National Centre for Good Governance

An autonomous & apex-level institution of Government of India

SUMMER INTERNSHIP PROGRAMME-2023

(New Delhi)

INNOVATION AND ENTREPRENEURSHIP

ORGANIC WASTE MANAGEMENT (SBM- G)

ORGANIC WASTE MANAGEMENT AND ENERGY RECOVERY IN INDIA WITH SPECIAL FOCUS ON GOBARDHAN SCHEME UNDER SBM 2.0

SUBMITTED BY:

SURYAKANT KUMAR

M.Sc. Agri-Business Economics (SEM-II)

Gokhale Institute of Politics and Economics, Pune, Maharashtra

Dated- July 2023

SUPERVISED BY:

MISS SRAVANTHI JEEVAN

ASSISTANT ADVISOR (PHE), CPHEEO

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.

TABLE OF CONTENTS

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 its strategy. 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.

1.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.

2. INTRODUCTION

2.1 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 constant prices). The amount 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. The management 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 urbanised (McKinsey Global Institute 2010).

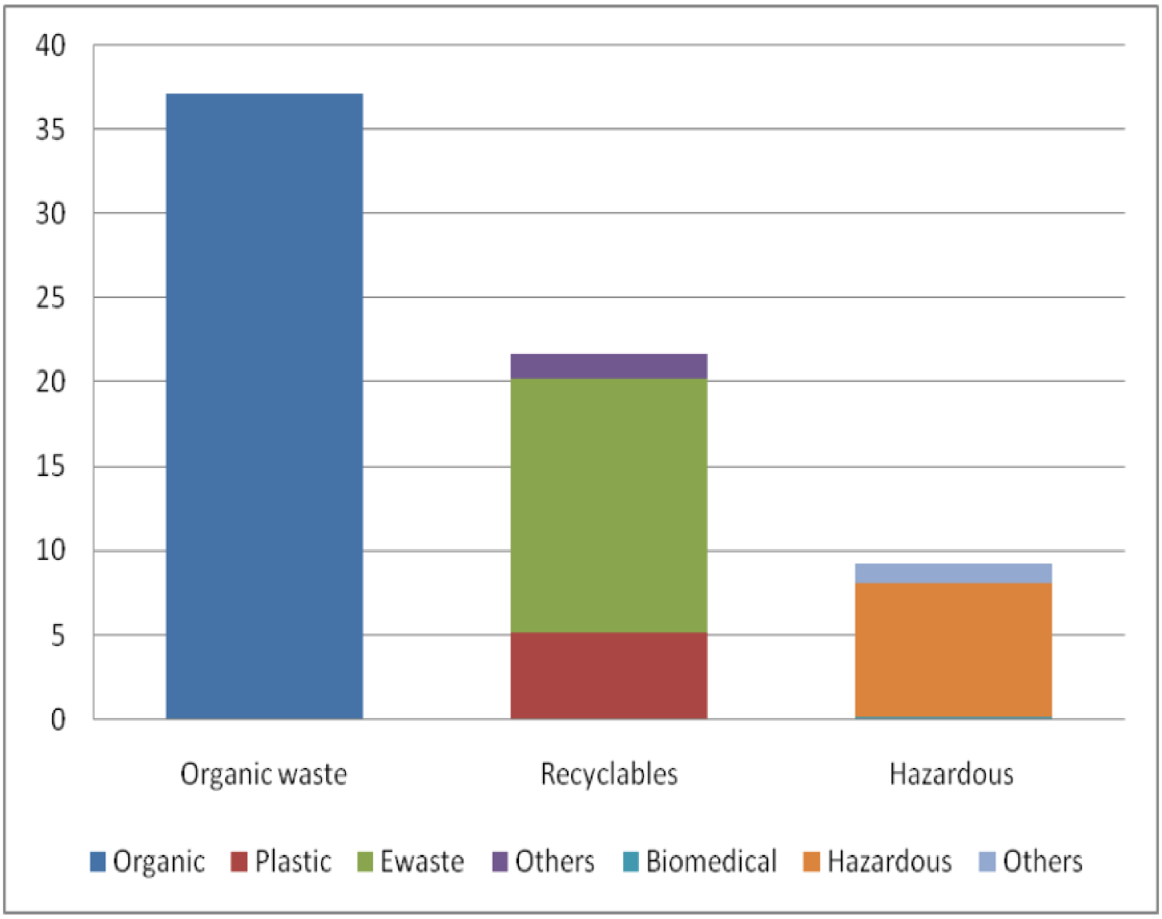


Figure 1: Waste Composition of India, in Million Metric Tonnes per annum.

SOURCE: PIB2016

2.2 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.

2.3 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 the mission 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.

2.4 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 be encouraged through Information, Education, and Communication (IEC) activities to construct biogas plants using their resources or support obtained from 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/organic manure.

Source of fund: Funding can be sourced from various avenues such as NNBOMP, SBM-G, 15th Finance Commission, MPLAD, MLALAD, and other State schemes.

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, and entrepreneurship in rural areas.

2.5 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 emphasizes the 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, highlighting its environmental and socio-economic benefits.

3. SOLID WASTE MANAGEMENT

3.1 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 economic crisis.

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 and domestically 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.

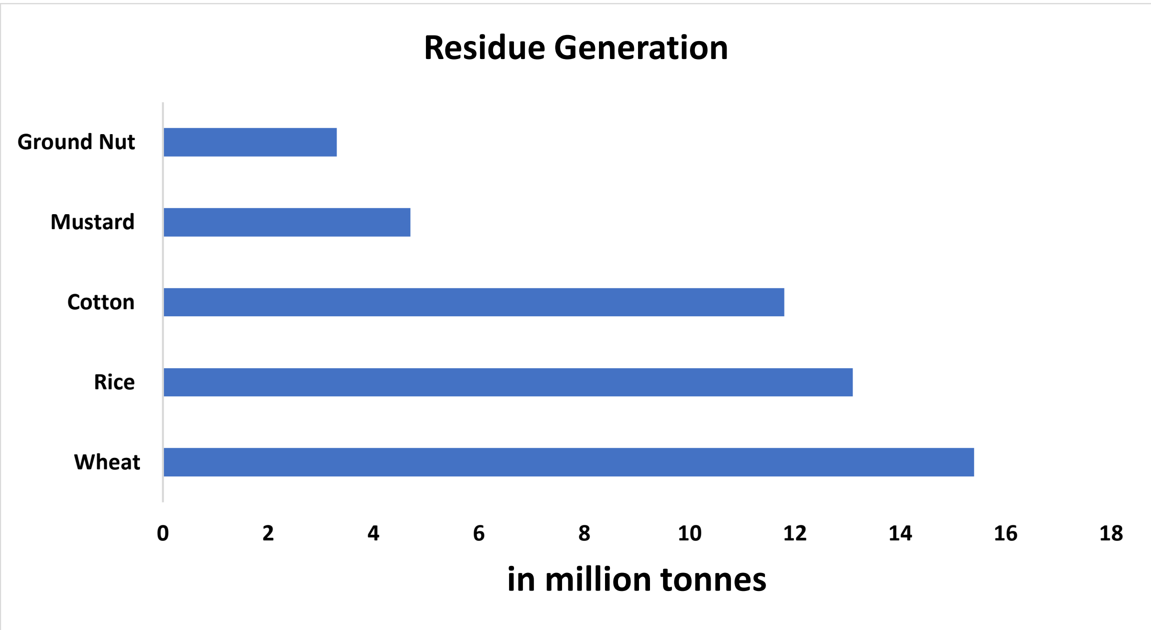
Moreover, the promotion of biofuels aligns with India's commitments to combat climate change and reduce greenhouse gas emissions. By transitioning from fossil fuels to biofuels, the country can significantly lower its carbon footprint and contribute to global efforts in addressing climate-related challenges. 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 sustained support and further development of biofuels will play a pivotal role in securing a resilient and self-reliant energy future for India.

3.2 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.

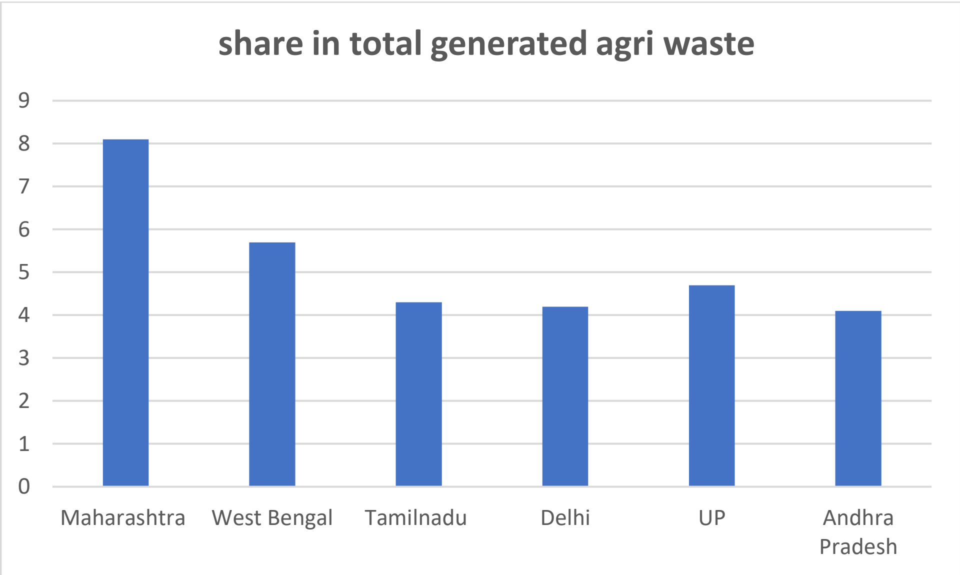
Figure-2 Crop wise contribution of waste



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 at large 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.

3.3 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 a great 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 utilised as an organic fertiliser instead of chemical fertiliser in agriculture. Conversion of cow dung into vermin-compost will be an additional source of income for the farmer but will also replace chemical fertiliser and will enrich the environment. The sale of organic fertilisers increased at 4.8 percent CAGR between 2017 and 2021, with states such as Madhya Pradesh, Maharashtra, Karnataka, Rajasthan, Uttar Pradesh, and Orissa accounting for a substantial portion of the Indian market. The organic fertilisers 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 12 household 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 CH_4 (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)

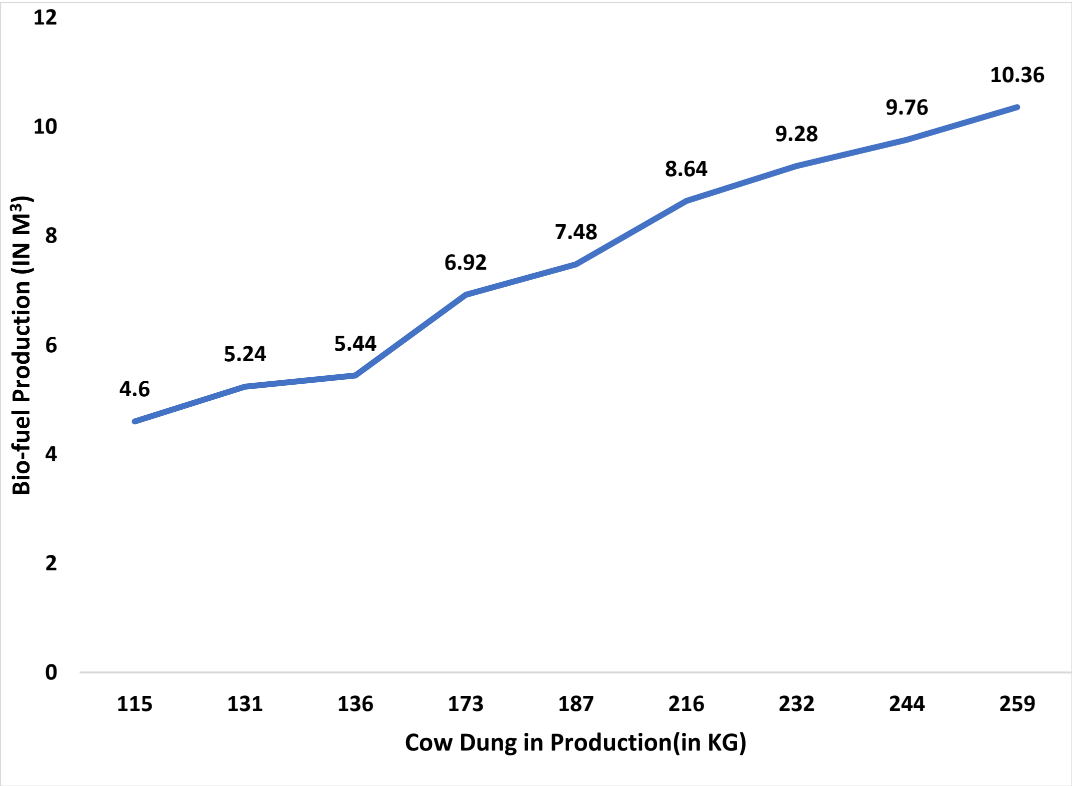
Y= Dependent variable (Bio- fuel produced from used cow dung)

After regressing X on Y we get value of $R^2 = 1$, 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 and House 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-fertiliser, helps in better yield, 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 fully harness 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.

3.4 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 may struggle 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.

3.5 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 solid waste 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 and heat. 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 gain more importance and effect in past few decades and one of the best way 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 minimise at the initial phase of waste generation that would be the best way to utilize waste management concept. It need 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 part 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. There are multiple chemical reactions occurs during the whole process CBG production. One of the major reaction 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 phase 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.

4. COMPILATION OF PREVALING POLICIES AND THEIR EFFECT

4.1 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 BI0-GAS PLANTS

Column1	Column2	Column3	Column4
S.No	State Name	Total Installed Capacity of Bio-Gas (in m3)	Total Installed Capacity of commercial CBG plants(in kg)
0	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 operational in 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.

4.2 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 number of 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 used in 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 the biogas 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 regulatory authorities.

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 issues 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.

4.3 CASE STUDY OF AN IDEAL CITY IN WASTE MANGEMENT – 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 Indore CBG 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.

5 CONCLUSION

5.1 SUMMARIZTION

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 analyse the potential of agricultural and industry waste for biofuel production. The study also examines modern 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.

5.2 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 develop innovative 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 on chemical 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.

BIBLIOGRAPHY

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/164241468178757464/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.