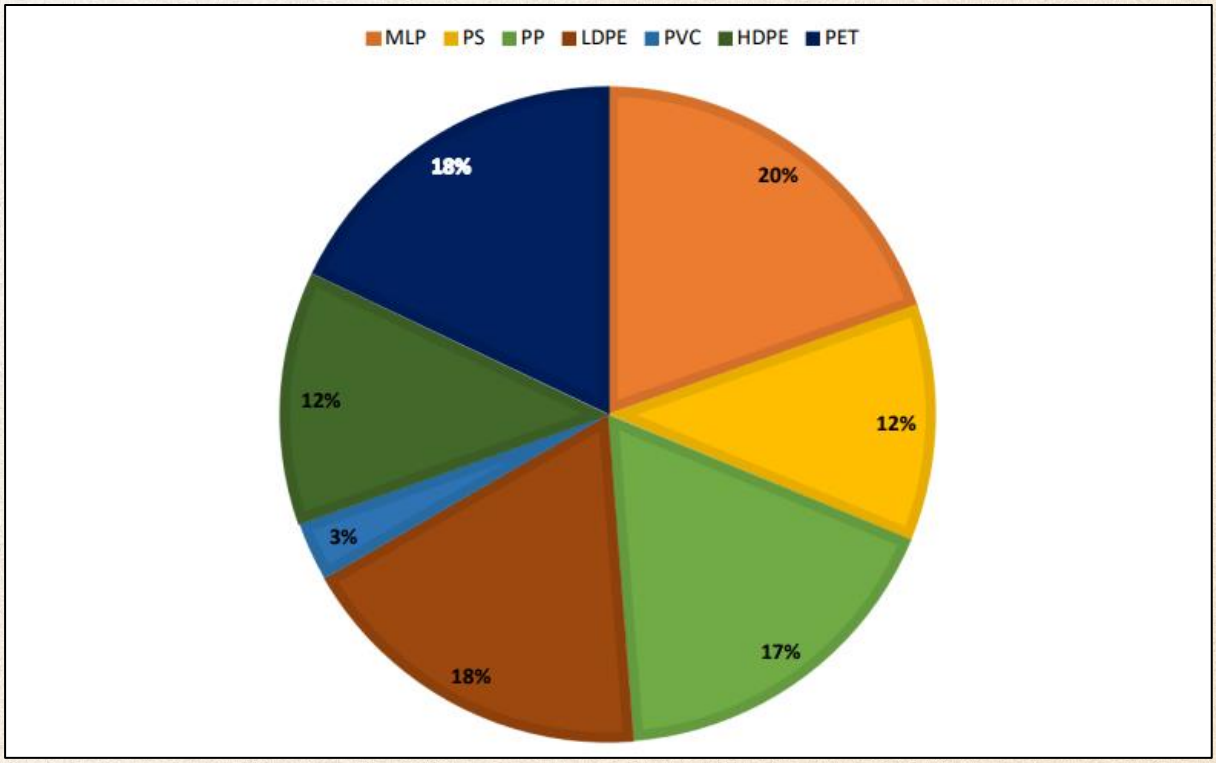


Figure 7 GIZ dry recyclables

PVC and polystyrene (PS) do not have recyclers in and around Delhi, and PP is captured and processedby the informal sector (unmonitored!). Therefore, it becomes necessary to create a framework for incentivising recycling in Delhi, in Narela, Bhawana, Bahadurgarh, and Kirti Nagar. Virgin plastic produced by the MSME-dominated plastic industry must be carefully monitored and registered on the EPR Portal. The sector can create nearly 1 crore jobs by 2027, and already exports consist of Rs. 35000 crores worth of plastic. However, green jobs are predicted to also create nearly 1.5 million jobs by 2030 in India. So, if what continues to be produced is recycled and/or converted to more recyclable or compostable type of plastic, the payoff in the long-term would be tremendous, leading to India's economic & green growth.

For PIBOs

In Delhi, 72 percent of plastic waste generated by households of MLP, which is the commonly used material for packaging of consumables these days, 6 percent of plastic waste

is PET, 7 percent is HDPE,another 7 percent is PVC, a further 6 percent of from LDPE while PP and polystyrene are lower at 1 and2 percent respectively (GIZ India, 2022).

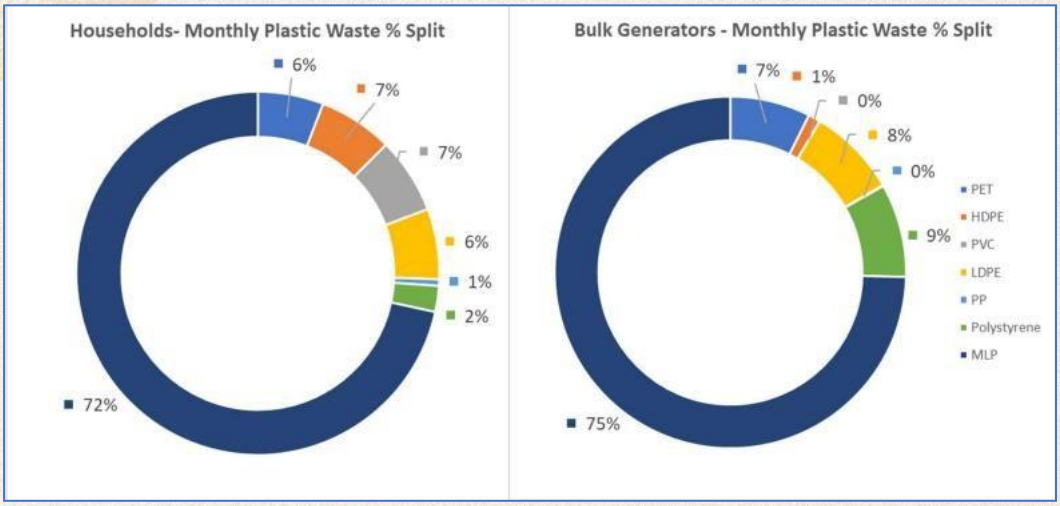


Figure 8 Disposal of plastics from households and BWGs - Delhi

75 percent of plastic waste generated from bulk generators is MLP, 7 percent is PET, 8 percent is LDPE,9 percent is Polystyrene while HDPE is a lowly 1 percent (GIZ India, 2022).

Conducting a waste composition study in plastic hotspots and accordingly installing Hi-Tech RecyclingDepots will enable PIBOs to fulfil their EPR obligations and also generate and sell EPR certificates via trading to other PIBOs. This is an opportunity for PIBOs to facilitate a market system for recycling, andbe pioneers in bringing about a plastic green revolution in Delhi, the city with the second highest per capita plastic waste generation.

For The Informal Sector Recyclers

An in-depth study in the area is lacking, but there is informal recycling happening in clusters situated inthe outskirts of the city – like Kirti Nagar and Tikri Kalan. These recyclers do not register themselves or claim to recycle used post-consumer plastic waste, as they use unscientific methods that can impact public health and would fail environmental norms of the Central Pollution Control Board. These recyclers can benefit from the EPR Rules Mechanism, by generating certificates that can be bought by PIBOs who need to fulfil their environmental commitments. However, they will not be able to do this unless:

a) The fees for signing on to the EPR portal is made affordable for theseMSMEs in the informal recycling sector

b) They receive technical assistance and assurances from a trusted technical partner like GIZ India to help them navigate the nuances ofthe EPR portal

c) They receive financial assistance via government schemes to switch tomore cleaner recycling technologies.

Average Selling Price (SP) and Buying Price (BP) of Waste for Different Players in Rs per kg								
Waste Material	Prices	Doorstep waste collector	Rag Picker	Itinerant buyer	Scrap Trader	Small Aggre-gator	Large Aggre-gator	Re-cycler
PET	BP	4.00	0.00				10.21	16.50
	SP	12.33	11.00	6.20	11.60	10.00	14.75	80.00
HDPE	BP	1.50	2.00		5.00		11.00	12.50
	SP	10.00	19.00		6.00		14.25	35.00
PVC	BP	2.50					12.00	16.00
	SP	14.33					14.60	32.00
LDPE	BP	2.40	1.40		9.00	11.00	11.14	10.00
	SP	10.75	10.75		12.00	12.50	14.67	75.00
PP	BP	3.50	0.00		16.00	44.00	11.50	
	SP	15.00	15.00		18.00	80.00	13.00	
Polystyrene	BP	2.50			7.00			
	SP	14.00			10.00			
MLP	BP	3.09	1.17	2.60	8.88	7.20	10.00	12.00
	SP	8.33	8.47	6.20	11.60	10.00	14.75	80.00

Figure 9 Buying and Selling price of plastic items across all value chain actors – Delhi, GIZ India Report

GIZ Study on Delhi's plastics shows that the presence of a recycler within a 48 km distance also leads to lower logistics cost for the collector which helps them to earn higher margins. As stated in Figure 8, the wastepickers do not make much of a wage because of the gap that exists in the buyingand selling price of plastic at the lowest level (ragpickers) to the highest level (recyclers). Bridging the gap and allowing wastepickers to move up the chain will alleviate and streamline higher recycling rates, by cutting time and costs and increasing money earned.

Additionally, the margins earned from each step is dependent on the distance of the recycler from the city, as logistics costs are embedded in the value. Incentivising the creation of recycling clusters located can really enhance the collection rates for the informal recyclers. Infrastructure capacities need to be enhanced through decentralised waste management, to cut down the logistics cost.

Case Story 2 Ghazipur observational study

The Ghazipur landfill in East Delhi is the oldest landfill in the city containing at least 12 million tonnes of waste. The Ghazipur residents often meet their ends by digging through mountains of waste in the landfills. They know plastic is valuable. Plastic for them is a source of income, of survival. What most do not give a second thought to while disposing plastic, they scrummage in the most unhygienic conditions to find it.

Fires frequently break out in the Ghazipur landfill site, reportedly due to the huge amounts of plastic that sits as legacy waste, and produces methane that causes large fires.

1500 ragpickers with 350 rupees a day for a family of 6 to survive on.

A compositional study of the collected plastic shows that PET bottles are the most collected commodity. The belief was that MLPs are recycled the least, however, gutka packets were bundled up and are being reportedly sold for Rs. 20/kg. EPR obligations are being met, especially for hard-to-recycle multilayered plastics.

Figure 10 Chintan Report (2018)

The informal waste chain detaches the ones who undertake painstaking efforts of collecting and segregating different types of plastic from the recyclers who recycle the plastics in one quick motion. A resident of Ghazipur even mentions that she has never seen a recycled product. The time and effort is not matched by the wages and lifestyle that accompanies the occupation.

The Ghazipur WtE plant at one point in 2019 provided a source of income to a few residents, including women. All prepped with protective equipment, the power plant engaged these informal workers by giving them salaried jobs. However, within a few months, the women were laid off and their jobs outsourced to others more skilled, outside of Ghazipur colony. Capacity-building and upskilling ragpickers into an Integrated Solid Waste Management (ISWM) system for the city can provide a source of livelihood for the unemployed women workers living in Ghazipur. Digital enhancement measures for plastic waste management must enhance, capacitate, and include the informal sector to truly bring about a transformative change in the city.

IMPLICATION 3 Integrate the informal sector into the plastic recycling framework of Delhi

A major fraction of plastic waste is being recycled by informally by wastepickers. When asked why a similar model of organising wastepickers in Pune (SwaCh) and Bangalore (Hasiru Dala) was not possible in Delhi, many suggested that Delhi is a city of migrants. Without a personal sense of responsibility to keep their city clean, such an organised cooperative would not be possible. Also, legal documentation would not be available with many of the informal sector wastepickers.

Wastepickers collect the plastic for a way lesser amount than what they sell it to small aggregators for. Poor living conditions and occupational health hazards leave this section worse-off, despite their role in contributing towards environmental sustainability. Recycling by the informal sector also helps save energy as making products from recycled materials requires less energy than sourcing and processing virgin raw materials (Centre for Science and Environment, 2021).

In a report that was prepared after the “Round-Table Discussion on Inclusion of Waste-pickers in Solid Waste Management in Delhi”, two suggestions were brought up on how wastepickers could be inculcated into the formal waste management system: -

1. Wastepickers should have the rights to buy and sell waste in the Material Recovery Facilities
2. They should have the right to access dry, clean and segregated waste. In fact, in many localitiesin Delhi, the wastepickers arrive earlier than the municipal tipping trucks and collect valuable plastic. This prevents it from landing up in the landfills.

Transforming EPR into an efficient and inclusive recycling structure will lie with the municipal authorities. To fulfil their obligations, PIBOs will soon be tasked with setting up infrastructure facilities like Hi-Tech Recycling Depots, or hiring recycling agencies. Making use of the local knowledge that lies with traditional wastepickers by hiring them in these facilities can enhance the plastic waste management process for more than one party. 50

workers are needed to operate 10 TPD recycling plant(Chawla, 2023). 150 wasteworkers are needed for collection of waste of an area the size of Najafgarh region in Delhi. 200 workers may be employed in such an occupation.

Replicating such a structure near Ghazipur in East Delhi can save 300 MT of plastic waste from landingup in the landfill site.

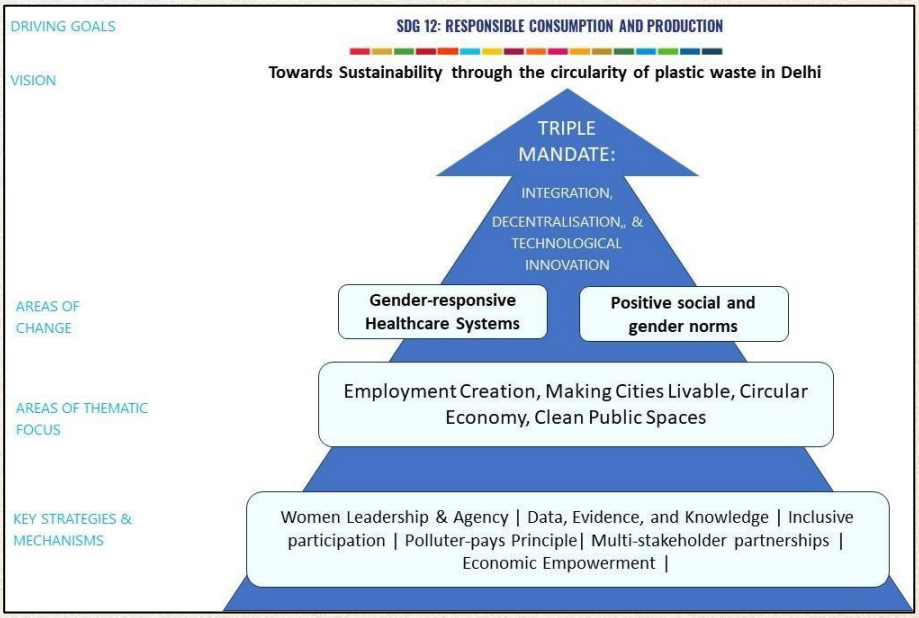


Figure 11 Gender Empowerment in IRS & Plastic Circularity in Delhi

Observation shows that women wastepickers are primarily engaged in sorting, more than collection and actual recycling of materials. Women make 33% lesser wages from wastepicking, even though 49% of wastepickers are women. In one of Chintan's MRFs, a woman leads the MRFs operations. Capacity building and enabling training of women in plastic waste management apart from just sorting materials becomes necessary in order to enhance their agency. When women fall sick, they do not get access to healthcare services, hoping that they can save the money for when their son or husband gets sick.

Wastepicking contains severe health hazards. They were forced to migrate from towns of Bihar and UP to Delhi by their husbands, who lured them with hopes of finding better economic opportunities in metropolitan cities. By making them leaders and increasing their

awareness of their capabilities, they will be more upfront in asking and thereby receiving healthcare services, which they will be able to pay out of their own earned income.

MRFs are located at a distance from these women, which restricts their ability to move up the recycling chain from waste picker to small aggregator. Mobility, safety, accessibility, and purchasing power are all reasons why a decentralised system for plastic waste management with a special focus on inclusion and capacity-building of women workers should be facilitated by public and private contractors responsible for the O&M of the MRFs.

A Way Forward for Good Governance in Plastic Waste Management

Delhi Development Authority has started to fulfil its compensatory afforestation obligations in neighbouring states, owing to land constraints. Delhi has set a target of June 2024 to increase its wasterecycling and managing capacity so that it can recycle all the plastic waste it generates per day.
Increasing the capacity of the Waste to Energy plants is one step, but what needs to accompany this topromote circularity is a focus on promoting recycling.

The way forward includes -

- Communicate the chosen purpose – using technology to digitally track the plastic consumption, generation, and recycling, and communicating the same to all stakeholders can imbibe a sense ofresponsiveness to plastic recycling for a green and clean city.
- Under EPR initiatives, brand owners or producers might provide financial help to construct theinfrastructure and machinery needed for Material Recovery Facilities.
- Creating a market for recycled products.
- All plastic packaging made to be 100% reusable, recyclable or compostable
- More effort must be placed into integrating the unorganised sector of waste pickers in plasticrecycling.
- Incorporate sustainable innovation in the plastic packaging of products.
- Mainstream recycling in Delhi’s socio-cultural environment through public awareness and behavioural change initiatives.

Around 150 acres are being occupied by Delhi’s mountainous waste sites. MRFs usually take up less than 1 acre of land. These will be functional throughout the year, unlike WtE plants. A recycling waste value chain has to be inculcated into the SWM chain, for promoting India’s economic growth and sustainable development. Delhi needs a robust policy for phasing out single-use plastics, as it is difficulty to monitor its production. Brand owners and producers have to invest in sustainable packagingthat will be affordable for Delhi’s lower and middle-income population, a section that makes up nearly 95% of Delhi’s population. It is a governance challenge, and with EPR, even if the onus shifts to the producers, it needs monitoring and evaluation. The MCD must weigh in on these aspects and institute a policy for monitoring plastic generation and recycling. Thus, plastic waste management in Delhi must be countered quickly, before its citizens chokes under itsmountains of waste.

References

- ASHAYA. (2023, Feb 17). *https://ashaya.in/*. Retrieved August 2023
- Ashootosh Mandpe, A. B. (ScienceDirect). Life-cycle assessment approach for municipal solid waste management system of Delhi city. *Environmental Research*, 2022.
- Centre for Science and Environment. (2019). *THE PLASTICS FACTSHEET 3.* Retrieved from CSE.
- Centre for Science and Environment. (2021). *INTEGRATION OF INFORMAL SECTOR IN SOLID WASTE MANAGEMENT : STRATEGIES AND APPROACHES.* New Delhi: 2021 Centre for Science and Environment.
- Chawla, D. (2023, July 14). UNDP MRF Plant Field Interview. (U. Sharad, Interviewer)Chengappa. (2013). *Organizing Informal Waste Pickers.* WIEGO.
- Chintan Environmental Action Group. (2018). *Wastepickers: Delhi's Forgotten Environmentalists.* New Delhi: Chintan. Chintan India. (n.d.). *Wasting Our Local Resources.* Publication, New Delhi.
- delhi urban art commission. (2017). *SOLID WASTE MANAGEMENT*.
- DEPARTMENT OF URBAN DEVELOPMENT. (2021). *Draft Plastic Waste Management Bye-laws, 2021.* MCD. ETInsights. (2023). *Mother Dairy weighs in on product localisation, affordability and sustainability.* Economic Times. Ghanshyam, S. (2023, August). CSE Perspective on Plastic Waste Management in Delhi. (U. Sharad, Interviewer)
- GIZ . (2022). *Plastic Credits.* Deutschland: GIZ .
- GIZ India. (2022). *Value Chain of Dry Waste Recyclables in India : FIELD RESEARCH AND ANALYSIS REPORT FORMINISTRY OF HOUSING AND URBAN AFFAIRS (MOHUA).* New Delhi: GIZ India.
- Gupta, E. (2023). MCD Stakeholder Interview - Solution Oriented. (U. Sharad, Interviewer)
- Indian Pollution Control Association, Delhi Pollution Control Committee, Government of NCT. (2022). *A Handbook forEnforcement Personnel of Plastic Waste Management.* Govt. of NCT.
- Kaveri Kala et al, N. B. (2022). Analysis of informal waste management using system dynamic modelling. *Heliyon*.
- Kumar, S. (n.d.). Interview with Chief Engineer for Environmental Services in SDMC. (U. Sharad, Interviewer) Ministry of Housing and Urban Affairs. (2021). *Circular Economy in Municipal Solid and Liquid Waste.* New Delhi: Nirman Bhawan.
- Ministry of Housing and Urban Affairs. (2021). *Toolkit: plastic Waste Management.*
- Naranjan, A. (2023). The governance of plastic in India.

- Niti Aayog. (2021). *WASTE-WISE CITIES: Best Practices for Solid Waste Management.*
- Scheinberg, A. (2012). *Informal Sector Integration and High Performance Recycling: Evidence from 20 Cities.* WIEGO.
- Shivani Wadehra, .. A. (2017). Delhi's Waste Woes: Is There a Way Out? *EPW (Engage).*
- Singh, A. A. (n.d.). Solid Waste Management in India: A State-of-the-Art Review. *Environ. Eng. Res. 2023*. Singh, R. (2015). *Exploring the potential of decentralised solid waste management in New Delhi.*
- South Delhi Municipal Corporation. (2017). *Request of Proposal for Setting up MSW to Waste to Energy Processing Facility at Tehkand, Okhla, New Delhi.* New Delhi: SDMC.
- Status Report on Behalf of Government of NCT of DELHI, Delhi Pollution Control Committee, OA No. 288/2022 (National Green Tribunal, Principal Bench, New Delhi February 16, 2023).
- The Print. (2023, Jan 7). *Delhi: MCD accredits 69 colonies with 'Sahbhagita', 60 with 'Harit Mitra', aims to make 'Zero Waste Colony'.*
- Times of India. (2022, July 19). *Delhi: Why recycling, not waste plants, is key to tackling plastic waste*. Retrieved August 2023
- UN News, United Nations Department of Economic and Social Affairs (DESA). (n.d.). *Around 2.5 billion more people will be living in cities by 2050, projects new UN report*. Retrieved from UN.org: https://www.un.org/es/desa/around-25-billion-more-people-will-be-living-cities-2050-projects-new-un- report (n.d.). *Waste-to-Energy or Waste-of-Energy.* New India: Chintan.
- Wilson, D. R. (2015). Wasteaware' Benchmark Indicators for Integrated Sustainable Waste Management in Cities.
- *University of Leeds*, 329 - 342.

[i] Swachh Survekshan, conducted by MoHUA since 2016, is the world's largest urban sanitation and cleanliness survey. It has been instrumental in fostering a spirit of healthy competition among towns and cities to improve their service delivery to citizens and towards creating cleaner cities

[ii] Sansaadhan is a digital monitoring platform that enables national, state, and city level agencies to regularly monitor the progress of material recovery facilities (MRFs) under their jurisdiction. The newly-launched platform also establishes information exchange mechanism between MRFs and companies engaged in recycling activities and energy recovery-facilitating movement of materials back to circular economy loop.

Varshit Aggarwal

Master in Public Policy, Kautilya School of Public Policy, Hyderabad.
Mentored by Mr. Victor Shinde, National Institute of Urban Affairs (NIUA).

Domain for Internship: Public Policy & Governance

Decentralized Wastewater Treatment: A compilation of Best Practices for ULB Training

India as a nation needs to plan and encourage adoption of initiatives to boost wastewater treatment through its local urban bodies, and introduce the uptake of treated 'used' water in all probable and at least non-potable application domains – such as industry, agriculture, horticulture, rejuvenation of natural ecosystems, outdoor washing and flushing. The current research explored governance models and Decentralized Wastewater Treatment (DWWT) systems to be utilized in helping the urban local bodies with their capacity-building and to come up with solutions withstanding their set of local constraints, needs and existing legacy infrastructure. The current research study followed qualitative methodology of research by analysing various case studies based on the categorization of scope of urban population coverage. The findings of the study highlighted the Public-Private Partnership models in the wastewater sector are successful where the revenue risk is taken by the government. The study advocated DWWT as an innovative approach to India's wastewater problem. Empowering individuals and communities to become self-sustainable and self-reliant. Recommendations include treating waste water, commercializing by-products of waste water, boosting domestic startups, strengthening the ecosystems of policies and schemes on both central and state level, building water reservoirs to cater irrigation needs while strengthening Indian agriculture's resilience to climate change.

Keywords: decentralized wastewater treatment, ULB's, governance model, PPP's model

1. Introduction

The water challenges which India faces are not only diverse in as many senses, but multifaceted at the same time. It is therefore, not a surprise India to be ranked as 13th most water stressed country in the world, accounting for both surface and ground water (Pandey, 2019). An aspect of the diversity of the India's water challenge can be understood from the facts that almost 1/3rd of India's geographical region is prone to drought-like conditions and nearly a tenth is prone to floods (Lahiry, 2017); the monsoons which cover 80 percent the country's water supply from rainfall, have been deficit over 13 years in last 2 decades Panday, 2018); and therefore owing to such short period of rainfall, most of the water is lost to the run-offs (Chakraborti, 2019). Another aspect of the Indian water systems management is that it relies a lot on its aquifers to meet the demand for potable drinking water – be it through municipal distribution systems, or independent borewells. It accounts for around 40 percent of total supply. As a result, the water levels of the underground reserves across the country have been steadily depleting at an unsustainable rate, especially in the absence of adequate water replenishment for almost (NITI Aayog, 2019). In an assessment of 5,7,23 blocks or sub-districts in India, it was found that groundwater resources in 226 blocks are critical, for 550 blocks they are semi-critical and in case of 850 sub-districts they are over-exploited (Central Groundwater Board, 2019). Another aspect of the diverse issues with respect to India's water challenge stems from its population. India represents 17 percent of the world's population, and through 500 million livestock a 20 percent of world's livestock population. The spree of rapid urbanization, industrialization and population increase in India along with changing lifestyle, is adding to the water burden on an already water-stressed nation (ADRI, 2017).

The aforementioned economic and demographic changes are impacting the water demand and its usage intensity. Estimates suggest that irrigation sector would be requiring an additional 250 bcm of water by 2050, as opposed to additional 71 bcm of water usage increase by 2025, basing the comparison with 2010 figures (PIB, 2013). India being an agrarian economy, this is especially important. The total consumption of water tends to increase by 30 percent by 2050. (PIB, 2013).

Sector	Water demand in bcm					
	2010		2025		2050	
	High	Low	High	Low	High	Low
Irrigation	543	557	561	611	628	807
Drinking Water	42	43	55	62	90	111
Industry	37	37	67	67	81	81
Energy	18	19	31	33	63	70
Other	54	54	70	70	111	111
Total	694	710	784	843	973	1180

Water Requirement (High Demand Scenario) for Different Uses for the Years 2010, 2025 and 2050 (Source: PIB, 2013)

Since it has already been established that the groundwater recharge does not meet the water being extracted, over a long-term analysis of the pre-monsoon and post-monsoon seasons (ADRI, 2017), a large-scale water deficit is soon to be a reality if no intervention is done to address the issue.

1.1 State of water availability in India

Following the findings from the study 'Reassessment of Water Availability in India using Space Inputs, 2019' by the Central Water Commission, it can be seen that the per capitaannual water availability was assessed as 1486 cubic meter for 2021, and is estimated as 1367cubic meter for 2031 (WRIS, 2021). According to the international norms, a country is recognized as water scarce when the availability is lower than 1000 m^3, and as water stressed when the availability goes below the 1700 m^3. The historic water availability in India between 1991 and 2001 were between 1900 and 2300 m3. The same was recorded in the year 2010 as 1588 m^3. Projections indicate water availability to reduce to 1200 m^3 by 2050 (WRIS, 2021).

Average estimates of annual rainfall indicate 4000 km^3, of which 1900 km^3 flows in river and is available as resource. Accounting for the constraints, a 1120 km^3 is accessible – 690 km^3 from surface water resources and 400 km^3 from underground water resources. The water demand by 2025 is likely to become 1100 km^3 (WRIS, 2021). The table below capturesthe water availability facts:

Area of the country as % of World Area	2.4%
Population as % of World Population	17.1%
Water as % of World Water	4%
Rank in per capita availability	132
Rank in water quality	122
Average annual rainfall	1160 mm (world average 1110 mm)
Range of distribution	150-11690 mm
Range Rainy days	5-150 days, Mostly during 15 days in 100 hrs
Range PET	1500-3500 mm
Per capita water availability (2010)	1588 m^3

Source: WRIS India, 2021

Average Annual Precipitation	3880 BCM
Average Annual Water Resources	1999.2 BCM
Estimated Utilizable Surface Water Resources	690 BCM
Total Annual Ground Water Resources (2017)	432 BCM
Total Annual Utilizable Water Resources	1122 BCM
Per Capita Water Availability (2011 Census)	1651 m^3/Year

Water resources in India Source: CWC, 2021

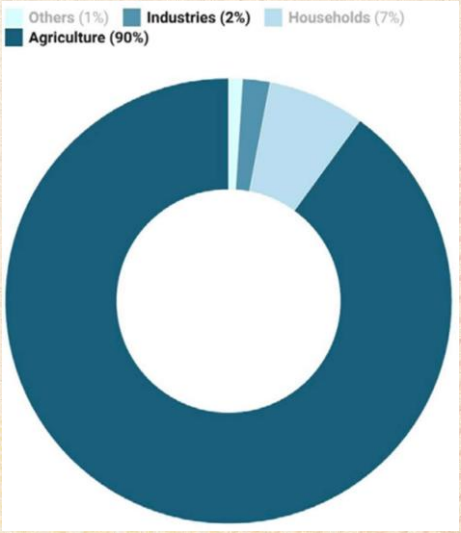
Sl.No.	Water Resource at a Glance	Quantity (km^3)	Percentage
1	**Annual precipitation (Including snowfall)**	4000	100
2	**Precipitation during monsoon**	3000	75
3	**Evaporation + Soil water**	2131	53.3
4	**Average annual potential flow in rivers**	1869	46.7
5	**Estimated utilizable water resources**	1123	28.1
	Surface water	690	17.3
	Replenishable groundwater	433	10.8
	Storage created of utilizable water	253.381	22.52
	Storage (under construction) of utilizable water	50.737	4.5
6	**Estimated water need in 2050**	1450	129
7	**Estimated deficit**	327	29
	Interlinking can give us	200	17.8

Source: WRIS India, 2021

1.2 The need for water conservation

Apart from the economic impacts that water shortage entails, the sociological impacts associated as well. The issue of water availability is highly gendered in India, and the rural- urban gender-based inequality is prone to worsen with incrementally reducing water availability. The associated socio-economic cost with this phenomenon is estimated at INR 1000 crores (or USD 133 million), accounting for 150 million days spent annually in water collection (ORF, 2021).

As apparent in the figure, the agriculture sector would be the worst affected, along with water-dependent industries such as food processing, leather, textile, to name a few. Estimates indicate a loss of 6 percent in GDP by 2050 (WRG 2030, 2009).



Water use across sectors in India (Source: Food and Agriculture Organisation of the UnitedNations, 2018)

1.3 The case for the Safe Re-Use of Treated Used Water

Singapore serves as a model for countries across the world facing water crisis. It so happens that the water system model which Singapore adopted is how the brainstorming starts when deliberating on water solutions, and so for good reason. When Singapore restored its independence in 1965, it shortly-enough realized the shortage of water that had ensued.

How far Singapore has come since, is a lesson and roadmap for nations struggling in establishing water sustainability and water security. The end of water treaty with Malaysia does not pose concern to Singapore's water independence. There are 4 water supply pipelines in Singapore, which indicate the extensive government intervention in water management – first, delivering incoming water from Malaysia (imported water), second carries desalinated sea water, third for locally obtained water from catchment, and lastly carrying treated wastewater (or, as Singapore branded it, New water).

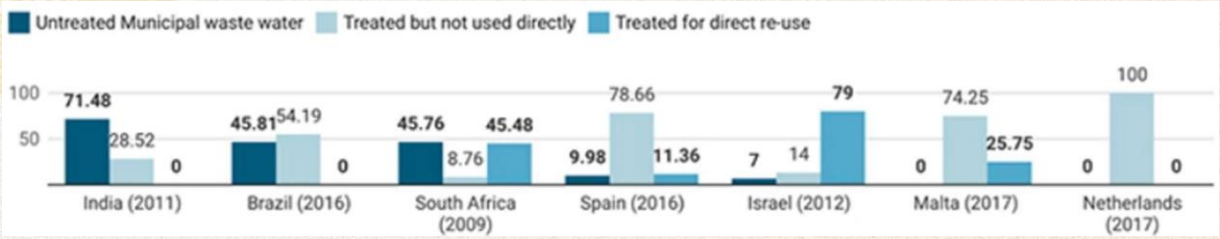
Hence, under the NITI Aayog's LiFE mission (NITI Ayog, 2022), there is the concept unfolding of 'Used water' borrowed from the New Water (Singapore's National Water Agency, 2018), to meet India's growing water demand. By employing technology-led, government-planned and incentive-led increase in the processing capacity or building of the treatment plants, the Government of India intends to install and build internal capacity at various level of administration (central, state, municipal, and local individual) to treat water, to required level depending upon use, and build resilience to water shortages and introduce sustainability to its water delivery.

The need for aforementioned intervention and pro-active governance comes from the urbanization spree which India is experiencing. India is projected to have urban population growth to 40 percent by 2030 (NIUA, 2016). The effect of urbanization in form of water shortages is more prominent in low and middle-income countries. And then there is the erratic seasonal change which further exacerbates the shortages of water owing to climate change. By harnessing wastewater, the municipal, agricultural and industrial water needs canbe addressed; alongside addressing the water quality in natural water systems. By finding application of treated used water, not only water security is met, but the natural sources of water can be conserved simultaneously – such as underground water sources. By using treated wastewater, the water sources can be diversified. Diversification leads to water resilience.

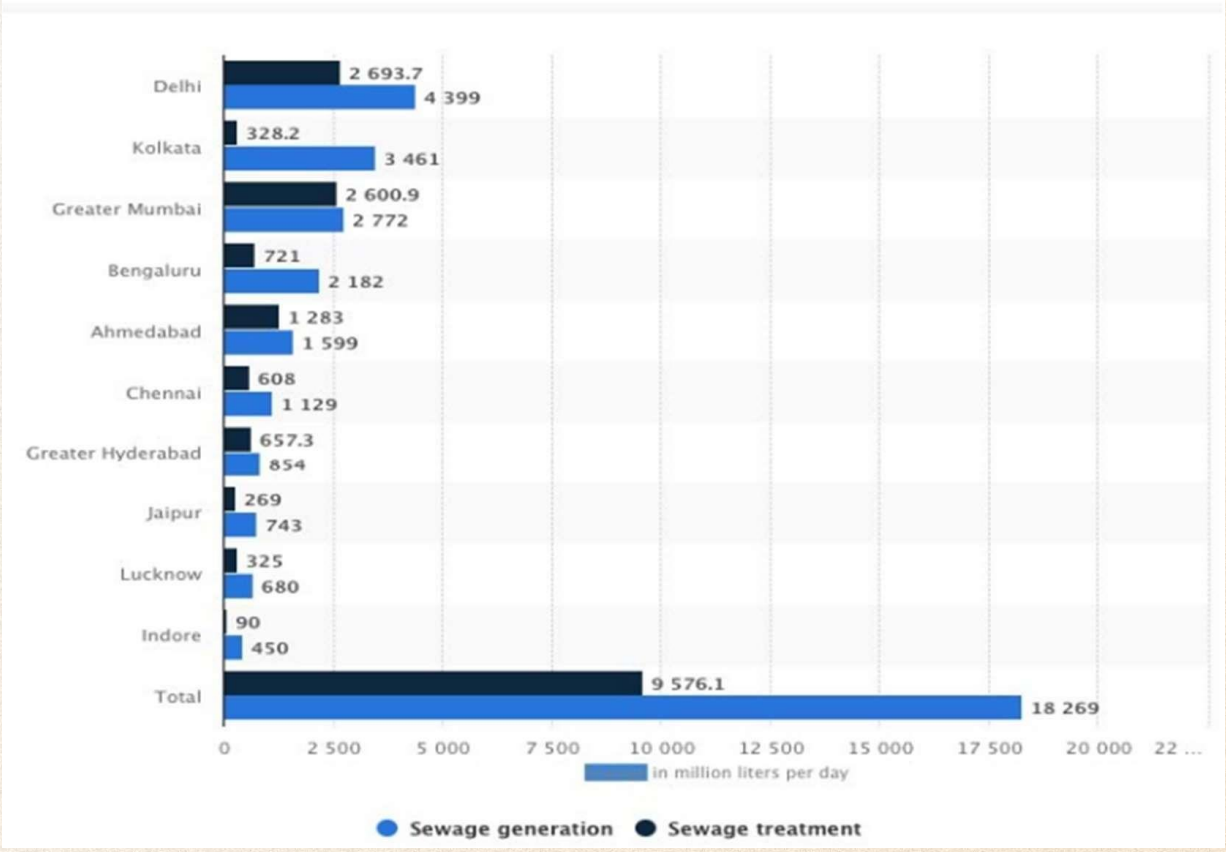
The by-products obtained from the treating process can always be used in agricultural sector or horticulture, and hence, serves as a source of revenue to meet to some extent operating expenses.

In the current scenario in India, the potential which the wastewater has to provide fresh water has remained under-utilized. To give a sense, top 100 cities produce enough wastewater to make-up 75 percent of the industrial needs in India (IWMI, 2016). The quantity of domestic wastewater generated in India amounts to 62,000 million liters per day (or as is represented by MLD), and the current 920 sewage treatment plants depicting a capacity of treating 23,000 MLD, only address 37 percent of the treatment requirement

(Singh, 2019). The portion of this treated wastewater used in various domains is way less. A comparison to the wastewater treatment and use of treated wastewater with the countries which are socio-economically similar to India is captured in the figure below.



Wastewater treatment and reuse in the developing countries comparable to India (Source: ORF, 2016)



Wastewater generation in major Indian cities (Source: Climate Centre for Cities, 2022)

1.4 Decentralized Wastewater Treatment System

Decentralized wastewater treatment (DWWT) systems are installed in a local set-up to treat the wastewater coming from either individual houses, community areas or buildings. The wastewater is treated close to the origin of the wastewater. The DWWT systems have a definite geographic boundary identified wherefrom the wastewater is collected and sourced, and a low-cost collection system for wastewater and transfer of treated water, making the whole setup on-site for a given locality consisting of cluster of houses, individual houses, cluster of buildings, or communities.

As a result, a city or town may have more than such decentralized wastewater treatment systems. The case for choosing this system is made by: The treatment capacity required reduces, and the need for sewage lines and pipelines reduces, the whole setup

becomes economically viable to be setup; the case for decentralized system is a good option when the institute or community is located far, significantly, from the centralized system; topographical challenges that may exist in setting up the required infrastructure and capacity for the transport, collection and disposal associated are also redressed; and since the cities areexpanding, the newer establishments may not be feasible to connect to the central plant, or the central plant may not have the capacity to treat the newly incoming sewage. Such cases also call for this approach to treatment.

The advantages of Decentralized Wastewater Treatment systems are enumeratedbelow (NIUA, 2019): -

a) Cost efficient

The requirement for the underground sewer system is completely eliminated or partially required (within the settlement area from the household to the decentralized treatment system).

Lower capital cost and O&M costs, due to absence of complex mechanical as well as electrical systems associated.

b) Environment Friendly

Complete absence or lower electric consumption and hence power saving.

Due or absence of underground sewer system, negligible possibility of ground water contamination.

Odorless, hence can be built within a living habitat also.

c) High user acceptance

Minimal O&M needs and costs as lower human resources capacity levels needed. Easy and efficient user involvement and participation (e.g. in decision makingand O&M).

d) Flexibility in scale

Can be built easily at remotest places, even by regularly skilled labor.

Can be built for a scale fit for a household, cluster as well as community level or a town level.

2. Problem statement

India is a developing nation, and has been going through a spree of urbanization involving a significant rate of urbanization. The problem of water scarcity and water shortages is, but a foreseeable outcome, as has been experienced by all developing countries that have had their development streak preceding that of India. The water reclamation from the generated wastewater in India has been far low as compared to the comparable developing countries, which makes a strong case for investment and prioritizing the used water treatment and imbibe the practice of the re-use of treated used water. The emerging climactic changes and shift in rainfall patterns has also made the water scarcity issues more complicated.

Hence, India as a nation needs to plan and encourage adoption of initiatives to boost wastewater treatment through its local urban bodies, and introduce the uptake of treated 'used' water in all probable and at least non-potable application domains – such as industry, agriculture, horticulture, rejuvenation of natural ecosystems, outdoor washing and flushing.

The adoption of the said practice, in the end, lies with the urban local bodies in how pro-actively the ULBs invest in the outcome-based and impact-oriented plans pertaining to increasing or developing the wastewater treatment capacity and addressing water needs which remain unmet in industrial, agricultural and municipal setup. As a result, the Government of India and its domain-relevant think-tanks bodies need to invest in the capacity-training of the ULBs with the objective to help them ideate solutions to meet their area-specific challenges and water demands.

3. Objective

To conduct a study into and explore governance models and DWWT systems, which innovatively and successfully have addressed the then existent water availability issues, and thereby, cutting-down on associated challenges which may either be access to water, availability of water, economic aspects of water procurement or environmental impacts of untreated used water.

Such examples or case-studies can then be utilized through a documented training manual, in helping the urban local bodies with their capacity-building so to come up with solutions withstanding their set of local constraints, local needs and existing legacy infrastructure, conducted under the coordination and organization of the National Institute ofUrban Affairs.

4. Methodology

The each of the urban local bodies are better equipment to oversee the implementation of undertake initiatives to build or develop wastewater treatment capacity. Also, the urban local bodies are more equipped and well-positioned to account for and understand the local issues, challenges and demand, and carry-out the facilitate or undertake the required public interaction. Since, the ULBs can come any combination of limitations and scenarios, the approach followed for this report was to identify one case study for each of the implementation cases categorized based upon the area-wise scope of the population coverage for each model which is identified, across various scenarios of municipal, industrial and agricultural use. The methodology adopted accounts for the fact ULBs have different set of issues, implementation constraints pertaining to finance and existing infrastructure.

The focus of the report is upon collating the evidences of successful setup and demonstration of successful attempts at implemented decentralized wastewater treatment systems, without much emphasis on the technology used or costing involved. In the current marketplace, there are ample start-up introducing their share of technological innovation in the wastewater treatment domain technology.

As aforementioned, the selected case studies cater to the following categorization of the scope of urban population coverage:

Case 1: Independent house level
Case 2: Building scale/Community centre Case 3: Neighborhood and community scale
Case 4: Organizational scaleCase 5: Industrial level
Case 6: Joint venture of Industrial and Municipal Corporation Case 7: Agriculture – Circular and climate resilient food systemsCase 8 and 9: Public-Private partnership
Case 10: Incentivized public spending
Case 11: Pilot program of a new governance model in agricultural sector Case 12: Pilot program of new governance model in municipal setup

5. Case review

Case 1: Independent house level[i]

Case-study:

Residential Household Building, Sangli City (Maharashtra)

Unique feature of the case study and the category:

Represents maximal localization in decentralized approach to wastewater treatmentand re-use of wastewater.

Location:

Sangli city, Maharashtra

Objective:

The system treats locally-produced wastewater (both black and grey) using an in- house setup, and locally reuses treated water for meeting its horticultural water requirements – setting a good example of sustainable decentralized water management practice in unsewered residential area

Scale:

People covered:	Family of 4
Treatment capacity:	1 KLD
Treatment water output:	0.5 KLD
Plant area:	2.8 sq. m.

Cost

Cost (per 2010 standards)	
Capital expenditure	INR 35,000
Operation and maintenance	INR 900 per annum

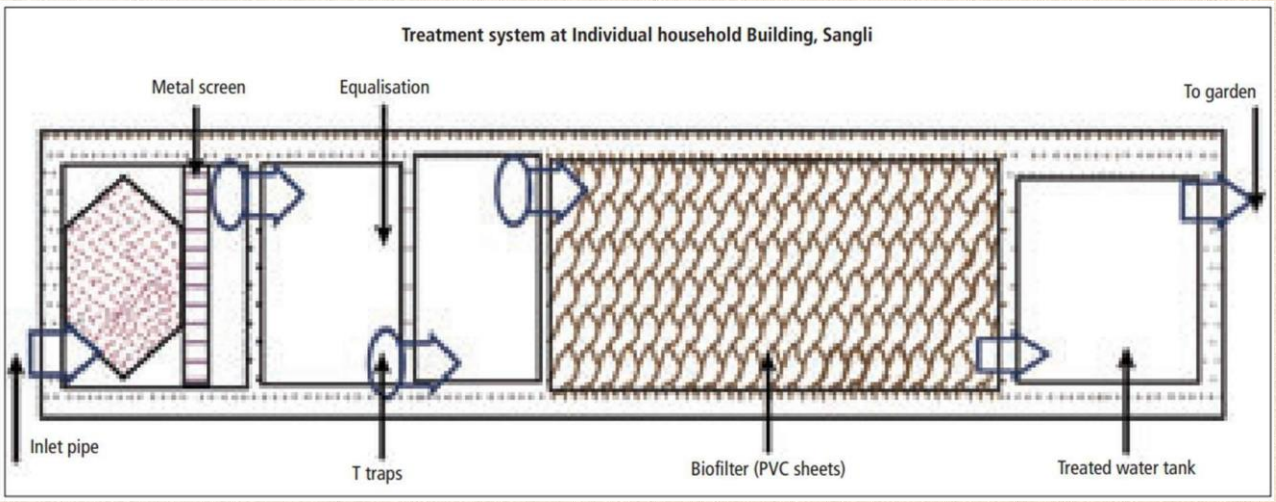
Technology:

Name: Fixed Film Biofilter Technology (FFBT)

Brief:

- The technology is becoming popular among the individual house owners and residential colonies, since it is environment-friendly and economical compared to septic tanks and soak pits.
- The technology aims at bio-degradation of the wastewater contaminants by providing sufficient surface area required for the growth of micro-organisms (microbial culture) for optimum time duration. This retention time ensures maximum microbial growth. The culture consumes the contaminants from the wastewater and breaks them down as part of their food cycle.

Illustration:



Graphical representation of fixed-film biofilter technology (Matto et al, 2014)

Size requirements:

The four toilets, bathrooms and the kitchen wastewater enter into the 2 equalization tanks followed by the filter chamber of dimension 1.2 m x 1.2 mand a depth of 0.8 m.

Purpose use:

The treated wastewater is being used for in-house non-potable purposes, which include meeting horticultural water requirement of the household and for maintaining and landscaping a kitchen garden plantation over a 240 square meterarea.

Cost benefit:

This represents the aspect where a remarkable outcome of implementing an in-house DWWT set-up was realized. The system allowed for a relatively free of charge supply of treated water fit for non-potable application, as an alternative to a water tanker of 8000 liters capacity costing Rs. 800 -1000/tanker. As a result, the annual 90 KL of treated water as output allowed for annual saving of INR 10,000.

Ecological benefits:

Since, the treated water is put to horticulture and landscaping usage, it adds to the

groundwater recharge. The switch to treated water allows for non to lesser consumption of freshwater and aids in freshwater/groundwater conservation. The transport of water through tankers acts as a source of pollution, which to some extent is mitigated through local DWWT systems.

Case 2: Building scale/Community centre[ii]

Case study:

Indradhanushya Center, Pune (public facility of Pune Municipal Corporation)

Unique feature:

Taking-in water from adjoining stream, treating it and using it, Discharging the water back into the stream post-treatment.

Objective:

Full-scale treatment system installed to treat wastewater flowing through an open stream alongside the Indradhanushya Environment Education and Citizenship Centre.

Location:

Indradhanushya Environment Education and Citizenship Centre (Rainbow Museum) Opposite Sachin Tendulkar Jogging Park, Anant Kanhere Path, Near Mahtre Bridge, Rajendranagar, Pune - 411030

Scale:

People covered:	250
Treatment capacity:	50 KLD, with 50 m3 /day
Treatment water output:	40 m3 /day

Cost:

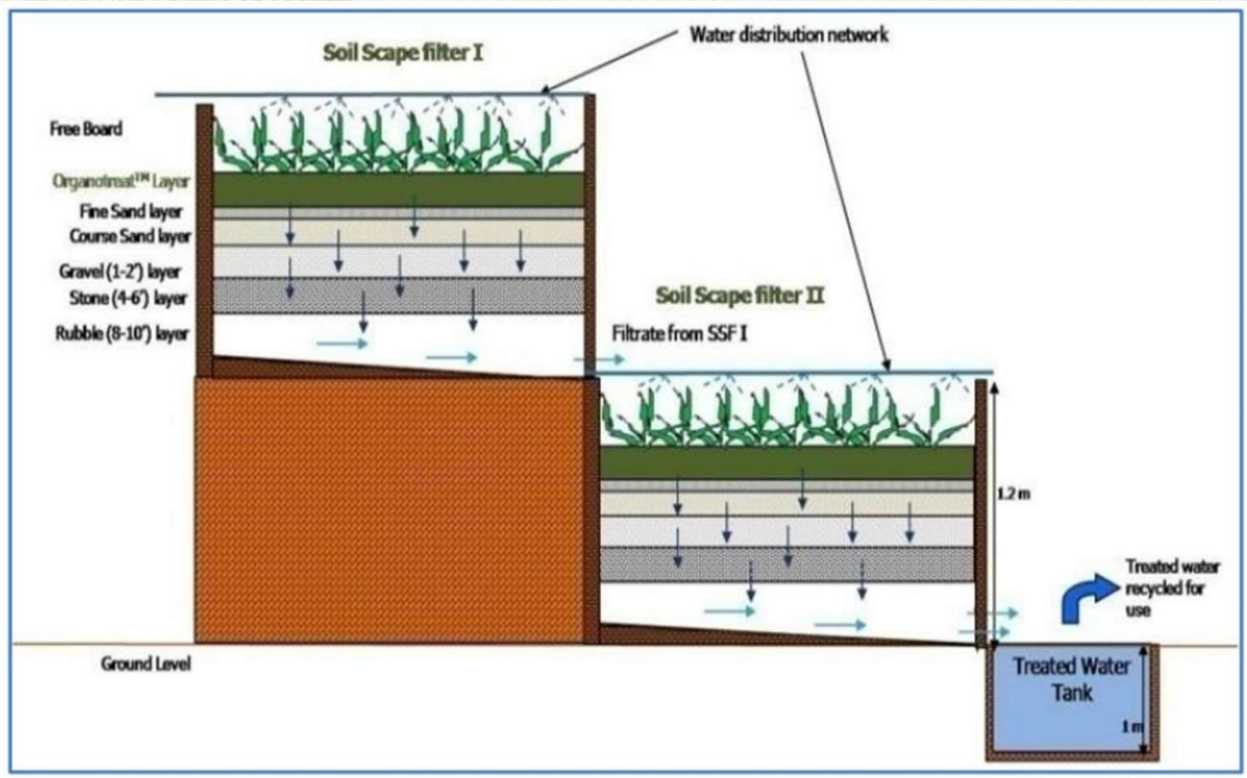
Capital	EUR 51,000
Operation and maintenance	INR 3,360 per annum

Technology

Name: Eco-filtration bank system

Brief: Eco-filtration bank (EFB) technology is a horizontal filtration technique, which is combined with medi-filter, mini–quay and a green pitching system. The maintenance requirements associated with the system are minimal, which are removal of debris from metal screens on a daily frequency, cleaning of intake well every 15 days, and uprooting of plantation every 2 to 3 months.

Illustration:



Graphical representation of Vertical Eco-filtration bank (Source: Sayali et al, 2015)

Size requirements:

Two linearly placed tanks, 25 m 2 surface area for each tank with effective depth of each tank being 1.2 m (10 m Length x 2.5 m Width and 1.2 m Depth of each SSF bed).

Purpose use:

The treated wastewater from the in-house treatment plant has sufficient output of water to meet with non-potable water requirements regarding gardening and maintenance of the campus' green cover, which constitutes water demand of 12 cubicmeters/day, along with water requirement for maintaining Sachin Tendulkar jogging track (opposite to the Indradhanushya centre) amounting to 15 cubic meters/day. In addition, the treated water is also used for flushing purpose in washrooms within the campus.

Ecological benefits:

The ecological benefits of the project are manyfold. It directly contributes to the cleaning of Ambil stream, which acts as the water source. Not only the waste waterproduced from community centre treated before being released into the stream, the water in-take from the stream for usage also gets treated, hence adding to the clean water flowing within the stream. The project also strengthens the collective effort towards fresh water conservation, by supporting transition to safe re-use of treated water instead of freshwater for non-potable purposes.

The ecological impact of the same has been summarized as below:

	collection and transport			treatment			transport and reuse		
Sustainability criteria:	+	o	-	+	o	-	+	o	-
• health and hygiene	X			X				X	
• environmental and natural resources	X			X			X		
• technology and operation	X			X			X		
• finance and economics			X			X			X
• socio-cultural and institutional	X			X			X		

Source: Sayali et al, 2015

Case 3: Neighborhood and community scale[iii]

Case study:

Naval civilian housing colony, Kanjurmarg (Mumbai)

Unique feature:

The wastewater was treated in-house facility and used locally.

Unique feature:

Fresh Water conservation.

In-house treatment of waste water.

Natural groundwater recharge through maintenance of green cover.

Objective being achieved:

The residential housing colony treats the domestic wastewater generated in its campus (both black and grey) by applying the Soil Biotechnology (SBT) which is a natural wastewater treatment method. The treated wastewater is used for meeting the landscaping water requirements within the colony campus, to maintain green areas.

This approach is an example of effective Decentralized Waste Water Treatment(DWWT) in practice.

Location:

Kanjurmarg (Mumbai)

Wastewater scenario in the area:

There exists intermittent supply of water, on rotational basis to different wards. It has been common feature across the Mumbai. Of total sewage produced, up to 60-70 percent undergoes preliminary treatment before being disposed-off intothe sea; which highlights the need for scaling up WW treatment. Also, the city of Mumbai has its water-wastewater facilities overstretched and unable to cater to theincreasing demand-supply gap.

Scale:

Waste generated:	7 Buildings x 24 Flats
Treatment capacity:	50 MLD
Plant area:	500 sq.m.
Treatment water output:	16.2 million liters/annum
Area irrigated:	2.2 acres

Cost:

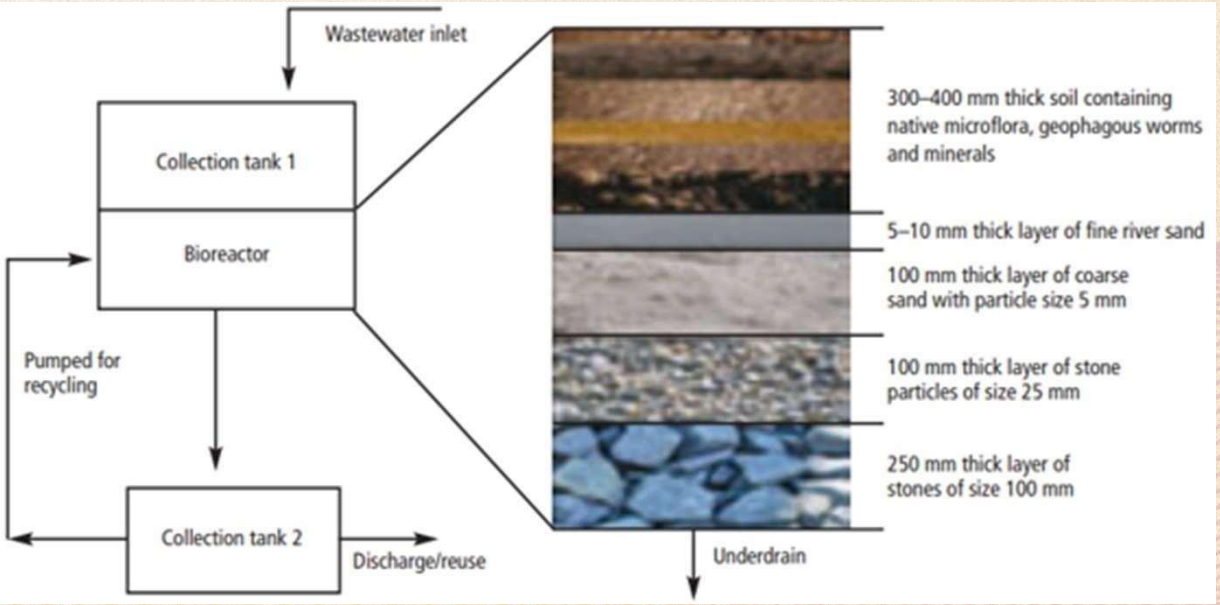
Capital cost	INR 7,00,000
Operation and maintenance cost	INR 1,000,000 per annum

Technology

Name: Soil biotechnology

Brief: The technology combines sedimentation, infiltration and biodegradationprocesses. It works with formulated geological environment wherein fundamental reactions of nature, namely respiration, photosynthesis and chemical mineral weathering are responsible for bioconversion of sewage.

Illustration:



Schematics of Soil biotechnology and the bioreactor (Source: HS Shanker et al, Soil conditioning products from organic waste, Patent no. 760474282)

Area requirements:

The SBT plant in this colony consists of a raw water collection tank, a constructed soil filter bioreactor and an effluent collection tank. The raw sewage after screening is collected in the tank from where it is directed towards the trench filled with gravels. Each trench is 25 m long and 1.5 m wide. The sewage is then pumped and distributed over the reactor bed. The bed surface area is 500 sq.m. The total depthof the bed is 0.7 m with 0.3 m of red soil layer (laterite soil) and 0.4 m of layer of stone at the bottom.

Application area and ecological benefits:

The clean water from the treatment unit is used for green cover maintenance and irrigation, instead of relying on freshwater sources for the purpose. This reduces the groundwater or freshwater from tankers consumption, and aids in freshwater conservation. The significant amount of treated water used in green cover maintenance makes way for groundwater recharge.

Cost benefit:

Prior to the implementation of DWWT system the water requirement for maintenance of green area and landscaping was dependent on municipal water tankers. Around 6 to 7 water tankers were required for landscaping water requirements in the neighborhood. The average cost of water tanker (capacity being 8,000 liters) in Mumbai is Rs. 1200 per tanker. As a result, the administration was incurring a cost of INR 1.1 - 1.3 million per annum towards arranging water from tankers.

Case 4: Organizational scale

Case study:

National Environmental Engineering Research Institute (NEERI)[iv]

Unique feature:

Setting-up used water treatment facility in-house, and deploying the treated water fornon-potable use within campus.

Objective:

The key objective of the project was to successfully demonstrate treatment of wastewater (grey water) generated in the institute and local reuse for meeting the horticulture water requirement

Location:

Worli, Mumba

Scale:

People covered:	100
Treatment capacity:	5 KLD

Treatment water output:	900 KLD
Green area irrigated:	550 sq. m.

Cost:

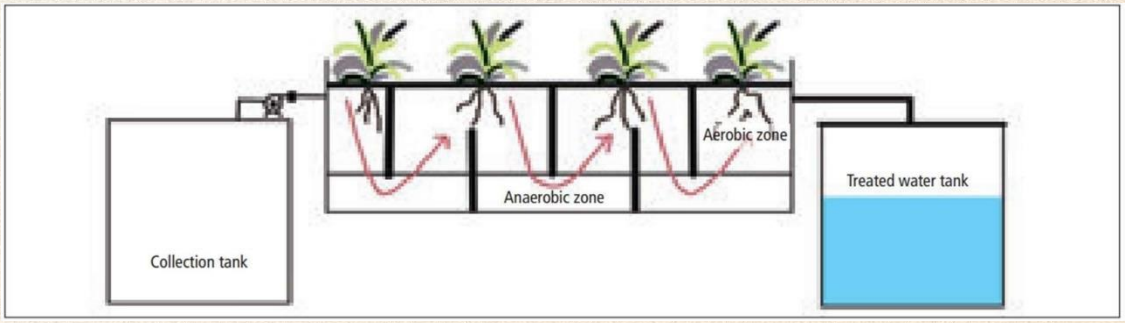
Capital	INR 14000 – Rs. 35000 per KLD
Operation and maintenance	INR 1,000-2,000 for a system of 50-100 KLD

Technology:

Name: Phytoid-based DWWT

Brief: Phytorid technology is a self-sustainable technology developed by NEERI, CSIR in 2005 for sewage treatment. The technology works on the ecological principles of a wetland and acts as a nutrient sink which helps in removal of pollutants from the wastewater. As part of regular maintenance, the plants need to be harvested periodically to maintain the wastewater treatment efficiency. The upper layer of media in the inlet zone requires scrapping or needs to be replaced periodically to avoid clogging due to the settlement of suspended particles

Illustration:



Schematic representation of Phytoid-based DWWT (Source: Matto et al, 2014)

Purpose use:

The treated wastewater obtained from the treatment system is being locally applied to meet the green area water requirements, water requirement for car washing and as water in cleaning of the institutional parking space.

Cost benefit:

The average cost of water through a water tanker (of 8,000 liters) in Mumbai ranges from INR 1,000 to INR 1,200. Hence, by putting to use the treated water as alternative to water fetched using tanker, about INR .15 million are saved each year.

Ecological benefits:

The re-use of water with the help of locally implemented wastewater treatment facility, allows for freshwater conservation, and cuts the fossil fuel consumption in transport of water. The in-situ treatment and reuse of grey water up to 95 percent, helps to attract

total of 5 credits on Indian Green Building Certification.

Case 5: Industrial level

Case study:

eMalahleni Water reclamation plant, eMalahleni, South Africa[v]

Unique feature:

Industrial plant is the sole consumer of municipal waste water. Successful PPP model.

Objective:

To create technology to treat used water from mines, local and others in the region,and meet the water requirements for industrial and municipality function, without relying on diminishing natural water sources.

Location:

Mpumalanga/eMalahlenni, South Africa

Scale:

People covered: The treatment plant is able to meet 20 percent of the city's potable needs, the total population of the city being 510,000 people

Wastewater generated:

Treatment capacity: 50 MI/day

Treatment water output: 30 m^3/day potable quality, of which half is chlorinated.

The water reclamation plant has treated 30 billion liters and supplied 22 billion liters to the eMalahleni Local Municipality.

Water scenario which forms the context:

The city is already struggling to meet the water demand by extracting 120m/day from the local Witbank Dam, exceeding the licensed withdrawal volume of 75 m3 /day. This volume is set to increase to 180 m^3 /day by 2030. Too little water on the surface is a problem for communities. Too much water underground is no less of aproblem for a mining company.

The area around eMalahleni, however, contain approximately 140,000 megaliters (Ml) of wastewater from active and inactive mines, and continues to rise by over 25 Ml a day. Anglo American Thermal Coal invested a decade of research and development into mine water treatment technology. This was aligned with the central government mine closure and rehabilitation strategy, and the employment, development and environmental requirements of local authorities. By involving stakeholders, the WAPs provide links with other operational plans, including community development, social investment and biodiversity conservation programs.

Use case of the treated:

The treated water is of sufficiently pure quality to be used in meeting municipal drinking water needs, and need for water in cooling system for the miningindustries.

Cost benefit:

The cost benefit of the project can be assessed from the fact that the project was examined by six of Anglo American's 10 thermal coal operations; and has been replicated by a private mining company Optimum Coal Holdings.

Social benefits:

Daily by-product of the water reclamation of 200 tones consists gypsum- based solids, which is has been used in making bricks for affordable community houses. 66 affordable homes have been built from the gypsum waste for employees and it is hoped that it will soon be expanded to a total of300 residential units.

The local community has access to an additional source of drinking water for60,000 people.

The percentage of people without drinking water has been reduced from 14%to 2%, aiding the provincial government in meeting one of its Millennium Development Goals to ensure that no household goes without a potable, reliable and predictable water supply.

The construction of the plant created almost 700 temporary jobs, two-thirds ofwhich were filled by people from the local community. It now has 57 permanent employees - almost all of whom are local.

Ecological benefits:

Conservation of fresh water, above and below the surface

Reduction on strain on region potable water resource

Habitat and industrial sustainability in the long run

Case 6: Joint venture of Industrial and Municipal corporation

Case study:

Ordinance factory, Nagpur[vi]

Unique feature:

The excess treated water from the facility is used by the municipal corporation to meet its demand.

Scale:

People covered:	250 households (1000 people)
Treatment capacity:	100 cubic meter/day

Cost:

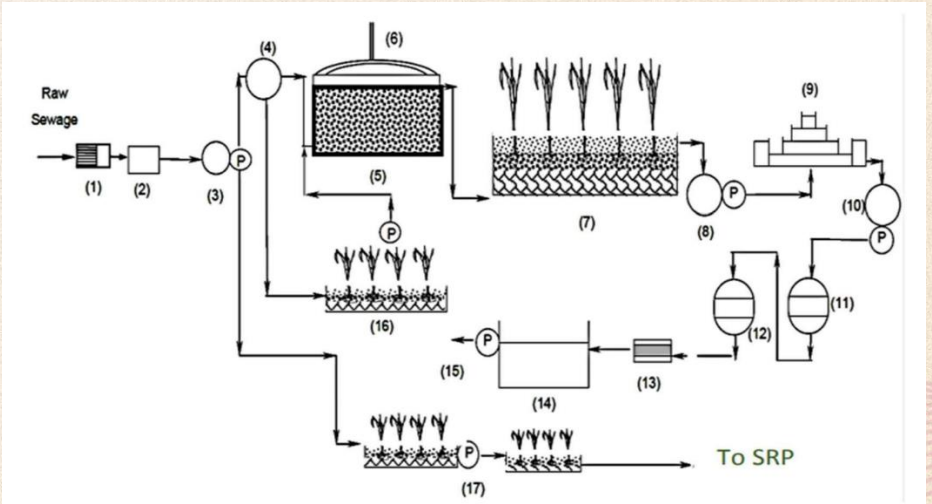
Capital	EUR 90,000
Operation and maintenance	EUR 9,000

Technology:

Brief: The main treatment system consists of a bar screen chamber, oil and grease trap, inlet sump, primary clarifier, improved up-flow anaerobic filter followed by subsurface horizontal flow constructed wetland, cascade aerator, dual media and activated carbon columns and finally UV disinfection. The settled sludge from the primary clarifier will be treated in sludge drying reed beds, permitting the final reuse of the sludge as soil conditioner and avoiding any external disposal. The improved anaerobic filter ensures substantial removal of organic content. The filter media consists of poly propylene (PP) or high density poly ethylene (HDPE) material. The anaerobic reactor is filled with filter media 80% of total volume and provision is made for a biogas collection system, which is proposed to be utilized as fuel.

Treated effluents from the anaerobic filter are fed by gravity into two parallel sub-surface horizontal flow (HF) constructed wetlands planted with Typha latifolia and Canna indica. Horizontal flow constructed wetlands ensure the removal of remaining organics and nutrient reduction. Thereafter, treated wastewater is pumped to the cascade aerator to infuse dissolved oxygen and enhance the quality of effluent. The aerated wastewater is subsequently conveyed for tertiary treatment comprised of a dual media filter followed by granular activated carbon column for removal of colloidal solids and non- biodegradable organics & pharmaceutical and personal care products (PPCPs), respectively. Disinfection through UV is provided to the final treated effluent which is then ready to be recycled and reused for various non-potable uses of the community.

Illustration:



1)	Screen chamber	10)	Effluent collection tank
2)	Oil & Grease Trap	11)	Dual media (pressure) filters
3)	Raw Sewage Sump	12)	Activated carbon columns
4)	Primary Clarifier	13)	UV Disinfection
5)	Upflow attached growth anaerobic filter	14)	Treated effluent collection tank
6)	Bio-gas vent and collection	15)	Pumping & Piping for treated effluent reuse
7)	Subsurface flow constructed wetland	16)	Sludge Drying Reed Beds
8)	Holding Tank	17)	French Reed Beds – 1st & 2nd Stage, P – Pumps
9)	Cascade aeration		

Schematic treatment of wastewater treatment plant (Source: World Bank, 2019)

Size requirements:

Anaerobic filter and HF constructed wetland is 24 hours. The anaerobic filter consists of two tanks with the size of each tank being 4.5 x 4.5 x 2.5 m. Filter media of cylindrical shape with size of 37.5 – 50 mm and specific surface area of 150 m^2/m^3 are provided. The size of the wetland beds is twice times 12.5 x 5 x 0.8 m

Purpose use:

The treated water finds application in horticulture for in-campus multi-purpose lawns and orchards.

Cost benefit:

Price of water is approx. €33/d per 100 m3 and costs incurred for generating non-potable recyclable water for 100 m3 is €14/d.

Net saving in respect to using recycled water would be €33/d – €14/d = €19/d. This would ensure savings of €19/d x 365 = €6,935 per annum from a 100 m3 /d capacity decentralized wastewater treatment plant.

Other benefits:

	Collection and transport			Treatment			Transport and reuse		
Sustainability criteria:	+	o	-	+	o	-	+	o	-
• health and hygiene		X		X			X		
• environmental and natural resources		X		X			X		
• technology and operation		X		X			X		
• finance and economics	X				X			X	
• socio-cultural and institutional		X		X			X		

Source: World Bank, 2019

Case 7: Agriculture - Circular and climate resilient food systems

Case study:

Sugar beet root factory Cosun in Dinteloord[vii]

Unique feature:

Purified effluent water from mill is used as irrigation water for nearby greenhouse

horticulture, and hence sustainable irrigation.

Location:

Dinteloord, Denmark

Water scenario in the area:

During a low river discharge and a high precipitation deficit, the freshwater supply cannot meet agricultural freshwater demand during the growing season, especially in rainfed agricultural areas in the southwestern part of the Netherlands that have no access to river water.

Hence, as a nature-based solution was ideated to address the challenge, i.e. shortage of irrigation water. This was done through Aquifer storage and recovery (ASR) method, which involves using wells for the subsurface storage and recovery of excess freshwater to satisfy later periods of demand. The water is treated using reverse osmosis technology. The ASR-coastal is a special form of ASR in which several well screens are installed above each other in a single borehole, and can be independently operated. This enables the optimization of the recovery of freshwater during ASR in aquifers with brackish groundwater. The buoyancy movement of the freshwater into the brackish groundwater can be overcome through deep infiltration and shallow recovery.

The treated water catered to the local farmers. The wastewater from the sugar factory served as the source for raw water that is then treated. The urban local body ULB is in the process of developing spatial plans to realize a climate resilient peri-urban catchment, on a larger scale, in cooperation with local food processing industry, farmers and owners of natural areas.

Size requirements:

A spread of individual 250 x 250 meters areas, each pertaining to single well, forms the entirety of space requirement for entirety of the set-up.

Purpose use:

Greenhouse horticulture needs irrigation water in spring/summer, purified waste water is stored within the aquifer (NBS solution) during winter and recovered in spring and summer. The intervention helps in ascertaining supply of water for irrigation to the local farmers, independent of the season which until were affecting water availability, hence adding to the climate resilience of the farming activity.

Ecological benefits:

The wastewater treatment helps in the rejuvenation of the groundwater, through manual aquifer recharge, which acts as water storage and aids in climate-resilient source of water for irrigation.

Case 8: Public Private Partnership

Case Study 8:

Koradi Thermal Power Plant (operated by Maharashtra Generation Company)

Unique feature:

The Build-Operate-Transfer End-User Public-Private Partnership Model, where MahaGenCo was the only end-user of wastewater.

Application areas: The project reduces net freshwater extractions by the power sector, freeing up freshwater resources for other uses (around 47 Mm3 per annum (Sharma, 2013)

Increased urban wastewater treatment capacity results in cleaner and healthier water bodies, with the associated environmental and social benefit

Objective:

Diversifying the water supply sources by incorporating alternative sources (treated wastewater) and invest in sanitation and wastewater infrastructure for the city.

Location:

Nagpur

Brief: Mahagenco is first company in India to enter into an agreement with Nagpur Municipal corporation to treat and reuse wastewater from Nagpur Municipal Corporation's Bhandewadi Sewage project with view to minimize use of fresh waterin power generation.

MahaGenCo and NMC partnership took the form of a build-operate transfer (BOT) end-user contract with a 30-year concession, with the option for extension. NMC agreed to provide the raw wastewater, and MahaGeCo agreed to be in charge of the transportation and treatment needed to be able to reuse the wastewater effluent from the NMC sewerage system. The contract was developed to ensure a regular source of water to the power plant (the raw wastewater) while providing NMC with a constant stream of revenue from MahaGenCo (in the form of raw wastewater fees). The city would also reap the environmental, health and social benefits from the extra wastewater treatment.

Scale:

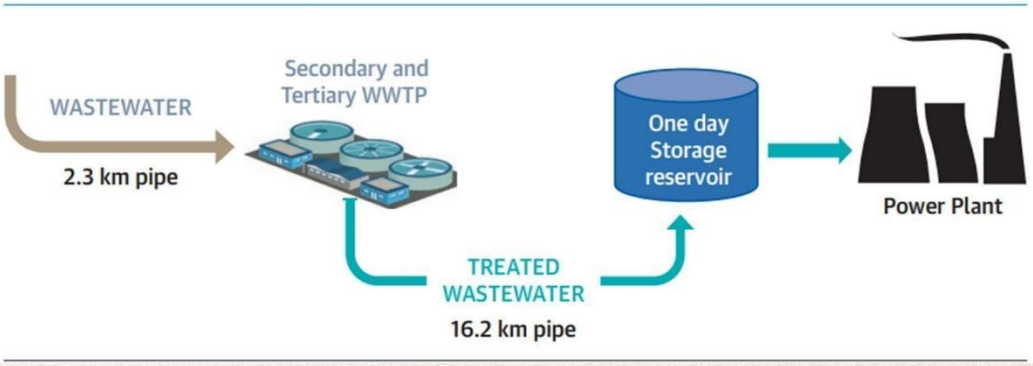
Treatment capacity: Stage 1 is 130 MLD, Stage 2 is 200 MLD

Cost:

Capital cost: INR 195 crores (inclusive of 90 cr. From NMC) + Land (fromNMC)

Operation and maintenance cost: fixed amount of INR 15 crore (US$ 2.25 million) a year for the raw wastewater (110 million liters a day). For flows that exceeded the contracted amount, MahaGenCo agreed to pay NMC INR 2.03 per cubic meter of raw wastewater.

Illustration:



Source: MahaGenCo, 2022

Size requirements:

The land to set up the WWTP was 2.3 km from the drainage supplying wastewater, and 16 km from the power plant.

Project highlight:

The fact that MahaGenCo was the only end-user of wastewater ensured strongproject ownership and management, which were facilitated by regular communication and coordination with the municipal authority. There was no bidding process, because the MahaGenCo directly approached NMC and selection was done on a sole-source (nomination) basis. The collaboration between Nagpur municipal corporation and MahaGenCo ensured that the synergies of wastewater treatment and reuse were fully exploited through the contractual arrangement. An important aspect of this project is that MahaGenCo did not undertake the transport and treatment of the wastewater but instead selected an engineering, procurement, and construction contractor and an operations and maintenance operator through a single-stage competitive tender.

Cost benefit:

The treatment and provision of water through this arrangement cost Mahagenco about INR 3.4 per cubic meter. Its costs would have been significantly higher if it had sourced fresh water from another municipal orirrigation project (about INR 9.6 per cubic meter for recent projects).

The royalties from the sale of wastewater to MahaGenCo represent an extrarevenue stream of nearly INR 400 crore over the concession period.

Ecological benefits:

The project reduces net freshwater extractions by the power sector, freeing up freshwater resources for other uses, by around 47 mm^3 per annum.

Increased urban wastewater treatment capacity results in cleaner and healthierwater bodies, with the associated environmental and social benefit.

Case study 9: Public-Private model

Case study:

New Cairo Wastewater Treatment plant[viii]

Unique feature:

Build–design–finance–operate–transfer (BDFOT) PPP model, with 20 years contractual period consisting of a construction period of two years and operationtenure of 18 years.

Location:

New Cairo, Egypt

Scale:

People covered: Close to 3 million people in New Cairo and the surrounding area will benefit

Treatment capacity: 250,000 cubic meters of wastewater per day

Use case scenario:

The treated water is directed to agricultural operations, reducing the demand for freshwater for agriculture and allowing that supply to be used by the city.

Cost:

Total private investment: USD 140 million

Project finance without recourse: USD 100 million

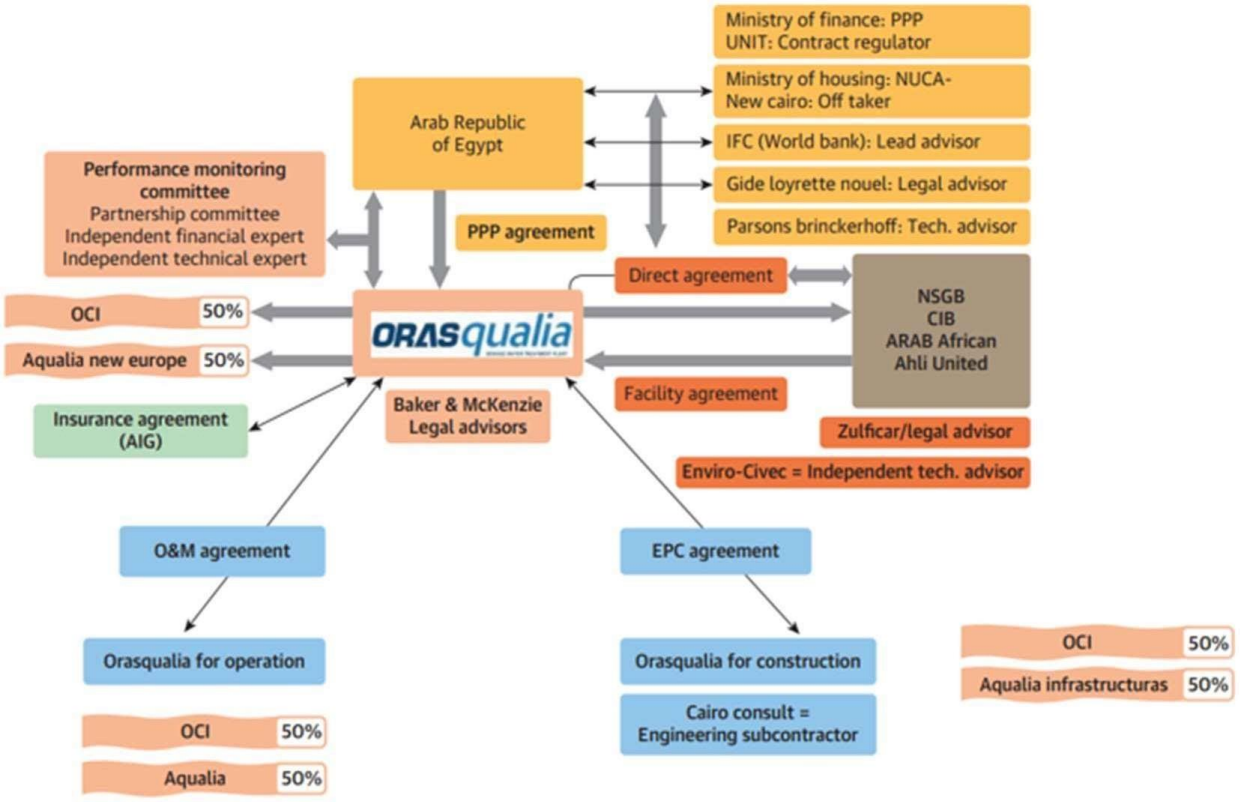
Equity: USD 40 million

Cost benefit:

- The compost from the wastewater sludge is sold to the cement industries locatedin the region, as fuel (which replaces coal, reducing greenhouse gas emissions). For the consortium, this is an extra revenue stream, although small, and avoids considerable sludge transport costs.
- The quality of the sludge is suitable to be used as agricultural fertilizer
- Plant reduces the volume of polluted water discharged into the river, bringing a significant improvement to human health and environmental quality.

Stakeholders:

The winning bid was made by a consortium of Orascom Construction Industries, an Egyptian firm, and Aqualia, a Spanish firm with international experience. The consortium provided the technical know-how associated with Aqualia, an international firm operating various water infrastructure projects around the world, and Orascom's knowledge of the Egyptian market, labor, and political conditions.



Source: World Bank, 2018

Benefits: -

- For city and environment:
    - Up to 3 million people benefited from the improved infrastructure and improvedservice quality
    - Increased availability of drinking water was achieved through substitution of treated water for irrigation and urban green areas in place of freshwater
    - Reduction in the pollutants being discharged into the river Nile
- For the private partner:
    - Knowledge transfer and higher visibility (for local private partner)
    - Some risk elements were taken by the Government of Egypt, including risks relating to inflation, interest rates, credit worthiness, and the supply of utilities
- For the utility and government:
    - Risk transfer such as financing, construction and operations and maintenance to the private partner. Foreign Exchange (ForEx) risk also assumed by the private sector.
    - Improved efficiency by bringing-in private sector
    - Reduction in pressure upon the public budget

- Knowledge transfer

- For the agricultural sector
  - Alternative source of irrigation water allows for potential increase in production inthe surrounding area
  - Treated sludge (biosolids) can be used as fertilizer

Case 10: Incentivized public spending

Case study: Watershed Cleanup Program or Programa Descontaminación de Cuencas Hidrograficas [PRODES][ix]

Unique feature:

The PRODES program is based on the idea of results-based financing (RBF).

RBF is an alternative type of development financing and assistance method. In contrast to conventional development financing that focuses on disbursement of inputs such as grants, loans, or guarantees to be used in construction of infrastructure, RBF focuses on providing funding and incentives for achieved development outcomesand outputs.

Objective:

Reduce the level of contamination of watersheds by untreated wastewaters and motivate integrated water resource management systems and programs by creating and empowering watershed regulatory bodies and introducing charges for water use and water resource management plan.

Brief:

Under PRODES, the national water agency of Brazil (or ANA, as commonlyreferred to) agrees to a contract with an eligible WWTP owner, either public or private. Eligible WWTPs are located in river basins with legally established and operational river basin committees. Up to 50 percent of the investment costs for WWTPs can be reimbursed over five to seven years, provided that the quality of the wastewater discharged meets the norms. The contracts move to new projects orupgrades in earlier ones.

Location: Brazil

Illustration

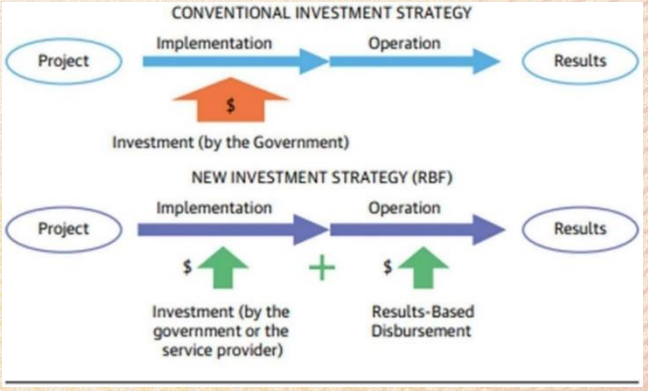


Figure Schematic representation of the incentivized public spending model (Source: World Bank, 2018)

The model establishes criteria set, which the interested WWTP entity must fulfil inorder to be eligible. Said criteria are enumerated below:

Criterion	Maximum score
Population served and treatment efficiency	50
Existence of Basin Committee in operation	5
Location of the development in priority basin	15
Municipalities prioritized in the Atlas Brazil	5
Allocation of resources to PRODES by committees	10
Planned development in water resource plans, investment programs, etc.	5
Project situated in municipalities with criticality criterion 1 and 2 of Portaria 062 / ANA, and listed in Annex IV of Res. 601, dated May 28, 2015	10
Total maximum points	100

Source: World Bank, 2018

Benefits:

- For public entity:
  - Total contribution by ANA through contracts valued over INR 400 million, whichhas mobilized over Rs 1,597 million of investment by service providers
  - Operational risk is assigned to the service provider
- For private entity:
  - Enhances the financial viability of utilities and increases ability to access commercial or development credit
  - Partial payment of construction cost is borne by public sector
- Public and environment:
  - Increased provision of wastewater treatment leads to reduced pollution in the ecosystem
  - 7.49 million people are estimated to have benefited from improved water quality.

Case 11: *Pilot program of a new governance model in agricultural sectorCase study*

Water Solutions for Farmers by Milken innovation lab[x]

Location:

State of California, United States

Backdrop:

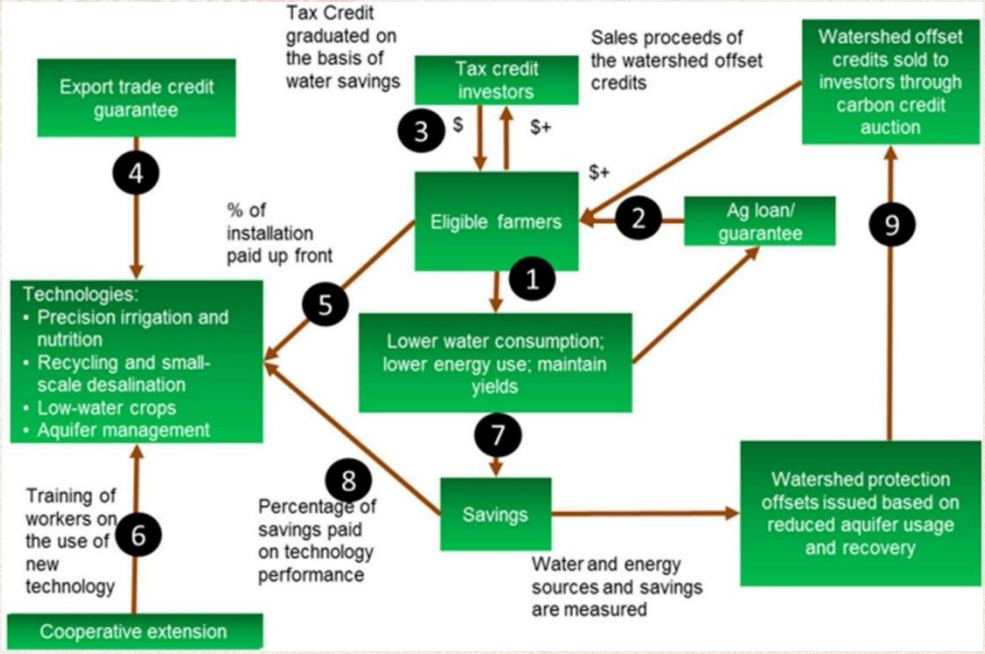
Farmers do not invest in buying the water resource to meet their field's water needs. Instead, the farmers simply drill for the water as per their needs. Such farmers, referred to as independent farmers, are not depended on the regulated sources of water. With the drilling for water becoming expensive on account of scarcity and shortage of water, and alternative in itself being a costly option where the unmet waterdemand has to be fulfilled

through regulated water resources, the farmers either leave water needs unmet or the trees are removed to reduce the natural consumption ofwater to conserve it.

In light of aforementioned developing situation, ideating tools to help farmers use water as a resource efficiently by employing practices of precise irrigation and water recycling, to help such farmers find new sources of water, and along the way also repair the damage done to the aquifers, would go a long way. The design to devise a market for agriculture where government intervention ensures a market requirement, and partnership with leading tech companies which develop solutions for wastewater treatment creates opportunity to access the required technologies for the farmers at a more economic price, giving farmers an option to utilize their resources by exercising choice and alongside creating opportunity for restoration of the environment, forms the basis of the pilot project identified as the case study.

The model delineation of the aforementioned pilot project is described in the processes that take place, using a sequence of numbers, and subsequently depicted schematically in the figure:

1. Farmers decide that they want to save water, reduce energy use, and save money.
2. Farmers secure affordable financing from the state loan funds for agriculture producers. The local or state government may capitalize an agricultural revolving loan fund or a loan-loss reserve fund to provide lower-cost loans to small holder farms for eligible capital equipment purchase and installation.
3. Farmers receive state tax credits to use themselves or to sell to tax credit investors. Tax credit investors could provide some of the capital needed to install new technologies, e.g., drips in alfalfa fields.
4. Farmers contract with equipment providers to meet the farmers water savingsneeds. The technology providers have arranged a trade credit guarantee (where needed).
5. A portion of the initial installation is paid by the farmer through the financing.
6. The University of California's Cooperative Extension of its Division of Agricultural and Natural Resources could be deployed to train farmers in the use ofthe new water technologies.
7. Savings from the deployment of the equipment and technologies would bemeasured
8. Once the savings are realized, the farmer pays a portion of savings to the equipment and technology suppliers to reimburse the remainder of the capital costsplus a cost of capital and risk premium
9. Savings would result in watershed savings credits issued by a "watershed district bank" and given to farmers. Farmers can sell watershed credits to investors or use "senior water rights" themselves.



Schematic representation of the model (Source: Milken innovation lab, 2016)

Case 12: Pilot program of a new governance model in municipal sectorCase study:

Water Solutions for Farmers by Milken innovation lab[xi]

Location:

State of California, United States

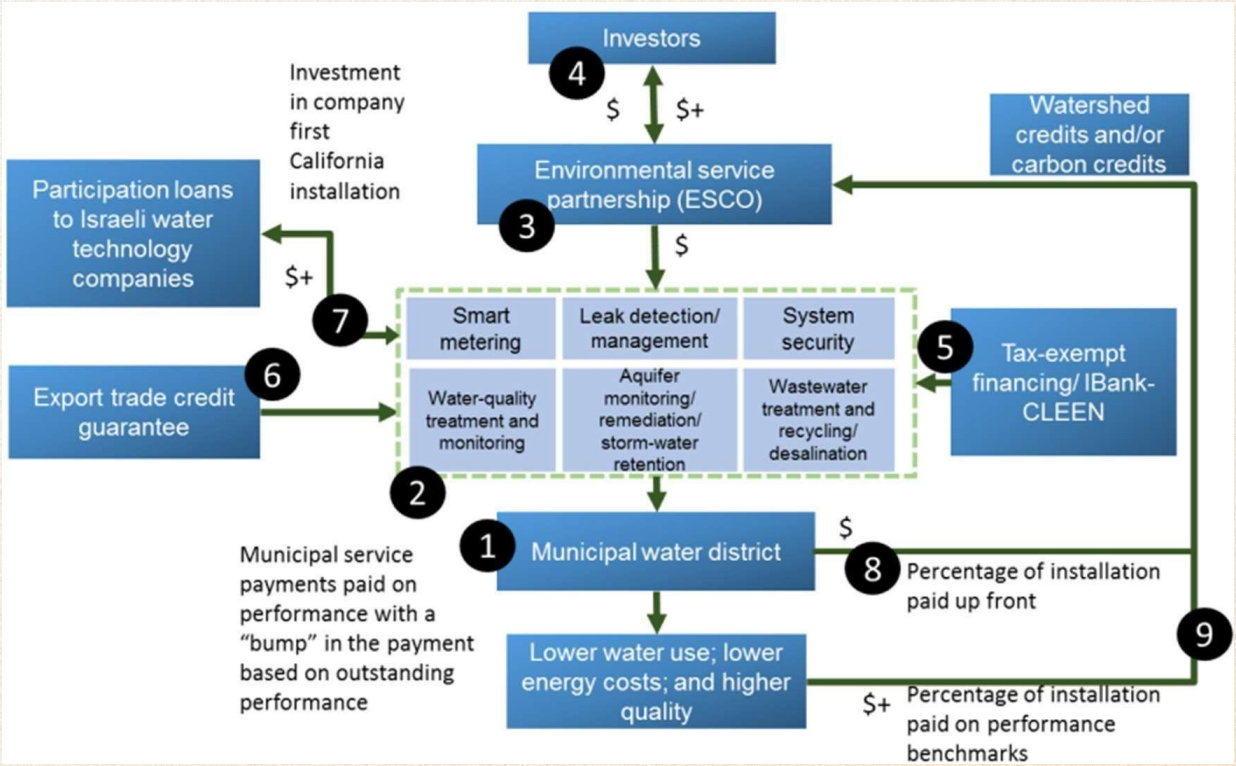
Highlight:

The model aims at setting-up an ecosystem through planned state intervention, whichinvites collaboration with the private sector in municipal context. The model delineation is as follows:

1. The municipal water district decides what water savings technologies it wants touse.
2. The municipality contracts with an environmental services company (structured asan ESCO) to bundle the technologies and solutions. The ESCO partnership would contract with an array of companies to provide a systems solution based on the needs of the water district.
3. The ESCO raises investment capital to provide the needed funds to organize and deploy the technology solutions for the municipal water authority.
4. The municipal water district would secure financing through existing (tax-exempt financing) or expanded programs (iBank's California Lending for Energy and Environmental Needs (CLEEN) targeted to water savings solutions.
5. The Israeli export trade office would provide trade guarantees to cover the crediton the Israeli companies' trade risks.
6. The Israeli companies can apply for special export programs offered by the Israeli export trade office. The Israeli Office of the Chief Scientist would provide R&D

investment to test innovations implemented in live beta sites (such a program exists in Israel and is considered to be significant in the implementation of new water technologies in municipal water systems.

7. The US water district partially pay capital costs up front and a contingent portionof the capital costs based on the "solution set" meeting successful outcomes.
8. Additional service payments may be based on meeting savings outcomes,including a share of savings on high success thresholds being met.



Schematic representation of the model (Source: Milken innovation lab, 2016)

6. Learnings and Findings

6.1 Public-private partnership models

Wastewater treatment plants are capital-intensive owing to the construction costs and the technological equipment costs the revenue stream in case of the treatment may not be consistent, which in totality with the cost of the capital investment make the proposal for the private entities non-lucrative. This constraint makes a strong case for the public-private partnership approach to developing wastewater treatment capacities, as also seen in many of the world-over cases where wastewater treatment was made intobusiness proposition for the private firms by government participating in tandem with them in matters of investment and easing the resource allocation.

Government participation lowers the over-all risk, make it easier the process of building and future procurement, and in some cases meeting the capital cost to some extent. The PPP model also benefits the government, for the availability of public funds in developing economies can hardly match such capital requirement.

Per the discussed case studies, some governance models or capacity development involved a

PPP approach, where-in government side was represented by the urban local body or the municipal corporation and the other side by a private party which took a variety of role and function in the PPP arrangement. Hence below are some of the variations of arrangements, in context wastewater treatment capacity building, which the involved parties agree to in a PPP agreement.

1. **Build, Operate, Transfer (BOT): End-User PPP**

   This model the end user takes the risk of design, technology, construction. Municipal corporation ensures the availability and access to the land resource requirement for construction, and the timely availability of sewage and its quality. This is feasible optionwhen the supply of raw sewage is meant for use by the industry as a whole.

2. **Design, Build, Operate: PPP**

   The private entity designs, builds and operates (DBO) for the term of the project, of 30 years. Hence, Municipal Corporation funds the capital expenditure, provides land for the tertiary treatment plant and builds pipeline required for the transfer of water to the industry and for agriculture purpose, as deemed convenient. Municipality also bear demand off-take or revenue risk. Private entity bears the risk of technology, construction and operation and maintenance. ULB have the liberty to decide the tariff. But private sector will bear the risk of timely payment even though work is completed on time.

3. **BOT- Third Party Annuity**

   The private agency bears the risk of major capital expenditure, along with technology, construction and operation and maintenance risk. Municipality takes the risk of partial funding for capital expenditure, and annuity payment to ensure expected returns of the private operator. Demand off-take and thereby revenue risk is borne by theULBs.

4. **BOT- Third Party PPP (User Charge)**

   Risk of capital expenditure can be partially borne by municipality, but majority of capital expenditure has to be borne by private agency, along with that of technology, construction and operation and maintenance cost. However, the major risk of demand off-take and revenue has to be borne by private agency, and has therefore been the failure in most of the cases as demand off-take and revenue is often uncertain.

Observation

Most successful options in wastewater sector in India we find those cases are successful when revenue risk is taken by government. However, most successful options in waste water sector in India we find those cases are successful when revenue risk is taken by government (IWMI, 2020).

6.2 Application areas

The treated wastewater which is fit for the purpose of drinking or potable consumption has

to be treated up to the tertiary level. But the treated water processed to a lower level – secondary or primary – is, nevertheless, fit for use or application in non-potable cases.

Such a water resource can be directed for application in industries, in irrigation and other agricultural purposes such as horticulture, in community circles for landscaping and maintaining green cover, in commercial sector for purposes such as washing of coaches in metro depots, roads and parking spaces, watering public trees, and maintaining playgrounds and public parks, in individual houses for maintaining lawns and kitchen gardens, and in various other such opportunities of use.

The treated water as an alternative to freshwater, directly supports the conservation of natural water resources and conservation of water resources which supply potable water.

Another major use of treated wastewater is in the natural rejuvenation of the ecological systems. By introducing treated wastewater into the streams, the overall quality of water flowing in the streams is improved through addition of water of relatively higher quality. Also, it reduces the instances where the polluted water is introduced into natural water or overall ecological systems. Another aspect of introduction of treated wastewater in the natural ecosystems is creating catchment areas for this treated water, and allowing it to percolate underground and recharge the natural aquifers.

The investment into development of capacity for treating more of the wastewater being generated close to agricultural land and farms, and extending the same to as well include water storage options and facilities for this water – maybe through artificial wells or man-made aquifers – and use this water during off-seasonal requirement of water in farms and agricultural lands, or to have reserved source of irrigation water to meet rainfall shifts or meet topographical challenges for certain 'farmable' areas.

6.3 Decentralized wastewater treatment systems

i. Decentralized wastewater treatment systems go a long way in developing economies, which have a common set of challenges all over the world. Such challenges include economic constraints when it comes to huge capital investments by public sector towards building infrastructure, or the steep rise in either size of urban areas/cities or the municipal requirements – where the legacy infrastructure either does not have the capacity to match the growing demands, or is unable to cover the geographical reach to cover the expanding cities.

ii. The DWWT systems require smaller investment – be it capital, land or capacity - and are not required to necessarily be undertaken by public sector. The topographical challenges which certain regions may pose to infrastructure development, are accounted for; and the newer areas which undergo development can be covered in a planned manner. The capital cost which is sunk, in the laying of the sewers and pipeline redundantly over long stretches, is also avoided, making this option more economic.

iii. The innovative approach to India's wastewater problem, water's efficient use as a resource problem, problem of water shortage and scarcity of potable problem, can be found and designed through making institutes, houses or communities individually

capable to become self-sustainable and self-reliant in terms of meeting own needs to partially or full extent and meeting he obligations of environment friendliness.

This approach empowers individuals and communities by having them become self-reliant, and paves way for the building a diversified capacity to meet the water demand. Strategically speaking, such diversified sources of water reduce the threat and pressure upon the public sector in case of system failure.

7. Recommendations

i. Waste water treatment carries a huge market potential, if the treated water and the by-products from the process can be commercialized. The entry of the private sectors in the space will not only benefit the government through the influx of capital to develop state capacity, but aids directly in addressing the myriad of challenges which the country's different areas face pertaining to shortage of water and natural water sources conservation.

ii. The conventional technologies in the sector of wastewater treatment are very expensive, especially for the developing countries like India which are economically-strapped when it comes to huge capital investment. The leading private players in technology are based out of India, and the exchange rate does not help in the adoption of the foreign technology on a large scale. Therefore, the need to boost domestic start-ups which are geared towards innovations in the space of wastewater treatment is the need of the hour. Not only such enterprises help India build its capacity, they could potentially bring-in business from other developing economies.

iii. Indian government – Centre and of states, need to envisage or design plans and introduce the same as pilot projects in areas or domains that represent need for critical intervention. The plans would revolve around creating an ecosystem of polities and schemes to enable farmer or other water demanding entities to fulfil their needs and alongside re-align their usage system to meet the needs and goals of ecosystem preservation. The associated policies would ensure that there are incentives to the parties involved, and have financial support to adopt wastewater treatment technologies. The market can be attuned to provide additional benefit to the farmers and introduction of a credit system to monitor the progress made and involvement committed.

iv. The government needs to introduce a guideline through iteration in health, agricultural, urban, or related policies, focusing upon the measured to be adhered to when incorporating the use of treated used water which has not undergone tertiary treatment. Such water may or may not be purified enough to allow human contact. This is especially of concern since the farming activities in India are mostly undertaken through manual work. A set of guidelines can either delineate the purity levels that are safe for human contact, given the domains or purpose which for the treated water is being supplied; or can highlight the protective measures that should be undertaken.

v. Building state capacity in wastewater treatment should be followed up with

building water reservoirs to cater to agricultural needs, especially when the treatment plants are close to the cultivation farmlands. Given the climatic shifts as are evident in Indian weather systems, and fact that weather pattern shift is prone to become severe, having a perennial source of water for irrigation needs would strengthen theIndian agriculture's resilience to climate change.

References

1. ADRI. (2017). India water facts. *Asian Development Research Institute*. https://www.adriindia.org/adri/india_water_facts
2. Akpon, V. E. et al. (2020). Assessing the public perceptions of treated wastewater reuse. *Heliyon*. https://edepot.wur.nl/540464 Anglo American plc. (2007). eMalaheni water reclamation plant, South Africa.
3. *UNFCCC*.
4. https://unfccc.int/files/secretariat/momentum_for_change/application/pdf/3_water_reclammation.pdf
5. Central Ground Water Board (2019). Annual report 2018-19. *Central Ground Water Board*. http://cgwb.gov.in/Ann-Reports.html
6. Chakraborti, R. et al. (2019). Water shortage challenges and a way forward for India.
7. Journal AWWA. https://doi.org/10.1002/awwa.1289
8. Climate centre for cities. (2022). Wastewater recycle and reuse: Training manual.
9. *National Institute for Urban Affairs*. https://niua.in/ccube/sites/all/themes/zap/pdf/WWRR.pdf
10. CWC. (2021). Water Resources at a Glance 2021 Report. *Central Water Commission*. https://cwc.gov.in/sites/default/files/registered-water-resources-glance-2021.pdf
11. Freedman, J. et al. (2020). Addressing India's Water Crisis. *Water Technologies and Solutions*. https://www.suez.com/-/media/suez-global/files/india/publication-docs/addressing-india-water-crisis-through-reuse-2020.pdf
12. Food and Agriculture Organisation of the United Nations. (2018). Progress on water-use efficiency. *UN Water*. https://www.unwater.org/sites/default/files/app/uploads/2018/10/SDG6_Indicator_Report_641-progress-on-water-use-efficiency-2018.pdf
13. India WRIS. (2021, September 24). India's water wealth. *India WRIS*. https://indiawris.gov.in/wiki/doku.php?id=india_s_water_wealth
14. IWMI. (2020). Financial compendium and feasibility analysis of waste water reuse for industry and agriculture in Solapur and Vijayawada. *International Water management Institute*. https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/59128/IDL%20-%2059128.pdf

15. Labhasetwar, P. et al. (2015). Wastewater treatment and reuse at Ordinance Factory Ambajhari. *Natural Water Treatment and Technologies*. https://sswm.info/node/6308

16. Lahiry, S. (2017, July 3). Why India needs to change the way it manages water resources.

17. *Down to Earth*. Why India needs to change the way it manages water resources (downtoearth.org.in)

18. Matto, M. et al. (2014). Case studies on wastewater treatment and reuse. *Centre for Science and Environment*. https://www.cseindia.org/content/downloadreports/5431#:~:text=Third%2C%20case%20study%20is%20of,meeting%20the%20horticultural%20water%20requirements

19. Milken Innovation Lab. (2016). Financial innovation models for water sustainability.

20. *Jerusalem Institute Milken Innovation Lab*. https://milkeninnovationcenter.org/wp-content/uploads/2016/04/Financial- Models-for-Water-Sustainability-FIL-ENG-2.pdf

21. NITI Aayog. (2018). Composite Water Management Index. *NITI Aayog*. Composite WaterManagement Index | NITI Aayog

22. NIUA. (2016). Transit oriented development for Indian smart cities. *National Institute of Urban Affairs*. https://www.niua.org/tod/todfisc/book.php?book=1&section=2

23. NIUA. (2019). Decentralized wastewater management. *Namami Gange*. http://urbanrivers.niua.org/sites/default/files/2020-07/Participant%20Handbook_Advance%20Training.pdf

24. ORF. (2021). Arresting India's water crisis. *Observer Research Foundation*. https://www.orfonline.org/research/arresting-indias-water-crisis-the-economic- case-for-wastewater-use/#:~:text=To%20begin%20with%2C%20water%20scarcity,US%24133%20million)%20in%20incomes

25. Pandey, K. (2018, October 1). India had a deficit monsoon in 13 of the last 18 years.

26. *Down to Earth*. India had a deficit monsoon in 13 of the last 18 years (downtoearth.org.in)

27. Pandey, K. (2019, November 2). India world's 13th most water-stressed country: WRI. *Down to Earth*. India world's 13th most water-stressed country: WRI (downtoearth.org.in)

28. Press Information Bureau (2013, November 140. Withdrawal of fresh water. *Ministry of Water Resources. Government of India*. https://pib.gov.in/newsite/PrintRelease.aspx?relid=101519

29. Sayali, J. et al. (2015). Wastewater treatment and reuse in Indradhanushya Centre.

30. *NaWaTech*. https://www.susana.org/en/knowledge-hub/resources-and-publications/case-studies/details/2436#

31. Singh, S. (2019). Hidden Risks and Untapped Opportunities: Water and the Indian Banking Sector. World Wildlife Fund for Nature. http://www.indiaenvironmentportal.org.in/files/file/hidden_risks_and_untapped

32. _opportunities.pdf

33. Veraart, J. et al. (2020). Nature-based solutions for waste water re-use. Wageningan University and Research. https://edepot.wur.nl/540464

34. World Bank Water and Sanitation Program and International Water Management Institute. (2016). *Recycling and Reuse of Treated Wastewater in Urban India: A Proposed Advisory and Guidance Document.* http://www.iwmi.cgiar.org/Publications/wle/rrr/resource_recovery_and_reuse-series_8.pdf

35. World Bank. (2018). From wastewater to resource: The case of PRODES, Brazil.

36. *World Bank Group*. https://elibrary.worldbank.org/doi/abs/10.1596/29488 World Bank. (2018). From wastewater to resource: The case of New Cairo, Egypt.

37. World Bank Group. https://elibrary.worldbank.org/doi/abs/10.1596/29488 World Bank. (2019). From wastewater to resource: The case of Nagpur. *World Bank*

38. *Group*. https://documents1.worldbank.org/curated/en/847531576610020104/text/Waste water-From-Waste-to-Resource-The-Case-of-Nagpur.txt

39. WRG. (2009). Charting our water future. Water Resource Group 2030. https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/sustainability/pdfs/charting%20our%20water%20future/charting_our_water_future_full_report_.ashx

---

[i]Matto, M. et al. (2014)
[ii]Sayali, P. et al. (2015)
[iii]Matto, M. et al. (2014)
[iv]Matto, M. et al. (2014)
[v]Anglo American plc, 2007
[vi]World Bank, 2019
[vii]Veraart, J. et al. (2020)
[viii]World Bank (2018)
[ix]World Bank (2018)
[x]Milken Innovation Lab. (2016)
[xi]Milken Innovation Lab. (2016)

Yamini Rajora

LL.M. in Environmental and Natural Resources Law, TERI School of Advanced Studies, New Delhi.
Mentored by Shri Yugal Joshi, Adviser, NITI Aayog.
Domain for Internship: Public Policy & Governance

Analyzing the Need for a Climate Change Legislation in India

India is one of the most vulnerable countries to climate change, about half of India's population is dependent upon agriculture or other climate sensitive sectors. Various progressive steps such as release of the National Action Plan on Climate Change in 2008 and re-constitution of the Prime Minister's Council on Climate Change in 2014 are signaling India's commitment in addressing climate change. There is a need to address the climate crisis and effects of climate change. A dedicated climate change legislation will ensure that the government and citizens are reminded of their duty to protect, restore and manage the natural environment. The present study attempted to analyze the lack of and the need to enact an exclusive climate change legislation for India. Also, the research examined the global trends in climate change law to review the climate change policy of India, and identify crucial points for future climate change law. The research followed an analytical and qualitative methodology to understand Indian climate change policies including NAPCC, SAPCCs and government's engagement at the international fora and its obligations under the international conventions and agreements like the UNFCCC and the Paris Agreement. The study also examined climate change laws around the world to ascertain the global perspectives and trends for exclusivity in climate change law. The study proposed various recommendations including a law dedicated to the cause of climate change that sufficiently details the adaptation and mitigation measures, defining purpose and the objectives of the law, identifying a governing body that can properly implement laws, reviewing and updating of action plans by the Governing Body, adopting participatory processes and traditional knowledge to overcome and adjust changing climatic conditions, ensuring fund allocation from National budget like Green Climate Fund under the United Nations Framework Convention on Climate Change (UNFCCC), nationwide ranking for States and Union Territories based on their climate action performance that can act as catalyst for timely action and dissemination of information.

Keywords: climate change, legislation, climate change policy, climate change law, India

Research Objective

The primary objective of the current research report is to study the lack of and analyse the need for an exclusive climate change legislation in India. The report includes ancillary objectives to the primary objective as well which are to study the global trends in climate change law; to review the climate change policy of India, and to identify crucial points to be considered for a future climate change law, that is both cohesive and practicable.

Research Methodology

In order to achieve the research objectives, an analytical and qualitative study of the Indian climate change policy including the NAPCC, SAPCCs, government's engagement at the international fora and its obligations under the international conventions and agreements like the UNFCCC and the Paris Agreement have been employed. The researcher has also undertaken a study of the climate change laws around the world such as in the United Kingdom to ascertain the global perspectives and trends with respect to an exclusive climate change law.

Literature Review

Global Trends in Climate Change Law

The nations, worldwide, have been discussing how to combat climate change since the 1990s. The Kyoto Protocol and the Paris Agreement are only two of the significant agreements that came out of these negotiations. The author has highlighted that while governments largely concur that climate change is real, but they disagree about who is most to blame, how to monitor emissions reduction targets, and whether to pay more severely affected nations.[1]

Over the past twenty years, there has been a twenty-fold growth in the number of climate change legislation or laws related to climate change.[2] This illustrates how much ground is already covered by current climate regulations. Most nations have a solid legal foundation upon which to base future actions. The paper highlights that as the number of low-income nations enacting laws to combat climate change is rising, thus, development strategies need to properly incorporate climate change.[3]

Review of India's Initiatives and Global Engagement

The authors delve into the evolving position of India from a trial ground for environmental policies to a policy driver at international forums. India now has a large influence on climate

[1] Global Climate Agreements: Successes and Failures | Council on Foreign Relations,https://www.cfr.org/backgrounder/paris-global-climate-change-agreements (last visited Aug 15, 2023).

[2] Shaikh Eskander, Sam Fankhauser & Joana Setzer, *Global Lessons from Climate Change Legislation and Litigation*, 2 ENVIRONMENTAL AND ENERGY POLICY AND THE ECONOMY 44 (2021).

[3] Michal Nachmany et al., *Global Trends in Climate Change Legislation and Litigation: 2017 Update*, (2017), http://www.lse.ac.uk/GranthamInstitute/publications/ (last visited Jun 20, 2023).

politics and policy.[4] Climate change will impact a variety of areas, including agriculture, which will further jeopardize food security, sea level rise, increased coastal zone erosion, intensifying natural disasters, species extinction, and the spread of vector-borne diseases[5], thus, the paper explores the reasons for formulation of the National Action Plan on Climate Change and whether the Plan achieved what it set out to. There is a growing understanding that there will be significant differences in how climate change affects Indian states, and several may do worse than the area as a whole. The author discusses that since the state climate plans were designed as a way to decentralize national efforts on combating climate change, they have proven to be a successful exercise in launching action, mostly on adaptation, at the subnational level.[6] However, the documentation and monitoring of their operationalization are still insufficient.

Analyzing the need for a climate change legislation

The laws and policies that control climate change action by establishing its legal foundation are collectively referred to as "climate legislation", or simply "climate legislation." These laws and regulations cover activities that fall under the purview of catastrophe risk reduction, adaptation, and mitigation for climate change.[7] A climate change law for India will provide a legal basis to the international commitments as well as weave India's considerations as a developing country into the climate change narrative. Further, the law will be useful in attracting investment into green technologies developed within the country.

Introduction

The human civilization is currently under threat from climate change. It is the result of millennia of unchecked depletion of natural resources, exploitation of biodiversity, and polluting human activities to satiate their insatiable appetites. As the effects of climate change worsen on a global scale, it is clearer than ever that countries must take proactive measures to lessen their negative effects.

The Stockholm Convention, or the United Nations Conference on Human Environment held in Stockholm, Sweden in 1972, launched a number of international governance initiatives to combat environmentally risky human activities while sustaining and advancing economic and social development.[8] When the west highlighted the plight of the environment and demanded that developing countries adopt a more environmentally sound development strategy, Mrs. Indira Gandhi argued for developing countries to fight their current battles, such as the

---

[4] Navroz K. Dubash et al., *India and Climate Change: Evolving Ideas and Increasing Policy Engagement*, 43 ANNUAL REVIEW OF ENVIRONMENT AND RESOURCES 395 (2018).

[5] Harshal T. Pandve, *India's National Action Plan on Climate Change,* 13 INDIAN J OCCUP ENVIRON MED 17(2009).

[6] Anu Jogesh & Mridula Mary Paul, *Ten Years After: Evaluating State Action Plans in India,* 86 SCIENCE AND CULTURE 38 (2020).

[7] What is climate change legislation?, GRANTHAM RESEARCH INSTITUTE ON CLIMATE CHANGE AND THE ENVIRONMENT, https://www.lse.ac.uk/granthaminstitute/explainers/what-is-climate-change-legislation/ (last visited Sep 5, 2023).

[8] United Nations, *United Nations Conference on the Human Environment, Stockholm 1972* , UNITED NATIONS, https://www.un.org/en/conferences/environment/stockholm1972 (last visited Aug 5, 2023).

elimination of poverty, at the 1972 Convention.[9] In 1983, a report titled "Our Common Future" was released by the World Commission on Environment and Development, also known as the Brundtland Commission which further christened climate change as the common concern of mankind and thus solidified the resolve of nation-states towards combating it.[10] "Global Warming in an Unequal World"[11], a report by the not-for-profit organization named Centre for Science and Environment ("CSE") laid down the ideological cornerstones of India's international climate policy. It declared that "carbon colonialism" was the fault of wealthy nations. The report categorically argued that since the global north historically contributed the majority of the global pool of emissions, the world owed it to the global north to reduce its emissions as well as emissions intensity, and that the per-capita emissions should ideally be the metric used to evaluate the responsibility for mitigation.[12]

India, one of the most populous and climate-vulnerable nations in the world, has a pressing need to tackle the issue of climate change through effective legislative measures. According to climate change forecasts for India, temperatures would generally rise by 1-4 degrees Celsius and precipitation will increase by 9–16% by the mid-2050s.[13] However, it is anticipated that the amount of rainfall would vary in different places in the ensuing decades.[14] The occurrence of extreme events like cyclones, floods, and droughts is occurring more frequently as a result of climate change, which is another important factor. All of these anticipated changes will negatively affect human health as well as climate-sensitive industries including agriculture, coastal habitats, and forests, as well as the availability of water for various uses. The need of adaptation in addressing climate change has finally been correctly acknowledged by the international climate change negotiations. Even dramatic mitigation measures won't stop the predicted rise in temperature until 2100 because the world has already committed to some degree to climate change.[15] Therefore, it is important to give adaptive measures for coping with climatic variability and change more attention through institutional, research, and policy interventions. This study examines the vital justifications for India to pass a thorough climate change law. The study gives reasons and argues for the need to pass a framework law on climate change for India while, providing information about the possible advantages of such law.

---

[9] Antto Vihma, *India and the Global Climate Governance: Between Principles and Pragmatism*, 20 THE JOURNAL OF ENVIRONMENT & DEVELOPMENT 69 (2011).
[10] *Id.*
[11] Anil Agarwal & Sunita Narain, *Global Warming in an Unequal World: A Case of Environmental Colonialism*, *in* INDIA IN A WARMING WORLD: INTEGRATING CLIMATE CHANGE AND DEVELOPMENT 0 (Navroz K. Dubash ed., 2019).
[12] *Id.*
[13] K Krishna Kumar et al., *Simulated Projections for Summer Monsoon Climate over India by a High-Resolution Regional Climate Model (PRECIS)*, 101 CURRENT SCIENCE (2011).
[14] Asha V., Munisamy Gopinath & A. Bhat, *Impact of Climate Change on Rainfed Agriculture in India: A Case Study of Dharwad*, INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCE AND DEVELOPMENT 368 (2012).
[15] C. A. Rama Rao et al., *A District Level Assessment of Vulnerability of Indian Agriculture to Climate Change*, 110 CURRENT SCIENCE 1939 (2016).

Climate change law: global trends and perspectives

Climate change is a global emergency that transcends national boundaries and calls for worldwide collaboration and coordinated responses at every level. All 195 Parties to the United Nations Framework Convention on Climate Change ("UNFCCC") have signed the Paris Agreement and have agreed to decrease their emissions and cooperate to adapt to the effects of climate change.[16] The Agreement also encourages nations to make stronger pledges over time. The provisions of the Agreement, although legally enforceable, lack the same force of law that the Kyoto Protocol that came before it held.[17] For a select group of nations, the Kyoto Protocol established clear emission reduction goals; in contrast, the Paris Agreement requires all nations to choose their own goals.[18] In addition to the international instruments, the world also experienced a slew of public interest litigations against national governments and private corporations to hold them responsible for the action contributing to and inaction towards climate change. The overall number of climate change cases has more than doubled, from 884 in 2017 to 2,180 in 2022.[19] Despite the fact that the majority of claims have been filed in the United States, climate litigation is spreading throughout the world, with about 17% of cases now being recorded in poor nations, including Small Island Developing States. Sixty- five courts, tribunals, quasi-judicial bodies, and other adjudicative bodies, including the United Nations' special procedures and arbitration tribunals, received these legal actions from all around the world.

It is pertinent to note that none of the international instruments offers a method of enforcement similar to that of national legislation. International courts have limited jurisdiction, and there is no international regulator or enforcement body that can keep a check on climate actions by nations around the world. Therefore, when nations withdrew from the Kyoto Protocol, there was not much that could be done legally to check and ensure that the Parties adhered to their emission targets.[20] Thus, it was deemed necessary that each Party in the process of ratification of the Paris Agreement and the UNFCCC devise their own national law or policy on climate action. These domestic laws or policies would be based on local considerations while at the same time operate in accordance with the commitments and obligations under the international instruments on climate change. There isn't a nation on this planet without at least one law or policy addressing climate change. There are more than twenty in the most prolific nations, and 1,800 such laws exist worldwide, of which state governments issue some as executive orders

[16]United Nations, *The Paris Agreement*, UNITED NATIONS, https://www.un.org/en/climatechange/paris-agreement(last visited Aug 15, 2023).

[17]Global Climate Agreements: Successes and Failures | Council on Foreign Relations,https://www.cfr.org/backgrounder/paris-global-climate-change-agreements (last visited Aug 15, 2023).

[18] *Id.*

[19]Climate litigation more than doubles in five years, now a key tool in delivering climate justice, UN ENVIRONMENT (2023), http://www.unep.org/news-and-stories/press-release/climate-litigation-more-doubles-five-years-now-key-tool-delivering (last visited Aug 15, 2023).

[20]Scott Barrett, *Political Economy of the Kyoto Protocol*, 14 OXFORD REVIEW OF ECONOMIC POLICY 20 (1998).

or policies, while parliament passes others as laws.[21] Only 110 key legislation and programs that directly or indirectly addressed climate change were passed between 1990 and 1999 and there were around 1,100 laws and policies enacted between 2010 and 2019 - a tenfold increase.[22] Today, there are about 1,800 laws and policies related to climate change in existence worldwide, and this number is only rising, signaling that nations are now considering climate change as one of the major concerns of today's mankind that could potentially disrupt economies and hamper life. Several nations like the United Kingdom, Sweden France, Scotland and New Zealand have come up with exclusive laws on climate change. These laws include a pledge to reach net zero emissions and a framework to guide the adaptation and mitigation measures in response to national concerns associated with climate change. An example of a broad adaptation framework that establishes a process of ongoing knowledge production and adaptation planning is the UK Climate Change Act.[23] The UK Climate Change Act covers both adaptation and mitigation of climate change, like many framework legislation. However, as is common in many nations, the mitigation clauses set precise emission reduction goals while the focus of adaptation is on creating the proper institutions and procedures.[24]

Climate action in India: Strategy and Initiatives

India's Engagement in Global Climate Governance from COP1 to COP27

India ratified the UNFCCC in 1993 and the Kyoto Protocol in 2002 and has been an active participant in global climate negotiations. From COP1 to COP27, India has maintained developing nations have a right to development, thus, emissions are expected to occur. When it comes to addressing fundamental development issues like hunger and poverty, India sees itself as a developing country with much to do.[25] The Global North has historically viewed India as a partner in their efforts to reduce global emissions. The Conference of Parties' decisions are the outcome of extensive deliberations that adhere to the idea of the lowest common denominator. Despite this, India has been effective in promoting its objectives and making sure that crucial principles like technology transfer, respect for each other's capabilities and common but differentiated responsibilities, and developed nations' responsibility for climate change, are at the core of every CoP decision.

---

[21]Eskander, Fankhauser, and Setzer, *supra* note 2.

[22]Gabriela Iacobuta et al., *National Climate Change Mitigation Legislation, Strategy and Targets: A Global Update*, 18 CLIMATE POLICY 1114 (2018).

[23] Michal Nachmany, Rebecca Byrnes and Swenja Surminsk, *National laws and policies on climate change adaptation: A Global Review*, GRANTHAM RESEARCH INSTITUTE ON CLIMATE CHANGE AND THE ENVIRONMENT , https://www.lse.ac.uk/granthaminstitute/publication/national-laws-and-policies-on-climate-change-adaptation-a-global-review/ (last visited Aug 13, 2023).

[24]Sam Fankhauser, Alina Averchenkova and Jared Finnegan, *10 years of the UKClimate Change Act*, GRANTHAM RESEARCH INSTITUTE ON CLIMATE CHANGE AND THE ENVIRONMENT, https://www.lse.ac.uk/granthaminstitute/publication/10-years-climate-change-act/ (last visited Aug 15, 2023).

[25]India and the MDGs | UN ESCAP, https://www.unescap.org/sites/default/files/India_and_the_MDGs_0.pdf (last visited Aug 15, 2023).

At subsequent COPs, India and other emerging nations prioritized economic development and the eradication of poverty, which is to expected to result in an increase in GHG emissions. India revised its position on the Clean Development Mechanism[26] ("CDM") after realizing how valuable it was for it to attract foreign investment and clean technology from the West. In fact, India not only actively participated in developing the principles, regulations, and institutions governing the CDM during this time, but it also, along with China, rose to the top of the CDM project hosting rankings in the years that followed, with its private sector capturing a sizeable portion of the global market.[27]

India has advocated strongly for the adoption of technology transfer and financial assistance from industrialized to developing countries in any official agreement on climate change as well as further urged increased focus on adaptation funds at COP7 in Marrakesh in 2001.[28] India also urged the removal of financial and intellectual property rights-related barriers to the effective adoption of emerging technology alternatives in energy efficiency, fuel switching, and renewable energy.[29] India and other developing nations compelled developed Parties to uphold their mitigation obligations and implement more robust procedures to handle money, transparency, and technology.[30] Towards the later COPs, from COP17 to COP 21, India reiterated the need of including "loss and damage" in the new accord, along with the Least Developed Countries and Small Island Developing States, stressing that the "mechanism for addressing loss and damage must be taken to its logical conclusion."[31]

Although the most recent COP27 concluded with a purported cursory reiteration of the international commitment to close the gaps in mitigation, adaptation, and climate finance, it amassed greater importance due to the establishment of a new mechanism in global climate-change governance known as the "loss and damage fund".[32] The developed nations upheld India's position as one of the top polluters while diminishing its heightened geographical and socio-economic vulnerabilities in light of the threat posed by climate change. However, the composition of the contributors to the aforementioned fund became a contentious contestation between the global north and India.

India's participation in the COP27 has shown that it is a significant and engaged nation that is committed to upholding the interests of developing and underdeveloped economies. It was established to defend the rights of the numerous individuals on the earth who are the victims of the climate crisis rather than its perpetrators. The ideas of equity, fairness, and universal

---

[26]The Clean Development Mechanism | UNFCCC, https://unfccc.int/process-and-meetings/the-kyoto-protocol/mechanisms-under-the-kyoto-protocol/the-clean-development-mechanism (last visited Aug 15, 2023).

[27]Michael Richards, *A Review of the Effectiveness of Developing Country Participation in the Climate Change Convention Negotiations* (2011).

[28]Funding under the Convention and the Kyoto Protocol, https://unfccc.int/cop7/issues/convkpfunding.html (last visited Aug 21, 2023).

[29]Outcome and Indian stance in COPs 1 - 21 - Indian Council of World Affairs (Government of India), https://www.icwa.in/show_content.php?lang=1&level=3&ls_id=607&lid=551 (last visited Aug 24, 2023).

[30]Chime Youdon and Pushp Bajaj, *India's Approach and Position on Climate Change Governance*, NATIONAL MARITIME FOUNDATION (Nov. 19, 2022), https://maritimeindia.org/indias-approach-and-position-on-climate-change-governance/ (last visited Aug 25, 2023).

[31]Outcome and Indian stance in COPs 1 - 21 - Indian Council of World Affairs (Government of India), *supra* note 29.

[32]Harsh V. Pant, *The World in 2022: An Epilogue*, ORF, https://www.orfonline.org/research/the-world-in-2022-an-epilogue/ (last visited Aug 22, 2023).

justice that are significant to India will continue to govern India's involvement and contribution in ongoing international climate negotiations. Ambition, making climate action a top priority in national policies, encouraging international cooperation, and taking the lead on ambitious global climate action can help India resolve its climate issue.

Review of National Initiatives

Prime Minister's Council on Climate Change

The Prime Minister's Council on Climate Change ("PM Council") was reconstituted in 2014, after its initial constitution in 2008, to coordinate national action for assessment, adaptation, and mitigation of climate change.[33] The PM Council was tasked to develop a national response that is coordinated to climate change-related challenges; exercise control over the creation of action plans for assessing, adjusting to, and mitigating climate change as well as to monitor important policy decisions on climate change.[34] Over three sessions between July 13, 2007 and June 2, 2008, the first council was able to formulate the National Action Plan on Climate Change (NAPCC), a month before the 'Group of Eight' countries summit that was held in July 2008.[35] The council has not met since 2015, according to information publicly available.

National Action Plan on Climate Change

The National Action Plan on Climate Change ("NAPCC") was formulated in 2008 by the PM Council. The action plan highlights several initiatives that can be taken to promote both, India's development goals and targets connected to climate change.[36] It establishes eight missions, ranging from solar to climate research, that will be described and then followed up on by the PM Council in order to prioritize national action.[37]

It is evident that efforts are being made to stop climate change, but what is most important is that these efforts must be ongoing and long-lasting, and every person in every nation must make a contribution.[38] The government of India has demonstrated its commitment to addressing climate change issues by releasing the NAPCC. In addition, the government has positively communicated its desire to address the climate change issue through coordinated action to the general public, businesses, and civil society.[39] It is imperative to deal forcefully and effectively with issues relating to the general public's understanding of global warming and climate change, as well as issues relating to agriculture and health risks brought on by climate change.

---

[33]Government reconstitutes the Prime Minister's Council on Climate Change, https://pib.gov.in/newsite/printrelease.aspx?relid=111090 (last visited Aug 18, 2023).

[34]Shyam Saran, *India's Climate Change Policy: Towards a Better Future*, https://www.eoimadrid.gov.in/pdf/Article%20by%20Shyam%20Saran%20on%20India's%20Climate%20Change%20Policy,%20Towards%20a%20Better%20Future.pdf (last visited on Aug 16, 2023).

[35]PM's climate change council has not met in almost 7 years, https://www.downtoearth.org.in/news/climate-change/pm-s-climate-change-council-has-not-met-in-almost-7-years-80369 (last visited Aug 15, 2023).

[36]Pandve, *supra* note 5.

[37]National Action Plan on Climate Change | Ministry of Environment, Forests and Climate Change (Government of India), https://cckpindia.nic.in/napcc/ (last visited Aug 26, 2023).

[38]Harshal T. Pandve, *Global Initiatives to Prevent Climate Change*, 12 INDIAN J OCCUP ENVIRON MED 96 (2008).

[39]Harshal Pandve, *Global Warming: Need to Sensitize General Population*, 11 INDIAN J OCCUP ENVIRON MED 86 (2007).

State Action Plan on Climate Change

Post the formulation of the NAPCC, it was observed that effective climate action would also require action at the state and the district level, hence, all states and Union Territories were urged to come up with their own State Action Plans on Climate Change ("SAPCC") consistent with the objectives of the NAPCC. The SAPCCs are cited as a crucial component of India's efforts to combat climate change in the NDC. According to the Parliamentary Committee on Estimates' report on the NAPCC's performance, "actions at the level of state governments and Union Territories supplement broad policy initiatives of the Central Government." [33] While Delhi took eight years to complete its action plan, which was completed in 2019, Odisha was among the first to produce their document in 2010.

In reality, however, there has been a mismatch between local and national attempts to combat climate change. The money given to states under national programs like MGNREGA and the value of the benefits they provide for the climate are the main areas of attention in the current measurement of sub-national action.[40] Regarding sectoral concentration, plans largely align with national missions, but they place a strong emphasis on adaptation. States that have considered operations involved in mitigation, such as energy and transportation, have done so in accordance with regional priorities. For instance, Odisha emphasized on interventions in the energy sector in its SAPCC which was in line with only one mission under the NAPCC, that is, the National Mission on Energy Efficiency.

Climate Change Bill, 2015

In 2015, a private member's bill to enact a climate change law known as the Climate Change Act was tabled in the Lok Sabha of the Parliament by Kalikesh Narayan Singh Deo, Member of Parliament. The bill was introduced with a view "*to set a target for the reduction of targeted greenhouse gas emissions; to establish a National Committee on Climate Change; to provide for carbon budgeting and carbon trading schemes and to encourage other such activities to reduce greenhouse gas emissions and for matters connected therewith or incidental thereto*."[35] In order to keep a track of the government's actions and policy decisions with respect to climate change, the Bill also stipulated that the government must submit "*a report setting out proposals and policies for meeting carbon budgets for the current and future periods*" before the Parliament.[41]

Assessing the need for a climate change legislation in India

By the end of the century, it is predicted that the Indian subcontinent would have warmed significantly, with large changes in the frequency and severity of precipitation, flood, and drought events.[42] The full scope of these anticipated changes is currently being determined through multiple state and district-level climate modelling efforts due to the agro-climatic

[40]India's Intended Nationally Determined Contribution is Balanced and Comprehensive: Environment Minister, https://pib.gov.in/newsite/printrelease.aspx?relid=128403 (last visited Sep 3, 2023).
[41]Siddharth Chaturvedi, *Analysing India's Climate Change Policy*, The Leaflet (2021), https://theleaflet.in/analysing-indias-climate-change-policy/ (last visited Jun 14, 2023).
[42]What's in it for South Asia | Climate & Development Knowledge Network, (2014), https://cdkn.org/resource/highlights-south-asia-ar5 (last visited Aug 14, 2023).

variability of Indian states.[43] There is broad consensus that climate impacts are already making it more difficult for states to develop in terms of food production, forest and biodiversity, water availability, and human health.[44] The recent string of extreme weather events in Maharashtra, Kerala, Assam, Uttarakhand, and Himachal Pradesh are a part of a bigger trend that is anticipated to get worse if existing infrastructure development, key service provision, and resource management practices continue and are not regulated from the perspective of climate emergency.[45]

The Paris Agreement lacks instruments to raise ambition. The globe is still on course to warm by well over 2 degrees Celsius by the year 2100, according to the total of the Nationally Determined Contributions ("NDCs") made by the various countries as required by the Agreement.[46] The Agreement commits all parties to collectively limit global warming to 2 degrees Celsius and to use their best efforts to limit it to 1.5 degrees Celsius. Even worse, nations' actions fall far short of their declared goals. This includes India, which has the most equitable NDCs for an emerging economy. India is on course to reach the renewable energy and energy intensity of Gross Domestic Product ("GDP") targets set forth in its NDC, while progress on the country's forest carbon target has lagged.[47]

The atmospheric buildup of greenhouse gases ("GHGs") is the primary cause of climate change and India ranks among the top emitters of GHGs because of its sizeable population and expanding economy.[48] An exclusive climate change law can establish precise emission reduction goals and procedures for the nation to lower its GHG emissions, assisting in the worldwide mitigation of climate change. India is susceptible to the effects of climate change due to its geographical location and topography, which leads to more frequent and severe floods, cyclones, and sea level rise.[49] A climate change law can, therefore, aid in allocating funds and establishing plans for coping with these effects, safeguarding the populace, the nation's infrastructure, and its ecosystems.

India has ratified international accords like the Paris Agreement, which mandates that nations take particular steps to keep global warming to well below 2 degrees Celsius above pre-

[43]Pritha Datta, Bhagirath Behera & Dil Bahadur Rahut, *Climate Change and Indian Agriculture: A Systematic Review of Farmers' Perception, Adaptation, and Transformation*, 8 ENVIRONMENTAL CHALLENGES 100543 (2022).
[44]N. Ravindranath et al., *Climate Change Vulnerability Profiles for North East India*, Vol.101 CURRENT SCIENCE 384 (2011).
[45]Assessing India's mounting climate losses to financial institutions | PreventionWeb, (2019), https://www.preventionweb.net/publication/assessing-indias-mounting-climate-losses-financial-institutions (last visited Aug 14, 2023).
[46]NDC compliance not enough, world may still be 2.5°C warmer by 2100: Study, https://www.downtoearth.org.in/news/climate-change/ndc-compliance-not-enough-world-may-still-be-2-5-c-warmer-by-2100-study-84071 (last visited Aug 15, 2023).
[47]India stands committed to reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level, https://pib.gov.in/pib.gov.in/Pressreleaseshare.aspx?PRID=1885731 (last visited Aug 15, 2023).
[48]Thomas Harrisson, *The Carbon Brief Profile: India*, CARBON BRIEF (2019), https://www.carbonbrief.org/the-carbon-brief-profile-india/ (last visited Aug 14, 2023).
[49]India: Climate Change Impacts, WORLD BANK, https://www.worldbank.org/en/news/feature/2013/06/19/india-climate-change-impacts (last visited Aug 24, 2023).

industrial levels.[50] India can contribute to global efforts to address climate change and fulfill its obligations under these agreements with the aid of a climate change law. A climate change law can give the different government departments and agencies involved in climate-related activities a legal basis.[51] Further, it can assure the consistency of policies and activities across numerous industries, including those related to energy, transportation, agriculture, and forestry, all of which are crucial for effective climate action.

An exclusive climate change law will also lead to increased investments and financial benefits. Investments in green and sustainable technology, renewable energy, and climate-resilient infrastructure can be attracted on a national and worldwide level with the aid of a clear and comprehensive climate change law. Investors may benefit from the assurance it can give them on the legal framework and financial incentives for climate-friendly initiatives.[52]

A climate change law may raise people's awareness of the issue's significance and the urgency of taking action. India can protect its residents, uphold its international obligations, enhance policy coordination, promote economic growth, and involve its citizens in the global fight against climate change by passing such laws.[53] The government can be held responsible for attaining its climate goals by establishing mechanisms for tracking and reporting progress. The Constitution of India guarantees the right to a healthy environment under Article 21, as well as imposes a duty on the state to protect and improve the environment under Article 48A. A dedicated climate change legislation will not only bind the government to act upon its constitutional duty towards its citizens as well as under the international accords but also raise awareness and devolve responsibility upon the public about their role in combating climate change. The justiciable nature of the duties of both the government and the citizens will ensure that effective climate action policies are framed under the law. Further, while India's legal regime ensures that activities contributing to GHG emissions are regulated such as through the implementation of Factories Act, 1948; The Air (Prevention and Control of Pollution) Act, 1981; The Water (Prevention & Control of Pollution) Act, 1974; all of which set standards for factory operations, emissions into air as well release of waste into water bodies respectively, yet do not address the issue of climate change directly. It is required that the existing legislations be updated to reflect new concerns of the nation.

Achievement of sustainable development goals is directly related to combating climate change. A climate change law can, therefore, assist in incorporating climate action into larger development plans and strategies, while guaranteeing economic growth is socially and environmentally responsible. A climate change law can also offer a legal framework for

---

[50]Cabinet approves ratification of the Paris Agreement, https://pib.gov.in/newsite/PrintRelease.aspx?relid=151205 (last visited Aug 25, 2023).

[51]What is climate change legislation?, GRANTHAM RESEARCH INSTITUTE ON CLIMATE CHANGE AND THE ENVIRONMENT, https://www.lse.ac.uk/granthaminstitute/explainers/what-is-climate-change-legislation/ (last visited Aug 25, 2023).

[52]Ananthakrishnan Prasad et al, *Mobilizing Private Climate Financing in Emerging Market and Developing Economies*, IMF (2022), https://www.imf.org/en/Publications/staff-climate-notes/Issues/2022/07/26/Mobilizing-Private-Climate-Financing-in-Emerging-Market-and-Developing-Economies-520585 (last visited Aug 25, 2023).

[53]Social Dimensions of Climate Change, WORLD BANK, https://www.worldbank.org/en/topic/social-dimensions-of-climate-change (last visited Aug 27, 2023).

tackling environmental and climate justice issues as climate-related conflicts and lawsuits increase in frequency across the globe.[54]

Conclusion

Identification of crucial points to be included in a future legislation

This paper has sufficiently highlighted that in absence of a hard law or an exclusive law on climate change, most of the initiatives by India, although laudable are largely unregulated and therefore, lack the force of law. It is proposed that an exclusive, that is, a law dedicated to the cause of climate change that sufficiently details the adaptation and mitigation measures may be introduced and brought into effect. Such piece of legislation shall operate to serve a dual purpose, that is, to not only honour India's international commitments and obligations under the Paris Agreement and UNFCCC but also takes the national growth objectives into account. To this effect, it is also proposed that this framework legislation should be inclusive as well, that is, the law must consider all aspects associated with climate change that the nation is facing and address the threats as well as the impact of climate change. The legislation should include measures that are under the purview of disaster risk management, mitigation, and adaptation to climate change.

The researcher has identified certain crucial points for consideration in a future climate change law for India. Firstly, the framework legislation should contain an objects clause that defines the purpose and the objectives of the law. The objects clause should be followed by a title clause and a definition clause that contains definitions of all terms necessary for understanding and effective implementation of this law. Further, this exclusive legislation must also identify a governing body that can sufficiently administer and overlook the implementation of this law. Adaptation and mitigation measures form an important aspect of climate action; hence, the law should contain provisions for the same. The National Action Plan on Climate Change, State Action Plans on Climate Change and Disaster Management Plans for disasters induced by climate change should find a place in the law. Further, as recommended in the Climate Change Bill of 2015, provisions with respect to emission standards, carbon budgeting and trading would also forma vital part of the framework legislation. The law should also envision a process for regular review and updating of these action plans by the Governing Body. Provisions with respect to recognition of rights of those sections of society that are impacted most by climate change such as indigenous communities who have not only borne the brunt of climate change due to their close association and dependence on natural resources but have also transformed into actors of environmental protection must be included. Such provisions should entail a participatory process for such communities who have utilized their traditional knowledge in the past to overcome and adjust to the changing climatic conditions. These provisions could be modelled after the Paris Agreement which includes provisions on the rights of indigenous peoples, their traditional knowledge, and their contributions to climate change

[54]Climate litigation more than doubles in five years, now a key tool in delivering climate justice, *supra* note 19.

mitigation and adaptation.[55] The law must also ensure that sufficient funds are set aside from the national budget or from global climate funding such as the Adaptation Fund or the Green Climate Fund under the UNFCCC to implement alternative public goods like flood defenses and nature-based solutions. Lastly, a nationwide ranking for States and Union Territories could also be adopted on the basis of their climate action performance.[56] The ranking could be displayed on a digital dashboard and updated either monthly and annually. This ranking system will provide the much-needed encouragement to States and Union Territories for timely action as well as be instrumental in dissemination of information among the public.

Concluding Remarks

Science has proven beyond a shadow of a doubt that there is a finite window of opportunity for combating climate change. Business players, in particular, now play a more significant role than ever in the implementation of emissions reductions as carbon markets acquire growing importance. Non-Governmental Organizations ("NGOs") are being used more frequently to create, oversee, and protect projects. In fact, the UN struggles to remain relevant in the face of so many governing structures outside the international system, and it is past time that support for market mechanisms was recognized as a successful method of regulating climate change. The ideology, institutions, and material interests that prevail in the larger global economy, where climate politics exists and with which it strives to engage, cannot be understood in isolation from climate governance.

Due to the urgent need for adaptation to the growing impacts of climate change, all nations must implement laws or policies that address adaptation at the national level, mandate adaptation activities across sectors, and coordinate subnational action. India, which has now emerged as a major environmental policy driver at the global level must take initiative in coming up with a framework law on climate change that guides the adaptation and mitigation measures across the nation at all levels of governance. While India is known to have a robust legal regime that individually targets the sectors or activities contributing to climate change as well as addresses the effects of climate change, be it on wildlife, forest rights of communities or the increasing pollution levels, it cannot be denied that these specific laws still do not mention the term "climate change" and fail to address it directly. India, therefore, needs a climate change law to address its role in reducing climate change, adapt to its effects, meet its international obligations, and promote sustainable development while preserving the environment and the welfare of its people.

[55]How Indigenous Peoples Enrich Climate Action | UNFCCC, https://unfccc.int/news/how-indigenous-peoples-enrich-climate-action (last visited Aug 23, 2023).
[56]Chaturvedi, *supra* note 36.

Bibliography

1. Sam Fankhauser, Alina Averchenkova & Jared Finnegan, *10 years of the UK Climate Change Act*, Grantham Research Institute on climate change and the environment, https://www.lse.ac.uk/granthaminstitute/publication/10-years-climate-change-act/ (last visited Sep 5, 2023).
2. C. A. Rama Rao et al., *A District Level Assessment of Vulnerability of Indian Agriculture to Climate Change*, 110 Current Science 1939 (2016).
3. Michael Richards, *A Review of the Effectiveness of Developing Country Participation in the Climate Change Convention Negotiations* (2011).
4. Analysing India's Climate Change Policy – The Leaflet, (2021), https://theleaflet.in/analysing-indias-climate-change-policy/ (last visited Jun 14, 2023).
5. Navroz K. Dubash & Anirudh Sridhar, *As Global Warming Proceeds, How Can India Introduce Climate Governance to Law?*, Scroll.in (2022), https://scroll.in/article/1036966/as-global-warming-proceeds-how-can-india- introduce-climate-governance-to-law (last visited Jun 14, 2023).
6. Assessing India's mounting climate losses to financial institutions | PreventionWeb, (2019), https://www.preventionweb.net/publication/assessing-indias-mounting- climate-losses-financial-institutions (last visited Sep 4, 2023).
7. Charvi Jain & Gunika Razdan, *Assessing the Necessity for a Separate Climate Change Legislation in India*, 3 Jus Corpus L.J. 920 (2022).
8. Cabinet approves ratification of the Paris Agreement, https://pib.gov.in/newsite/PrintRelease.aspx?relid=151205 (last visited Sep 5, 2023).
9. S. Chauhan, *Climate Change , Disasters and Security ... ... Issues , Concerns and Implications for India* (2009), https://www.semanticscholar.org/paper/CLIMATE- CHANGE-%2C-DISASTERS-AND-SECURITY-...-...-%2C-Chauhan/d746c8a3dd405b2c3d4228dfd24f49fb36c27a25 (last visited Sep 6, 2023).
10. Pritha Datta, Bhagirath Behera & Dil Bahadur Rahut, *Climate Change and Indian Agriculture: A Systematic Review of Farmers' Perception, Adaptation, and Transformation*, 8 Environmental Challenges 100543 (2022).
11. Varun Rai & David G Victor, *Climate Change and the Energy Challenge: A Pragmatic Approach for India*, 44 Economic and Political Weekly 78 (2009).
12. Climate Change Laws of the World, Grantham Research Institute on climate change and the environment, https://www.lse.ac.uk/granthaminstitute/climate-change-laws-of- the-world-database/ (last visited Sep 3, 2023).
13. N. Ravindranath et al., *Climate Change Vulnerability Profiles for North East India*, Vol.101 Current science 384 (2011).
14. Devesh Kapur, Radhika Khosla & Pratap Bhanu Mehta, *Climate Change: India's Options*, 44 Economic and Political Weekly 34 (2009).
15. Climate litigation more than doubles in five years, now a key tool in delivering climate justice, UN Environment (2023), http://www.unep.org/news-and-stories/press- release/climate-litigation-more-doubles-five-years-now-key-tool-delivering (last visited Sep 5, 2023).
16. Aaron Atteridge et al., *Climate Policy in India: What Shapes International, National and State Policy?*, 41 Ambio 68 (2012).

17. Committee Reports, PRS Legislative Research, https://prsindia.org/policy/report-summaries/performance-of-national-action-plan-on-climate-change (last visited Sep 6, 2023).
18. Navroz K. Dubash et al., *Developments in National Climate Change Mitigation Legislation and Strategy*, Climate Policy (2013), https://www.tandfonline.com/doi/abs/10.1080/14693062.2013.845409 (last visited Jun 20, 2023).
19. Samuel Fankhauser, Caterina Gennaioli & Murray Collins, *Do International Factors Influence the Passage of Climate Change Legislation?*, 16 Climate Policy 318 (2016).
20. Shanmuga Sundara Bharathi, *Does India Need an Exclusive Climate Change Law?*, YourStory.com (2022), https://yourstory.com/socialstory/2022/02/india-need- exclusive-climate-change-law (last visited Jun 14, 2023).
21. Navroz K. Dubash & Anu Jogesh, *From Margins to Mainstream? State Climate Change Planning in India as a "Door Opener" to a Sustainable Future*, (2014), https://papers.ssrn.com/abstract=2474518 (last visited Sep 4, 2023).
22. From Margins to Mainstream? State Climate Change Planning in India as a "Door Opener" to a sustainable future, CPR, https://cprindia.org/briefsreports/from-margins- to-mainstream-state-climate-change-planning-in-india-as-a-door-opener-to-a- sustainable-future/ (last visited Sep 4, 2023).
23. Funding under the Convention and the Kyoto Protocol, https://unfccc.int/cop7/issues/convkpfunding.html (last visited Sep 4, 2023).
24. Global Climate Agreements: Successes and Failures | Council on Foreign Relations, https://www.cfr.org/backgrounder/paris-global-climate-change-agreements (last visited Sep 5, 2023).
25. Harshal T. Pandve, *Global Initiatives to Prevent Climate Change*, 12 Indian J Occup Environ Med 96 (2008).
26. Shaikh Eskander, Sam Fankhauser & Joana Setzer, *Global Lessons from Climate Change Legislation and Litigation*, 2 Environmental and Energy Policy and the Economy 44 (2021).
27. Michal Nachmany et al., *Global Trends in Climate Change Legislation and Litigation: 2017 Update*, (2017), http://www.lse.ac.uk/GranthamInstitute/publications/ (last visited Jun 20, 2023).
28. Anil Agarwal & Sunita Narain, *Global Warming in an Unequal World: A Case of Environmental Colonialism*, *in* India in a Warming World: Integrating Climate Change and Development 0 (Navroz K. Dubash ed., 2019), https://doi.org/10.1093/oso/9780199498734.003.0005 (last visited Sep 4, 2023).
29. Harshal Pandve, *Global Warming: Need to Sensitize General Population*, 11 Indian J Occup Environ Med 86 (2007).
30. Government reconstitutes the Prime Minister's Council on Climate Change, https://pib.gov.in/newsite/printrelease.aspx?relid=111090 (last visited Sep 5, 2023).
31. How 6 countries are fighting climate change with legislation, Inter-Parliamentary Union, https://www.ipu.org/news/news-in-brief/2022-11/how-6-countries-are- fighting-climate-change-with-legislation-0 (last visited Sep 1, 2023).
32. Chandni Singh, Divya Solomon & Nitya Rao, *How Does Climate Change Adaptation Policy in India Consider Gender? An Analysis of 28 State Action Plans*, 21 Climate Policy 958 (2021).

33. Terry Townshend et al., *How National Legislation Can Help to Solve Climate Change*, 3 Nature Clim Change 430 (2013).
34. Asha V., Munisamy Gopinath & A. Bhat, *Impact of Climate Change on Rainfed Agriculture in India: A Case Study of Dharwad*, International Journal of Environmental Science and Development 368 (2012).
35. Navroz K. Dubash et al., *India and Climate Change: Evolving Ideas and Increasing Policy Engagement*, 43 Annual Review of Environment and Resources 395 (2018).
36. Lavanya Rajamani, *India and Climate Change: What India Wants, Needs, and Needs to Do*, 8 India Review 340 (2009).
37. Antto Vihma, *India and the Global Climate Governance: Between Principles and Pragmatism*, 20 The Journal of Environment & Development 69 (2011).
38. India stands committed to reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level, https://pib.gov.in/pib.gov.in/Pressreleaseshare.aspx?PRID=1885731 (last visited Sep 5, 2023).
39. India: Climate Change Impacts World Bank, https://www.worldbank.org/en/news/feature/2013/06/19/india-climate-change- impacts (last visited Sep 4, 2023).
40. Harshal T. Pandve, *India's National Action Plan on Climate Change*, 13 Indian J Occup Environ Med 17 (2009).
41. Chime Youdon and Pushp Baja, *India's Approach and Position on Climate Change Governance*, National Maritime Foundation (Nov. 19, 2022), https://maritimeindia.org/indias-approach-and-position-on-climate-change-governance/ (last visited Sep 4, 2023).
42. Shyam Saran, *India's Climate Change Policy: Towards a Better Future (2023)*, https://www.eoimadrid.gov.in/pdf/Article%20by%20Shyam%20Saran%20on%20India's%20Climate%20Change%20Policy,%20Towards%20a%20Better%20Future.pdf (last visited on Aug 16, 2023).
43. India's Intended Nationally Determined Contribution is Balanced and Comprehensive: Environment Minister, https://pib.gov.in/newsite/printrelease.aspx?relid=128403 (last visited Sep 3, 2023).
44. Integrating Climate Action in the Existing Environmental Legislation in India, Shakti Sustainable Energy Foundation, https://shaktifoundation.in/initiatives/integrating- climate-action-in-the-existing-environmental-legislation-in-india/ (last visited Sep 5, 2023).
45. Anna Kukkonen et al., *International Organizations, Advocacy Coalitions, and Domestication of Global Norms: Debates on Climate Change in Canada, the US, Brazil, and India*, 81 Environmental Science & Policy 54 (2018).
46. Brian Stone, Jason Vargo & Dana Habeeb, *Managing Climate Change in Cities: Will Climate Action Plans Work?*, 107 Landscape and Urban Planning 263 (2012).
47. Brian Stone, Jason Vargo & Dana Habeeb, *Managing Climate Change in Cities: Will Climate Action Plans Work?*, 107 Landscape and Urban Planning 263 (2012).
48. Ananthakrishnan Prasad Oman Elena Loukoianova,Alan Xiaochen Feng,William, *Mobilizing Private Climate Financing in Emerging Market and Developing Economies*, IMF, https://www.imf.org/en/Publications/staff-climate- notes/Issues/2022/07/26/Mobilizing-

Private-Climate-Financing-in-Emerging-Market- and-Developing-Economies-520585 (last visited Sep 5, 2023).
49. NAPCC – MoEF&CC, https://cckpindia.nic.in/napcc/ (last visited Sep 6, 2023).
50. Gabriela Iacobuta et al., *National Climate Change Mitigation Legislation, Strategy and Targets: A Global Update*, 18 Climate Policy 1114 (2018).
51. National laws and policies on climate change adaptation: a global review, Grantham Research Institute on climate change and the environment, https://www.lse.ac.uk/granthaminstitute/publication/national-laws-and-policies-on- climate-change-adaptation-a-global-review/ (last visited Sep 5, 2023).
52. NDC compliance not enough, world may still be 2.5°C warmer by 2100: Study, https://www.downtoearth.org.in/news/climate-change/ndc-compliance-not-enough- world-may-still-be-2-5-c-warmer-by-2100-study-84071 (last visited Sep 5, 2023).
53. Outcome and Indian stance in COPs 1 - 21 - Indian Council of World Affairs (Government of India), https://www.icwa.in/show_content.php?lang=1&level=3&ls_id=607&lid=551 (last visited Sep 4, 2023).
54. PM's climate change council has not met in almost 7 years, https://www.downtoearth.org.in/news/climate-change/pm-s-climate-change-council- has-not-met-in-almost-7-years-80369 (last visited Sep 5, 2023).
55. Policy brief National laws and policies on climate change adaptation: a global review, https://primarysources.brillonline.com/browse/climate-change-and-law- collection/policy-brief-national-laws-and-policies-on-climate-change-adaptation-a- global-review;cccc014820190148510 (last visited Sep 5, 2023).
56. Scott Barrett, *Political Economy of the Kyoto Protocol*, 14 Oxford Review of Economic Policy 20 (1998).
57. Anjan Sahu, *Securitization of Climate Change: A Case Study of India's National Action Plan on Climate Change (NAPCC)*, 5 IUP Journal of History and Culture (2012).
58. Jagadish Thaker & Anthony Leiserowitz, *Shifting Discourses of Climate Change in India*, 123 Climatic Change 107 (2014).
59. K Krishna Kumar et al., *Simulated Projections for Summer Monsoon Climate over India by a High-Resolution Regional Climate Model (PRECIS)*, 101 CURRENT SCIENCE (2011).
60. Anu Jogesh & Navroz K. Dubash, *State-Led Experimentation or Centrally-Motivated Replication? A Study of State Action Plans on Climate Change in India*, 12 Journal of Integrative Environmental Sciences 247 (2015).
61. Rachel Brewster, *Stepping Stone or Stumbling Block: Incrementalism and National Climate Change Legislation*, 28 Yale L. & Pol'y Rev. 245 (2009).
62. Anu Jogesh & Mridula Mary Paul, *Ten Years After: Evaluating State Action Plans in India*, 86 Science and Culture 38 (2020).
63. Michal Nachmany et al., *The 2015 Global Climate Legislation Study: A Review of Climate Change Legislation in 99 Countries: Summary for Policy-Makers*, (2015), http://www.lse.ac.uk/GranthamInstitute (last visited Jun 20, 2023).
64. Thomas Harrisson, *The Carbon Brief Profile: India*, Carbon Brief (2019), https://www.carbonbrief.org/the-carbon-brief-profile-india/ (last visited Sep 4, 2023).

65. The Clean Development Mechanism | UNFCCC, https://unfccc.int/process-and- meetings/the-kyoto-protocol/mechanisms-under-the-kyoto-protocol/the-clean- development-mechanism (last visited Sep 5, 2023).
66. United Nations, *The Paris Agreement*, United Nations, https://www.un.org/en/climatechange/paris-agreement (last visited Sep 5, 2023).
67. Navroz K. Dubash, *The Politics of Climate Change in India: Narratives of Equity and Cobenefits*, 4 Wiley Interdisciplinary Reviews: Climate Change 191 (2013).
68. Harsh V. Pant, *The World in 2022: An Epilogue*, ORF, https://www.orfonline.org/research/the-world-in-2022-an-epilogue/ (last visited Sep 4, 2023).
69. These are the countries that have made climate commitments law, World Economic Forum (2019), https://www.weforum.org/agenda/2019/11/new-zealand-net-zero-2050/ (last visited Sep 1, 2023).
70. These are the US states where homes sell the slowest, Quartz (2023), https://qz.com/these-are-the-us-states-where-homes-sell-the-slowest-1850780178 (last visited Sep 1, 2023).
71. United Nations, *United Nations Conference on the Human Environment, Stockholm 1972*, United Nations, https://www.un.org/en/conferences/environment/stockholm1972 (last visited Sep 5, 2023).
72. What are the world's countries doing about climate change?, Imperial College London, https://www.imperial.ac.uk/grantham/publications/climate-change-faqs/what-are-the- worlds-countries-doing-about-climate-change/ (last visited Sep 3, 2023).
73. What is climate change legislation?, Grantham Research Institute on climate change and the environment, https://www.lse.ac.uk/granthaminstitute/explainers/what-is- climate-change-legislation/ (last visited Sep 5, 2023).
74. What's in it for South Asia | Climate & Development Knowledge Network, (2014), https://cdkn.org/resource/highlights-south-asia-ar5 (last visited Sep 4, 2023).
75. Namrata Patodia Rastogi, *Winds of Change: India's Emerging Climate Strategy*, 46 The International Spectator 127 (2011).

Abbreviations

AAP	Annual Action Plan
ADRI	Asian Development Research Institute
AHP	Analytic Hierarchy Process
AI	Artificial Intelligence
AIIMS	All India Institute of Medical Sciences
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
ANPR	Automatic Number Plate Recognition
ARYA	Attracting and Retaining Youth in Agriculture
ASHAs	Accredited Social Health Activists
ATCS	Adaptive Traffic Control System
ATM	ATM - Automated Teller Machine
BDA	Bangalore Development Authority
BJP	Bharatiya Janata Party
BSNL	Bharat Sanchar Nigam Limited
BWGs	Bulk Waste Generators
CBBOs	Community-Based Business Organizations
CBD	Central Business District
CBOs	Community Based Organizations
CBUD	Capacity Building for Urban Development
CDB	Central Development Board
CDPA	Comprehensive Development Plan Area
CEO	Chief Executive Officer
CMO	Context-Mechanism-Outcome
CoWIN	Covid Vaccine Intelligence Network
CPCB	Central Pollution Control Board
CSE	Centre for Science and Environment
CWC	Central Water Commission
DALYs	Disability Adjusted Life Years
DDWS	Department of Drinking Water and Sanitation
DICCC	Doon Integrated Control and Command Centre
DPR	Detailed Project Report
DSCL	Dehradun Smart City Ltd.
DWWT	Decentralized Wastewater Treatment
EFB	Eco-Filtration Bank
EPR	Extended Producer’s Responsibility
ERCP	Eastern Rajasthan Canal Project
ETS	Emissions Trading System
EU	European Union
FFBT	Fixed-Film Bio-filter Technology
FPO	Farmer Producer Organization
FTKs	Field Test Kits

GDP	Gross Domestic Product
GHG	Greenhouse Gas
GI	Geographical Indication
GIC	Government Inter College
GIS	Geographic Information System
GPAI	Global Partnership on AI
GSDP	Gross State Domestic Product
HDI	Human Development Index
HDPE	High Density Polyethylene
HH	Household
IDA	International Development Association
IEC	Information, Education, and Communication
IIP	Index of Industrial Production
INR	Indian Rupees
IOP	Institute of Physics
IPR	Intellectual Property Rights
IRNSS	Indian Regional Navigation Satellite System
IRS	Informal Recycling Sector
IS	Implementation Science
ISO	International Organization for Standardization
ITDA	Integrated Traffic and Data Analysis
IUAC	Inter University Accelerator Centre
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
KLD	Kilo Liters per Day
KM	Knowledge Management
KRCs	Key Resource Centres
KRWSSA	Karnataka Rural Water Supply and Sanitation Agency
LA	Land Acquisition
LBs	Local Bodies
LDPE	Low Density Polyethylene
LiFE	Lifestyle for Environment
LPCD	Liters per Capita per Day
LULC	Land Use and Land Cover
M&E	Monitoring and Evaluation
MCD	Municipal Corporation of Delhi
MDDA	Mussoorie Dehradun Development Authority
MeitY	Ministry of Electronics and Information Technology
MIT	Massachusetts Institute of Technology
MLD	Million Liters per Day
MLP	Multilayered Plastic
MoHUA	Ministry of Housing and Urban Affairs
MoU	Memorandum of Understanding
MRF	Material Resource Facility
MRTS	Mass Rapid Transit System

MSW	Municipal Solid Waste
NA	Not Applicable
NABARD	National Bank for Agriculture and Rural Development
NCDs	Non-Communicable Diseases
NCR	National Capital Region
NCRPB	National Capital Region Planning Board
NDMC	New Delhi Municipal Corporation
NFHS	National Family Health Survey
NGO	Non-Governmental Organization
NGT	National Green Tribunal
NIC	National Informatics Centre
NIH	National Institutes of Health
NIT	National Institute of Technology
NITI	National Institution for Transforming India Aayog
NIUA	National Institute of Urban Affairs
NJJM	National Jal Jeevan Mission
NRLM	National Rural Livelihood Mission
NRW	Non-Revenue Water
O&M	Operation & Maintenance
OBC	Other Backward Classes
ORF	Observer Research Foundation
OSM	OpenStreetMap
PE	Peer Education
PEARL	Peer Experience and Reflective Learning
PET	Polyethylene terephthalate
PHE	Public Health Engineering
PHED	Public Health Engineering Department
PHFI	Public Health Foundation of India
PIBOs	Producers, Importers, Brand Owners
PPP	Public-Private Partnership
PRODES	Programa de Despoluição de Bacias Hidrográficas
PS	Polystyrene
PVC	Polyvinyl Chloride
PWS	Pipe Water Supply
QR	Quick Response Code
QRT	Quick Reaction Team
R&D	Research and Development
RDF	Refuse Drive Fuel
RHIs	Regional Hub Institutions
RKSK	Rashtriya Kishor Swasthya Karyakram
RLVD	Red Light Violation Detection
RTDAI	Real-Time Digital Identity Authentication
RTP	Rapid Training Program
RWA	Residents Welfare Association

SBCC	Social and Behavior Change Communication
SBT	Soil Biotechnology
SCM	Smart City Mission
SCs	Scheduled Castes
SDGs	Sustainble Devlopment Goals
SFAC	Small Farmers Agriculture Consortium
SHG	Self Help Group
SNA	System of National Accounts
SPV	Special Purpose Vehicle
SRH	Sexual and Reproductive Health
SRTU	Safe Re-Use of Treated Used water
SRTW	Safe Re-Use of Treated Wastewater
SSF	Soil Sand Filter
STs	Scheduled Tribes
SWM	Solid Waste Management
TDE	Theory-Driven Evaluation
TK	Traditional Knowledge
TNA	Training Need Assessment
TPD	Tonnes Per Day
UAR	Urban Area Ratio
ULB	Urban Local Body
UMANG	Unified Mobile Application for New-age Governance
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
UPCL	Uttarakhand Power Corporation Limited
UPI	Unified Payments Interface
USA	United States of America
VAT	Value Added Tax
VWSC	Village Water and Sanitation Committee
WASH	Water, Sanitation and Hygiene
WASMO	Water and Sanitation Management Organization
WBG	World Bank Group
WHO	World Health Organization
WRG	Water Resource Group
WRI	World Resources Institute
WtE	Waste to Energy
ZA	Zonal Atlas

सत्यमेव जयते

NATIONAL CENTRE FOR GOOD GOVERNANCE

Department of Administrative Reforms and Public Grievances

Ministry of Personnel, Public Grievances and Pensions

Government of India