Study on Sustainable Agriculture: Pathways for Climate-Resilient Farming Practices, 2023

Kuntal Ghosh
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ABSTRACT

In this current situation the use of organic fertilizer to be a viable option for restricting the spread of chemical fertilizer. The proposed project, led by the Indian Institute of Social Welfare and Business Management (IISWBM), focuses on addressing the critical issue of organic waste disposal in urban and agricultural settings. By introducing an innovative Organic Waste Decomposer, composed of microbial consortia and enzymes, the project aims to transform decomposable materials into carbon and nutrient-rich organic manure. The technology's efficacy has been validated by the Indian Agriculture Research Institute in Gujarat. The project targets methane emission reduction by applying the decomposer to animal dung and agricultural waste, generating carbon credits in alignment with UNFCCC methodologies. With a focus on waste handling, livestock management, and organic fertilizer production, the project contributes to sustainable practices. Ownership lies with Kuntal Ghosh, a student at IISWBM, and collaboration includes a technical consultant, Mr. Abhijit Chatterjee. The project demonstrates a feasible solution to reduce greenhouse gas emissions and prevent burning of agricultural residues, fostering environmental sustainability.

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CHAPTER ONE
EXECUTIVE SUMMARY

Methane, despite being present in smaller quantities than carbon dioxide, is a powerful contributor to climate change. Its impact on global warming is over 28 times greater than that of carbon dioxide over a century as per Inter-Governmental Panel on Climate Change Assessment Report Five,2014 ((AR-5, 2014)). This means that even small reductions in methane emissions can have a significant positive effect on the climate.

Improving agricultural practices can be a key approach to mitigating methane emissions. Implementing measures such as better animal diets, efficient manure management techniques, and improved rice cultivation methods can significantly reduce methane release from these sources.

The project **"Study on Sustainable Agriculture : Pathways for Climate-Resilient Farming Practices, 2023"** aims to reduce methane emissions, enhance soil health, and promote sustainable development in the agricultural sector. By implementing waste decomposers and advocating for sustainable organic farming practices, the project seeks to mitigate climate change, improve resource management, and provide economic benefits to farmers. Through research, field trials, training, and awareness campaigns, the project aims to achieve significant methane emission reduction, soil fertility enhancement, efficient waste management, and contribute to the overall sustainable development goals in India.

It By reducing methane emissions and promoting sustainable organic farming, the project supports environmental conservation, enhances agricultural productivity, and can fosters a circular economy. Through collaboration with farmers, scientific research, and widespread of knowledge, the project strives to drive sustainable development in India's agricultural sector, paving the way for a greener and more resilient future.

The present report tries to form aims to create a paradigm shift in waste management practices by harnessing the potential of waste decomposers to convert organic waste into valuable resources.. The objectives of this report are threefold, namely:

First, to conduct Methane(CH4) accounting at Baseline Emission and Emission Reduction inventory development of the current state of GHG emissions from various Organic Wastes in India;

Second, to achieve a low carbon economy by developing nature-based solutions in the agriculture sector and promoting organic farming in India.

Third, to develop pathways for 2040 in Indian Agricultural sector which will contribute to sustainable development in India.

The report's first section analyses emissions from cattle dung and agriculture residues and discovers that the one ton of cattle dung is responsible for up to 0.246 million metric tons of CO2e emissions. Although, with more usage of organic fertilizer in the state, maybe replacing chemical fertilizers, could result from a rise in demand for organic waste decomposers. Organic waste decomposer is a greener alternative that would reduce India’s GHG emissions.

Regarding the second, this research examines various possibilities for the agriculture sector and Livestock enterprises potential for low-carbon trajectory.

Finally, the report takes a brief look at longer-term measures that need to be adopted to develop low carbon pathways for the agriculture sector in India, through pathways of further studies to analyses potential for climate resilient farming.

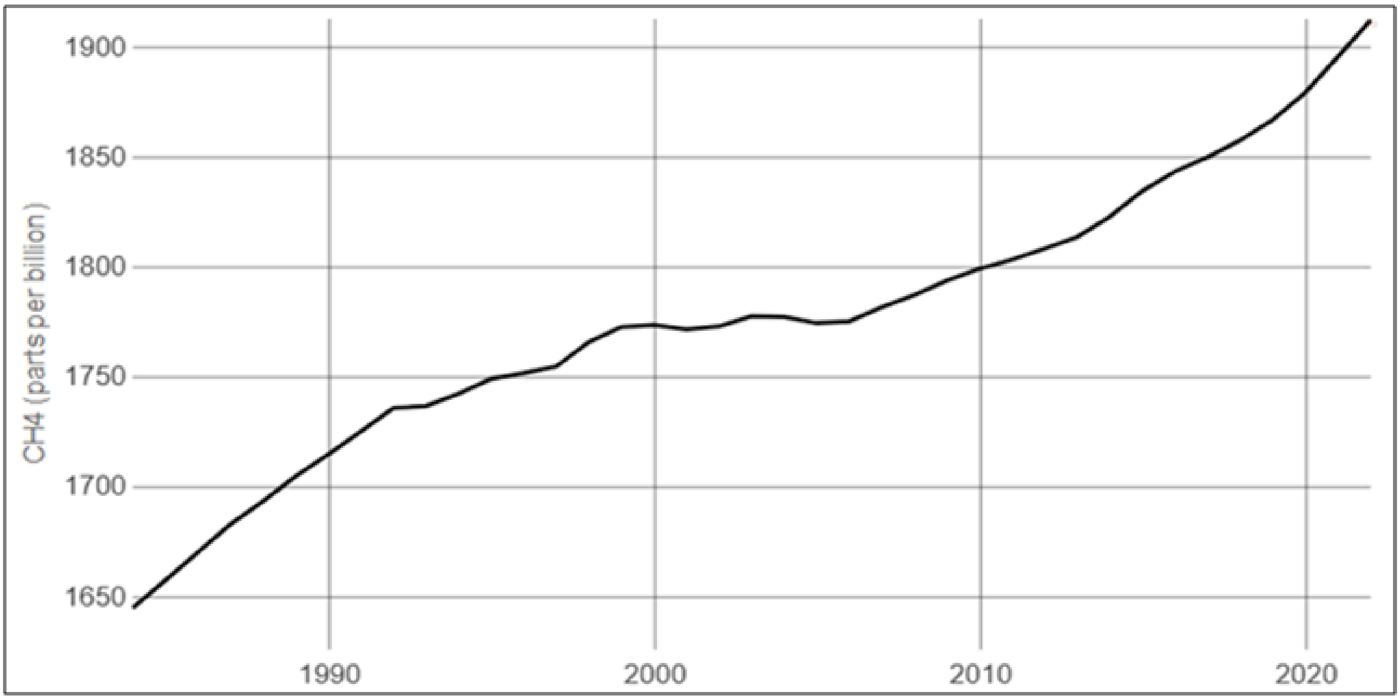

Fig 1 Atmospheric Methane Concentration Since 1984
Source - NOAA

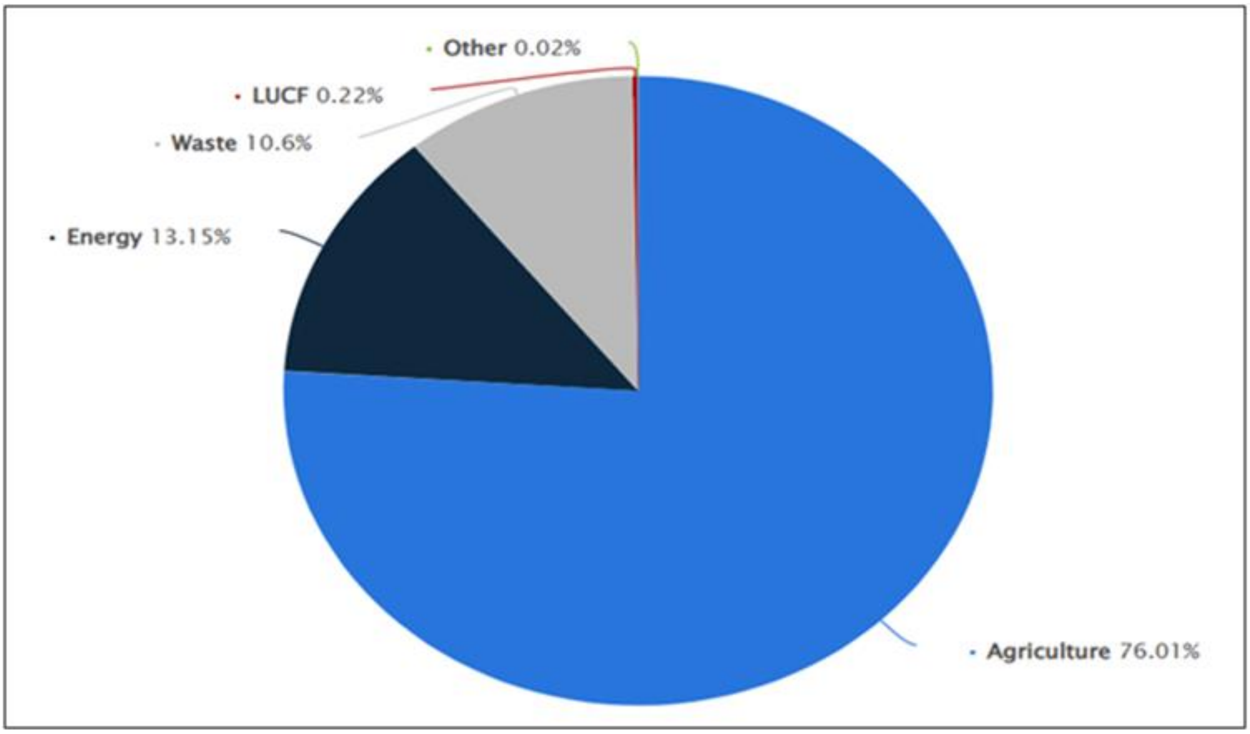

Fig 2 Sector-Wise Distribution of Methane
Source – Statista.com

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CHAPTER TWO
CONTEXTS

Methane (CH4) is a powerful greenhouse gas, and is the second-largest (NASA, 2023) contributor to climate warming after carbon dioxide (CO2). Methane molecules trap more heat than CO2 molecules do, but they only live in the atmosphere for 7 to 12 years as opposed to hundreds of years or more for CO2.

Both natural and human-made sources produce methane. Methane emissions from today are thought to be caused by human activity to the extent of 60%. The main sources of methane are fossil fuels, landfill waste decomposition, and agriculture. Wetlands are the main source of natural methane emissions, which make up 40% of total emissions. Over the last 200 years, the amount of methane in the atmosphere has more than doubled. According to scientific estimates, since the Industrial Revolution, 20 to 30 percent of the global warming has been caused by this rise (which began in 1750) (NASA, 2023) shown in above fig.

Methane emissions in India totaled 658.09 million metric tons of carbon dioxide equivalent in 2019 (Statista, 2019). It shows that three quarters of all methane emissions in that year came from the agriculture sector. Livestock accounts for the majority of methane emissions from the agricultural sector. In India, landfills are another significant source of methane emissions; over 10% of methane emissions come from the garbage industry.

Five times as much methane is released into the atmosphere by the agriculture sector in India, the second-biggest producer of rice in the world and home to the greatest number of cattle worldwide. According to the Global Methane Tracker 2022, India's energy sector contributes 16.4% of methane emissions, trash accounts for 19.8%, and agriculture accounts for 61% of overall methane emissions. (IEA, 2023).

The US and the European Union declared in September 2021 that they would support the Global Methane Pledge at the Major Economies Forum (MEF) on Energy and Climate, which was scheduled to be introduced at the 26th Conference of Parties (COP26) of the UNFCCC in Glasgow in November 2021. The Glasgow promise, which calls for a 30% reduction in methane emissions from 2020 levels by 2030, was signed by 103 nations. However, Russia, China, and India—three of the top four methane emitters—did not sign the commitment. (IndiaSpend, 2023).

The Ministry of Environment, Forest and Climate Change (MoEFCC) also cited the threat to small farmers' livelihood in its reasons for not signing up to the methane pledge, and pointed to a number of initiatives it has taken to reduce methane emissions, in the Union Government's reply to Parliament. According to experts, these plans would not have much of an impact considering the amount of methane emissions coming from India. In the government's December 2021 response to Parliament, Union environment minister of state Ashwini Kumar Choubey mentioned a number of programs including the National Livestock Mission and the Galvanizing Organic Bio-Agro Resources (Gobar-Dhan) scheme, which was introduced in 2018 and is in progress with the aim of reducing methane in various sectors.

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CHAPTER THREE
REVIEW OF LITERATURE

Table 1 Literature Review

Title and Year	Description	Author
"Sustainability in global agriculture driven by organic farming",2019.	In order to achieve the Sustainable Development Goals of the United Nations by 2030, agricultural methods must alter. There is much debate on how to accomplish the SDGs. Here, we suggest a framework of policies that initiates the necessary shift. While not a panacea, organic farming can be a valuable element of such a plan.	Frank Eyhorn, Adrian Muller, John P. Reganold, Emile Frison, Hans R. Herren, Louise Luttikholt, Alexander Mueller, Jürn Sanders, Nadia El-Hage Scialabba, Verena Seufert & Pete Smith
Reducing agriculture emissions through improved farming practices, April,2020.	Although commonly acknowledged, the contribution of the agriculture industry to greenhouse gas (GHG) emissions is poorly understood. The truth is that land-use change, forestry, and agriculture account for more than 25% of global greenhouse gas emissions. And if nothing is done about it, these emissions will probably get worse as the world's population grows and the need for food rises. Agriculture and climate change, our most recent report, takes a closer look at these problems.	Daniel Aminetzah Nicolas Denis Kimberly Henderson Joshua Katz and Peter Mannion
Sustainable Agriculture in India 2021, COUNCIL ON ENERGY, ENVIRONMENT AND WATER (CEEW).	This report presents an assessment of the current status of sustainable agriculture practices and systems (SAPSs) in India in cooperation with the Food and Land Use Coalition (FOLU). In the framework of a future with limited resources due to climate change, it seeks to assist administrators, donors, policymakers, and others in supporting an evidence-based scaling-up of SAPSs. Using agroecology as an analytical lens, the study identified 16 SAPSs, including agroforestry, crop rotation, rainwater collection, organic farming, and natural farming. It comes to the conclusion that sustainable agriculture is not common in India based on a thorough examination of sixteen practices. Additionally, it suggests a number of actions to advance SAPSs, such as reorganized government assistance and meticulous evidence production.	Niti Gupta Shanal Pradhan Abhishek Jain Nayha Patel

CHAPTER FOUR
OBJECTIVE AND PURPOSE FOR THE PROJECT

- Cracking the Methane Equation to calculate the methane emissions generated during the composting process of various organic waste sources such as cow dung, agricultural residue, and municipal solid waste. This involves assessing the magnitude of methane emissions and understanding their environmental impact.

- Assess the Impact of Organic Fertilizers reducing methane emissions. By calculating the potential reduction in methane emissions through the use of organic fertilizers, I aim to showcase the environmental benefits of organic fertilizer adoption.

- Develop Scenarios for a Low Carbon Economy: One of the purposes of my project is to develop scenarios that outline pathways towards a low carbon economy in the agricultural sector. This includes identifying strategies, policies, and technological innovations that can promote sustainable farming practices, mitigate greenhouse gas emissions, and contribute to India's climate change targets.

- Decoding Organic Waste's Environmental Legacy is one of the genuine purposes of this project is to generate valuable insights and knowledge that can inform sustainable waste management practices and facilitate the development of effective environmental policies. By understanding the environmental legacy of organic waste, stakeholders, including policymakers, waste management agencies, and farmers, can make informed decisions to minimize negative impacts and maximize the potential benefits.

CHAPTER FIVE
PROJECT DETAILS

➢ Summary Description

An organic waste decomposer, which is made up of microbial consortia and enzymes, to combat the issue of garbage disposal. Waste decomposer is a great soil property enhancer since, according to its working principle, it transforms all decomposable materials into carbon and nutrient-rich organic manure.

This substance, refers to the waste decomposer, can be applied in various application such as animal dung, municipal organic waste, farm waste and other organic decomposable substance. The organic fertilizer made from the waste decomposers' dung has a high carbon and nutrient content. The technology proof of concept can also be validated by Indian Agriculture Research Institute's Directorate of Medicinal and Aromatic Plants (DMAPR) at Anand, Gujarat for conversion of organic waste into manure in a lesser time.

The proposed project will calculate Methane emission reduction (ER) by introducing and adopting waste decomposers as an organic waste decomposer to treat animal manure and agricultural waste. The proposed project is intended to solve environmental issues brought on by the disposal of these waste in urban and agricultural settings by generating carbon credits through emission reduction scheme of Voluntarily Carbon Standard (VCS) or The Gold Standard which is in line with the United Nations Framework Convention for Climate Change (UNFCCC) methodologies. . The project activity thus result into reduce greenhouse gas (methane) emissions, stop agricultural residue from being burned, and generate carbon credits through controlled aerobic treatment by composting of Cattle manure and agricultural waste.

In absence of the project, Cattle manure and agricultural waste produced was left to decay at the project sites, which is the most economic, viable and reasonable for livestock farm owners. In some cases, the agricultural waste is often burned at the site to recover the land for next harvesting.

The project activity does not recover or combust landfill gas from the disposal site and does not undertake controlled combustion of the waste that is not treated biologically in a first step.

➢ Sectoral Scope and Project type

The project falls under UNFCCC sectoral scope 13: Waste handling and disposal and sectoral 15: Livestock and manure management.

This Project is not a grouped project.

➢ Project Eligibility

The Project is eligible under the scope of United Nations Framework Convention on Climate Change (UNFCCC) program because:

- Six Kyoto Protocol greenhouse gases: The project activity results in methane (one of the six Kyoto Protocol Greenhouse gases) emission reduction. Thus, the project applicable to this scope.
- Project activities supported by the applied methodology AMSIII.F (Version 12.0) is approved under Clean Development Mechanism (CDM) Program, which is an Inter-Governmental Panel on Climate Change (IPCC) approved GHG program.

➢ Project Proponent

Table 2 Led by and Project Proponent

Organization name	Indian Institute of Social Welfare and Business Management (IISWBM)
Contact person	Kuntal Ghosh
Title	Sustainability Consultant – Analyst Intern
Address	Tantisal, Arambag, Hooghly, West Bengal, India, 712412

➢ Other Entities Involved in the Project

Table 3 Collaboration of Stakeholder

Organization name	Individual
Role in the project	Project Design Document development and carbon asset syndication
Contact person	Mr. Abhijit Chatterjee
Title	Technical consultant

Address	Delhi, India
Telephone	+91 98xxx xxxxx

- Ownership

The owner of the project is Kuntal Ghosh who has the legal rights to control and operate the project activities. Kuntal Ghosh retains the ownership of this model developed, as well as assets and liabilities arising wherefrom, out of resultant emission service. Kuntal Ghosh is a registered student of Indian Institute of Social Welfare and Business Management in India.

- Description of Activity that will Result in Net Emission Reduction (ER)

Organic Waste Decomposer is a microbial consortium consisting of novel strains of bacteria (pseudomonas and bacillus) and actinomycetes that are widely involved in the decomposition of organic waste materials. Organic Waste Decomposer is a great soil property enhancer since, according to its working principle, it transforms all decomposable materials into carbon and nutrient-rich organic manure. This substance, Organic Waste Decomposer, can be applied in various application such as animal dung, municipal organic waste, farm waste and other organic decomposable substance. It can decompose both animal waste and crop residue with carbon rich [up to 3.5%] manure and up to 3.5-5% of micro and macro nutrients.

The proposed project will analyze the adoption of Organic Waste Decomposer as an organic waste decomposer to treat animal manure and agricultural waste. The proposed project is intended to solve environmental issues brought on by the disposal of these waste in urban and agricultural settings.

The project activity will help reduce greenhouse gas (methane) emissions, stop agricultural residue from being burned, and generate carbon credits through controlled aerobic treatment by composting of Cattle manure and agricultural waste.

Agriculture and municipal solid waste sector will be the specific consumers of Organic Waste Decomposer. The various methods of spraying are direct spray on residues, spray using happy seeder drill, spray after mixing residues in soil, foliar spray followed by irrigation.

From the trial that were carried out at farm site, it was observed that the decomposition efficiency of spraying after mixing residues in soil is the most promising, with 80-90% on a paddy field. Other methods like Foliar spray followed by irrigation has 70-85% decomposition whereas spray using happy seeder drill has 60-70% decomposition efficiency. Happy seeder drill method got good responses from most numbers of farmers considering its compatibility and rotary plough operation which led to proper mixing of soil and residues resulting in better decomposition. Direct spray method was observed to have the lowest decomposition efficiency of 50-60%.

The project in future can introduce methods such as spray using happy seeder drill and spray after mixing residues in soil which will ensure proper spraying of Organic Waste Decomposer and decomposition of waste. However, there will be, in some cases, where farmers opt for direct/ manual spraying.

On an average, 75g Organic Waste Decomposer is required to treat 1 ton of Cattle manure whereas 187.5g of Organic Waste Decomposer is required to treat 1 ton of agricultural waste.

In the baseline scenario, the animal dung, mainly Cattle dung is disposed in pit storage below animal confinements for more than 1 month at the farm site/ project site. The animal dung is decomposed anaerobically to form manure and generates methane into the atmosphere during the process. The project activity converts anaerobic decomposition into aerobically decomposed farmyard manure. Thus, generating methane avoidance and other environmental benefits.

Additionally, in the baseline scenario, there are agricultural waste/ crop residues left at the farm site/ project site after harvesting which are either burnt or decomposes anaerobically, leading to methane emissions to the atmosphere. In the proposed project activity, the agricultural waste will be treated with Organic Waste Decomposer to convert the anaerobic decomposition to aerobic decay avoiding methane emissions.

- *The Flow Diagram of the Activity has to be Performed is Shown in Figure 1 below.*

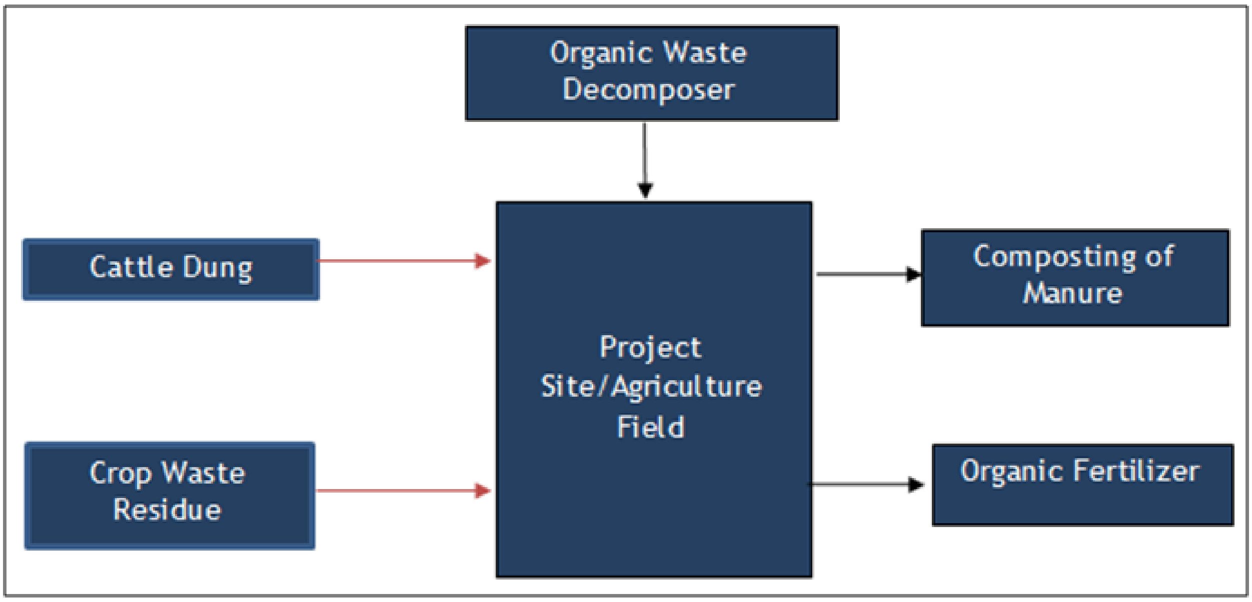

Fig 3 Activity

➢ Compliance with Laws, Policies and Other Regulatory Frameworks

The project activity complies with all relevant laws and regulations of India (host country) including the following:

Table 4 Compliance with Laws and Policies

#	Policy/ regulations	Year	Description
1	National Policy for Management of Crop Residues (NPMCR)	2014	In 2014, the Ministry of Agriculture developed a National Policy for Management of Crop Residue (NPMCR) to prevent agricultural residue burning and circulated the same to all states/union territories.
2	National Biogas and Manure Management programme	2014	The National Biogas and Organic Manure Programme's goals are to enhance organic manure systems based on biogas and organic manure, as well as to supply clean cooking fuel for kitchens, lighting, and other thermal and small power needs of farmers, dairy farmers, and users, including individual households.
3	Solid Waste Management Rules, 2016 and subsequent amendment in 2020	2016, 2020	The Solid Waste Management (Amendment) Rules, 2020 have been released by the Ministry of Environment, Forests, and Climate. Every village with a population of more than 3,000 is now subject to the updated rule, and the responsibilities of local authorities as outlined in section 15 have been modified as follows: The Local Authorities are responsible for gathering and transporting domestic hazardous waste, non-hazardous waste, and waste that is biodegradable from homes, including those in slums and informal settlements, multi-story buildings, large commercial complexes, malls, housing complexes, and the like, to the appropriate processing facility in covered and compartmentalized vehicles.
4	The Swachh Bharat Abhiyan (Clean India Mission) in 2014	2014	Under this mission, the government has launched various initiatives and policies to promote sustainable waste management practices, including composting of organic waste.
5	Paramparagat Krishi Vikas Yojana (PKVY), in 2015	2015	It aims to promote organic farming and improve soil health by providing financial assistance to farmers for adopting organic farming practices, including the use of organic fertilizers

➢ Additional Information Relevant to the Project

- *Leakage Management*

In project activity, the method of spraying of Organic Waste Decomposer on the Cattle dung or agricultural waste is important to ensure that there are no leakage emissions, and all waste is treated aerobically to avoid methane emissions. The various methods of spraying are direct spray on residues, spray using happy seeder drill, spray after mixing residues in soil, foliar spray followed by irrigation. The spray using happy seeder drill and spray after mixing residues in soil gives better results in terms of decomposition of waste based on the trials which were carried out by the project proponent.

The project will introduce methods such as spray using happy seeder drill and spray after mixing residues in soil which will ensure proper spraying of Organic Waste Decomposer and decomposition of waste. However, there will be, in some cases, where farmers opt for direct/ manual spraying. This will lead to leakage emissions. Therefore, leakage emissions to the tune of 5% of baseline emissions have been considered.

- *Sustainable Development*

The project has strong contribution to the global Sustainable Development Goals (SDGs) by virtue of its positive emission reduction and sustainable resource consumption. It also contributes to the overall resilience of the cattle owners and the farming and helps in an environmentally friendly way of disposal of organic waste. The project activity contributes towards following sustainable development:

Environmental Well Being: The Project activity will also contribute towards a cleaner environment. In the present situation, cattle waste and agricultural waste are being dumped in an unscientific manner, thereby causing emissions of greenhouse gases (mostly methane) in an uncontrolled manner. The proposed project activity will generate employment in the region and will also equip them with knowledge of the bio fertilizer manufacturing process.

Social Well Being: In the present scenario, cattle waste is dumped in pit storage below animal confinements for more than 1 month and is left to decay in an unscientific manner. These waste matters over a period get decomposed and emit gases such as methane into the atmosphere, giving rise to obnoxious smell. With the implementation of the project activity the region would be free from such problems and will make it a better place to live in.

End poverty: This project will also improve soil condition by providing organic fertilizer for local people, boosting farm crop production, and promoting the incomes of local farmers which is in line with SDG 1 (End poverty in all its forms everywhere).

Table 5 Contribution to Sustainable Development Goals

Project contribution towards Sustainable Development Goals	
Sustainable Development Goals	**Linkage**
SDG – 13: Climate Action	The project conserves climate by reducing GHG emissions, helping in the disposal of organic waste and thereby having a positive effect on addressing the climate change.
SDG – 11: Sustainable Cities and Communities	Implementing this project will help in an easier way of disposal of organic waste and in a way help in reducing the air pollution that is caused because of incineration of the crop residues.
SDG – 1: End poverty in all its forms everywhere	This project will help enhance soil quality by supplying locals with organic fertilizer, increasing farm crop yield, and enhancing local farmers' earnings.

CHAPTER SIX
SAFEGUARDS

- No Net Harm

The project activities do not negatively impact the natural environment or local communities. The project promotes sustainable development by supporting small and marginal farmers in better management of their farmlands, replace traditional fertilizer by organic farmyard manure and promoting sustainable manure management. In addition, the project results in reduction of greenhouse gas emissions and environmental pollution caused by methane release.

- Environmental Impact

The project activities do not negatively impact the natural environment. The project activity results in reduction of greenhouse gas emissions and environmental pollution caused by methane release.

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CHAPTER SEVEN
APPLICATION OF METHODOLOGY

➢ Title and References

The following methodologies are applicable to the project activity:

- AMS-III.F Avoidance of methane emissions through composting, version 12.0
- For the baseline manure emissions, this methodology refers to "AMS-III.D: Methane recovery in animal manure management systems", version 21.0.

➢ *The Latest Version of the following Tools will also be used in this Project Activity:*

- Tool 04 – "Emissions from solid waste disposal sites" (Version 08.0)
- Tool 13 – "Project and leakage emissions from composting" (Version 02.0)
- All above methodology and tools can be found through:
- https://cdm.unfccc.int/Reference/tools/index.html

➢ Applicability of Methodology

Justification for the choice of the selected methodology is shown in the following table

Table 6 Applicability of Methodology

AMS-III.F Avoidance of methane emissions through composting, version 12.0	
Applicability Criteria	**Justification**
1. This methodology is applicable to the composting of the organic fraction of municipal solid waste and biomass waste from agricultural or agro-industrial activities including manure	Applicable. In the proposed project, Cattle manure and agricultural waste are composted by applying Organic Waste Decomposer.
2. This methodology includes construction and expansion of treatment facilities as well as activities that increase capacity utilization at an existing facility. For project activities that increase capacity utilization at existing facilities, project participant(s) shall demonstrate that special efforts are made to increase the capacity utilization, that the existing facility meets all applicable laws and regulations and that the existing facility is not included in a separate CDM project activity. The special efforts should be identified and described.	Not applicable.
3. This methodology is also applicable for co-composting wastewater and solid biomass waste, where wastewater would otherwise have been treated in an anaerobic wastewater treatment system without biogas recovery. The wastewater in the project scenario is used as a source of moisture and/or nutrients to the biological treatment process e.g. composting of empty fruit bunches (EFB), a residue from palm oil production, with the addition of palm oil mill effluent (POME) which is the wastewater co-produced from palm oil production.	Not applicable. The project does not involve co-composting wastewater and solid biomass waste.
4. In case of co-composting, if it cannot be demonstrated that the organic matter would otherwise been left to decay anaerobically, baseline emissions related to such organic matter shall be accounted for as zero, whereas project emissions shall be calculated according to the procedures presented in this methodology for all co-composted substrates.	Not Applicable. This project activity does not involve co-composting
5. The location and characteristics of the disposal site of the biomass, animal manure and co-composting wastewater in the baseline condition shall be known, in such a way as to allow the estimation of its methane emissions, using the provisions of AMS-III.G, AMS-III.E (concerning stockpile), AMS-III.D "Methane recovery in animal manure management systems" or AMS-III.H respectively	The location and characteristics of the disposal site of the Cattle manure and the agricultural waste in the baseline condition are well known. The estimation of manure methane emissions is as per the latest version of AMS III.D (Version 21.0) and that of biomass methane emissions as per the latest version of methodology tool 04 "Emission from solid waste disposal sites" (Version 08.0).
6. Blending materials may be added in the project scenario to increase the efficiency of the composting process (e.g. to achieve a desirable C/N ratio or free air space value), however, only monitored quantity of solid waste or manure or wastewater diverted from the baseline treatment system is used	No blending materials added in the project scenario.

for emission reduction calculation. Project activities for composting of animal manure shall also meet the requirements under paragraphs 3 and 4(c) of the latest version of AMS-III.D.	
7. For solid wastes diverted from a solid waste disposal site, the following requirement shall be checked ex ante at the beginning of each crediting period: (a) Establish that identified landfill(s)/stockpile(s) can be expected to accommodate the waste to be used for the project activity for the duration of the crediting period; or (b) Establish that it is common practice in the region to dispose of the waste in solid waste disposal site (landfill)/stockpile(s).	Prior to the project, the farm waste residue is left to decay anaerobically in agricultural land, which is the common practice in the region. Under the baseline conditions, the Cattle manure are disposed in pit storage below animal confinements for more than 1 month
8. The project participants shall clearly define the geographical boundary of the region referred in paragraph 11(b), and document it in the CDM-PDD. In defining the geographical boundary of the region, project participants should take into account the source of the waste i.e. if waste is transported up to 50 km, the region may cover a radius of 50 km around the project activity. In addition, it should also consider the distance to which the final product after composting will be transported. In either case, the region should cover a reasonable radius around the project activity that can be justified with reference to the project circumstances but in no case, it shall be more than 200 km. Once defined, the region should not be changed during the crediting period(s).	The waste being used in the project activity is Cattle manure and farm waste residue. The Cattle manure used in this project comes from local farm Similarly, the farm waste residue is in the field which is in the same as the project site, which is also within a radius of 50 km. The final compost used in the farmers land so the final product after composting will not be transported.
9. In case produced compost is handled aerobically and submitted to soil application, the proper conditions and procedures (not resulting in methane emissions) must be ensured.	The compost produced will be used as fertilizer for the soil itself.
10. In case produced compost is treated thermally/mechanically, the provisions in AMS-III.E related to thermal/mechanical treatment shall be applied.	This project activity does not involve thermal/mechanical treatment to the compost once it is produced.
11. In case produced compost is stored under anaerobic conditions and/or delivered to a landfill, emissions from the residual organic content shall be taken into account and calculated as per the latest version of the methodological tool “Emissions from solid waste disposal sites”.	The project does not involve storage of produced compost in an anaerobic condition, nor would it be delivered back to landfill.

- *Justification for the Choice of the Selected Tools are Shown in the Following*

Table 7 Tool 04 - SWDS

Tool 04 – “Emissions from solid waste disposal sites” (Version 08.0)	
Applicability Criteria	**Justification**
This tool provides procedures to calculate baseline, project or leakage emissions of methane from solid waste disposed or prevented from disposal at a SWDS.	Applicable. Agricultural waste is disposed of at the farm site after harvesting which leads to methane emissions. In the proposed project, agricultural waste is treated with Organic Waste Decomposer to avoid methane emissions.
The tool can be used to determine emissions for the following types of applications: (a) Application A: The CDM project activity mitigates methane emissions from a specific existing SWDS. Methane emissions are mitigated by capturing and flaring or combusting the methane (e.g. “ACM0001: Flaring or use of landfill gas”). The methane is generated from waste disposed in the past, including prior to the start of the CDM project activity. In these cases, the tool is only applied for an ex ante estimation of emissions in the project design document (CDM-PDD). The emissions will then be monitored during the crediting period using the applicable approaches in the relevant methodologies (e.g. measuring the amount of methane captured from the SWDS);	Not applicable.
The tool can be used to determine emissions for the following types of applications: (b) Application B: The CDM project activity avoids or involves the disposal of waste at a SWDS. An example of this application of the tool is ACM0022, in which municipal solid waste (MSW) is treated with an alternative option, such as composting or anaerobic digestion, and is then pre-	Applicable. The proposed project will treat the agriculture waste by applying Organic Waste Decomposer through aerobic composting.

vented from being disposed of in a SWDS. The methane is generated from waste disposed or avoided from disposal during the crediting period. In these cases, the tool can be applied for both ex ante and ex post estimation of emissions. These project activities may apply the simplified approach detailed in 0 when calculating baseline emissions.	
These two types of applications are referred to in the tool for determining parameters In the case that: (a) different types of residual waste are disposed or prevented from disposal; or that (b) both MSW and residual waste(s) are prevented from disposal, then the tool should be applied separately to each residual waste and to the MSW.	Not applicable. Residual waste is not disposed or prevented from disposal in the baseline or project case. Only agricultural waste is disposed at the field site.

Tool 13 "Project and Leakage Emissions from Composting" (Version 02.0)

Applicability Criteria	Justification
Typical applications of the tool include projects composting municipal solid wastes, agricultural wastes and digestate.	Applicable. The proposed project is designed to treat the Cattle manure and farm waste by applying Organic Waste Decomposer through aerobic composting.
The following sources of project emissions are accounted for in this tool: (a) CH4 and N2O emission from composting; (b) CO2 emissions from consumption of fossil fuels and electricity associated with composting; and (c) CH4 emissions from run-off wastewater associated with co-composting.	(a) CH_4 emission from composting are accounted. (b) CO2 emissions from consumption of fossil fuels and electricity associated with composting is not accounted because project activity does not require fossil fuel or electricity. (c) This project is not involving co-composting, therefore, no CH_4 emissions from run-off wastewater is generated.
The following source of leakage emissions is accounted for in this tool: (a) CH4 emissions from the anaerobic decay of the residual organic content of compost disposed of in a landfill or subjected to anaerobic storage.	Applicable. Although project activity will introduce equipment for proper spraying of Organic Waste Decomposer on the waste so that no leakage emission is encountered. However, in some cases, manual spraying may be used which could lead to leakage emissions
Transport emissions are not accounted for in this tool because it is assumed that similar transportation activities would occur in the baseline.	Transport emissions are not accounted.
The applicability conditions of the tools referred below also apply. This tool also refers to the latest approved versions of the following tools: (a) Methodological tool "Emissions from solid waste disposal sites" (b) Methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (c) "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" and (d) "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"	This project involves composting of agricultural waste through controlled aerobic treatment. Therefore, Methodological tool "Emissions from solid waste disposal sites" is applicable. The project activity does not involve use of fossil fuel or any electricity consumption or any gaseous stream therefore all other tools are not applicable.

➢ Project Boundary

According to methodology AMS-III.F., version 12.0, the project boundary applicable to the proposed project activity is the physical geographical site:

Table 8 Project Boundary

No.	Methodology requirement	Project activity
a.	Where the solid waste would have been disposed and the methane emission occurs in absence of the proposed project activity;	Included. In the absence of proposed project, the Cattle manure are left to decay as in pit storage below animal confinements for more than 1 month and the agricultural waste decay at the farm land
b.	In the case of projects co-composting wastewater, where the co-composting wastewater would have been treated anaerobically in the absence of the project activity;	The project does not involve co-composting of wastewater.
c.	Where the treatment of biomass through composting takes place;	Included. In the project activity, agricultural waste is being treated with Organic Waste Decomposer to avoid methane emissions
d.	Where the products from composting (compost) is handled, dis-	The products from compost are submitted to soil

	posed, submitted to soil application, or treated thermally/mechanically;	application and is not treated thermally/ mechanically
e.	And the itineraries between them (a, b, c and d) where the transportation of waste, wastewater, where applicable manure, product of treatment (compost) occurs.	Not applicable

➤ *The Project Boundary is Defined as Figure below.*

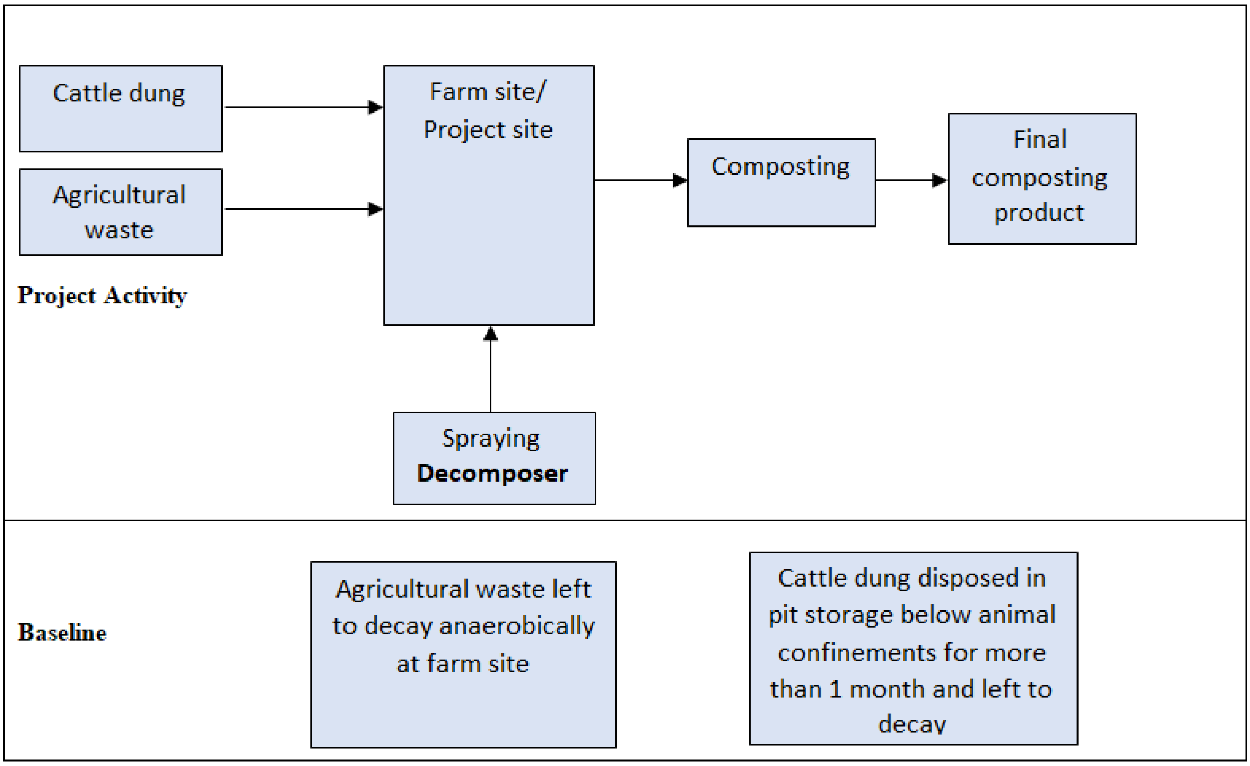

Fig 4 Project Boundary

➤ *The Greenhouse Gases Included or Excluded from the Project Boundary are Summarized in below.*

Table 9 Green House Gases

Source		Gas	Included?	Justification/Explanation
Baseline	Biomass disposed in solid waste	CO_2	No	CO2 emissions from the decomposition of organic waste are not accounted
		CH_4	Yes	The major source of emissions in the baseline
		N_2O	No	According to Tool 4 “emission from solid waste disposal site version (08.0)”, N_2O emission is not accounted.
	Manure disposed in uncovered field	CO_2	No	CO2 emissions from the decomposition of organic waste are not accounted
		CH_4	Yes	The major source of emissions in the baseline
		N_2O	No	According to AMS-III.D “methane recovery in animal manure management systems”, N_2O emission is not accounted.
Project	Emissions from composting processes	CO_2	No	Excluded for simplification.
		CH_4	Yes	An important emission source from composting process.
		N_2O	No	N_2O is not emitted in the project activity
	Emissions from transport	CO_2	No	According to Tool 13 “project and leakage emission from composting (version02.0)”, transport emission is not accounted.
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
	Emissions from on-site electricity use	CO_2	No	Excluded. The project is not involving on site electricity use
		CH_4	No	Excluded. The project is not involving on site electricity use
		N_2O	No	Excluded. The project is not involving on site electricity use
	Emission from fossil fuel consumption	CO_2	No	Excluded. The project is not involving any fossil fuel consumption
		CH_4	No	Excluded. The project is not involving any fossil fuel consumption
		N_2O	No	Excluded. The project is not involving any fossil fuel consumption

Source		Gas	Included?	Justification/Explanation
	Emissions from run-off water	CO_2	No	Excluded. The project is not involving co-composting.
		CH_4	No	Excluded. The project is not involving co-composting.
		N_2O	No	Excluded. The project is not involving co-composting.

➢ Baseline Scenario

In the baseline scenario, the animal dung, mainly Cattle dung is disposed in pit storage below animal confinements for more than 1 month at the farm site/ project site. The animal dung is decomposed anaerobically to form manure and generates methane into the atmosphere during the process. The project activity converts anaerobic decomposition into aerobically decomposed farmyard manure. Thus, generating methane avoidance and other environmental benefits.

Additionally, in the baseline scenario, there are agricultural waste/ crop residues left at the farm site/ project site after harvesting which are either burnt or decomposes anaerobically, leading to methane emissions to the atmosphere. In the proposed project activity, the agricultural waste will be treated with Organic Waste Decomposer to convert the anaerobic decomposition to aerobic decay avoiding methane emissions.

CHAPTER EIGHT
QUANTIFICATIONS

➢ Baseline Emission

The baseline emissions for this project are the amount of methane emitted from the decay of the degradable organic carbon in the agricultural waste and Cattle dung (manure). The yearly Methane Generation Potential for the agricultural waste is calculated using the first order decay model as described in the latest version (v8.0) of the methodological tool "Emissions from solid waste disposal sites". Baseline emissions from the manure composted are calculated as per the procedures of AMS-III.D.

- *As per paragraph 24 of the applied methodology (AMS III F), baseline emissions are calculated as follows:*

$$BEy = BE_{CH4,SWDS,y} + BE_{WW,y} + BE_{CH4,manur,y} - MD_{y,reg} \times GWP_{CH4} \quad \text{(Equation 1)}$$

Where:

Table 10 Baseline Emission

BEy	**Baseline emissions in the year y (t CO2e)**
$BE_{CH4,SWDS,y}$	Yearly methane generation potential of the solid waste composted by the project activity during the years x from the beginning of the project activity (x=1) up to the year y estimated as per the latest version of the methodological tool "Emissions from solid waste disposal sites" (tCO2e).
$BE_{WW,y}$	baseline emissions from the wastewater co-composted, calculated as per the procedures in AMS-III.H (tCO2e)
$BE_{CH4,manur,y}$	baseline emissions from manure composted by the project activities, as per the procedures in AMS-III.D (tCO2e)
$MD_{y,reg}$	Amount of methane that would have to be captured and combusted in the year y to comply with the prevailing regulations (tonne)
GWP_{CH4}	Global Warming Potential for CH4 applicable to the crediting period (t CO2e/t CH4)

- *Baseline Emissions from Agricultural Waste ($BE_{CH4,SWDS,y}$)*

As per the latest version 8.0 of the methodological tool "Emissions from solid waste disposal sites", the baseline emissions ($BE_{CH4,SWDS,y}$) are calculated as follows:

$$BE_{CH4,,y} = \varphi y \times (1-f_y) \times GWP_{CH4} \times (1-OX) \times 16/12 \times F \times DOC_{f,y} \times MCFy \times \sum_{x=1}^{y} \sum_j \left(Wj,x \times DOCj \times e^{-kj\times(y-x)} \times (1-e^{-kj})\right) \quad \text{(Equation 2)}$$

Where,

Table 11 Baseline Emission from Agricultural Waste

$BE_{CH4,SWDS,y}$	**Baseline methane emissions occurring in year y generated from waste disposal at a SWDS during a time period ending in year y (t CO2e/yr)**
x	Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (x = 1) to year y (x = y)
y	Year of the crediting period for which methane emissions are calculated (y is a consecutive period of 12 months)
φy	Model correction factor to account for model uncertainties for year y
f_y	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y
GWP_{CH4}	Global Warming Potential of methane
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
F	Fraction of methane in the SWDS gas (volume fraction)
$DOC_{f,y}$	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year y (weight fraction)
$MCFy$	Methane correction factor for year y
Wj,x	Amount of solid waste type j disposed or prevented from disposal in the SWDS in the year x (t)
DOCj	Fraction of degradable organic carbon in the waste type j (weight fraction)
k	Decay rate for the waste type j (1 / yr)
J	Type of residual waste or types of waste in the MSW

- *Baseline Emissions from the Wastewater Co-composted ($BE_{ww,y}$)*
  Since there is no co-composting in this project, therefore $BE_{ww,y}$=0.

- *Baseline Emissions from Cattle Dung Manure ($BE_{CH4,manure,y}$)*
  As per paragraph 17 of "AMS-III.D: Methane recovery in animal manure management systems", version 21.0, Baseline emissions ($BE_{CH4,manure,y}$) are calculated by using one of the following two options:

- Using the amount of the waste or raw material that would decay anaerobically in the absence of the project activity, with the most recent IPCC Tier 2 approach. For this calculation, information about the characteristics of the manure and of the management systems in the baseline is required.
- Using the amount of manure that would decay anaerobically in the absence of the project activity based on direct measurement of the quantity of manure treated together with its specific volatile solids (SVS) content.

The project applies option (b) to calculate baseline emissions from the manure treatment processes ($BE_{CH4,manure,y}$). so, as per para.19 of AMS-III.D (version 21.0),

$$BE_{CH4,manure,y} = GWPCH4 \times DCH4 \times UFb \times \sum_{j,LT} MCFj \times B0,LT \times Q_{manure,j,LT,y} \times SVS_{j,LT,y} \quad \text{.........(Equation 3)}$$

Where:

Table 12 Baseline Emission from Cattle Manure

$BE_{CH4,manure,y}$	**Baseline CH4 emissions in year y (t CO2e)**
GWP_{CH4}	Global Warming Potential (GWP) of CH4 applicable to the crediting period (t CO_2e/t CH_4)
D_{CH4}	CH4 density (0.00067 t/m3 at room temperature (20 ºC) and 1 atm pressure)
UFb	Model correction factor to account for model uncertainties (0.94)
LT	Index for all types of livestock
j	Index for animal manure management system
$MCFj$	Annual methane conversion factor (MCF) for the baseline animal manure management system j
$B0,LT$	Maximum methane producing potential of the volatile solid generated for animal type LT (m3 CH4/kg-dm)
$Q_{manure,j,LT,y}$	Quantity of manure treated from livestock type LT and animal manure management system j (tonnes/year, dry basis)
$SVS_{j,LT,y}$	Specific volatile solids content of animal manure from livestock type LT and animal manure management system j in year y (tonnes/tonnes, dry basis)

- *MDy,reg*
  No regulatory requirements in India specify the amount of methane that should be captured or combusted. Therefore $MD_{y,reg}$ = 0.

➢ Project Emission
Project emissions from composting process (PEy) is determined as per the Methodology Tool 13:" Project and leakage emissions from composting (Version 02.0)". PEy is equivalent to parameter PECOMP,y in the tool.

➢ *Project Emissions are Estimated as follows:*

$$PEy = PE_{EC,} + PE_{FC,} + PE_{CH4,} + PE_{N2O,} + PE_{RO,} \quad \text{.........(Equation 4)}$$

Where,

Table 13 Project Emission

PEy	**Project emissions associated with composting in year y (t CO2e/yr)**
$PE_{EC,y}$	Project emissions from electricity consumption associated with composting in year y (tCO2/yr)
$PE_{FC,y}$	Project emissions from fossil fuel consumption associated with composting in year y (tCO2/yr)
$PE_{CH4,y}$	Project emissions of methane from the composting process in year y (tCO2e/yr)
$PE_{N2O,y}$	Project emissions of nitrous oxide from the composting process in year y (t CO2e/yr)
$PE_{RO,y}$	Project emissions of methane from run-off wastewater associated with co-composting in year y (tCO2e/yr)

- *Project Emissions from Electricity consumption Associated with Composting in year y (PEEC,y)*
  Project does not involve use of electricity from the grid or from a fossil fuel fired on-site power plant. Therefore, PEEC,y = 0

- *Project Emissions from Fossil Fuel Consumption Associated with Composting in year y (PEFC,y)*
  Project does not involve use of fossil fuel with composting. Therefore, PEFC,y = 0

- *Project Emissions of Methane from the Composting Process in year y(PECH4,y)*

$PECH4, = Qy * EFCH4, * GWPCH4$……………………………………………………………………………….(*Equation 5*)

Where：

- ✓ $PE_{CH4,y}$ Project emissions of methane from the composting process in year y (tCO_2e/ yr)
- ✓ Qy Quantity of waste composted in year y (t/yr)
- ✓ $EF_{CH4,y}$ Emission factor of methane per tonne of waste composted valid for year y (tCH4/ t)
- ✓ GWP_{CH4} Global Warming Potential of CH4 (t CO_2e / tCH4)

- *Project Emissions of Nitrous Oxide from the Composting Process (PEN2O,y)*

$PE_{N2O,} = Qy * EF_{N2O,} * GWP_{N2O}$……………………………………………………………………………….(*Equation 6*)

Where:
- ✓ $PE_{N2O,y}$ Project emissions of nitrous oxide from composting in year y (t CO_2e/yr)
- ✓ Qy Quantity of waste composted in year y (t/yr)
- ✓ $EF_{N2O,y}$ Emission factor of nitrous oxide per tonne of waste composted valid for year y (tN_2O/t)
- ✓ GWP_{N2O} Global Warming Potential of N_2O (tCO_2e/t N_2O)

- *Project Emissions from Run-off Wastewater (PERO,y)*
  Project emissions of methane from run-off wastewater (PERO,y) are calculated only for the case of co-composting. The proposed project not involves co-composting, therefore PERO,y=0.

➢ Leakage

Leakage emissions from composting process (LEy) is determined as per the Methodology Tool 04: “Emissions from solid waste disposal sites (Version 08.0)”. LEy is equivalent to parameter $LE_{COMP,y}$ in the Methodology Tool 13:”Project and Leakage emissions from composting”.

- *Leakage Emissions are Estimated as follows:*

$LEy = \times (1-f_y) \times GWP_{CH4} \times (1-OX) \times 16/12 \times \times DOC_{f,} \times MCFy \times \sum_{x=1}^{y} \left(W_x \times DOC \times e^{-k \times (y-x)}\right) \times (1-e^{-k})$……………………………………………………………………………….(*Equation 7*)

Where

Table 14 Leakage Emission

LE_y	**Leakage methane emissions occurring in year y generated from waste disposal at a SWDS during a time period ending in year y (t CO2e/yr)**
x	Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (x = 1) to year y (x = y)
y	Year of the crediting period for which methane emissions are calculated (y is a consecutive period of 12 months)
φy	Model correction factor to account for model uncertainties for year y
f_y	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y
GWP_{CH4}	Global Warming Potential of methane
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
F	Fraction of methane in the SWDS gas (volume fraction)
$DOC_{f,y}$	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year y (weight fraction)
$MCFy$	Methane correction factor for year y
Wx	Amount of solid waste type j disposed or prevented from disposal in the SWDS in the year x (t)
DOC	Fraction of degradable organic carbon in the waste type j (weight fraction)
k	Decay rate for the waste type j (1 / yr)

➢ Net Emission Reduction and Removals

The emission reduction achieved by the project activity will be measured as the difference between the baseline emission and the sum of the project emission and leakage as follows:

$ERy = BEy - (PEy + LEy)$……………………………………………………………………………………….(*Equation 8*)

As discussed above, the baseline, project and leakage emissions are calculated and presented below:

- *Calculation of Baseline emissions:*

✓ *Baseline Emission – Cattle Manure*

Table 15 Ex-ante Calculation of BECH4,Manure,y

Parameters	Value	Unit	Justifications/ Remarks
GWP_{CH4}	28	t CO2e / t CH4	As per IPCC Fifth Assessment Report, GWP for methane varies between 84-87 when considering its impact over a 20-year timeframe (GWP20) and between 28-36 when considering its impact over a 100-year timeframe (GWP100)
D_{CH4}	0.00067	tons/m3	As per AMS-IIID Methodology Document
UF_b	0.94		As per AMS-IIID Methodology Document
MCFj	78%		As per Table 10.17 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Chapter 10. Baseline manure management system - disposal pit storage below animal confinements for more than 1 month. Average annual temperature at the project sites is 27ºC
Bo,LT	130	m3 CH4/ton-dm	As per Table 10 A-4 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Chapter 10. Value for Dairy Cattle in Indian Subcontinent: 0.13 m3 CH4/kg-dm
SVSj,LT,y	0.138	tons/tons	Haryanto, Agus & Triono, Sugeng & Wicaksono, Nugroho. (2018). Effect of Hydraulic Retention Time on Biogas Production from Cattle Dung in A Semi Continuous Anaerobic Digester. International Journal of Renewable Energy Development. 7. 93. 10.14710/ijred.7.2.93-100.
Qmanure,j,LT,y	Refer below	ton/year	The quantity of manure is based on the year wise projected sale of Organic Waste Decomposer

Table 16 BECH4, Manure, y Result from Year 1

Year	$Qmanure_{j,LT,y}$	$BE_{CH4,manure,y}$
Year 1	**1**	**0.246**

✓ *Baseline Emissions – Agricultural waste*

Table 17 Ex-ante Calculation of BECH4, SWDS, y

Parameters	Value	Unit	Justification/ Remarks
φy	0.85		IPCC default value (baseline emission) for Application B in humid/ wet conditions, provided in methodological Tool 'Emissions from solid waste disposal sites' (Tool 4 Version 8)
fy	0		Since no methane is being captured, flared, combusted, or used in another manner at the site.
1-fy	1		calculated
GWP (CH4)	28		IPCC Fifth Assessment Report
OX	0.1		IPCC default value
1- OX	0.9		calculated
F	0.5		IPCC default value
DOCf,y	0.5		IPCC default value
MCFy	1.0		IPCC default value for anaerobic managed solid waste disposal sites
DOCj	0.2		IPCC default value for Garden, yard and park waste
kj	0.17		IPCC default value for Garden, yard and park waste and Tropical Wet climate
y	Refer below		
x	Refer below		
e^(-kj*(y-x))	Refer below		calculated
1 - e ^ (-kj)	0.2		calculated

Wj,x	Refer below	tons/ year	

Table 18 BECH4, SWDS, y Result from Year 1

Year	Wj,x	y	x	e^(-kj*(y-x))	$BE_{CH4,SWDS,y}$
Year 1	**1**	**1**	**1**	**1**	**0.223**

- ✓ *Baseline Emissions – Total*

Table 19 Results of BECH4,Y / BEy from year 1

	$BE_{CH4,manure,y}$	$BE_{CH4,SWDS,y}$	BEy
Year 1	**0.246**	**0.223**	**0.469**

- *Calculation of Project Emissions:*

Table 20 Ex – ante Calculation of PECH4,Y

Parameters	Value	Unit	Justifications/ Remarks
Qy	Refer below	tons/yr	
EFch4,y	0.002	tCH4/ t	Default IPCC as per Tool 13
GWPch4	28	t CO_2e / tCH4	IPCC Fifth Assessment Report

Table 21 Ex – ante Calculation of PEN20, Y

Parameters	Value	Unit	Justifications/ Remarks
Qy	Refer below	tons/yr	
EFn20,y	0	t N2O/t	Not considering N_2O emissions
GWPn20	265	t CO2e/t N2O	IPCC Fifth Assessment Report

Table 22 Result of PEY for year 1

Year	Q_y	$PE_{CH4,y}$	$PE_{N2O,y}$	PE_y
Year 1	**1**	**0.05**	**-**	**0.05**

- *Calculation of Leakage Emissions:*

Table 23 Ex -ante Calculation of LEY

Parameters	Value	Unit	Justification/ Remarks
φy	1		IPCC default value (leakage emission) for Application B in humid/ wet conditions, provided in Methodological Tool 'Emissions from solid waste disposal sites' (Tool 4 Version 8)
fy	0		Since no methane is being captured, flared, combusted, or used in another manner at the site.
1-fy	1		calculated
GWP (CH4)	28		IPCC Fifth Assessment Report
OX	0.1		IPCC default value as per Tool 4
1- OX	0.9		calculated
F	0.5		IPCC default value as per Tool 4
DOCf,y	0.5		IPCC default value as per Tool 4
MCFy	1.0		IPCC default value for anaerobic managed solid waste disposal sites
DOC	0.2		IPCC default value for Garden, yard and park waste
k	0.17		IPCC default value for Garden, yard and park waste and Tropical Wet climate
y	Refer below		
x	Refer below		
e^(-k*(y-x))	Refer below		calculated
1 - e ^ (-k)	0.2		calculated
Wx	Refer below	tons/ year	

Table 24 Result of LEY from year 1

Year	Wx	y	x	e^(-kj*(y-x))	LEy
Year 1	1	1	1	1	0.26

- *Net Emissions Reduction*

Table 25 Net Emission Reduction

Year	Use of Organic Waste Decomposers (tons)	Total amount of animal (Cattle) manure treated (tons)	Total amount of agricultural waste treated (tons)	Estimated net GHG emission reductions (tCO_2e)
Year 1	9	1,00,800	7,680	19,089

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CHAPTER NINE
MONITORING

- Data and Parameters Available at Validation

Table 26 Methane Data and Parameter

Data / Parameter	**GWP_{CH4}**
Data unit	tCO_2e/tCH_4
Description	Global Warming Potential of CH4
Source of data	IPCC Fifth Assessment Report
Value applied	28
Justification of choice of data or description of measurement methods and procedures applied	100-year values are adopted from Box 3.2, table 1, IPCC Fifth Assessment Report, 2014 (AR-5, 2014)
Purpose of Data	*Used in baseline, project, and leakage emission calculations*
Comments	NA

Table 27 Nitrous Oxide Data and Parameter

Data / Parameter	**GWP_{N20}**
Data unit	tCO_2e/tN_2O
Description	Global Warming Potential of N_2O
Source of data	IPCC Fifth Assessment Report
Value applied	265
Justification of choice of data or description of measurement methods and procedures applied	100-year values are adopted from Box 3.2, table 1, IPCC Fifth Assessment Report, 2014
Purpose of Data	*Used in project emission calculations*
Comments	NA

Table 28 Density of Methane

Data / Parameter	**D_{CH4}**
Data unit	t/m^3
Description	Density of Methane (CH_4)
Source of data	AMS-III.D Version 21.0 Methodology Document
Value applied	0.00067
Justification of choice of data or description of measurement methods and procedures applied	Density of Methane at room temperature 20℃ and 1 atm pressure is 0.00067 t/m^3
Purpose of Data	*Used in baseline emission calculations*
Comments	NA

Table 29 Methane Conversion Factor of AWMS

Data / Parameter	**MCF_j**
Data unit	NA
Description	Methane conversion factor for the baseline Animal Waste Management System (AWMS) j
Source of data	Table 10.17 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Chapter 10
Value applied	78%
Justification of choice of data or description of measurement methods and procedures applied	MCF_j value for pit storage below animal confinements for more than 1 month (baseline AWMS) is chosen. At the project site, the annual average temperature is 27 °C and the conservative value of 78% is applied.
Purpose of Data	*Used in baseline emission calculations*
Comments	NA

Table 30 Potential of Volatile Solids

Data / Parameter	**$B_{0, LT}$**
Data unit	$m^3CH_4/kg\text{-}dm$
Description	Maximum methane producing potential of the volatile solid generated by animal type LT
Source of data	Table 10A-4 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Chapter 10
Value applied	0.13

Justification of choice of data or description of measurement methods and procedures applied	Since the animal in the baseline scenario is dairy Cattle and the project location lies in Indian Subcontinent, therefore the corresponding value of 0.13 m^3CH_4/kg-dm has been chosen
Purpose of Data	*Used in baseline emission calculations*
Comments	NA

Table 31 Model Correction Factor

Data / Parameter	**UF_b**
Data unit	NA
Description	Model correction factor to account for model uncertainties
Source of data	AMS-III.D Version 21.0 Methodology Document
Value applied	0.94
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	*Used in baseline emission calculations*
Comments	NA

Table 32 model correction factor

<table>
<tr><th>Data / Parameter</th><th>$\varphi_{default}$</th></tr>
<tr><td>Data unit</td><td>NA</td></tr>
<tr><td>Description</td><td>Default value for the model correction factor to account for model uncertainties</td></tr>
<tr><td>Source of data</td><td>Tool 04: “Emissions from solid waste disposal sites (version08.0)”</td></tr>
<tr><td>Value applied</td><td>0.85</td></tr>
<tr><td>Justification of choice of data or description of measurement methods and procedures applied</td><td>For project or leakage emissions: φdefault = 1.
For baseline emissions: refer to the table below to identify the appropriate factor based on the application of the tool (A or B) and the climate where the SWDS is located. Default values for the model correction factor
<table>
<tr><th></th><th>Humid/ wet conditions</th><th>Dry conditions</th></tr>
<tr><td>Application A</td><td>0.75</td><td>0.75</td></tr>
<tr><td>Application B</td><td>0.85</td><td>0.80</td></tr>
</table>
The Application B is applicable to the baseline scenario and the SWDS is in humid/ wet conditions, thus 0.85 is chosen.</td></tr>
<tr><td>Purpose of Data</td><td>Used in baseline and leakage emission calculations</td></tr>
<tr><td>Comments</td><td>NA</td></tr>
</table>

Table 33 Fraction of Methane Captured at the SWDS

Data / Parameter	**f_y**
Data unit	NA
Description	Fraction of methane captured at the SWDS and flared, combusted, or used in another manner that prevents the emissions of methane to the atmosphere in year y
Source of data	Regulation requirements specifying the amount of methane that must be destroyed/used (if available)
Value applied	0
Justification of choice of data or description of measurement methods and procedures applied	There are no regulations in the country of the project activity (i.e. India) specifying the amount of methane that has to be destroyed or used or flared. Also, there are no historical or existing system for capturing methane at the SWDS.
Purpose of Data	*Used in baseline emission calculations*
Comments	NA

Table 34 Oxidation Factor

Data / Parameter	**OX**
Data unit	NA
Description	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data	Table 3.2, Section 3.2.3, Chapter 3, Volume 5, 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
Value applied	0.1
Justification of choice of data or description of measurement methods and procedures applied	2006 IPCC Guidelines for National Greenhouse Gas Inventories is a reliable data source.

Purpose of Data	*Used in baseline emission calculations*
Comments	NA

Table 35 Fraction of Methane in the SWDS Gas

Data / Parameter	**F**
Data unit	NA
Description	Fraction of methane in the SWDS gas (volume fraction)
Source of data	Section 3.2.3, Chapter 3, Volume 5, IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied	0.5
Justification of choice of data or description of measurement methods and procedures applied	2006 IPCC Guidelines for National Greenhouse Gas Inventories is a reliable data source.
Purpose of Data	*Used in baseline emission calculations*
Comments	NA

Table 36 Default Value for the Fraction of Degradable Organic Carbon

Data / Parameter	**$DOC_{f,default}$**
Data unit	Weight fraction
Description	Default value for the fraction of degradable organic carbon (DOC) in MSW that decomposes in the SWDS
Source of data	Section 3.2.3, Chapter 3, Volume 5, IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied	0.5
Justification of choice of data or description of measurement methods and procedures applied	2006 IPCC Guidelines for National Greenhouse Gas Inventories is a reliable data source.
Purpose of Data	*Used in baseline emission calculations*
Comments	NA

Table 37 Methane Correction Factor

Data / Parameter	**$MCF_{default}$**
Data unit	NA
Description	Methane correction factor
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied	1
Justification of choice of data or description of measurement methods and procedures applied	Default value in Tool 04: "Emissions from solid waste disposal sites (version08.0)" Application B in the tool is applicable to the baseline situation. The SWDS in this project does not have a water table above the bottom of the SWDS. Therefore, 1.0 for anaerobic managed solid waste disposal sites has been chosen.
Purpose of Data	*Used in baseline emission calculations*
Comments	NA

Table 38 Fraction of Degradable Organic Carbon

<table>
<tr><th>Data / Parameter</th><th>DOC_j</th></tr>
<tr><td>Data unit</td><td>NA</td></tr>
<tr><td>Description</td><td>Fraction of degradable organic carbon in the waste type j (weight fraction)</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)</td></tr>
<tr><td>Value applied</td><td>20%</td></tr>
<tr><td>Justification of choice of data or description of measurement methods and procedures applied</td><td>The DOCj value is provided based on the type of waste as follows:
<table>
<tr><td>Waste type j</td><td>DOCj (% wet waste)</td></tr>
<tr><td>Wood and wood product</td><td>43</td></tr>
<tr><td>Pulp, paper and carboard (other than sludge)</td><td>40</td></tr>
<tr><td>Food, food waste, beverages and tobacco (other than sludge)</td><td>15</td></tr>
<tr><td>Textiles</td><td>24</td></tr>
<tr><td>Garden, yard and park waste</td><td>20</td></tr>
<tr><td>Glass, plastic, metal, other inert waste</td><td>0</td></tr>
</table>
Agricultural crop residue is used for composting, which is similar to the waste type – 'garden, yard and park waste', therefore 20% is applied for calculation.</td></tr>
<tr><td>Purpose of Data</td><td>Used in baseline emission calculations</td></tr>
</table>

Comments	NA

Table 39 The Decay Rate for Waste Type

<table>
<tr><td>Data / Parameter</td><td>k_j</td></tr>
<tr><td>Data unit</td><td>NA</td></tr>
<tr><td>Description</td><td>The decay rate for the waste type j</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)</td></tr>
<tr><td>Value applied</td><td>0.17</td></tr>
<tr><td>Justification of choice of data or description of measurement methods and procedures applied</td><td>Apply the following default values for the different waste types j: Default values for the decay rate (kj)
<table>
<tr><td colspan="2" rowspan="2">Waste type j</td><td colspan="2">Boreal and temperate (MAT≤20°C)</td><td colspan="2">Tropical (MAT>20°C)</td></tr>
<tr><td>Dry (MAP/PET<1)</td><td>Wet (MAP/PET>1)</td><td>Dry (MAP <1000mm)</td><td>Wet (MAP>1000mm)</td></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.04</td><td>0.06</td><td>0.045</td><td>0.07</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.02</td><td>0.03</td><td>0.025</td><td>0.035</td></tr>
<tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.05</td><td>0.10</td><td>0.065</td><td>0.17</td></tr>
<tr><td>Rapid degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.06</td><td>0.185</td><td>0.085</td><td>0.4</td></tr>
</table>
Note: MAT – mean annual temperature, MAP – Mean annual precipitation, PET – potential evapotranspiration. MAP/PET is the ratio between the mean annual precipitation and the potential evapotranspiration.

Agricultural crop residue is used for composting, which is similar to the waste type – ‘Other (non-food) organic putrescible garden and park waste’. Also, the SWDS is in tropical wet climate. Therefore 0.17 is applied for calculation.</td></tr>
<tr><td>Purpose of Data</td><td>Used in baseline emission calculations</td></tr>
<tr><td>Comments</td><td>NA</td></tr>
</table>

Table 40 Default Emission Factor of Methane per Tonne of Waste

Data / Parameter	**$EF_{CH4,default}$**
Data unit	tCH_4/t
Description	Default emission factor of methane per tonne of waste composted (wet basis)
Source of data	Tool 13:” Project and leakage emissions from composting (Version 02.0)”
Value applied	0.002
Justification of choice of data or description of measurement methods and procedures applied	Tool 13 follows 2006 IPCC Guidelines for National Greenhouse Gas Inventories, thus a reliable data source.
Purpose of Data	*Used in project emission calculations*
Comments	Applicable to Option 2 in the step “Determination of project emissions of methane”

Table 41 Default Emission Factor of Nitrous Oxide

Data / Parameter	**$EF_{N2O,default}$**
Data unit	tN_2O/t
Description	Default emission factor of nitrous oxide per tonne of waste composted (wet basis)
Source of data	Tool 13:" Project and leakage emissions from composting (Version 02.0)"
Value applied	0.0002
Justification of choice of data or description of measurement methods and procedures applied	Tool 13 follows 2006 IPCC Guidelines for National Greenhouse Gas Inventories, thus a reliable data source.
Purpose of Data	*Used in project emission calculations*
Comments	Applicable to Option 2 in the step "Determination of project emissions of nitrous oxide"

➢ Data and Parameters Monitored

Table 42 Monitored Parameter Quantity of Manure

Data / Parameter	**$Q_{manure,j,LT,y}$**
Data unit	Tonnes-dm/year
Description	Quantity of manure treated from livestock type LT at animal manure management system j
Source of data	Data sourced from Project proponents, which is measured by electronic truck scales and electric scales
Description of measurement methods and procedures to be applied	The quantity of manure (wet basis) is measured by electronic truck scales. Water content of manure (wet basis) is measured by electric scale as per ……
Frequency of monitoring/recording	Annually, based on daily measurement and monthly aggregation
Value applied	Amount of Cattle manure disposed of from year 1 to year 10 that have been used for ex-ante calculation are as follows: Year | Amount of Cattle manure (tonnes) $Q_{manure,j,LT,y}$ will be determined during the monitoring period using electronic truck scales and electric scales
Monitoring equipment	Electronic truck scales and electric scales
QA/QC procedures to be applied	NA
Purpose of data	Calculation of baseline emissions and project emissions
Calculation method	Quantity of manure (dry basis) = quantity of manure (wet basis) × (1-water content of manure (wet basis))
Comments	NA

Table 43 Monitored Parameter Specific Volatile Solid

Data / Parameter	**$SVS_{j,LT,y}$**
Data unit	tonnes VS/tonnes--dm
Description	Specific volatile solids content of animal manure from livestock type LT and animal manure management system j in year y
Source of data	Data sourced from Project proponents, which is measured as per the guideline in Annex 2 of AM0073 (UNFCCC, 2022).
Description of measurement methods and procedures to be applied	Method for determination of Volatile Solids in animal waste as per the guideline in Annex 2 of AM0073. From: USDA. Agricultural Waste Management Field Handbook. Chapter 4 - Agricultural Waste Characteristics. Page 2. <u>Definitions</u> • Total Solids: Residue remaining after water is removed from waste material by evaporation; dry matter • Volatile Solids: The part of total solids driven off as volatile (combustible) gases when heated to 600ºC; organic matter • Fixed Solids: The part of total solids remaining after volatile gases driven off at 600ºC; ashes. <u>Determination method</u> 1. Evaporate free water on steam able and dry in oven at 103°C for 24 hours or until constant weight to obtain the Total Solids. Place Total Solids residue in furnace at 600ºC for at least 1 hour. Volatile Solids are determined from weight difference of total and Fixed Solids.

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	$$volatile\ matter\ (dry\ basis) = \frac{W2 - Wf}{W2 - W1}$$ Where W1 is the weight of sample container, W2 is combined weight of the sample container and oven dried sample (total solids), Wf is the combined constant weight of the sample container and sample after heating at 600ºC (fixed solids)
Frequency of monitoring/recording	Annually
Value applied	13.8% is used for ex-ante calculation. $SVS_{j,LT,y}$ will be determined as per the guideline in annex 2 of AM0073 during the monitoring period.
Monitoring equipment	Electric scales
QA/QC procedures to be applied	NA
Purpose of data	Calculation of baseline emissions
Calculation method	NA
Comments	NA

Table 44 Monitored Parameter Total Amount of Waste

Data / Parameter	$\mathbf{W_{j,x}}$
Data unit	tonne
Description	Total amount of waste disposed in a SWDS in year x
Source of data	Data sourced from Project proponents, which is measured by electronic truck scales
Description of measurement methods and procedures to be applied	Measured on wet basis
Frequency of monitoring/recording	Continuously, aggregated at least annually for year x
Value applied	Amount of agricultural waste disposed of from year 1 to year 10 that have been used for ex-ante calculation are as follows: **Year** | **Amount of agricultural waste (tonnes)** $W_{j,x}$ will be determined during the monitoring period using electronic truck scales
Monitoring equipment	electronic truck scales
QA/QC procedures to be applied	NA
Purpose of data	Calculation of baseline emissions and project emissions
Calculation method	NA
Comments	NA

Table 45 Quantity of waste Monitored

Data / Parameter	$\mathbf{Q_y}$
Data unit	tonne
Description	Quantity of waste composted in year y
Source of data	$Q_{manure,j.LT,y}$ and $W_{j,x}$ is measured by electronic truck scales respectively, and Q_y is the sum of $Q_{manure,j.LT,y}$ and $W_{j,x}$
Description of measurement methods and procedures to be applied	NA
Frequency of monitoring/recording	NA
Value applied	Amount of waste composted from year 1 to year 10 that have been used for ex-ante calculation are as follows: **Year** | **Amount of waste (tonnes)** Qy will be determined during the monitoring period using the measured values of $Q_{manure,j.LT,y}$ and $W_{j,x}$
Monitoring equipment	NA
QA/QC procedures to be applied	NA
Purpose of data	Calculation of project emissions
Calculation method	$Q_y = Q_{manure,j.LT,y} + W_{j,x}$
Comments	NA

Table 46 Monitored Parameter Amount of Compost

Data / Parameter	**W_x**
Data unit	tonne
Description	Amount of compost produced that is disposed of in a SWDS or subjected to anaerobic storage
Source of data	Q_y is determined using the measured values of $Q_{manure,j.LT,y}$ and $W_{j,x,}$ and W_x ……
Description of measurement methods and procedures to be applied	NA
Frequency of monitoring/recording	NA
Value applied	The amount of compost subjected to anaerobic decomposition has been calculated as 5% of Q_y for ex-ante calculation. The values for year 1 to year 10 that have been used for ex-ante calculation are as follows: **Year** | **Amount of waste (tonnes)** W_x will be determined using the values of Q_y ……………
Monitoring equipment	NA
QA/QC procedures to be applied	NA
Purpose of data	Calculation of leakage emissions
Calculation method	W_x = 5% of Q_y
Comments	NA

➢ Monitoring Plan

The monitoring plan assures that all relevant data/ parameter necessary for estimating/ calculating the project GHG emissions and leakages detailed in section 8.2 of this document are undertaken in accordance with the applied methodologies and are recorded and reported. This monitoring plan will be implemented by the project proponent. The details of the monitoring plan are specified as follows:

A Monitoring Team will be established to collect and record monitoring data within the project boundary. The monitoring team will be responsible for the operation of the manure treatment system as well as agricultural waste treatment system and the collection and recording of all the monitoring data. All the data will be reviewed by the project developer and Validation/ Verification Bodies (VVB) at regular intervals or appropriate duration.

- *Data Management*

All data collected as part of monitoring plan should be saved until the end of the crediting period with a backup. After the crediting period ends, the data should be archived electronically on hard disks and be kept for at least 2 years.

- *Quality Control and Quality Assurance Procedures*

A quality management system should be established to ensure the quality and accuracy of the measured data. *The monitoring team will follow recognized standard data evaluation methods to guarantee that the data is reliable and accurate. The quality control and quality assurance procedures shall include the handling and correction of non-conformities in the implementation of the project or the monitoring plan.* In case such non-conformities are observed:

- ✓ An analysis of the non-conformity and its causes will be carried out immediately by the project owner, with the help of external experts if necessary.
- ✓ A corrective action plan should then be developed to eliminate the non-conformity and its causes to prevent its recurrence.
- ✓ Corrective actions are implemented and reported back to the monitoring team.
- ✓ Related information will be included in the monitoring report and reported to VVB during the verification.
- ✓ If the data record is missing or damaged during the monitoring periods, the following makeup process will be conducted:
- ✓ The general principle is that the most conservative approach will be followed for the missing or damaged data. The monitoring team will be trained before the start of the project operation to ensure that each team member is fully aware of and able to strictly follow this conservative principle.
- ✓ If this is due to an error by the monitoring personnel, conservative value will be used for the missing or damaged data in the meantime and further training of the person shall be provided so that he or she can perform the job properly.
- ✓ If some of the recorded data is significantly higher than the normal range, then the monitoring team should immediately look for its reason. If it is due to the damage of measurement equipment, then conservative value will be used for that day's data and the measuring equipment is immediately repaired/ maintained and re-calibrated to avoid this situation in the future.

If the monitoring results are satisfactory in terms of correct reporting, data completeness and correct analysis, the data will be accepted for the monitoring report.

CHAPTER TEN
RESULTS AND DISCUSSIONS

According to the type of fertiliser, the Indian fertiliser market is divided into nitrogenous, phosphatic, potash, complex, secondary nutrient, and micronutrient fertilisers. Fertilisers can be divided into chemical fertiliser and biofertilizer based on their nature. Urea accounts for about 55% (MoPNG & MoPNG, 2023) of all fertilizer consumption, with diammonium phosphate (DAP), muriate of potash (MOP), and single superphosphate (SSP) following. About 30% (MoPNG & MoPNG, 2023) of India's total fertiliser consumption is imported. Increased use of synthetic chemical fertilisers helped reduce India's hunger by increasing crop production, but it has also had unfavourable effects on the environment, including poor soil quality and potential water pollution effects. Due to these undesirable results, organic, bio-fertilizer, and compost are being used in place of chemical fertiliser in sustainable agriculture practises.

The penetration of organic fertiliser in India is very low; for the years 2018–19 and 2019–20 *(MoPNG & MoPNG, 2023)*, respectively, the proportion of organic fertiliser in total fertiliser consumption was only 0.29% and 0.34%, respectively.

The emission reductions over the years are highly dependent on the market growth of Organic Waste Decomposer which is increasing in India.

- On an average, 75g waste decomposer is required to treat 1 ton of Cattle manure whereas 187.5g of waste decomposer is required to treat 1 ton of agricultural waste as per market standard developed and validated by Indian Agriculture Research Institute's Directorate of Medicinal and Aromatic Plants (DMAPR) *(Research, 2022)* at Anand, Gujarat for conversion of farm and animal dung into manure in 30-45 days' time (Survey shown in Annexture I).

➢ Emission Reduction from using Cattle Manure for Organic Farming in India

- Baseline Emission almost about 0.246 tons of CO_2 equivalent per ton of Cattle Manure.
- Estimated Leakage around 5.2% of Baseline Emissions if we use in-house (non-transported) Cattle manure to produce organic fertilizer.
- Estimated Project emission is between 22.5% of Baseline Emissions, Project emissions consist of methane from the composting process in year y (tCO_2e/yr).
- Saving around 72% of GHG Emissions.

➢ Emission Reduction from using Agriculture Residues for Organic Farming in India

- Baseline Emission almost about 0.513 tons of CO_2 equivalent per acre of agricultural land.
- Estimated Leakage around 5.9% of Baseline Emissions as there will be some error during manual spraying of waste decomposer and 25.1% of baseline emissions are project emissions . Thus removals of 69% of methane emission.

➢ Emission Reduction from using Both Cattle Manure and Agriculture Residues in India

- Baseline Emission almost about 0.2638 tons of CO_2 equivalent per ton of Cattle Manure.
- Estimated Leakage around 5.4% of Baseline Emissions if we use in-house Cattle Manure to produce organic fertilizer (non-transported).
- Estimated Project emission is between 22.8% of Baseline Emissions,
- Emission reduction about 71.8% of GHG Emissions.

CHAPTER ELEVEN
SCENARIO DEVELOPMENT : LOW CARBON ECONOMY

➢ Organic Decomposer uses in 100% Agricultural land in India by 2035:

In 2020, agricultural land area for India was 1.79 million sq. km. Though India agricultural land area fluctuated substantially in recent years, it tended to decrease through 1971 - 2020 period ending at 1.79 million sq. km in 2020 (Bank, n.d.).

Table 47 Agriculture Land Area

Land Area	**2,973,190 sq. km**
Agricultural land as a share of land area	60.2% (442 million acre)
Forest area as a share of land area	24.3%

In India, the penetration of organic fertilizer is very low .The proportion of organic fertilizer of the total fertilizer consumption is only 0.29% for the year 2018-19 and 0.34% for the year 2019-20.

If we continue to increase the use of organic waste decomposer in our agriculture field to produce organic fertilizer, we can roughly save around 17,452 million tons of CO2 in India.

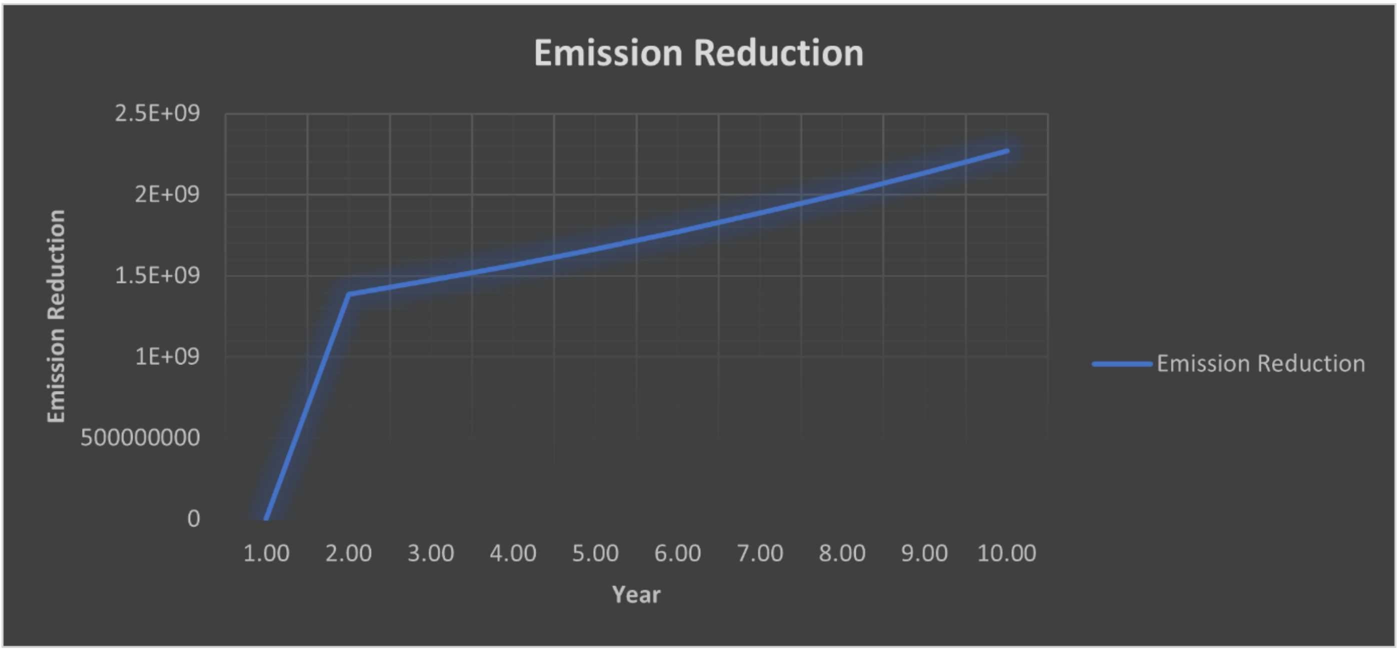

Fig 5 100% Organic Fertilizer used

➢ Utilizing Wasted Cow Dung to Produce Organic Fertilizers:

Livestock production is an important source of income for the rural poor in developing countries, like India, where 70% (Dairying, 2023) of the livestock is in the hands of small and marginal farmers and landless labourers, who own less than 30% of the land area. Production Systems are based on low cost agro-byproducts as nutritional inputs, using traditional technologies for production. A sizeable percentage of livestock owners are below the poverty line.

Raising livestock is an enterprise that allows landless and poor farmers to make money using common resources and land that cannot be used for other sustainable agricultural uses. Agricultural farm byproducts and crop residues that would otherwise go to waste are fed to the cattle and other livestock. Adding milk to the diet adds protein, calcium, vitamins, and other nutrients that would otherwise be lacking. Cattle products are a significant source of nutrients. Cattle are the most significant non-human source of power available to poor farmers, aside from food.

As per Department of Animal Husbandry and Dairying (GoI)

Table 48 Cattle Dung available as per GoI

Amount of Cattle Dung annually available	**1200 million tons**
Amount of Cattle Dung used as Fuel	400 million tons
Amount of Cattle Dung used as Manure annually	215 million tons
Amount of wasted Cattle Dung annually	585 million tons

If we can utilize the remaining cattle dung to produce organic fertilizer by using organic waste decomposer, we can remove around 711 million tons of CO2. While 22.5% which is 225 million tons CO2e is project emission and 5.3% is subjected to leakage.

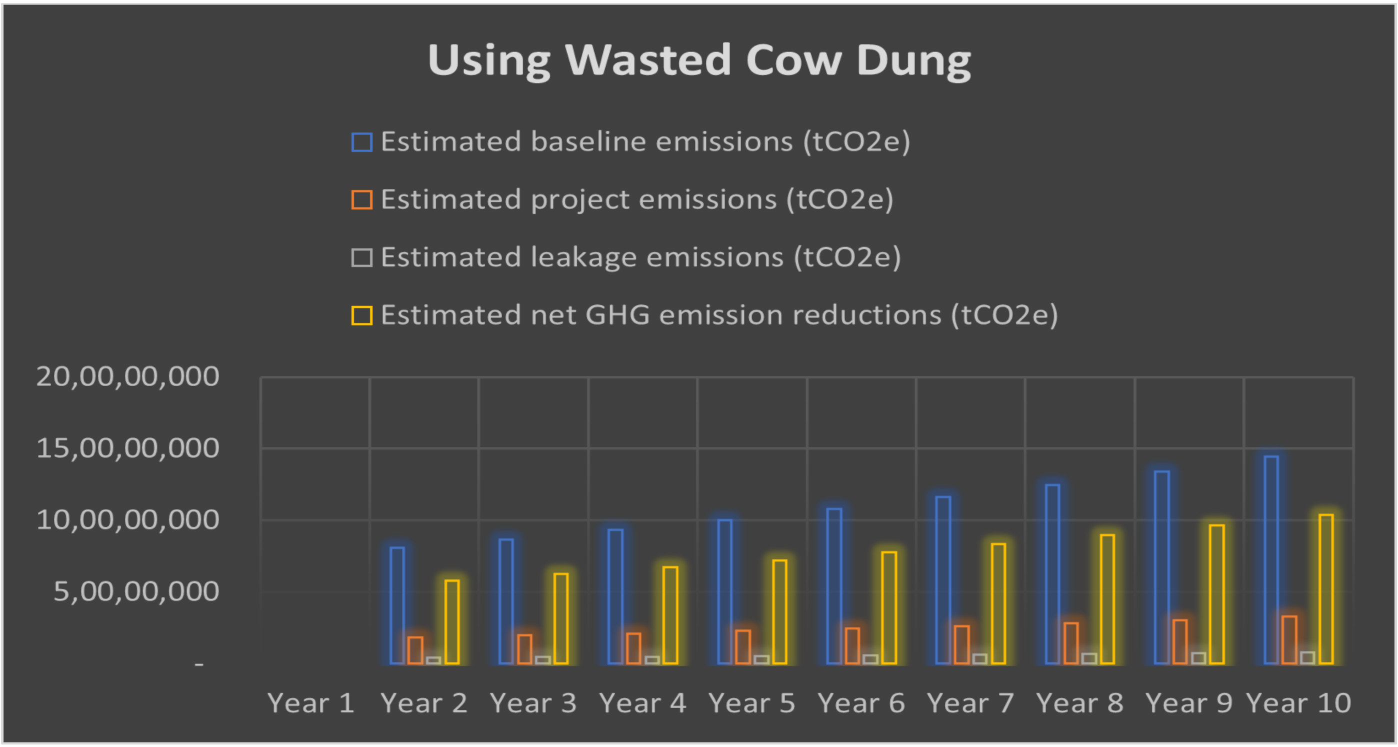

Fig 6 Using Wasted Cattle Dung

➢ Cow Dung to Alternative Fuel:

The production of bio-gas from cow dung and urine is a very easy, affordable method of generating energy for cooking and lighting. Simple equipment that produces biogas can be installed in rural areas. People who have access to enough cow dung are installing these generators even in urban and semi-urban areas, and enough gas is produced from the output of a pair of cattle to meet the lighting, heating and cooking requirements of entire families.

Villagers have traditionally used firewood and cow dung cakes as a common fuel source. The vast majority of our population, who reside in villages, lacks access to electricity and piped gas as sources of energy. The country's forest cover has been reduced as a result of using other fuels like wood and coal, which has caused severe ecological and environmental issues. Even if the product is delivered to the villages, there is a shortage of paraffin and the prices are out of reach for the locals. Cow dung cakes are the only alternative fuel source left for the rural populace. Only by increasing the cattle population will it be possible to meet the demand for this fuel. he ash obtained after burning cow-dung cakes acts as a very good fertilizer. It can also be used for cleaning utensils thus saving us from the harmful effects of using chemical cleaning agents.

Table 49 Types of Cow Dung Available

Amount of Cattle Dung annually available	**1200 million tons**
Amount of Cattle Dung used as Fuel	400 million tons
Amount of wasted Cattle Dung annually	585 million tons

When cow dung is used to produce biogas through anaerobic digestion, it is contained within a sealed system known as a biogas digester. The purpose of the digester is to create an oxygen-free environment where microorganisms can break down the organic matter in the cow dung and produce biogas as a byproduct. In a well-designed and properly maintained biogas digester, there should be minimal to no leakage of biogas. Thus, mitigating above 95% of emission.

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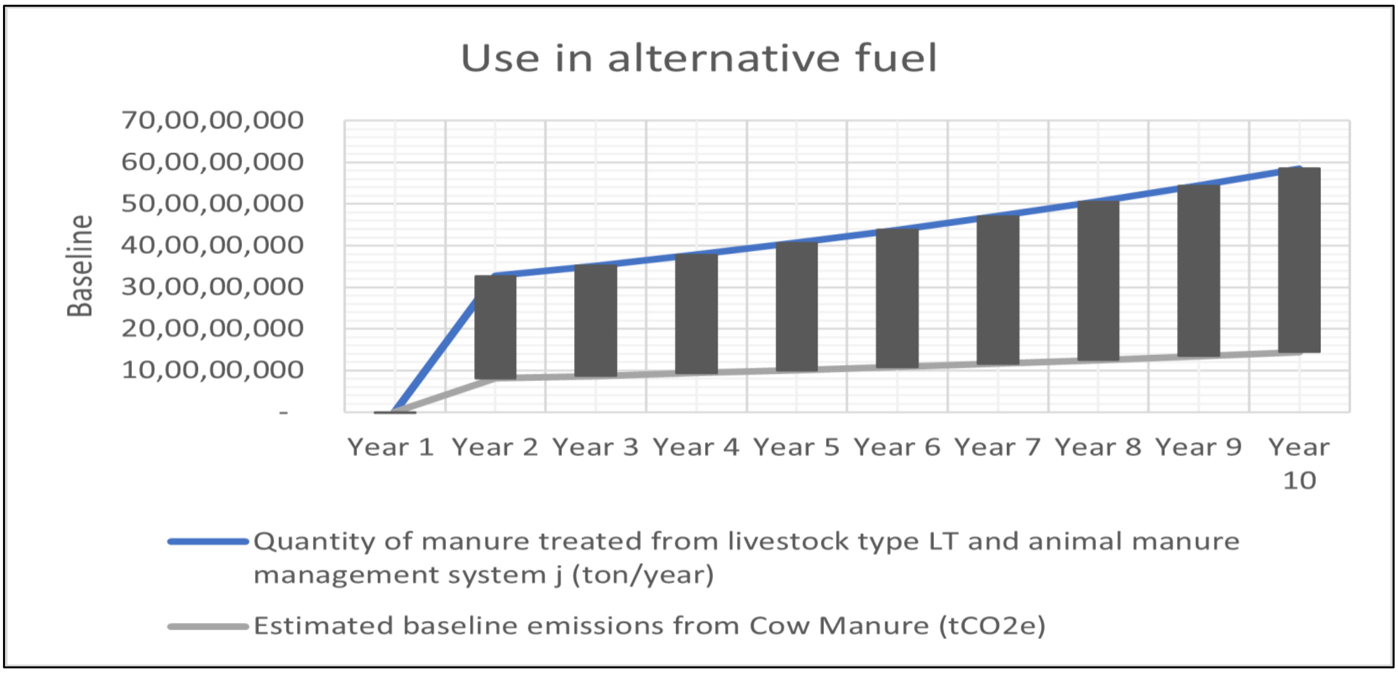

Fig 7 Cow Dung as an Alternative Fuel

CHAPTER TWELEVE
PATHWAYS FOR 2040: CLIMATE-RESILIENT FARMING PRACTICES

➢ Policy Support

- *Organic Farming Expansion:*

To lessen reliance on chemical fertilisers and reduce methane emissions, launch a national campaign to promote organic farming practises, including the use of organic fertilisers and composting methods. Provide financial incentives and subsidies for farmers to adopt climate-resilient farming practices and utilize organic fertilizers.

Facilitate access to affordable credit and investment opportunities for infrastructure development related to organic waste management and methane reduction.

Encourage public-private partnerships to mobilize funding and resources for climate-resilient farming initiatives.

Give farmers who use organic farming practises financial incentives and subsidies in order to promote widespread adoption and increase the supply of organic produce on the market.

- Sikkim, a state in India, has achieved 100% organic farming status. It promotes organic practices, reduces synthetic chemical use, and supports sustainable agriculture.
- The Government of India has launched the Paramparagat Krishi Vikas Yojana (PKVY) (Welfare, 2017) and the Organic Value Chain Development for North Eastern Region (OVCDNER) scheme to promote organic farming practices and provide financial assistance to farmers transitioning to organic cultivation.

- *Circular Economy Approach:*

The National Compost Policy of India aims to promote the recycling of organic waste through composting. Cities like Bengaluru have implemented decentralized composting units to manage organic waste efficiently and produce organic fertilizers. Promote the integration of composting units and biogas plants at the community level to encourage local circular economy models.

- The Swachh Bharat Abhiyan (Clean India Mission) (PMIndia, 2023) and the Solid Waste Management Rules (Ministry of Environment, 2021)focus on waste management, including composting, to minimize methane emissions and promote a circular economy.

➢ Technological Innovations through Green Cashflows and Artificial Intelligence (AI)

- *Climate Smart Crop Selection:*

The biggest problem with Indian farmers is the crop selection. They generally grow that product which was marketed at a great price last year. The use of cognitive technologies in agriculture could help determine the best crop choice or the best hybrid seed choices for a crop mix adapted to various objectives, conditions and better suited for farm's needs.AI has the potential to positively impact soil health. Each soil tablespoon contains millions of microbes that form an ecosystem for the plant (Konakalla, 2019).

- AI-based recommendations for enhancing soil health and crop yield can be given by extracting the DNA from soil and analysing its microbial community. In order to help identify which hybrids are most likely to produce their maximum yield potential in each environment, machine learning algorithms can be created.

- *Infrastructure Development:*

Invest in the development of decentralized composting facilities and biogas plants to efficiently manage organic waste and capture methane for energy generation.

Establish collection and transportation systems for organic waste from farms, livestock facilities, and municipal areas to ensure proper utilization and minimize methane emissions.

- The use of precision irrigation systems, such as drip irrigation, in Maharashtra has significantly improved water efficiency in agriculture, reducing water consumption and carbon emissions.
- The Pradhan Mantri Krishi Sinchai Yojana (PMKSY) (Welfare, 2023) aims to enhance water use efficiency in agriculture through micro-irrigation systems, promoting sustainable water management practices.

- Collaborative Partnership

- *Knowledge Exchange and Capacity Building:*

The Farmer Producer Organizations (FPOs) established under the Small Farmers' Agribusiness Consortium (SFAC) provide training and capacity-building programs for farmers, promoting knowledge sharing and adoption of sustainable farming practices. Conduct farmer training programs, workshops, and demonstration projects to educate farmers about low carbon farming practices, organic fertilizer usage, and methane emission reduction techniques. Foster collaboration between government agencies, research institutions, non-profit organizations, and private sector entities to leverage expertise, resources, and knowledge.

Engage with international organizations and participate in global initiatives on climate change and sustainable agriculture to exchange best practices and access funding opportunities.

Establish platforms for multi-stakeholder dialogue and knowledge-sharing to ensure a coordinated and collective effort towards climate-resilient farming.

- The National Agricultural Research and Extension System (NARES) (ICAR;, 2023) and Krishi Vigyan Kendras (KVKs) are government initiatives that facilitate knowledge exchange, training, and extension services to farmers, promoting sustainable agriculture and climate resilience.

- *Sustainable Crop Residue Management:*

The Punjab Remote Sensing Centre in Punjab, India, has developed an innovative technology called the Happy Seeder, which enables zero tillage sowing of crops without the need to burn crop residues.

The Government of India has implemented the Central Sector Scheme on 'Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue' ((GoI), 2021) to provide financial support to farmers for adopting machinery and equipment that facilitate residue management without burning.

CHAPTER THIRTEEN
CONCLUSIONS

In essence, our project underscores the efficacy of promoting organic farming and implementing organic fertilizers as potent measures to mitigate methane emissions originating from the composting of diverse organic waste sources, including cow dung, agriculture residue, and municipal solid waste. These sustainable practices hold substantial promise in curtailing greenhouse gas emissions, particularly methane, which is a formidable contributor to global climate change.

By encouraging the adoption of organic farming techniques and the utilization of organic fertilizers, we can achieve multiple environmental benefits. These encompass a substantial reduction in methane emissions during the composting process, thereby diminishing our carbon footprint and fostering progress towards India's climate change mitigation objectives.

Furthermore, the implementation of organic farming practices and organic fertilizers enhances soil health and nutrient content, facilitating the long-term sustainability and resilience of agricultural systems. This fosters the preservation of valuable ecosystems, promotes biodiversity, and fortifies the overall capacity of farms to withstand the challenges posed by climate variability.

Through our project's comprehensive analysis and calculations, we have quantified the potential methane emission reductions achievable through the promotion of organic farming and the utilization of organic fertilizers. By disseminating this knowledge and fostering awareness among stakeholders, policymakers, and farmers, we can inspire transformative changes in agricultural practices and facilitate the transition towards a low carbon economy.

In conclusion, the integration of organic farming practices and organic fertilizers presents a compelling pathway to address the urgent need for sustainable waste management, climate change mitigation, and resilient farming practices in India. By harnessing the power of these approaches, we can pave the way towards a greener, more sustainable future for agriculture and the environment.

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