Nanyang Technological University – MIT Sloan Sustainability Programme 2010

CoLab@MIT Project

Sustainable Management of Organic Wet Waste in Developing Cities

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NTU-MIT-Sloan Sustainability Module Group Assignment

Sustainable Management of Organic Wet Waste in Developing Cities

ABSTRACT

Economic growth, urbanization and rising standards of living in cities have led to an increase in the quantity and complexity of the waste generated. These factors, coupled with inefficient waste management and disposal practices, have detrimentally affected the urban environment and places serious stress on natural resources, which, in turn, undermines the equitable and sustainable development of these cities. This study aims to explore an alternative approach to the management of the municipal solid waste (MSW), through effective Public Private Partnership (PPP) approach and the use of a specific technology that is able to meet the social, economic and environmental needs of the society. Specifically, this is achieved by conducting an in-depth analysis of Mumbai's Waste-to-Energy Utility Company Business Model, and identify the key considerations in replicating it in other locations within the developing nations. As part of this study, we also reviewed a specific waste treatment technology, namely, the Nisargruna Technology, which uses a series of aerobic and anaerobic digestion of organic wet waste to produce bio-gas and high quality manure, which may eventually be sold off to generate revenues for the Mumbai wastepickers. Our study is focused on highlighting the key success factors and planning considerations for a community-based (small scale), affordable and sustainable bio-gas digester utility company. Through secondary research and interviews with a key player, namely, the Stree Mukti Sanghatana (SMS), we have formulated an approach which may be replicated in other developing nations facing similar situations.

INTRODUCTION

Municipal solid waste (MSW) management in developing cities, such as Mumbai, India, has become a great challenge for the municipalities as they try to cope with the burgeoning population growth and rapid urbanisation. The problems are multi-fold and cover issues that relate to the socio-political, economic and environmental sustainability. Several approaches have been taken to address these issue – employment of technology, new management approaches, imposition of regulations, among others. More importantly, public education and increasing the community's awareness towards waste management and treatment have shown to be increasingly important from the global perspective towards sustainable resource management. To this end, we had been informed about the amazing work carried out by a NGO in Mumbai, namely, the Stree Mukti Sanghatana (SMS), who had successfully pioneered an approach to waste management that is able to meet the social, economic and environmental needs of its community. The work done by this organization serves as an excellent model which may be replicated in other developing cities which are facing similar situations to those in Mumbai.

PART 1:

OVERVIEW OF MUMBAI'S WASTE MANAGEMENT SYSTEM

The Indian Municipal Solid Waste (Management and Handling) Rules 2000 require waste segregation at source and prohibit land-filling of biodegradable waste. Such materials have to be processed by composting, vermin-composting, anaerobic digestion or any other appropriate biological treatment for waste stabilisation. The public-private partnership (PPP) approach, while not new, have proven to be successful in harnessing the synergies of partnerships between the people/ public (e.g. the municipalities, NGOs) and the private sector companies to deliver effective waste management solutions in Mumbai. In addressing the specific social, economic and environmental issues, the humble anaerobic digestor, which has been around in India since 1859, have evolved substantially to become economical, efficient and effective in treating the organic wet waste which had often been regarded of low value.

Meeting the Social, Economic and Environmental Needs of its Community

1. The Public Sector: Municipal Corporation of Greater Mumbai (MCGM)

- *Enforces the MSW rules via the Advance Locality Management (ALM) Scheme*

  Under the Mumbai Municipal Corporation Act of 1988, it is the mandatory duty of the Corporation to maintain the area falling under its jurisdiction in clean and hygienic conditions in order to ensure a good and healthy environment. To this end, Mumbai was faced with the following challenges:

  a) lack of appropriate services and access on waste disposal in public areas due to the high density and large proportion of slum population;
  b) unavailability of landfill sites for waste disposal, especially for wet waste and other low and non valuable waste;
  c) incompetency in enforcement of MSW Rules in segregating waste at the household level and insufficient infrastructure available for lifting the waste mechanically; and
  d) lack of communication between government and community, resulting in the absence of legitimate community participation in the waste management mechanism.

  In Mumbai, the Advanced Locality Management (ALM) Scheme was started in 1997 by MCGM with the main objective of mobilizing citizens in a participative approach in setting up a system for dealing with the problem of solid waste management in an environmental friendly manner. In this scheme, each Municipal Ward is responsible for the waste collection at their respective vicinities. The focus of the initiative was decided as *'waste minimization'* and *'segregation of waste at source'*.

- *Manual collection – via community-level bin centres or door-to-door collection*

  Under the ALM scheme, the dry and recyclable are collected directly by waste-pickers, those formally employed by the MCGM or otherwise, directly from individual houses or delivered to community-level bin centres. The MCGM supports the waste-pickers by providing them with sheds, vehicles for dry transportation, open spaces, and recognizing their efforts by granting them access to Co-operatives Housing, Corporate and Ward Offices, among others.

2. Waste-pickers

The waste-picker community in Mumbai has been addressed as a special group as they constitute the 'poorest of the poor' of this city – they are among the most marginalized community, and more so for the women waste-pickers, who make up 85% of this community. The men waste-pickers make up 10% while the remaining 5% are children. 90% of all Waste-pickers are the primary breadwinners for their families, and 98% illiterate with no alternative skills. They suffer serious health hazards resulting from unhygienic work conditions, and subject to common occupational hazards such as injuries from carelessly thrown glass and metal pieces, acid bottles, needles and dog and vermin bite. Most also suffer from severe anemia, tuberculosis, respiratory diseases and backaches. Their day starts at dawn and extends to more than 10 hours, involving walking 10-12 km with daily loads of up to 40 kg. The women and children waste-pickers, in particular, are often victims of harassment by the police and municipal workers; being exploited by scrap traders and money-lenders are common occurrences. Despite the distressing conditions, the waste-pickers of Mumbai continue to contribute significantly to the city. In particular, they play an important role in (1) reducing the municipal waste handling and transport costs; (2) supplying of raw material to recycling factories; (3) saving space at dumping ground; (4) acting as resource recovery in form of valuable compost; and (4) acting as conservation agents of the environment.

3. Technology Providers, Private Sector Players and NGOs

Due to the challenges faced by the municipal government in implementation of effective MWS management, and in anticipating future problems, local NGOs along with the MCGM have taken up new initiatives through ALM Scheme to improve on existing practices. With the involvement of NGOs, the private corporations also joined the process by providing the technical skills, financial support and community action. Specifically on the management of the MSW for developing countries, recycling of the waste is the most economically viable option, in terms of employment generation for the urban poor with no skills and investment, as well as in meeting the environmental challenges.

Striking the Right Partnership and Technology Approach

1. Meeting the triple bottomlines through partnerships between the MCGM and the NGO Stree Mukti Sanghatana (SMS)

   The Parisar Vikas Programme (PVP) was one of the initiatives implemented by the Stree Mukti Sanghatana (SMS) under the ALM Scheme. The SMS, an NGO based in Chembur, Mumbai, is a Woman's Liberation Organization established in 1975. SMS has directed its efforts towards the upliftment of women, primarily by creating awareness in the society about women's issues. Its basic objective is in empowering the women, most of whom are from the lowest caste, through raising their income levels, giving them a distinct identity; raise their dignity and creating greater social acceptance through serial programmes. In short, the PVP is aimed at making these underprivileged women aware of their rights. To this end, the SMS has initiated a meaningful dialogue with the women waste-pickers, who are commonly addressed as "Parisar Bhaginis" (Neighborhood Sisters). With its 25 years experience of working in women's issues, SMS was able to develop a comprehensive approach towards resolving some of their problems through strategic initiatives. Specifically with regards to the waste value chain, the SMS was able to identify distinct roles for the women waste-pickers at different parts of the process chain, as shown in Figure 1 below.

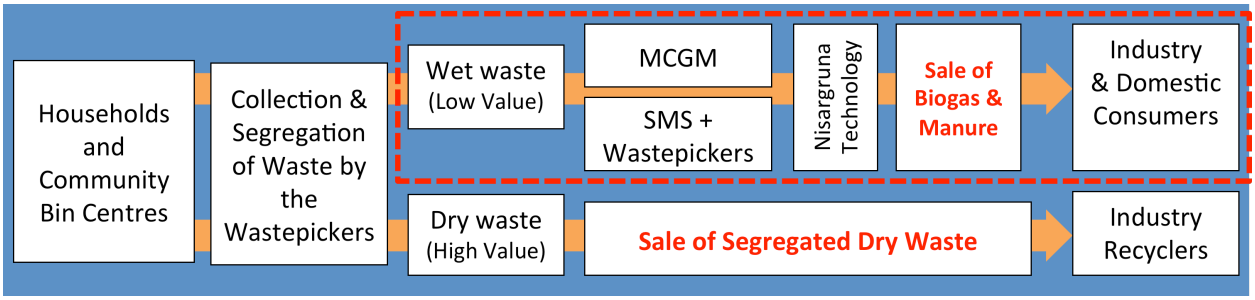


Figure 1: The Waste Value Chain for both Wet and Dry Waste, and the Role of the Waste-pickers

The PVP served as a good platform in: (1) organizing and conducting trainings for the woman waste-pickers; (2) improving their standard of living by understanding their specific problems; (3) developing new techniques for treatment of waste so as to increase their value; and (4) optimizing their productivity by adopting a zero waste philosophy through appropriate waste recycling

techniques. In doing so, the SMS also addressed the environmental problem faced by the MCGM in the collection, treatment and disposal of the low value, wet-organic waste through an economically sustainable means that also provide income and empowerment to the women waste-pickers. SMS, through the Parisar Vikas Programme (PVP) thus provide a holistic approach in combining the Social Value Chain with that of Waste management, as shown in Figure 2 below.

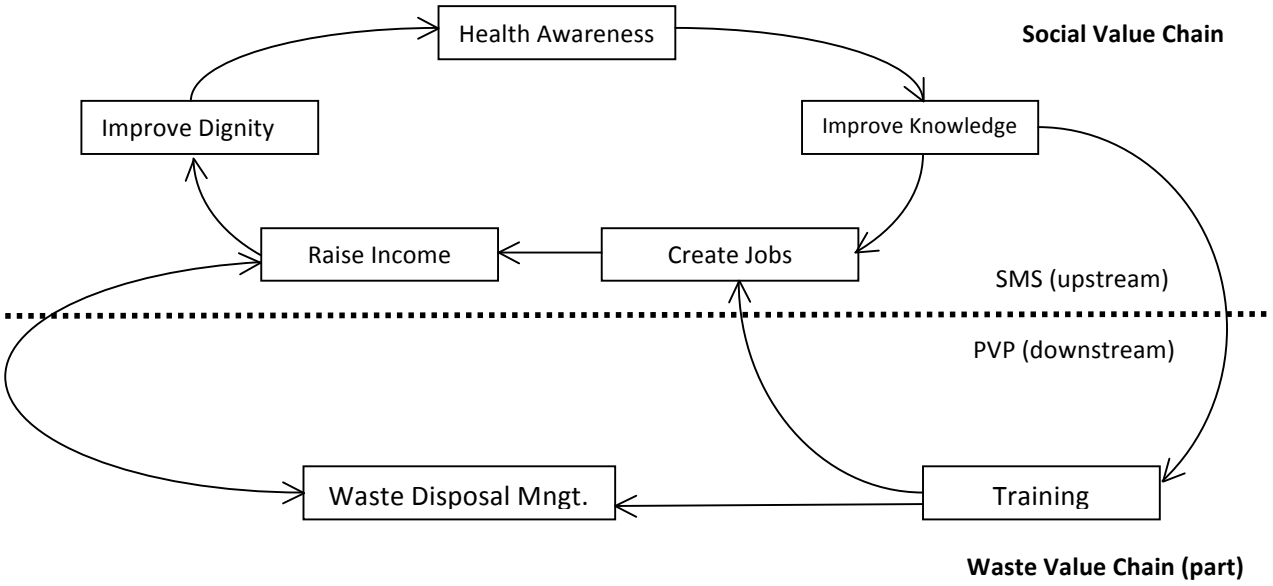


Figure 2: Combining the Social and Waste Management Value Chain

In other words, the synergies of the partnership between SMS and MCGM, through ALM Scheme, was able to address the two problems of: (1) waste disposal, resolving the environmental bottomline for the MCGM that is also economically viable; as well as (2) empowerment and increased standard of the social-economic aspects of the women waste-pickers, hence meeting the triple bottom lines of sustainability for community.

2. Using the Nisargruna Technology developed by the Babha Atomic Research Centre (BARC) to generate Biogas and Manure → ZERO Waste

Critical to the effective management of MSW is the use of the appropriate technology to enhance the value of the wet organic waste which are often regarded as low value and tend to make up a significant volume of the waste that is dumped at the Mumbai landfills. It is also pollutive, has a

pungent odour and is generally detrimental to the social environment if managed poorly. To this end, the SMS and MCGM had identified a technology developed by the Babha Atomic Research Centre (BARC), which is able to convert the organic waste into useful by-products, namely bio-gas and high quality manure, that can be sold back to the industries and households. This technology, while being low cost, has several advantages which are inherently built into its processes:

a) Mixing Stage: The waste that enters the Nisargruna Biodigesters has to be **properly segregated** as some materials may detrimentally affect the efficiency of the plant. These materials, such as coconut shells/ coir, egg shells, bones, plastic pieces and other inorganic materials may spoil the mixer blades as well as interfere with the microbial activities in both the aerobic and anaerobic digesters;

b) Pre-treatment Stage: The introduction of the high temperature water in the aerobic digester is essential for the breakdown of the sulphurus and other toxic products that may be present in the waste. The bacteria will ferment the waste aerobically (i.e. using oxygen) into acetic acid, hydrogen and carbon dioxide and will thrive under the acidic conditions. The conditions within the tank have to be **maintained under aerobic conditions through the use of an air compressor**. Some methane may be produced;

c) Anaerobic Digestion Stage: The two stage digestion helps in **improving the purity of the methane gas**, of up to 90%, thereby increasing its fuel efficiency when burned. However, this purity is dependent on how effectively the pre-digester temperatures are maintained and the amount/ quality of the waste that enters the system.

The Nisargruna Technology is shown diagrammatically in Figure 3 below:

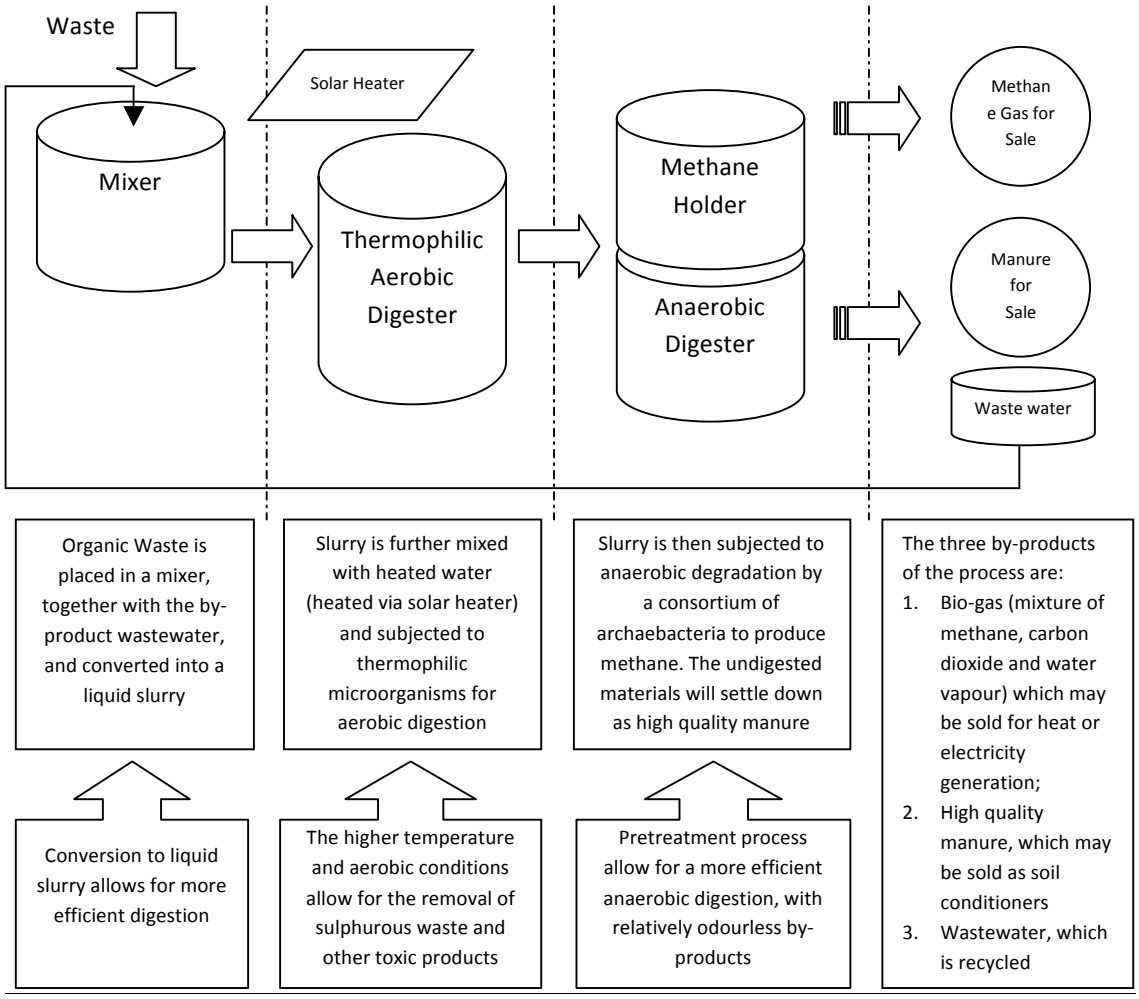


Figure 3: Diagrammatic Summary of the Nisargruna Technology, developed by BARC

Other considerations for the Nisargruna Plant include:

a) Manpower Requirements: Based on the Mumbai model, there is **no need for skilled workers** to operate the plant. Essentially, two men may be required to operate the mixers and in harvesting the biogas and manure. However, proper segregation of the waste at the upstream is required before the plant can function optimally.

b) Operational Requirements: In operating the plant, there are several key considerations that have to be monitored. These include material contents of the waste, retention time, process temperature,

volumetric load, among others. A **certain level of understanding is thus necessary** to optimize the efficiency of the system, particularly in terms of the quantity and quality of the biogas produced.

c) Key Applications: The BARC Nisargruna Plant is suitable as a **community plant rather than for individual dwellings**. Thus, its application is suitable for city corporations, big hotels, government establishments, housing colonies, residential schools and colleges, hospitals, power plants, agricultural produce market committees and large factories.

Economic Viability of the Model (indicative)

Based on the information about SMS, we tried to develop a high-level and simple financial simulation to see and test the financial sustainability of the SMS' business model to utilize the wet/organic waste.

The simulation is broadly based on the data provided, with some judgment involved. The monetary measures are adjusted in US$ currency to provide for convenient discussion.

	SMS Data	Our Assumption	Notes
Installation and Investment Costs	Rs. 32 - 35 lakhs ($ 72 - 79K)	$ 79,000.0	*One time, excl. Property Costs*
Input Capacity/day	1, 2 and 5 tons/day	5 tons/day	*5 tons/day capacity is described as the optimum size from the operating cash flow point of view*
Input is assumed to be free of Costs - unwanted waste			
Operating Costs/year	Rs. 4 - 5 lakhs	Rs. 4.6 lakhs	*≈ $ 10,300 / year Maintenance, Utiliities & Labor*
Output Ratio/Ton of Input			
Compost (in Kg)	30 - 80	55	*The data represent the range of possible scenarios of outcome which depends on various factors*
Biogas (in M^3)	50 - 90	70	
Selling Price of Outputs			
Compost (per Kg)	Rs. 3.0	Rs. 3.0	*$ 6.7 cents/Kg*
Biogas (per M^3)	Rs. 8.0	Rs. 8.0	*$ 18.0 cents/M^3*

At the moment, the model works on the basis of free availability of the organic waste input – made up of the "unwanted" wet organic waste. The assumption runs the risk that when the model works

commercially; people would start to put a price on the organic waste, thus undermining the viability of this model on a standalone. Based on the simulation, the business model has very limited capacity to bear the input costs while maintaining the financial viability. Assuming 10% ROI to be maintained, the SMS model can only bear the input cost of up to $ 6.00 per ton (*given the capacity of 5 tons/day*), as shown in Figure 4 below.

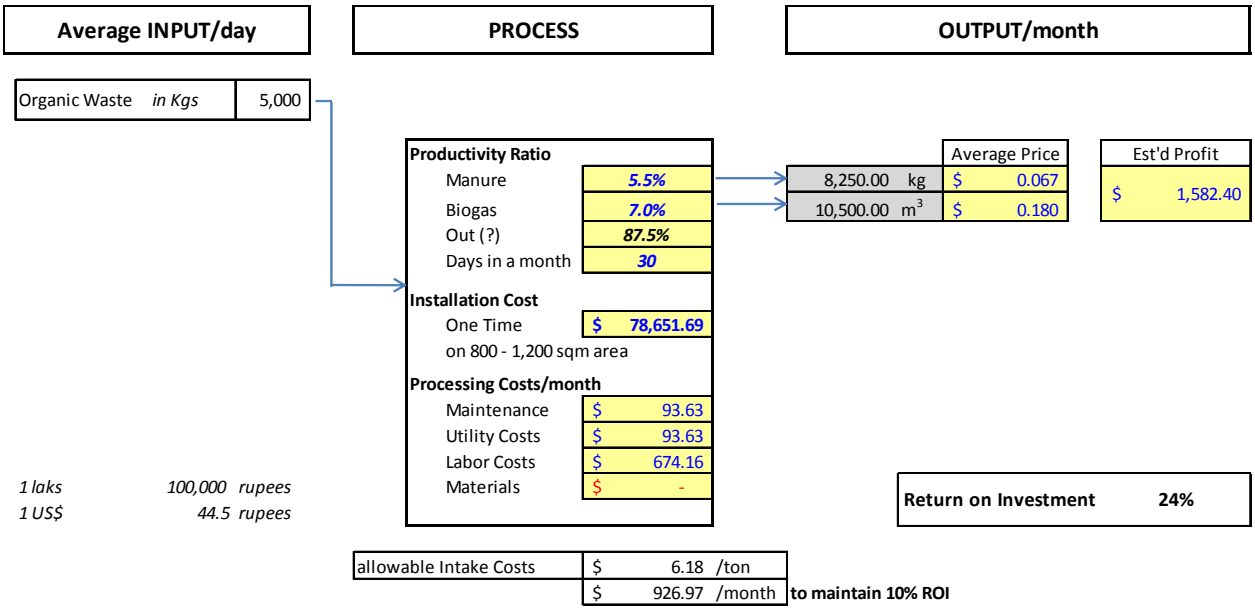


Figure 4: Financial Simulation of the SMS's Nisargruna Plant

Another point to note, these simulations are specific to the Nisargruna Plant operated by SMS, given the prevailing social and economical context of Mumbai. The figures may be different for other social and economic settings in the different regions. Notwithstanding, the key point is that, given the current state of Bio Digester technology, with its productivity in producing Biogas and Manure (Compost), it is imperative to integrate this model with the holistic waste management system, including the recyclable waste (i.e. the dry waste) to fund the acquisition and transportation costs of the waste. On a standalone basis, the financial viability of the project may be at the fringe, unless implemented as part of community charity program by a credible sponsor.

PART 2:

ESTABLISHING A MODEL THAT MAY BE REPLICATED IN OTHER DEVELOPING CITIES

Key Success Factors and Challenges for the Mumbai Model

In our analysis, the key success factors and challenges can be grouped into three major categories, namely Socio-Political, Economy and Environment; Technology and Market.

Below is the summary of the key success factors and challenges faced:

	Success Factors	*Challenges*
Socio-Political, Economy and Environment	• **Strategic partnership** among SMS, MCGM, Waste-picker and BARC • **Win – win propositions:** ✓ Uplift of women living standard ✓ Generate addition jobs and income ✓ Proper waste management ✓ Cost savings – transportation ✓ Business opportunity for private sectors - technology and sub-con	• Authority favors **large project** • Lack of funding • **Ineffective enforcement** – ALM • Low public awareness of environmental issue
Technology	• Simple to build, operate and maintain • Cost effective – small scale & decentralize • Environmental friendly (Zero waste) • High quality yield (bio-gas & manure)	• Waste segregation at source • Waste source • Energy resource distribution • Plant location
Market	• Established demand for manure and bio-gas	• Limited application for bio-gas. Expensive to compress biogas to cylinder

Through our study of the Mumbai case, we identified four important aspects of a sustainable organic wet waste management model in a developing city. These are key considerations for replicating the Mumbai model in another city and they are described in more detail in the following section.

1. Identifying the Objectives

First, it is important to identify the objective of implementing an organic wet waste management system. The relevant question here is what is the real problem we are trying to solve? More often than not, the motivation of such project is driven by a combination of the triple bottom-lines – Social, Environmental and Economy.

2. Establishing Strategic Partnership

Secondly, forming strategic partnership among the relevant stakeholders is key. In formulating a win – win proposal, the needs and wants of the various stake holders have to equally address. The important stakeholders include:

a. Government:

The city municipal, who is the responsible party for waste management and treatment, plays an important role to such project by providing the following resources:

- *Funding*: This can be the initial capital or land space for the construction of the plant
- *Regulation and recognition*: Government is in the position to introduce effective rules and regulations to support the initiative. The Advance Locality Scheme (ALS) introduced by MCGM is one good example.

b. Other parties:

- *NGOs* can play an important role by mobilizing the community through various social programmes. In the case of Mumbai, SMS plays a pivotal role to improve women waste-pickers' living standards by providing training and education.
- *Private sectors* who are interested in the business model can also be the source of funding. Rich communities, hotels, restaurants and resorts are able to provide funding to kick off the project while reaping the fruit of their investment in the form of waste management, quality manure as well as free supply of cooking gas, depending on the amount of investment and size of the plant.

Selecting the Appropriate Technologies

There are various waste management technologies available in the market. However, for developing countries, we believe the following criteria are important for successful implementation:

a. ***Simple –*** easy to install, operate and maintain

b. ***Cost effective –*** small scale and decentralized model

c. ***Environmental friendly –*** avoiding incinerators but move towards near zero-waste approach meaning recycling of dry waste and composting or bio digesting of wet waste by decentralised eco-friendly methods

d. Suitability

a. ***Climate*** – For example, Nisargruna plant uses solar energy to heat up the Thermophilic Aerobic Digester. Therefore, the technology may not be suitable in area outside the tropical belt

b. ***Type of waste source*** – In Nisargruna technology, different type of waste source affects the output produced.

c. ***Demand for the by-product***

Identifying the Market

a. Establishing the demand of the product – identify the buyer of the product. This is important to ensure the financial viability and sustainability of the plant.

b. Sale and distribution of the product

c. Source of wet waste – ensuring the consistent stable supply of the wet waste

Moving Forward

1. Current project limitations

- Secondary source of information:

  Due to time constraint, our research is limited mainly to the secondary source of information and the interview with Jyothi Mhapsekar, founder and director of SMS.

- Limited perspective as our research only focuses on SMS and Nisargruna technology.

2. Recommended Next Steps

- Learning journey: Conduct field research in Mumbai will provide better insights in the following areas:
    - *Financial analysis and modeling*
    - *Other stakeholders interview* including MCGM as the municipal government, BARC as the technological partner and the user. Such interviews will provide a more holistic views of the Mumbai model

B. In-depth analysis of the social, political and economic condition of the target city such as:
    - *Government role and responsibility* - understanding the government framework and policy on waste management
    - *End to End Supply/Value Chain* – understanding the existing supply chain starting from the source of waste until the generation of the by-products
    - *Local market condition* – understanding the local market condition will provide insight on type of waste produced and can be used in the plant. This will add value to the quality of output of the manure, methane gas and the electricity generation capacity of the plant.

C. Review other Solid Waste Management and Treatment technologies

D. Explore New Market Frontier
    - Supply of manure to the Organic Agriculture industry (local and overseas)
    - Public education to raise awareness of the technology and product to promote demand for organic manure as well as bio-gas.

APPENDIX A: Project Work Plan

I. Project Objective

The project objective is to conduct an in-depth analysis of Mumbai's Waste-to-Energy Utility Company Business Model, and identify the key considerations in replicating it in other locations within the developing nations (e.g. Bogota, Colombia and Bluefields, Nicaragua)

II. Project Timeline

Our work will be structured in three main stages:

Stage 1: Research and analysis stage (April 6th to April 9th)

During this stage of the project, we will conduct in-depth research on the bio-gas digester model implemented in Mumbai. More precisely, our analysis will cover the following:

- Review and research on the existing waste management technologies, particularly, the anaerobic digestion technology that treats organic waste and produces bio-gas, as implemented in Mumbai. The focus of our research will be on the key success factors and planning considerations for a community-based (small scale), affordable and sustainable bio-gas digester utility company;
- Research on the socio-political settings and demographics, with a focus on data that will help us understand market needs, ability to pay and how to deliver value to the customer;
- Discussions with Co-Lab on the primary and secondary information that are available for the project;
- Review the current business operation at both the upstream and downstream ends, including the waste collection and separation processes, management of the by-products (e.g. bio-gas, manure), energy generation and distribution; and
- Review the viability of the business model and its challenges

We will interview Jyoti Mhapsekar during the Stage 1 of this project to obtain more information of the Mumbai implementation and current status of the business

Stage 2: Technology and business model development stage (April 9th to April 15th)

By the end of the 1st week, we will discuss our findings and progress with CoLab. During that period of time we expect to complete the following tasks:

- Detailed analysis of the technology and business model of the bio-gas digester in Mumbai, including its key success factors, operational challenges and lessons learned.
- Establish a framework for the development of a community-based waste-to-energy utility company that can be replicated in other developing countries.

Stage 3: Synthesis and delivery of the final report (April 15th)

We target to complete our final report by 15th Apr.

III. Methodology

1. Research on the Mumbai Waste-to-Energy Utility company Model

   In order to obtain a detailed analysis of the Mumbai Model, our team will adopt a multi pronged strategy, specifically; (1) information mining through secondary sources, which include the internet and other published articles; (2) conduct a live interview via Skype with Ms Mhapsekar to further clarify on some of the key issues

2. Collaborative research work with Co-Lab/ MIT on the Socio-Political, Economic and Technological Aspects of the Project

   To this end, Co-Lab had kindly assigned an Intern to work closely with the team and identified possible contact persons who may be particularly useful in helping the team better appreciate and understand the technical aspects of the project. Specifically, the team will work closely with the intern to consolidate key background information relevant to the project, such as Co-Lab's findings on the Mumbai Model, briefs on the socio-economic and political situation in the target markets (e.g. Bogota and Bluefields), etc. The team will also work with Co-Lab to meet with relevant faculty staff in MIT who can provide us with information on the specific technology of interest, i.e. the anaerobic bio-digester technologies, its advantages and pitfalls, as well as share with us on any recent developments in the areas of low-cost organic waste treatment technologies.

3. Development of the Framework

   From the findings, the team will develop a framework for the development of a community-based waste-to-energy utility company that can be replicated in other developing countries.

4. Review and Finalize Report

IV. DELIVERABLES

Stage 1: **Interim report** that provides a detailed analysis of the existing model in Mumbai, including information on its business model, the technology used, processes and key operational challenges.

Stage 2: Present the **research findings** from the Mumbai Model and the **preliminary framework** for the development of a community-based waste-to-energy utility company

Stage 3: A **Final Report** consisting of:

1. **Research findings** from the Mumbai Model; and
2. **Framework** for the development of a community-based waste-to-energy utility company

APPENDIX B: Presentation Slides

Scope

Part 1

- Overview of Mumbai's Waste Management System
  - Meeting the Social, Economic and Environmental Needs of its Community
  - Striking the right Partnership and Technology Approach
  - Indicative economic viability of the Model
  - Key Success Factors and Challenges Faced

Part 2:

- Model for the Sustainable Management of Organic Wet Waste in Developing Cities
  - Clear Objective
  - Strategic Partnership
  - Technology Selection
  - Market Identification

Meeting the Social, Economic and Environmental Needs of the Community

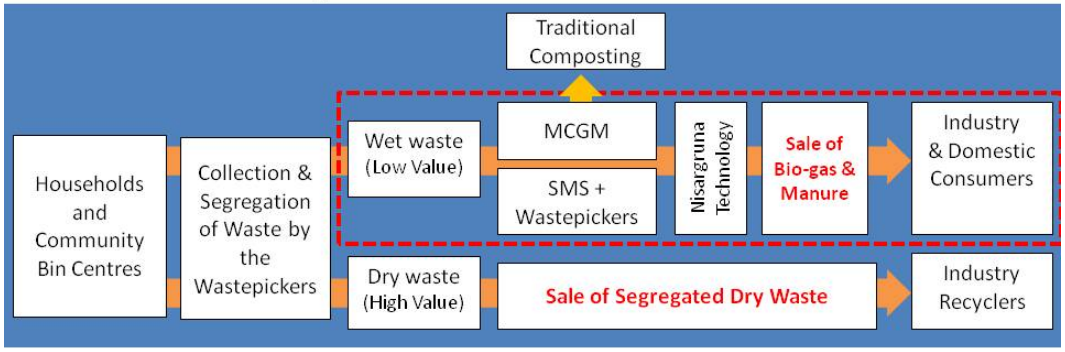
- **The Municipal Corporation of Greater Mumbai (MCGM)**
  - Enforces the municipal solid waste rules via the Advance Locality Management (ALM) Scheme
  - Each Municipal Ward is responsible for the waste collection at their respective vicinities – focused on **segregation of waste at source and waste minimization**
  - **Manual collection** – via community-level bin centres (85%) or door-to-door (15%) collection
  - **Recyclable dry waste are sold off,** while remaining waste (incl wet waste) is sent to landfills
- **Waste-pickers**
  - Provides the **labour force** for the waste collection – **poor and unskilled**, mainly women and children with **low bargaining power**
- **Technology Providers, Private Sector Players and NGOs**
  - Provides the **technical skills, financial support and community action**

KEY PROBLEMS: Social Conditions - Marginalization of Women Waste Pickers

Organic wet waste – Low value and increasing volume

Striking the Right Partnership and Technology

The Parisar Vikas Programme



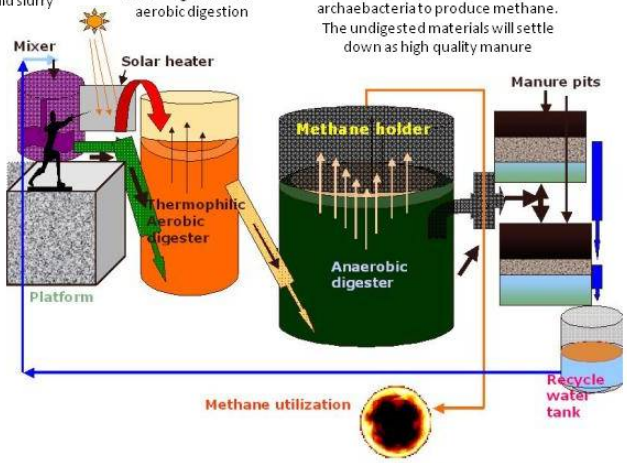
- Meeting the **triple bottomlines** through partnerships between the MCGM and the NGO Stree Mukti Sanghatana (SMS)
- Generate **new and stable income** for wastepickers (social & economic objectives) while **minimising waste** (environmental objective)
- Using the Nisargruna Technology developed by the Bhabha Atomic Research Centre (BARC) to generate Biogas and Manure → **ZERO Waste**

The Nisargruna Technology

Organic Waste is placed in a mixer, together with the by-product wastewater, and converted into a liquid slurry

Slurry is further mixed with heated water (heated via solar heater) and subjected to thermophilic microorganisms for aerobic digestion

Slurry is then subjected to anaerobic degradation by a consortium of archaebacteria to produce methane. The undigested materials will settle down as high quality manure



The three by-products of the process are:

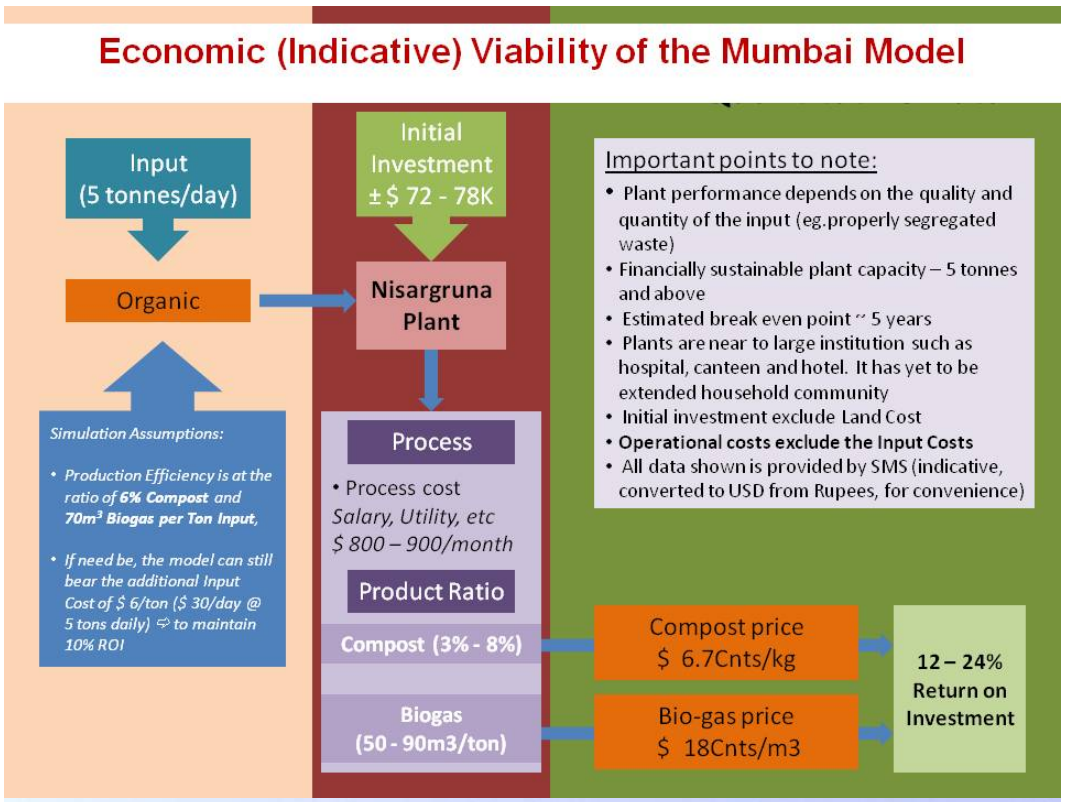
- **High quality manure**, which may be sold as soil conditioners
- **Bio-gas** (mixture of methane, carbon dioxide and water vapour) which may be sold for heat or electricity generation;
- **Wastewater**, which is recycled

Conversion to liquid slurry allows for more efficient digestion

The high temperature, aerobic conditions allow for effective removal of sulphurous waste and other toxic products

Pretreatment process allows for more efficient anaerobic digestion, with relatively odourless by-products

ZERO WASTE


Economic (Indicative) Viability of the Mumbai Model
Input
(5 tonnes/day)
Organic
Initial
Investment
± $ 72 - 78K
Nisargruna
Plant
Process
• Process cost
Salary, Utility, etc
$ 800 – 900/month
Product Ratio
Compost (3% - 8%)
Biogas
(50 - 90m3/ton)
Simulation Assumptions:
• Production Efficiency is at the ratio of 6% Compost and 70m3 Biogas per Ton Input,
• If need be, the model can still bear the additional Input Cost of $ 6/ton ($ 30/day @ 5 tons daily) ⇨ to maintain 10% ROI
Important points to note:
• Plant performance depends on the quality and quantity of the input (eg.properly segregated waste)
• Financially sustainable plant capacity – 5 tonnes and above
• Estimated break even point " 5 years
• Plants are near to large institution such as hospital, canteen and hotel. It has yet to be extended household community
• Initial investment exclude Land Cost
• Operational costs exclude the Input Costs
• All data shown is provided by SMS (indicative, converted to USD from Rupees, for convenience)
Compost price
$ 6.7Cnts/kg
Bio-gas price
$ 18Cnts/m3
12 – 24%
Return on
Investment


PART 2
Model for the Sustainable Management of Organic Wet Waste in Developing Cities

Key Success Factors and Challenges

	Success Factors	Challenges
Socio-Political, Economy and Environment	• **Strategic partnership** among SMS, MCGM, Waste-picker and BARC • **Win – win propositions:** ✓ Uplift of women living standard ✓ Generate addition jobs and income ✓ Proper waste management ✓ Cost savings – transportation ✓ Business opportunity for private sectors - technology and sub-con	• Authority favors **large project** • Lack of funding • **Ineffective enforcement** – ALM • Low public awareness of environmental issue
Technology	• Simple to build, operate and maintain • Cost effective – small scale & decentralize • Environmental friendly (Zero waste) • High quality yield (bio-gas & manure)	• Waste segregation at source • Waste source • Energy resource distribution • Plant location
Market	• Established demand for manure and bio-gas	• Limited application for bio-gas. Expensive to compress biogas to cylinder

Sustainable Organic Wet Waste Management Model

Strategic Partnership	Technology Selection	Market Identification
a. Government (Municipality) • Role in waste management • Funding – infrastructure • Regulation and recognition - waste segregation b. External parties: • NGOs – program to mobilize the community, training • Private – source of funding and technology provider	a. Simplicity - small scale & ease of O&M b. Cost effective c. Environment friendly - zero waste d. **Suitability:** • **Climate** • **Type of waste source** • **Demand for the product generated** ✓ NISARGRUNA technology	a. Identify the market of the by-product – potential buyers b. Identify the sale and distribution of the product • Plant location is key • Institutions – Hotel, Hospital

Moving Forward

<u>Current project limitations:</u>

- Source of info: Mainly secondary
- Limited perspective: SMS's point of view and Nisargruna Technology

<u>Recommended next steps:</u>

1. Learning journey: Field study in Mumbai
   - Financial analysis and modeling
   - Other stake holders interview – MCGM, BARC, Consumer
2. In-depth analysis of the socio-political, economic and environment condition in the target location
   - Government framework for waste management
   - E2E Supply/Value Chain (Input and Output)
   - Local market condition (Organic agriculture)
3. Review other Solid Waste Management and Treatment technologies
   - Bio-gas to electricity conversion
   - Storage, transportation and utilization of bio-gas
4. **Explore new market frontier**
   - For example, demand of manure in the Organic Agriculture industry (local and overseas)
   - Public education and awareness of technology and product

APPENDIX C: Clarifications on the Application of the Nisargruna Technology in Mumbai

1. **General Overview on the Cultural, Socio-Political, Geographical and Economic Climate in Mumbai**

- **What makes the Nisargruna Technology so relevant in the social context of Mumbai?**
  - Who are the key players (*e.g. the wastepickers, Stree Mukti Sanghatana, Municipal Corporation of Greater Mumbai, Bhabha Atomic Research Centre, other private sector players?*) in the application of the technology and what are their specific roles?
  - What are the relationships that exist amongst these key players?
  - How is this initiative supported by the Government and how is this project funded (in terms of the capital outlay, land acquisition, etc)?
  - What are its key success factors and challenges faced to-date?

- **How has the community benefited from the application of the Nisarguna Technology?**
  - Treatment Process: What motivated SMS to employ the use of the Nisargruna Technology over traditional composting of the organic wet waste?
  - Sale of Products: How are the products sold and delivered to the end customers? What is the general demand for the products?
  - Social Benefits: How have the various sectors of the Mumbai community benefited from the project?

2. Operational Application

- **Waste Segregation:**
  - What are the incentives or measures (eg. coupon, awareness or education campaign) taken by the municipal government in encouraging its residents to comply with the requirement for waste segregation? How effective are these measures and what are the penalties for non-compliance?

- **Waste Collection:**
  - What are the charges for the waste collection services who how is this revenue stream distributed out?
  - Are there separate charges for wet waste and dry waste? In particular, how much of these revenues from the wet and dry waste collected go to the wastepickers?
  - What is the organizational structure for the wastepickers and how do they go about their collection?

- **Waste Transportation:**
  - What are the transportation considerations (e.g. distance from source, mode and cost of transport, etc) in locating the plant?

- **Waste Treatment:**
  - How is the efficiency of the Plant measured and what are the control measures put in place to ensure the quality of the waste that enters the Plant?
  - How are the outputs (i.e. the manure and bio-gas) of the Plant measured?

- **Resource Sale and Distribution**
  - How are the key products, namely, the bio-gas, manure and electricity harvested, sold and distributed? How is the bio-gas converted to electricity?

3. <u>Cost considerations</u>

- It was stated that the cost of the plant including the operational cost has been Rs 22 lakhs. What is the breakdown between the initial capital outlay and operation cost? What capacity is this cost based on?
- What is the operating cost of a 5T Nisargruna plant? What is the capital outlay of a 5T Nisargruna plant?
- Does the plant need to be located in near to source of waste as well as resource (bio gas and electricity) utilization? Eg. near to Hotels or Hospital?
- How is the Nisargruna plant being operated particularly in terms of man-power training in operation supervision in ensuring the efficiency of the plant?
- What is the performance of the Nisargruna plant today in terms of the quality of the waste collected, the product quality and reliability and the revenue generated?

Response from Ms. Jyoti Mhapsekar from SMS:

1. <u>General Overview on the Cultural, Socio-Political, Geographical and Economic Climate in Mumbai</u>

What makes the Nisargaruna Technology so relevant in the social context of Mumbai?

We strongly believe that all wasted resources must be recycled. While recycling, we must stick to scientific methods. The first step in such processing of wasted resources is segregation. We have been trying to propagate the practice of segregation at source. However any such change takes a long time to set in especially in cities and metro-cities where people tend to become insensitive to such issues because they do not apparently affect their daily routines. Hence the role of rag-pickers becomes vital to do this segregation. The success of Nisargaruna depends to a large extent on segregation of biodegradable materials from inert materials.

The development of Nisargaruna technology has been aimed at decentralized processing of biodegradable resources generated in various parts of the cities and villages. Such smaller capacity Nisargaruna plants at ward levels or village levels would help in reducing burdens on the dumping yards They will also improve the potential of dry resource segregation. The expenditure involved in transporting huge amounts of wasted resources from various parts of the city to the dumping yards can be controlled by such decentralized processing centers for segregated resources.

Nisargaruna technology is easy to adopt, operate and maintain compared to many of the existent foreign technologies. The weather conditions of our country also make it more efficient. In a country which is starved for organic manure and energy, the returns from Nisargaruna technology would not only make it sustainable, but it would also maintain sustainability of resources.

Nisargaruna technology deserves carbon credit for following reasons:

- ✓ *It saves the methane escape from such resources in the environment when they are processed to capture it rather than when they are left at the dumping yards.*
- ✓ *The use of such captured methane helps in reducing the use of equivalent quantities of fossil fuels thus reducing the carbon emissions.*
- ✓ *Use of manure generated in the process replace an equivalent quantities of urea and other artificial fertilizers and reduce carbon emissions involved in their manufacture.*
- ✓ *The reduced costs of transportation and reduced use of fossil fuels involved in such transportation will reduce carbon emissions.*

Who are the key players (e.g. the waste pickers, Stree Mukti Sanghatana, Municipal Corporation of Greater Mumbai, Bhabha Atomic Research Centre, other private sector players?) in the application of the technology and what are their specific roles?

The entire above mentioned are Key players. BARC has designed the project . It also monitors the project. MCGM or private sector as financers and users of Gas) and waste pickers (for getting dry waste and jobs)are beneficiaries and also and SMS or other technology holders are implementing agencies

What are the relationships that exist amongst these key players?

With MCGM it is love and hate. Private sector it is win –win.

How is this initiative supported by the Government and how is this project funded (in terms of the capital outlay, land acquisition, etc)?

So far Maharashtra state Govt. has recommended this technology for Municipalities and they are implementing it.The government both at State and Central level is trying to provide enough financing for this purpose. However the procedures take a long time to set in. Land is being provided by Local Urban Bodies to put up such plants.

What are its key success factors and challenges faced to-date?

Simple ,cost effective and Environment friendly technology. Municipal Councils like Matheran, Kalameshwar, Katol, Pandharpur, Alibag, Sawantwadi, Dapoli, Roha, Pen, Panvel, Pune can be considered to be success stories. The challenges:

- ✓ *Changing the mental attitude of people and creating a definite political will are the challenges faced.*

- ✓ *Corruption, the attitude of Auhorities to have large projects , Apathy towards poor, Ignorance about the environmental issues, Non implementation of simple laws like segregation at source.*

How has the community benefited from the application of the Nisarguna Technology?

Community as such is not yet involved directly so far. We are treating hotel and restaurant and canteen waste. However community is benefited because low skilled persons get training and jobs. Also there are environmental benefits as waste is processed in proper way.

Treatment Process: What motivated SMS to employ the use of the Nisargaruna Technology over traditional composting of the organic wet waste?

It has double benefit of getting alternate fuel along with compost. Usually whenever technology enters any informal sector, women are the first ones to get marginalized.

Ease of application and operation

⇒ *Nisargauna is simple, cost effective and Environment friendly technology. Waste pickers are the best persons to sort the wet waste. We trained them in operation and though illiterate they learned fast.*

Sale of Products: How are the products sold and delivered to the end customers? What is the general demand for the products?

This area is still to be developed to the full potential of the process. Organic manure is finding very good application at all the levels. However utilization of gas is still in premature stage and it would take some time till a definite income starts flowing in from sale of biogas. However utilization is picking up.

Social Benefits: How have the various sectors of the Mumbai community benefited from the project?

Community is benefited because low skilled persons get training and jobs. Jobs give them steady income, fixed hours of work, clean work environment and training and capacity building enhances their confidence. Because of fixed jobs they can save, better food security. As members they can avail facilities of health and education for their family members.

2. <u>Operational Application</u>

Waste Collection: What are the charges for the waste collection services how is this revenue stream distributed out?

Waste collection is the responsibility of the people who give the contract. However it is possible to take the contract of collect the waste .That will create more jobs.

Are there separate charges for wet waste and dry waste? In particular, how much of these revenues from the wet and dry waste collected go to the waste pickers?

Dry waste is the property of the plant operators.

Waste Transportation: What are the transportation considerations (e.g. distance from source, mode and cost of transport, etc) in locating the plant?

We don' take transport responsibility at present. But it always better to have plants near the source.

Waste Treatment: How is the efficiency of the Plant measured and what are the control measures put in place to ensure the quality of the waste that enters the Plant?

By measuring quantity of gas and Ph, Analysing manure, Taking care that there is no smell.

How are the outputs (i.e. the manure and bio-gas) of the Plant measured?

There is meter to measure gas. Manure can be weiged.

3. Cost considerations

What is the operating cost of a 5T Nisargaruna plant? What is the capital outlay of a 5T Nisargaruna plant?

5T of Nisargaruna plant as on today will cost Rs. 32-35 lakhs and operational cost annually will be Rs. 4 to 5 lakhs

How is the Nisargaruna plant being operated particularly in terms of man-power training in operation supervision in ensuring the efficiency of the plant?

We maintain 8 plants with one main Supervisor,plants operator and under her sorters.

What is the performance of the Nisargaruna plant today in terms of the quality of the waste collected, the product quality and reliability and the revenue generated?

- ✓ *If the input is non vegetarian food gas generation and manure is of best quality*
- ✓ *If the input is vegetarian food gas generation is of good, better if oily*
- ✓ *If the input is green waste then gas generation is around 60 to 70% of first category*
- ✓ *Revenue depends on the quality.*

The plant should be taken as waste processing plant and not gas and manure generator plants. These are byproducts. Environment benefits are most important.

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Pictures used at Appendix B (Presentation Slides) were obtained from the website for the ***Envis Centres on Environmental Information System***: http://www.envis.icpe.com/waste_seg.htm ;