Submitted to:

Alternative Energy Promotion Center (AEPC)
National Rural and Renewable Energy Programme (NRREP)
PO Box: 14364, Khumaltar Height,
Lalitpur, Nepal
Phone: +9771-5539390/5536843
Fax: 5539392
Website: www.aepc.gov.np

Final Report
On
"Feasibility Study for Waste to Energy Project in Itahari Sub-Metropolitan City"

Submitted by:

Sustainable Energy and Technology Management P. Ltd. (SETM)
PO Box: 7039
Kathmandu, Nepal
Phone: +9771-4248521
Email: info@setmnepal.org
www.setmnepal.org

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1 INTRODUCTION

SETMPL has prepared this Final Report for "Feasibility Study for Waste to Energy Project in Itahari Sub-Metropolitan City" as per the contract agreement signed between Alternative Energy Promotion Centre (AEPC) and SETM on the date of 8 December 2016.

1.1 BACKGROUND

Nepal is one of six pilot countries identified for assistance under the Scaling-up Renewable Energy Program in Low-Income Countries (SREP) by the SREP sub-committee. As one of three programs under the Strategic Climate Fund, SREP aims to demonstrate the social, economic and environmental viability of low carbon development pathways in the energy sector. In particular, the objectives of SREP in Nepal are to (i) leverage complementary credit and grant co-financing; (ii) bring about transformational impacts through scaling up energy access using renewable energy technologies (RETs), poverty reduction, gender and social inclusiveness and climate change mitigation; and (iii) ensure sustainable operations through technical assistance and capacity building. The Government of Nepal (GoN) has designated the Ministry of Finance (MoF) and the Ministry of Population and Environment (MoPE) as the focal points for SREP. MoPE has designated the Alternative Energy Promotion Centre (AEPC) as the lead agency for SREP-related activities. Under SREP, there are two different types of large sized biogas plants or energy projects prioritized for implementation viz. commercial plants and municipal solid waste (MSW) to energy plants. The municipalities willing to develop the waste to energy project under this program are expected to partner with private entrepreneurs bringing technology to invest in the waste to energy project for commercial use.

1.2 OBJECTIVE OF THE ASSIGNMENT

The main objective of the assignment was to conduct the feasibility study for waste to energy project in Itahari Sub-Metropolitan City to determine the biogas potential from anorganic waste fraction of the City.

As indicated in the objective, the study intends to identify waste to energy potential in Itahari sub-metropolitan city through the conduction of feasibility study. Furthermore, the study intends to recommend sorting and pre-treatment options for extracting energy from the organic waste fraction and recommend treatment processes. The study also aims to suggest proven technologies readily available to treat the MSW with pre-digestion, digestion and post digestion of the digested slurry and technologies suitable for minimizing the amount of waste going to landfill.

1.3 SCOPE OF WORK

The key scope of work was;

Determination of Potential of Biogas from the Municipal Solid Waste of Itahari Sub-Metropolitan City by:

- Quantification of the waste production and collection in the municipality. The data has to be collected in association with the municipality.

- Determination of the organic waste fraction of the different samples of waste using an approved waste characterization protocol in the municipality.
- Analyze the anaerobically digestible waste fraction from the organic fraction of the municipality.
- Assess the potential of biogas energy from the waste fractions generated in the municipality.
- Recommend sorting and pre-treatment options for extracting energy from the organic waste fraction and recommend treatment processes.
- Obtain information and evaluate technologies suitable for minimizing the amount of waste going to landfill.
- Recommend proven technologies readily available to treat solid waste to help meet the relevant environmental and other waste management obligations along with pre-digestion, digestion and post digestion of the processed slurry.

2 STUDY METHODOLOGY

SETM has adopted the following methodology to conduct feasibility study of waste to energy project in Itahari SMC.

2.1 DESK STUDY

Desk study and interaction sessions were carried out to get valuable information related to large biogas from municipal waste. Available materials such as existing project records, previous feasibility study reports and various reports about municipal solid waste management were explored and thoroughly reviewed. The collection of relevant secondary information and data of Itahari SMC such as demography, population growth rate, temperature, waste management plans, municipality profile etc. were accompanied.

2.2 FIELD VISIT AND DATA COLLECTION PHASE

Based on the study objectives, data collection module wasprepared for the quantification and characterization of waste production in the SMC. As per suggestions received from AEPC/SREP, the modification was carried out. This feasibility study is primarily based on field study data. However, some relevant secondary data wereobtained from SMC officials and Enviro Care Concern (P) Ltd.

After finalization of all tools/methodologies and approval from AEPC, the Consultant team were mobilized to conduct feasibility study.

2.2.1 WASTE QUANTIFICATION

The main parameters for thewaste quantificationare basically density, mass and volume of the solid waste. The weight (mass) of each type of vehicle (waste carrier vehicle) with waste and without waste was measured in Weight Bridge.

The field survey was conducted from 27 December, 2016 to 5 January 2017. For data validation and precise examination, discussion and feedbacks were carried out with Itahari SMC officials and Enviro Care Concern (P) Ltd. Based on field observed data, the total quantification of collected waste by the SMC was calculated.

Besides this, the interrogation and data collection from residents in determining the sample sizewasnotpractical due to large number of population.However, fewselected householdswere taken into consideration for data collection which is used in projection and validation of per capita waste production.Similarly, the representative places of SMC waste collection centerswere visited for assessment of the current practice of residential solid waste collection and disposal system. Also the vegetable market centers, hotel, and restaurants etc. were randomly visited in close consultation with SMC and local stakeholders.The data relating to waste production, waste characteristics, transportation routes, collection systems, disposal sites, recycled materials markets etc.were also collected.

The proposed project site was visited to conduct meticulous study of location, water availability, transport links to the site, land availability and ownership, nearby market, energy demand, surrounding environment etc.

2.2.2 WASTE CHARACTERIZATION

The composition of the municipal solid waste assessment is important in determining the extent of organic substrates within the waste stream so as to determine the technical and economic viability of the proposed waste to energy project.

The waste was separated into 4 sections forming a square, rectangle or shapes in such manner. Then the diagonal wastes were excluded and remainingwere mixed and again separated into 4 sections as before. The same process was carried out until the waste was converging to a require sample weight of approximately 50 kg.After this, the composition study was carried out. The composition of solid waste was categorized into organic waste, paper, plastic, glass, construction material and others. Each separated components were weighed and percentage composition of such matters were calculated.

For characterization purposes, waste sample was sorted manually by the field team trained prior to initiation of the sampling and categorization process. For the waste analysis, the flat land was selected in close proximity to the landfill site for ease transportation of waste once the sorting processwas completed. The waste samples were designated randomly from arriving waste carriage vehicles.

In case of households, the average per capita generation of waste was calculated by the sample study in the different sizes of family in a day. Similarly, the characterization of the hotels, vegetable markets, and business/market center, industrial and others were conducted. This method was helpful to identify the overall physical characteristics of wastes. An-aerobically digestible waste fraction from the organic fraction of MSW wasanalyzed. Thus, characterized waste was further studied for estimation of the potential of biogas energy from the waste fractions generated in the SMC.

2.2.3 CONSULTATION WITH SMC/INTERACTION WITH LOCAL STAKEHOLDERS

The key informant interview was conducted with SMC officers and Enviro Care Concern (P) Ltd to acquire information at field level. Meetings were conducted with SMC team, Enviro Care Concern (P) Ltd team and other stakeholdersto know their commitments on waste management and biogas development activities in near future.

2.3 DATA INTERPRETATION AND ANALYSIS

All the information/data obtained from the SMC and field survey were properly managed by using appropriate database tools. On the basis of such processed data, thepotential of biogas energy generation from waste fractions generated in the SMC was assessed.

Such processed data is helpful to recommend relevant technologies for sorting, pre-treatment and treatment options for extracting energy from the organic waste fraction. Proven technologies are recommended to treat solid waste to help meet the relevant environmental and other waste management obligations along with pre-digestion, digestion and post digestion of the digested slurry. Site analysis was also conducted for theenvironmental and social screening of the potential site as per feasibility study guideline of AEPC. Also, the project timeframe for the development of such facility has been proposed.

3 INVENTORY OF CURRENT FRAMEWORK CONDITIONS

3.1 ABOUT ITAHARI SUB-METROPOLITAN CITY

Itahari is a Sub-Metropolitan and largest city in Sunsari District in the Koshi Zone of south-eastern Nepal. It is located at the main transport joint of eastern Nepal. It is the center of the east-west Mahendra Highway and north-south Koshi Highway and therefore is a city of promising importance.

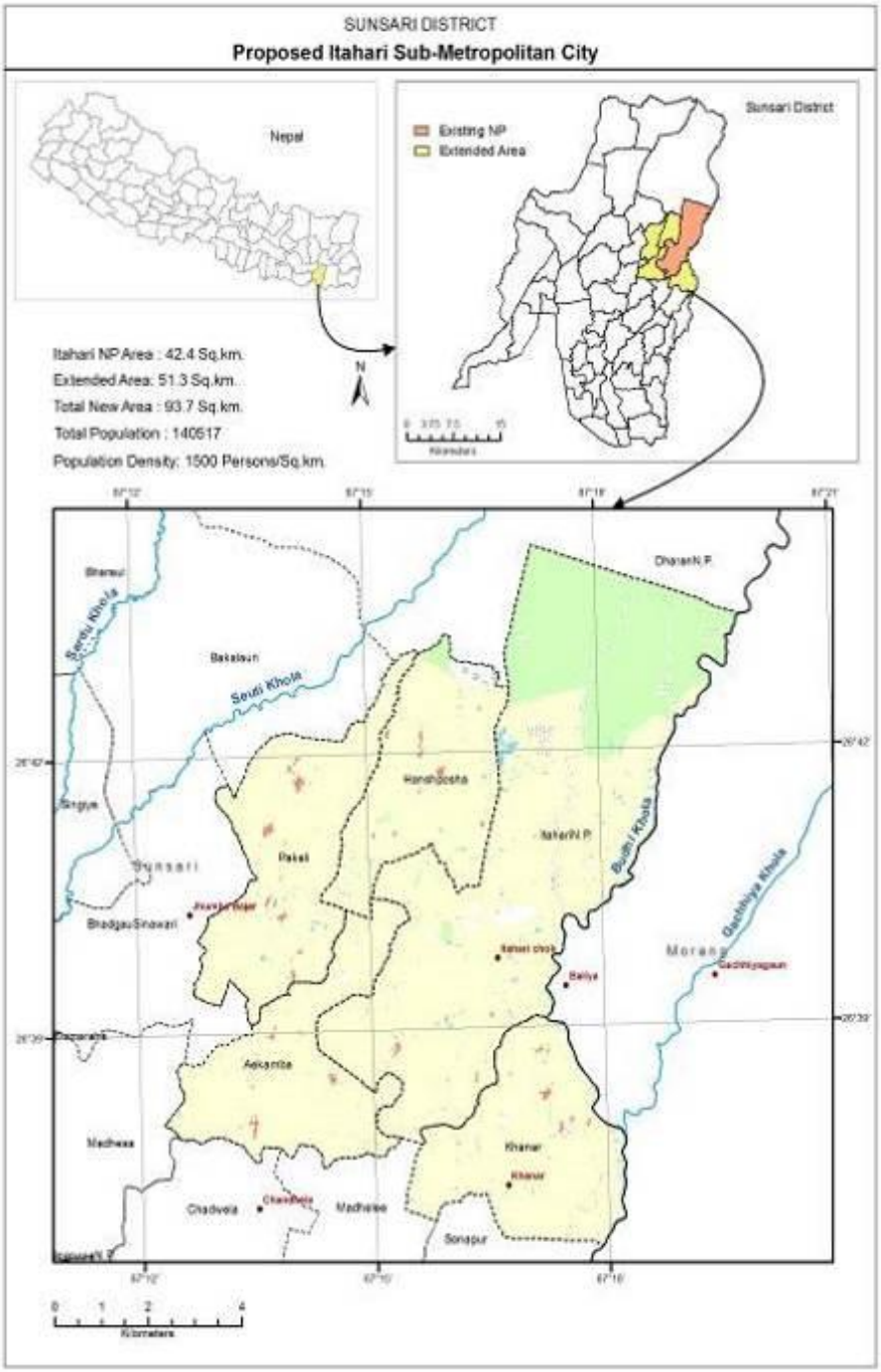

Figure 1: Map showing the location of Itahari SMC

Table 1: General Information of Itahari SMC

Name	Itahari Sub-Metropolitan City
District	Sunsari
No of wards	26
No of Urban Wards	6
No. of Rural and semi Urban Wards	20 (5+15)
Total Area	130 sq. Km
Major Rivers and Ponds	Budhi, Tangra rivers; Bhanse, Mechi-kali Ponds.
Population (2011)	140517
No. of Households (2011)	33,794
No. of Industries	355
No. of Hospital/Clinics/Nursing Home	8/107/20
No. of Shops and Business Centre	7,735
No. of Restaurants, Hotels	4 Star Hotels, 36 Restaurants, 773 hotels
Annual Population Growth Rate (2011)	6.23 %
Sewerage canal length (km)	17.693
Agricultural land area (Hectare)	5,880
Forest land area (Hectare)	2636.5

Source: Itahari SMC profile, 2015

3.2 CLIMATE

Climate data of nearest airport Biratnagar Airport is taken as reference. Itahari SMC experiences the tropical climate. The average high temperature of Biratnagar reaches maximum of 33.9 ˚C in the month of April and minimum of 22.7 ˚C in the month of January. The average low temperature reaches maximum in the month of August and minimum in the month of January. The annual average rainfall of 1891.8 mm had been recorded.

Table 2: Climate Data for Biratnagar Airport (1981-2010)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Maximum Temperature °C (°F)	22.7 (72.9)	26.1 (79)	30.9 (87.6)	33.9 (93)	33.3 (91.9)	32.9 (91.2)	32.1 (89.8)	32.5 (90.5)	32.1 (89.8)	31.6 (88.9)	29.3 (84.7)	25.4 (77.7)	30.23 (86.42)
Average Minimum Temperature °C (°F)	9.0 (48.2)	11.1 (52)	15.6 (60.1)	20.4 (68.7)	23.3 (73.9)	25.2 (77.4)	25.6 (78.1)	25.8 (78.4)	24.7 (76.5)	21.1 (70)	15.3 (59.5)	10.5 (50.9)	18.97 (66.14)
Precipitation mm (inches)	11.7 (0.461)	13.2 (0.52)	13.2 (0.52)	53.1 (2.091)	186.0 (7.323)	302.4 (11.906)	530.8 (20.898)	378.3 (14.894)	298.8 (11.764)	91.8 (3.614)	5.9 (0.232)	6.6 (0.26)	1,891.8 (74.483)

Source: Department of Hydrology and Meteorology (Nepal)

3.3 SEASONALITY

Municipal solid waste is generated every day and is available in Itahari Sub-Metropolitan City throughout the year**.** Quantity of waste and type of waste may vary seasonally**.** Quantity of waste generation increases mostly in festival and marriage season.

3.4 NATURAL RESOURCES

Budhi Khola is situated adjacent to the proposed project site so required water can easily be availed from the river. Use of water available at Budhi Khola can be used in the proposed project with no objection from stakeholders since water is usually used for irrigation purpose.

Proposed project development site is located at open terrain where abundant solar energy is available. So direct solar radiation can be used as per requirement of project.

3.5 GEOLOGY AND LOCATION

Proposed project location is situated near Khanar Bazar at Domartaka, Itahari SMC-10, Sunsari. GPS location of the proposed site is 2946224 N, 529286 E, 87m. The proposed location is linked Itahari by around 4.5 km long motor able road. Nearby market is Khanar Bazar which is around 2.6 km far from the proposed location.

3.6 HUMAN BACKGROUND

Since the land proposed for project is owned by Itahari Sub-Metropolitan City, the main authority of the area is Itahari SMC. The nearby community will have no objection if project is established in proposed location however, they demand for better transportation facility and social infrastructure. The major ethnic community around the proposed site is Tharu community.

Stakeholder matrix of relevant parties

Meet their needs: Local community Ethnic Group	Key Player: Itahari SMC Political Parties at local level
Least Important:	Show Consideration: Local Peoples Community leaders

3.7 LEGAL FRAMEWORK AND PERMIT REQUIREMENTS

Municipal solid waste management within Itahari Sub-Metropolitan City is currently undertaken by Enviro Care Concern Private Limited. However, Itahari Sub-Metropolitan City is the authorized body for any permissions required regarding project development. Itahari SMC is always interested in managing their municipal solid waste and its conversion to energy and therefore agreed for the establishment of waste to energy project in their SMC. Itahari SMC already has ownership of 3.385 Hectare (5 Bigha) of land and in process of acquisition for additional 2 Hectare (3 Bigha) of land.

3.8 PAST EXAMPLES, LESSONS LEARNED

Solid waste processing plant was established at the project location by Itahari SMC with Enviro Care Concern Private Limited. The processing plant was established with objective of segregating waste. However, there hasn't been any renewable energy projects in the past carried out in the same location.

3.9 WASTE MANAGEMENT SECTOR

Itahari SMC has been managing MSW generated in SMC with support of various stakeholders but the official records of the MSW generation and management lack the required data base maintenance. Major objective of SMC and other associated stakeholders used to be collection and transportation into the dumping site within the city area.

At present, waste management of Itahari SMC is being carried out by Enviro Care Concern Private Limited in agreement with SMC. There is no segregation of municipal solid waste carried out by SMC and Enviro Care Concern Private Limited. The reuse, recycle and reprocess of the collected MSW used to be limited to the Scrap vendors (Kawadi), the solid waste vendors.

Photo 1: Office of Enviro Care (P) Ltd, Itahari Nepal

3.10 HUMAN RESOURCES

Total of 51 employees are employed by Enviro Care Concern for waste management of Itahari SMC. Out of 51 employees; 5 are managerial level employees, 11 are skilled employees, 26 are labors and 9 other employees.

3.11 MATERIAL AND TRANSPORTATION CAPACITY

Total of 10 tractors are owned by Enviro Care Concern Private Limited which are used for day to day waste collection and transportation of SMW in Itahari SMC. However, only eight tractors are used on daily basis for waste collection and management.

3.12 Regular Membership Status

Enviro Care Concern Private Limited has maintained regular membership with various waste generating individuals and institutions with whom they charge certain waste management fee. From the data book of Enviro Care Concern Private Limited, ward wise number of members and waste collection points is obtained. Ward wise number of members and waste collection point is shown in Table 3.

Table 3: Ward wise number of member

Ward No	Membership Number	Remarks
1	4409	
2	443	
3	2	
4	3065	
5	2683	
6	47	
7	735	
8	2167	
9	31	
10	7	
11	3	
12	591	
13	83	
14	77	
15	N/A	No waste Collection
16	N/A	No waste Collection
17	93	
18	N/A	No waste Collection
19	211	
20	96	
21	1	
22	75	
23	N/A	No waste Collection
24	1606	
25	131	
26	436	
Total	**16992**	

Source: Enviro Care Concern (P) Ltd, 2016

3.13 WASTE COLLECTION AND LANDFILL

Solid Waste is collected from various waste generation points i.e. households, hotels, vegetable markets, industries, streets, etc. Waste generated on streets are accumulated by sweepers and taken to collection points. Waste from collection points are later taken to landfill site by tractors. Whereas waste generated from households, industries and institutions are directly collected by tractors and taken to landfill site for dumping. Waste is collected from generation point/collection point without segregation. So, collected waste consists of mixed waste including both organic, inorganic solid waste and hazardous waste.

Landfill site is located at Charkoshe Jhadi which is about 11 km away from Itahari Chowk. The landfill site at Charkoshe Jhadi is open landfill type where waste is openly dumped without any further treatment and processing.

Photo 2:Waste Carriage Vehicle of Enviro Care at Charkoshe Jhadi

3.13.1 DAILY COLLECTION OF SOLID WASTE FROM ITAHARI SMC

The existing solid waste generation pattern was studied during field observation. The solid waste collection pattern from daily collection is shown in Table 4:

Table 4: Existing daily solid waste collection pattern

Date	Tractor volume(m^3)	Tractor No	Frequency of Trip	Average Distance Covered (km)
2016/12/29	9.72	5315	1	1.5

2016/12/29	9.72	5317	1	1.5
2016/12/29	9.72	5318	1	1.5
2016/12/29	9.72	5319	1	1.5
2016/12/29	9.72	5316	1	1.5
2016/12/29	9.72	4891	1	1.5
2016/12/29	9.72	4892	1	1.5
2016/12/29	9.72	6404	1	1.5

Source: SETM field survey, 2016/17

3.14 Quantity Estimation of Daily Collection

The daily collection of the MSW, which is currently in practice serve the manual collection of the waste from the door to door for those, who pays for the management cost including the households and the institutions. Besides, the solid waste collections from the major routes of the streets are also conducted on the daily basis that may or may not include the paid members.

The door to door solid waste collection with the regular fixed monthly fee is still limited to just 16992 members. The MSW collection and disposal responsibility undertaken by the Enviro Care Concern Private Limited as per the bilateral contract with Itahari SMC actually fulfil the part and parcel of the total solid waste generated within the SMC.

The quantity estimation of daily collection of solid waste is made based on the primary field observation and conversation with Enviro Care Concern Staffs. The field observation included segregation and measurement of solid waste. Quantification of waste is made based on the by weighing waste carrying tractors.

The current practice of waste collection in Itahari SMC is from door-to-door collection and street collection. So for quantification of total solid waste collected from SMC, waste quantification has been made from door to door collection and street waste collection.

3.15 Collected Waste Quantification

Total of 8 tractors are used on daily basis for collection of municipal solid waste in Itahari Sub-Metropolitan City. Each tractor collects waste in single trip per day basis. Waste quantity in tractors was measured at weighing unit.

Total Number of Tractors that collects waste on daily basis =8

Total Number of trips per day =1

Average weight of empty tractor (without load kg) = 3116.67

Average weight of tractor with waste loaded (in kg) = 5073.33

Average weight of waste per tractor (in kg) = 1956.67

Average Total quantity of waste collected from SMC per day (kg/day)

= 8*1*1956.67 kg/day

= **15653.36 kg/day**

Source: SETM field survey, 2016/17

Photo 3:Weighing of waste carrying tractor at Weight Bridge

3.16 SECTOR WISE CHARACTERIZATION

Field characterization of solid waste was carried out to quantify organic and inorganic fraction of solid waste. Manual segregation and weighing of solid waste was done for field characterization. Also quantity of an-aerobically digestible solid waste out of organic waste which could be evenly and smoothly digestible under an-aerobic condition was quantified. Such an-aerobically digestible waste included paper, food, vegetables, etc.

3.16.1 STREET SOLID WASTE

Waste generated from streets are accumulated by sweepers and taken to collection points. Waste from collection points are later taken to landfill site by tractors for dumping. For quantification and characterization of street waste, two samples each of 10 kg weight was studied and assessed the results obtained are illustrated below:

Total quantity of waste in a sample (Total Sample weight) = 10 kg
Quantity of organic fraction of waste= 1.337 kg
Quantity of inorganic fraction of waste= 8.663 kg

Table 5: Waste fraction in percentage

Waste Type	Organic	Inorganic	Total
Weight of waste (kg)	1.337	8.663	10
Percentage (%)	13.37	86.63	100

Source: SETM field survey, 2016/17

Percentage of an-aerobically digestible waste fraction of street solid waste out of organic fraction of solid waste = 90 %
This is the indicative percentage of an-aerobically digestible waste for street solid waste as per field observation.

3.16.2 DOMESTIC SOLID WASTE

Waste generated in household sector is collected from door to door by tractors. Sample size of 21 households was taken for quantification and characterization to represent domestic solid waste. Results obtained from the study are presented in **Table 6.**

Table 6: Domestic solid waste

Sample Number	Total SW generated (kg)	Total Organic fraction (kg)	Total Inorganic fraction(kg)	Number of Family Member
1	1.22	0.80	0.42	3
2	1.77	1.08	0.69	5
3	4.27	2.90	1.37	13
4	0.81	0.49	0.32	2
5	1.51	1.01	0.50	5
6	1.81	1.24	0.57	5
7	2.27	1.37	0.9	9
8	3.37	2.1	1.18	11
9	0.99	0.65	0.34	4
10	0.72	0.44	0.28	2
11	1.45	1.01	0.44	5
12	1.68	1.08	0.60	5
13	1.30	0.97	0.33	4
14	3.56	2.42	1.14	9
15	2.67	1.87	0.80	7
16	1.09	0.87	0.22	4
17	4.41	2.69	1.72	11
18	1.13	0.68	0.45	4
19	0.91	0.63	0.28	4
20	0.52	0.52	0	1
21	0.89	0.49	0.4	3
Total	**38.35**	**25.31**	**13.04**	**116**
Percentage	**100**	**66.00**	**34.00**	

Source: SETM field survey, 2016/17

Primary field observation on household solid waste suggests that in an average around 90% of household organic waste fraction is an-aerobically digestible waste. This is the indicative percentage of an-aerobically digestible waste for domestic solid waste.

Per capita household waste=Total quantity of waste/total household member

= 38.35/116

= 330.6 gm/person

3.16.3 HOTEL/RESTAURANT WASTE

Characterization of solid waste generated from hotel and restaurant sector was studied. For this purpose, three hotels of varying capacity were selected for field observation and detailed characterization.

Case I (Small Hotel: New Swagatam Guest House)

Small sized hotel was chosen with guest accommodation capacity of 12 persons with 3 staffs.

Table 7: Waste characterization of small size hotel

Waste Type	Organic	Inorganic	Total
Weight (kg)	1.31	0.45	1.76
Percentage (%)	74.43	25.57	100

Source: SETM field survey, 2016/17

Case II (Medium Hotel: Balazi Hotel)

Medium sized hotel was chosen with guest accommodation capacity of 22 persons with 7 staffs.

Table 8: Waste characterization of medium size hotel

Waste Type	Organic	Inorganic	Total
Weight (kg)	4.27	1.61	5.88
Percentage (%)	72.64	27.36	100

Source: SETM field survey, 2016/17

Case III (Large Hotel: Premier Hotel)

Large sized hotel was chosen with guest accommodation capacity of 35 persons with 13 staffs.

Table 9: Waste characterization of large size hotel

Waste Type	Organic	Inorganic	Total
Weight (kg)	16.7	7.29	23.99
Percentage (%)	69.61	30.39	100

Source: SETM field survey, 2016/17

Average of all three Hotel/Restaurants

Table 10: Waste Characterization of Hotel

Waste Type	Organic	Inorganic	Total
Weight (kg)	22.28	9.35	31.63
Percentage (%)	70.44	29.56	100

Source: SETM field survey, 2016/17

3.16.4 VEGETABLE MARKETS

Characterization of solid waste generated from vegetable market was assessed from two different vegetable markets. Two of four vegetable markets within Itahari SMC were chosen for characterization and quantification. Average number of shops in each vegetable market was found to be 61.

Table 11: Waste Characterization of vegetable markets

Sample Number	Total Organic fraction (kg)	Total Inorganic fraction (kg)	Total SW generated (kg)
1	12.85	2.60	15.45
2	21.99	1.51	23.50
Total	34.84	4.11	38.95

Percentage (%)	89.45	10.55	100

Source: SETM field survey, 2016/17

3.16.5 INDUSTRIAL WASTE

Although large industries are not there inside Itahari SMC area but there are some small cottage industries i.e. shoes industries, candle industries, etc. Most of the industries manage their waste by themselves.

3.16.6 MEDICAL WASTE

Since medical waste is considered to be highly hazardous, Itahari SMC has made it mandatory for all hospitals, nursing homes, labs and medicals to manage their waste by themselves. Since medical waste can't be taken as feedstock in waste to energy because of its chemical and hazardous constituents, it hasn't been considered for assessment in this study.

3.16.7 LANDFILL WASTE

Waste characterization was carried out for MSW available at landfill site which is located at Charkoshe Jhadi. For this purpose, 50 kg of samples were taken for detail characterization. Composition of MSW available at landfill was characterized to find quantity of various fractions of waste i.e. biodegradable waste, plastics, glass/bottle, metals, paper/cartoon, construction and hazardous waste.

Photo 4: Waste characterization process in landfill site during field survey

Table 12: Characterization of collected waste at landfill site

Waste Type	Weight (kg)	Percentage composition
Biodegradable	20.44	40.88
Plastics	13.834	27.668
Glass/Bottle	2.407	4.814
Metals	0.927	1.854
Paper/Carton	9.063	18.126
Construction	3.329	6.658
Hazardous	-	-
Total	50	100

Source: SETM field survey, 2016/17

Table 13: Organic and inorganic fraction of collected waste

Waste Type	Total Organic fraction(kg)	Total Inorganic fraction(kg)	TotalQuantity of waste (kg)
Weight (kg)	32.832	17.168	50
Percentage (%)	65.664	34.336	100

Source: SETM field survey, 2016/17

3.17 NATURE OF THE MSW

Nature of MSW generated in Itahari SMC is mostly organic which constitute about67.05 % of total waste whereas inorganic wastes constitute about 32.95 % of municipal solid waste.However, waste collected and dumped at landfill constitute about 59.01 % of organic waste and 32.95 % of inorganic waste. Based on the detailed sector wise field characterization, nature of MSW in Itahari SMC is presented in Table 9.

Table 14: Nature of MSW in Itahari SMC

Sector	Wt. of organic fraction (kg)	Organic fraction (%)	Wt. of inorganic fraction (kg)	Inorganic fraction (%)
Domestic/Household SW	25.31	66.00	13.04	34.00
Street SW	1.34	13.40	8.66	86.60
Hotel / Restaurant SW	22.28	70.44	9.35	31.63
Vegetable Market	34.84	89.45	4.11	10.55
Landfill Site	29.50	59.01	20.49	40.99
Total (Weighted Average)	**113.27**	**67.05**	**55.66**	**32.95**

Source: SETM field survey, 2016/17

3.18 WASTE GENERATION POTENTIAL OF ITAHARI SMC

Waste generation potential is calculated on the basis of population data of National Census 2011 and waste generation potential calculated during field study.

Population Projection

Population in the year 2011= 140,517

Number of Household in the year 2011= 33,794

Annual Population growth rate= 6.23%

Table 15: Population projection of Itahari SMC

Year	2011	2012	2013	2014	2015	2016
Population	140517	149271	158570	168449	178944	190002
Year	**2017**	**2018**	**2019**	**2020**	**2021**	
Population	201934	214514	227878	242074	257155	

Source: Projection Made during data analysis.

3.18.1 WASTE GENERATION POTENTIAL OF 2016

Domestic Waste:

On our field observation and sample testing it is found that per capita household waste in Itahari SMC is 330.6 gm/day.

Total household waste in the year 2016 = Population in 2016 * per capita household waste generation

= 190092*330.6 gm/day

= 62844415.2 gm/day

= 62844.415 kg/day

Source: SETM field survey, 2016/17

Street Waste:

Street waste is collected by four tractors on daily basis from Army Camp to Saathi Petrol Pump (North-South Direction) and Kalanki Chowk to Budhi Khola (West-East Direction). Street waste of 24 hours was measured during the field. Result of field measurement is mentioned below:

Table 16: Characterization of street waste in Itahari SMC

S. No	Tractor No	Weight of Waste in kg	Remarks
1	KO2TA 5315	2060	
2	KO2TA 5317	1960	
3	KO2TA 5318	1980	
4	KO2TA 4892	2100	
Total		**8100**	
Average		**2025**	

Source: SETM field survey, 2016/17

Total Solid waste from Street = Number of tractor used to collect street waste * Average quantity of waste per tractor

= 8100 kg/day

Photo 5:A collection center and street waste characterization process during field survey

Hotel/restaurant waste:
Total number of Hotel/restaurant in Itahari SMC = 813
Average waste generation by one hotel = 10.54 kg
Total waste generation from hotel/restaurant = 813*10.54
= 8569.02 kg/day

Vegetable Market:
Total number of vegetable market = 4
Average waste generation by one market = 19.47 kg
Total waste generated by vegetable market = 4* 19.47 = 77.88 kg/day

Total Waste generation= Total waste generation of household waste+ Total waste generation of street waste + Total waste generation of hotel/restaurant waste + total waste generation of vegetable market
= 62844.415+ 8100+8569.02+77.88
= 79591.315 kg/day

Collectable solid waste:
Based on the field observation on various sector of Itahari SMC and consultative meeting with stakeholders including Enviro Care Concern Private Limited, it has been found that around 50% of total MSW generation can be considered as collectable MSW.

Total collectable solid waste= 39795.66 kg/day

3.18.2 WASTE GENERATION PROJECTION OF 2018

Domestic Waste
On our field observation and sample testing it is found that per capita household waste in Itahari SMC is 330.6 gm/day.
Total household waste in the year 2018 = Population in 2018 * per capita household waste generation
= 214514*330.6
= 70918328.4 gm/day
= 70918.328 kg/day

Total Waste generation= Total waste generation of household waste+ Total waste generation of hotel/restaurant waste + total waste generation of vegetable market + Total waste generation of street waste
= 70918.328+ 8100+8569.02+77.88
= 87665.228 kg/day

With reference to the population base of the census 2011 (CBS/2011) and the results of field study the feasibility study of the municipal solid waste to energy generation with the choice of an-aerobic digestion system has been worked out. For the present case, waste generation and waste collected in 2016 is projected and estimated in case I. As per the timeframe

proposed in this report, plant facility is proposed to be developed in the year 2018, so detailed waste estimation is made for 2018 in case II. Detailed technical calculations are presented in **excel sheet.**

Case I: Waste Generation and Collection in 2016

Waste Collection in 2016

Total daily waste collection of Itahari SMC in 2016= 15.65 MT/day
Quantity of collected organic waste = 9.23MT/day
Quantity of collected inorganic waste = 6.42MT/day
The quantity of an-aerobically digestible waste = 8.31 MT/day

Waste generation in 2016

The total waste generation potential of Itahari SMC in 2016 = 79.59 MT/day
Total municipal waste collectable from Itahari SMC = 39.79 MT/day
Quantity of collectable organic waste = 26.68 MT/day
The quantity of an-aerobically digestible waste = 24.01 MT/day
Quantity of collectable inorganic waste = 13.11 MT/day

Case II: Waste generation projection for 2018

The total waste generation potential of Itahari SMC in 2016 = 87.67 MT/day
Total municipal waste collectable from Itahari SMC = 43.832 MT/day
Quantity of organic waste generated = 29.389 MT/day
The quantity of an-aerobically digestible waste = 26.45 MT/day
Quantity of inorganic waste generated = 14.44 MT/day

3.19 Feedstock for An-Aerobic Digestion of the Itahari SMC

The total daily availability of the solid organic waste in the year 2016 is 26.68 MT per day. After the segregation the total organic solid, waste fit for the an-aerobic digester will be 24.01 MT per day. Biogas calculation tool v3.1 of AEPC is used for the calculation of biogas potential.

Biogas potential generation from collected waste in 2016:

Total quantity of biogas production from 8.31 MT of waste = 465.5 m^3/day
Biogas Digester Volume = 1016 m^3
Total biogas plant cost =NRs. 22,000,000
(NRs. 22000 per cubic meter *500 Cum Capacity*2 Numbers of Biogas Plants= NRs. 22,000,000)

Biogas potential generation calculations in 2016:

Total quantity of biogas production from 24.01 MT of waste = 1344.8 m^3/day
Biogas Digester Volume = 2935 m^3
Biogas Plant Cost=NRs. 66,000,000

(NRs. 22000 per cubic meter *800 Cum Capacity*4Numbers of Biogas Plants= NRs. 66,000,000)

Biogas potential generation projection for 2018:

Total quantity of biogas production from 26.45 MT of waste = 1481.2 m^3/day

Biogas Digester Volume = 3233 m^3

Total biogas plant cost =Rs. 70,400,000

(NRs. 22000 per cubic meter *400 Cum Capacity*8 Numbers of Biogas Plants= NRs. 70,400,000)

4 ASSESSMENT OF FEASIBILITY

4.1 ORGANIZATIONAL CAPABILITY

4.1.1 STAFFING AND OPERATIONS

Collection of total collectable municipal solid waste is achievable only with proper staffing and operations.

4.2 LOCATION

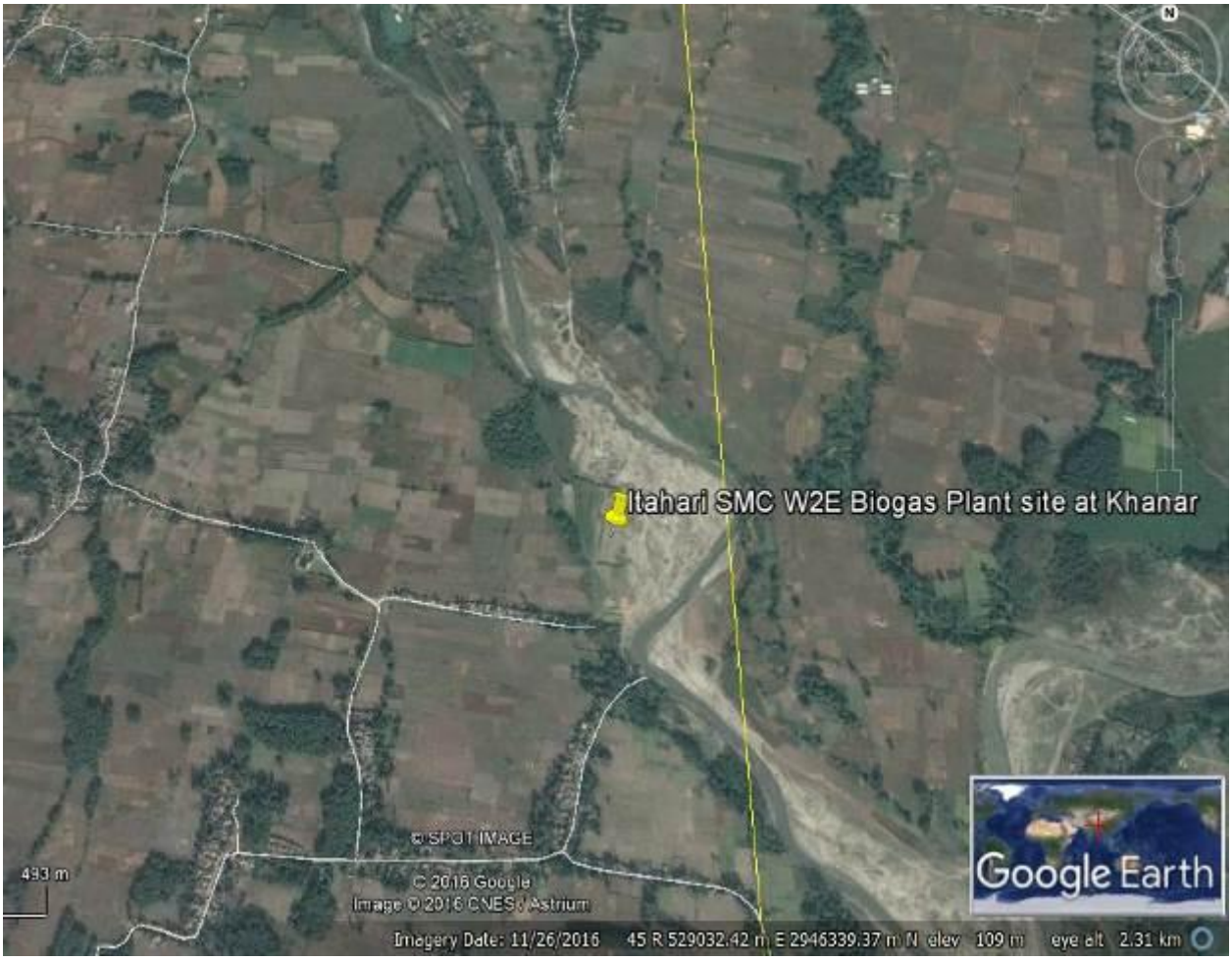

Figure 2: Proposed project location in google earth

Proposed land by Itahari SMC as project location is suitable for development of waste to energy project in Itahari SMC. Location is easy for assess for construction and routine operation of plant. Proposed location is only about 900 m from community so the biogas produced in the plant can be routed to consumer points. Proposed land is nearby river from where water can be used as per necessity in the plant however potable water courses are not near the site. The area available in the proposed site is about 3.385 Hectare (5 Bigha) of land which is in ownership of Itahari SMC. Itahari SMC is also in process of acquisition for additional 2 Hectare (3 Bigha) of land. So the land area is enough for building biogas plant and associated process units. The area gets enough sun light without any obstruction.

4.3 TECHNICAL

4.3.1 SUBSTRATE SUPPLY CHAIN

Availability, quantification and characteristics of substrate available in Itahari SMC is already discussed in previous chapters.

4.3.2 PROCESS DESIGN

An-aerobically digester plant is proposed as suitable biogas plant for the available feedstock. Several different types of an-aerobic processes and several different type of digesters are applicable for an-aerobic digestion. The type of digester depends on the type of organic waste so it is strongly recommended to conduct detailed laboratory testing of organic waste before the choice of digester is made. It is a proven set of technology that is available in worldwide scale.

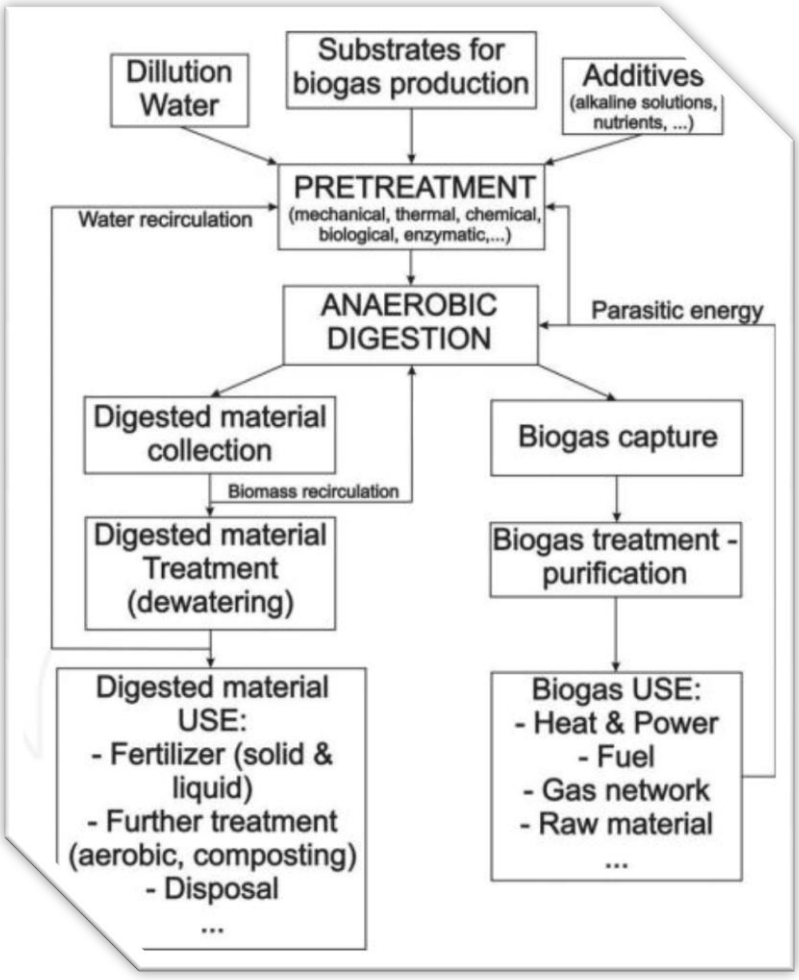

Figure 3: Block scheme of anaerobic digestion

Numerous technologies for the pre-treatment, digestion and post-digestion of anaerobically digestible organic waste are available. The quality of the solid waste will be a heterogeneous mass of organic solid remarkably of various shape, size and nature. For the purpose of the technical intervention that comprise of the an-aerobic fermentation process require to follow

up a pre-treatment process. The organic and inorganic solid waste should be collected in the separate containers. Thus, the organic waste that is free from inorganic materials should be exposed to the homogenizer plant which will attain a uniform shape and size of processed organic materials, then organic solid waste will be ready to feed up the biogas digester.

Mostly continuous an-aerobic digestion process is recommended since it is suitable for commercial biogas plant in large scale. Based on the utilization of digested substrate, an additional treatment is required. It can be mechanically dewatered first and then solid part can be stabilized by composting as a fertilizer whereas liquid part shall be further treated as a wastewater for other purposes.

The rudimentary part of the technical requirement of an-aerobic digestion of the Municipal Solid waste to Biogas energy are summarized below:

a. All organic solid waste with the CN ratio of more than 20 up to the less than 30 analytical rating values.
b. For mesophilic bacterial based process, the temperature maintenance within the digester will be in the range of 30-35ºC.
c. The digester will have an inlet for the continuous feed of the solid biomass and the appropriate volume of the water, an out let for the recovery of the effluent after the generation of the biogas.
d. The biogas generation will be in the range of 35 liters up to the 45 liters per Kg of solid feed. On an average 40 liters of biogas per kg of solid will be recovered.
e. The effluent mass will have the NPK (Nitrogen Phosphorus Potassium) value more than the influent biomass and hence can be utilized as the bio-fertilizer for the agriculture application.
f. Once the digester plant will be fully functional, the continuous consumption of the Itahari-SMC municipal solid waste will have the directed outlet instead of dumping to the land fill site.

Design outputs for proposed plant is worked out using biogas calculation tool V3.23 of AEPC.

Design and cost of plant with waste collected in 2016

Design outputs:

Total quantity of biogas production from 8.31 MT of waste = 465.5 m^3/day
Biogas Plant Volume= 1524.1 m^3
Biogas Digester Volume = 1016 m^3
Digester slurry production = 18473 Kg/day
Number of digester each of 500 m^3 capacity = 2

Cost Calculation

Biogas Plant Cost=NRs. 22,000,000
(NRs. 22000 per cubic meter *500 Cum Capacity*2 Numbers of Biogas Plants= NRs. 22,000,000)

If total of biogas produced is used for cooking then, meals can be cooked for 2095 people twice a day.
Nearly 320 LPG cylinders each of 14.2 kg capacity can be saved monthly.
Total of LPG expenditures that can be saved = Rs. 14680/day.

Design and cost of plant with waste collectable in 2016

Design outputs:

Total quantity of biogas production from 24.01 MT of waste = 1344.8 m^3/day
Biogas Plant Volume= 4402.6 m^3
Biogas Digester Volume = 2935 m^3
Gas Production = 1344.8 m^3/day
Digester slurry production = 53364 Kg/day
Number of digester each of 500 m^3 capacity = 6

Cost Calculation

Biogas Plant Cost=NRs. 66,000,000
(NRs. 22000 per cubic meter *500 Cum Capacity*6 Numbers of Biogas Plants= NRs. 66,000,000)

If total of biogas produced is used for cooking then, meals can be cooked for 6052 people twice a day.
Nearly 925 LPG cylinders each of 14.2 kg capacity can be saved monthly.
Total of LPG expenditures that can be saved = Rs. 42406/day.

Design and cost of plant with waste projected for 2018

Design outputs:

Total quantity of biogas production from 26.45 MT of waste = 1481.2 m^3/day
Biogas Plant Volume= 4849.2m^3
Biogas Digester Volume = 3232.8 m^3
Gas Production = 1481.2 m^3/day
Digester slurry production = 58778 Kg/day
Number of digester each of 800 m^3 capacity = 4

Cost Calculation

If total of biogas produced is used for cooking then, meals can be cooked for 6665 people twice a day.
Nearly 1019 LPG cylinders each of 14.2 kg capacity can be saved monthly

Total of LPG expenditures that can be saved = Rs. 46,707/day.

Biogas Plant Cost= Rs. 70,400,000
(NRs. 22000 per cubic meter *800 Cum Capacity*4 Numbers of Biogas Plants= NRs. 70,400,000)

4.3.3 Construction Aspects

Area available at proposed location for plant development is enough for development of all infrastructure. The area available in the proposed site is about 3.385 Hectare (5 Bigha) of land which is in ownership of Itahari SMC. Itahari SMC is also in process of acquisition for additional 2 Hectare (3 Bigha) of land. So the land area is enough for building biogas plant and associated process units.

4.3.4 By-Product Use

By-product of proposed an-aerobically digestible plant is compost manure which can be used as fertilizer. Fertilizer can easily be sold to market. Quantity of compost is calculated for present case and for the year 2018.By using Biogas calculation tool v3.23 of AEPC the calculation of compost production is worked out.

By-product production with collected waste (2016)

Total quantity of compost production = 1729 Kg/Day

By-product production with collectable waste (2016)

Total quantity of compost production = 4995 Kg/Day

By-product production projection in 2018

Total quantity of compost production = 5502 Kg/Day

4.4 Financial, Commercial Assessment and Market Study

4.4.1 Financial Analysis

Financial analysis of proposed plant with collected waste (2016):

Biogas Plant Cost=NRs. 22,000,000
(NRs. 22000 per cubic meter *500 Cum Capacity*2 Numbers of Biogas Plants= NRs. 22,000,000)

If total of biogas produced is used for cooking then, meals can be cooked for 2095 people twice a day.
Nearly 320 LPG cylinders each of 14.2 kg capacity can be saved monthly.
Total of LPG expenditures that can be saved = Rs. 14,679/day.

Total quantity of compost production = 1729 Kg/Day
Revenue from selling of compost fertilizer = Rs. 17,291/Day
Revenue from selling of compost fertilizer = Rs. 518,731/Month

Financial analysis of proposed plant with collectable waste (2016):

Biogas Plant Cost=NRs. 66,000,000
(NRs. 22000 per cubic meter *500 Cum Capacity*6 Numbers of Biogas Plants= NRs. 66,000,000)

If total of biogas produced is used for cooking then, meals can be cooked for 6052 people twice a day.
Nearly 925 LPG cylinders each of 14.2 kg capacity can be saved daily
Total of LPG expenditures that can be saved = Rs. 42406/day.

Total quantity of compost production = 4995 Kg/Day
Revenue from selling of compost fertilizer = Rs. 49,950/Day
Revenue from selling of compost fertilizer = Rs. 1,498,474/Month

Financial analysis of proposed plant in 2018:

Biogas Plant Cost= Rs. 70,400,000
(NRs. 22000 per cubic meter *800 Cum Capacity*4 Numbers of Biogas Plants= NRs. 70,400,000)

If total of biogas produced is used for cooking then, meals can be cooked for 6665 people twice a day.
Nearly 1019 LPG cylinders each of 14.2 kg capacity can be saved monthly

Total of LPG expenditures that can be saved = Rs. 46,707/day.

Total quantity of compost production = 5502 Kg/Day
Revenue from selling of compost fertilizer = Rs. 55,016/Day
Revenue from selling of compost fertilizer = Rs. 1,650,480/Month

4.4.2 MARKET STUDY

Biogas produced in the plant can distributed to nearby community which is only around 900 m from proposed plant site. Pipe line can be developed to transport biogas from biogas plant to nearby community.

Photo 6: Local Stakeholders meeting in Itahari SMC during field survey

4.5 TENTATIVE TIMEFRAME FOR DEVELOPMENT OF PROPOSED PLANT

Based on the current situation, following tentative time frame is proposed for the development of biogas plan facility.

Table 17: Tentative timeframe for biogas development in Itahari SMC

S. N.	Activity	Months																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Detailed Feasibility Study																		
2	Project Site Selection And Development																		
3	Biogas Plant Detailed Design																		
4	Procurement and Installation																		
5	Test Operation																		
6	Final Phase Operation and Maintenance																		

4.6 ENVIRONMENTAL AND SOCIAL IMPACT

The environmental and social screening of the proposed project was carried out by the study team during field visit. It was mainly aimed to identify likely environmental and social impacts or risks associated with the proposed W2E project. It was conducted on the basis of criteria mentioned in Schedule 1 and 2 of EPR 97 and in line with World Bank's Operational policies. For this the screening checklists were used. The project basically intends to generate energy from municipal waste and also for better waste management.

During field survey, the proposed location and nearby communities were visited for interaction. Moreover, consultative meetings with Itahari-SMC and Enviro Care Concern (P) Ltd were carried out to explore the likely socio-environmental implication of the proposed project. There is no remarkable loss of vegetation or other natural resources as the site is located in near premises of Budhi Khola river. The screening report indicates that the sub-project implementation will not disturb any community or private infrastructures. Moreover, the Itahari SMC has land area of 3.385 hectare and is in process of purchasing 2 hectares. The slum dwellers in surrounding areas are already convinced for the resettlement package. So, there will be no need for the displacement of inhabitants.

Table 18: Salient features of the proposed biogas project

Location	**Itahari-SMC,10 Domartaka**
GPS Location	2946224 N, 529286 E, 87m
Total project cost	Approx. 22,000,000 solely for biogas structure (*the cost of processing units is not considered*)
Feedstock type	Municipal Solid Waste
Technology Type	Anaerobic Digestion; Biogas
Capacity	1000 (digester volume)
Gas Production	465 m^3/day
Liquid Slurry Production	18473 kg/day
Beneficiaries	Nearby community people (Tharu community)
Key Note	Willingness of stakeholders; Itahari-SMC, Enviro-Care Concern (P) Ltd and local community seems very high.

Source: SETM field study 2016/17

During screening process, the negative impacts are not envisioned but there might have some adverse effects during construction and post installation period. Benefit sharing among the community people and other related stakeholders is a concern for the proposed project in future.

The local community people were found eager to see the project implementation. However, daily transportation of waste materials itself may create problem at local level. So proper mitigation measures should be adopted. The slurry management in nearby areas of the river bank is another challenge for this project. The impacts will be less significant as these are site specific and mitigation measures can be adopted. Based on the following field observation and calculations, the proposed project falls in **Category B** under SREP/W2E project.

Because of the EPR (97) schedule 1, study team recommends to conduct Initial Environmental Examination (IEE) study prior to Itahari-SMC biogas sub-project

implementation. The majority of local community in proximity to the implementation site are ethnic-people (Tharu community) thus a vulnerable action plan is also suggested.

4.6.1 SOCIAL IMPACT

For success of any development project, better understanding of social characteristics is most. For this proposed biogas plant also, detail social impact study has been carried out to better understand social impact of this project.There is no change in social structure in long term. Also there is very less loss of agriculture production due to construction of the landfill site because it falls in the Budhi River site.At present, no any physical structures, natural resources and any other assets are present that would be affected for the proposed biogas plant. Temporary small slum dweller community is located near 500 m from the proposed site which could be re-settled legally in next year as per discussion with stakeholders.However, project implementation at proposed site will have many benefits to local community. Local community people will get opportunities of employment in the project. Also infrastructures around the proposed would be developed for the ease of project and the communities.Nearby community is already convinced by Itahari SMC for the development of project in proposed location.

4.6.2 ENVIRONMENTAL IMPACT

In development of any project, study of environmental impact is important. There is no need of vegetation removal while developing project in proposed site. Budhi Khola river is located adjoining to proposed location. Water from the river is mostly used for irrigation in agricultural farm around the river. So project development can use water available in the river however, it will not have adverse impact to the river. Agricultural land might get affected by development of facility in the proposed site however that impact is supposed to be very low.

By-product (Bio-slurry) generated from the project can easily be sold as compost manure in the market at good price because there is huge demand of organic manure in the market. Since by-product of project can easily be used as compost fertilizer, there would be no need of storage of by-product on the site. Also effluent discharged from the plant need not be combined to drainage system.

The project site is far enough from the residential area so there is very lesser chances of public health impact from the project. However, the vehicular movement through on road through different wards might be risky in terms of foul smell and accident. Also there is chances of foul smell spreading in the local environment and disturb nearby community. For this measures should be taken from by developers to control foul smell and possible pollution hazard.

A copy of filled up environmental and social screening checklists are provided in Annex part of this report.

4.7 RISK ASSESSMENT

For development of project, risk consequences should be assessed to get feasibility of project. During field visit of the study, risk assessment was also assessed which are summarized as follow:

I. Field study showed that only fraction of collectable waste out of total municipal waste generation is being collected at present in Itahari sub-metropolitan city. The current practice of solid waste collection is not enough and appropriateto achieve the target of collectable MSW. Scientific and appropriate waste management protocol should be maintained at Itahari SMC to get enough feedstock for proposed biogas plant.

II. Waste characterization of landfill waste also found few traces of hazardous waste which cannot be accepted as feedstock for proposed biogas plant. Moreover, hazardous waste like medical waste, can contaminate other potential organic waste. So hazardous waste should be managed at source itself to control possible contamination and hazards.

III. Total land available as proposed site for plant development is around 3.385 Hectare which is in ownership of Municipality. Municipality is also planning to acquire additional 2 hectare of land whose acquisition process should be finalized and site should be made ready for further actions as soon as possible.

IV. Modality of operation and maintenance of proposed plant should be thoroughly discussed with all possible stakeholders i.e. Itahari SMC, Developers, Local community and experts. Proposed plant can only be developed and operated under close coordination of stakeholders. In addition, ownership of biogas plant, operation and management should also be finalized in advance.

V. Only60% of possible collectable MSW in Itahari SMC is fit for an-aerobically digestible biogas plant. Management of remaining 40% of organic and inorganic waste is further challenge in development of plant. So proper management of remaining waste which is unfit for biogas plant is mandatory for complete management of waste in Itahari SMC.

5 CONCLUSION AND RECOMMENDATIONS

From the filed study of Itahari SMC to assess the feasibility of waste to energy numerous information and data have been obtained. Further analysis of data has given overview of status of municipal solid waste in Itahari SMC. The result of estimation shows that, total daily waste collection of Itahari SMC at present is 15.65 MT/day out of which organic fraction is 9.23 MT/day (~59%) and inorganic fraction is 6.42 MT/day (~41 %). Out of organic fraction about 8.31 MT/day which is around 53 % of total waste being collected at Itahari SMC. Characterization of collected MSW was carried out in waste collected at landfill.It is calculated that approximately 465 m^3 biogas per day can be produced from the collected municipal solid waste in Itahari SMC.

Generation potential of MSW at present case (2016) was found to be 79.59 MT/day out of which around 39.79 MT/day waste only collectable from Itahari SMC. Out of total collectable MSW 26.68 MT/day (67.05 %)waste was found to be organic waste and 13.11 MT/day (32.95 %) was found to be inorganic waste. Around 24.01 MT//day of waste was found to be fit for an-aerobically digestible biogas plant.

Waste generation potential for 2018 was also projected since as per proposed schedule the plant development will take place in 2018. Projection made on waste generation of Itahari SMC for 2018 found that the total waste generation potential of Itahari SMC in 2018 is projected to be 87.67 MT/day. Out of total generation potential, total collectable MSW in Itahari SMC is projected to be 43.24 MT/day. The organic and inorganic fraction out of total collectable waste was found to be 29.24 MT/day and 14.44 MT/day. However, quantity of an-aerobically digestible waste was found to be 26.45 MT/day.

The study also found that total collectable MSW can be achieved only with scientific and practical waste management protocol. Otherwise with present management system and infrastructure, collectable MSW cannot be collected to achieve the target.

Following major recommendations are made based on the study:

I. There exists a huge gap between total collectable municipal solid waste and collected MSW in Itahari SMC. So to collect the entire collectable MSW there is need of entire management system intervention.

II. Current practice of dumping waste in landfill need to be changed immediately with proper segregation of organic/inorganic waste and management of hazardous waste at source of generation.

III. Reuse, recycle and reduce technique should be promoted in entire Itahari SMC area so that inorganic fraction of MSW can be managed at source of generation. Also there is need of management of organic fraction of waste unfit for an-aerobic digestion process.

IV. Detailed data base of waste management sector in Itahari SMC was found to be missing with major stakeholders. So detail data base and day-to-day update on waste management and collection data should be recorded and maintained.

V. Stakeholder's consultative meeting should regularly be conducted at every phase of pre-development of proposed plant. It will help to inform all stakeholders about the process in development and status.

APPENDICES

1. Biogas Calculation Tool v3.23 for 2016
2. Biogas Calculation Tool v3.23 for 2018
3. Data tables/Calculations/Graphs

4. Filled up Checklist

SOCIAL SCREENING CHECKLIST

<table>
<tr><td colspan="5">1. Title of the Sub project: Itahari SMC Waste-to-Energy Project (Category B- Municipal Sub-Project)</td></tr>
<tr><td colspan="5">1.1 Site Locality: Itahari SMC-10 Domartaka, Sunsari</td></tr>
<tr><td colspan="5">1.2 Sub project activities: Biogas Production from Municipal Waste</td></tr>
<tr><td colspan="5">1.3 Contact Details:
Mr. Mandwaj Khadka, Enviro Care Concern (P) Ltd. 9842531990</td></tr>
<tr><td colspan="5">2. Impact on specific assets due to project intervention</td></tr>
<tr><td>2.1 What are the asset(s) that would be affected due to Subproject Interventions?
☐Yes ✓ No</td><td colspan="4">✓ Land (Area = ~5000m^2): Biogas structures only
☐ Physical Structure (dwelling or commercial)
☐ Community Resources
✓ Natural Resources (✓Water bodies/ Forest/ Public Pond)
☐ Others (please specify)</td></tr>
<tr><td rowspan="10">2.1.1 Land</td><td>Currently Owned</td><td>Private</td><td colspan="2">Public</td></tr>
<tr><td>Total Area</td><td>NA</td><td colspan="2">33,000 m^2</td></tr>
<tr><td>Land use</td><td>NA</td><td colspan="2">Barren</td></tr>
<tr><td>Additional requirement</td><td>Private</td><td colspan="2">Public</td></tr>
<tr><td>Total Area</td><td>Planned to purchase</td><td colspan="2">NA</td></tr>
<tr><td>Land use</td><td>NA</td><td colspan="2"></td></tr>
<tr><td>Permanent/temporary</td><td>Permanent</td><td colspan="2"></td></tr>
<tr><td>Land Procurement</td><td>☐ Voluntary Donation
✓ Direct Purchase</td><td colspan="2">☐ Voluntary Donation
✓ Land Acquisition</td></tr>
<tr><td colspan="4">Presence of ☐Squatter/☐Encroacher/☐leaseholder in Private/Public land:
☐ Yes ✓ No
If Yes,
• Total number of affected families: NA
• Possibility of physical displacement: NA</td></tr>
<tr><td colspan="4">Procurement Procedure for additional land: Not required</td></tr>
<tr><td rowspan="4">2.1.2 Physical Structures (Specify Private (P), Squatter (S), Encroacher (E), Leaseholder (L) etc.)</td><td></td><td>Private</td><td>Public</td></tr>
<tr><td>Houses to be resettled:</td><td>NA</td><td>NA</td></tr>
<tr><td>Community resources:</td><td>NA</td><td>NA</td></tr>
<tr><td>Commercial/ business structures:</td><td>NA</td><td>NA</td></tr>
<tr><td rowspan="3">2.1.3 Is there any Community Resource Properties resources that might be affected due to project intervention?
☐Yes ✓No</td><td colspan="2">Community Resource Property</td><td colspan="2">No. of beneficiary households</td></tr>
<tr><td colspan="2">NA</td><td colspan="2">NA</td></tr>
<tr><td colspan="2">NA</td><td colspan="2">NA</td></tr>
<tr><td rowspan="2">2.1.4 Is there any natural resources that might be affected due to project intervention?
☐✓ Yes ☐ No</td><td colspan="2">Natural Resource</td><td colspan="2">Dependent households</td></tr>
<tr><td colspan="2">River: Course width will be shortened</td><td colspan="2"></td></tr>
<tr><td colspan="5">3. Impact in Livelihood</td></tr>
<tr><td rowspan="2">☐ Yes ✓No
(Specify Private (P), Squatter (S), Encroacher (E), Leaseholder (L) etc.)</td><td colspan="2">Impact</td><td colspan="2">No. of families</td></tr>
<tr><td colspan="2">☐Loss of shelter and housing structure</td><td colspan="2"></td></tr>
</table>

	☐Loss of income source ☐Loss of grazing field ☐Loss of agricultural land ☐Others	NA
4. Impact on Trees and Crops		
4.1 Vegetation clearance ✓Private Land ☐Governmental Forest ☐Community Forest	Tentative number of trees to be felled: • Tree size -NA • Pole size -NA	
4.2 Agricultural Crop/Fruit bearing trees loss *(Specify Private (P), Squatter (S), Encroacher (E), Leaseholder (L) etc.)*	Agricultural Land	Horticulture (Fruits)
	NA	NA
5. Vulnerable Groups		
5.1 Are there Vulnerable Groups (Adibasi/Janajati/Dalit/Women headed households residing within or adjacent to project site? ✓Yes ☐ No	If yes, does project intervention affect these groups? ☐ Land ☐ Physical Structure ☐ Income generating activities ✓Not at all	
5.2If yes, displacement of these people needed?	No	
5.3 Is there any way that proposed project may pose any threat to cultural tradition and way of life of vulnerable groups?	No	
5. Community Benefits from sub-project intervention		
• Cooking energy based on the clean energy derivatives shall be distributed to nearby households through accessible pipeline connections. • Management of waste will be organized in order and properly settled. • Employment opportunities at local level will be created.		
6. Perception toward project		
6.1 Community Perception toward project	✓Positive ☐ Negative	
7. Suggestion from Community		
The Community people were found keenly interested to consume and participate in such biogas project whenever implemented. The inclination of local people regarding this project seems very high. Though there is a concern regarding provision of certain incentives in separation of bio-degradable waste from its source pool. Local community comprising of ethnic Tharu people would want to shed a light upon their status of community development from SMC as they hold a very sensitive response to this stimulating project as they request an enrollment of active participation and involvement of some kind. They believe they can steer the proposed project in a direction of successful execution and it would benefit their overall development in the locality.		

Recommendations:

Based on field information and the social screening process, it was indicated that the sub-project intervention will not necessitate in any land acquisition process as well as displacement of local inhabitants. Nonetheless, the local community encompasses mostly Tharu people, so the preparation of vulnerable action plan would be preferable during the detail project design. As per the consultation with nearby community people, it can be stated that there are enthusiastic helping hands readily eager to support the biogas project from municipal waste in near future.

ENVIRONMENTAL SCREENING FORMAT

Project Brief

Name/ Address	Itahari SMC Waste to Energy Project (Category B- Municipal Sub-Project)
Contact Details (Telephone, Email)	Mr. Mandwaj Khadka, Enviro Care Concern (P) Ltd. 9842531990
Technology (type and capacity)	Anaerobic Digestion; Biogas
Implementation approach (approach, schedule, institution involved, and stakeholders)	Itahari-SMC, Enviro Care Concern (P) Ltd, Local Community, AEPC and other relevant stakeholders
Total Project Cost	NRs. 22,000,000.00 (Only for biogas structure)

Environmental setting of the project locality

2.1 Location		
Location of the project (settlement/ ward/ VDC/ District)	Itahari SMC-Ward No-10, Domartaka, Sunsari	
Adjoining/nearby settlement(s):	Tharu Community	
Community facilities (school, playground, etc.):	Not existing within proposed location	
Is the project located in forest area or close to forest	Yes	✓ No
If Yes,		
Name of forest	NA	
Management regime	NA	
Does vegetation need to be removed for the project? Give estimate?	NA	
Permission to operate in the forest?	NA	
Is the project located in the protected area or any protected area in vicinity	Yes	✓ No
Is yes, please provide details on		
(a) name of PA	NA	
(b) area to be acquired	NA	
(c) distance to PA from the project site	NA	
(d) access from the project to the PA	NA	
2.2 Water sources/ water bodies		
Area there any water sources/ water bodies in and around the project site	✓ Yes	No
If yes provide details on		
Location/Type	Budhi Khola River (Adjacent to the proposed site)	
Use of water	Irrigation purpose; Farm use	
Potential impact by the project	Chance in Leakage of bio-slurry or waste materials	
2.3 Air pollution		
Number and type of vehicles to be used per day	8 nos (existing)	
Capacity of vehicles	2 MT	
Condition of the road (asphalted, earthen)	Asphalted with earthen (~1.5 km). Presently under construction.	
2.4 Land use		
Land required for the project and type of land use		

Facilities	Required Area	Land use type	Location
1) Segregation Unit	1000 m^2	Uncultivated	Within proposed site
2) Digesters including compost pits	4800 m^2 1000 m^2	Uncultivated Uncultivated	Within proposed site Within proposed site
3) Purification and other infrastructures			

2.4.1 Impact due to land use change

a) Loss of private land- No
b) Loss of agricultural product - No
c) Loss of private structures/community structures - No
d) Loss of Forest and vegetation - No
e) others – No

2.5 Waste input for the project	
Define waste (type)	Municipal Solid Waste
Quantity of waste	8.31 metrictons per day
Location of collection	Itahari SMC
Workers involved	5 additional worker needed for the operation
Legal clearance required	The land area is owned by Itahari-SMC and waste is managed by Enviro Care Concern (P) Ltd. Both are unanimous on waste to energy project implementation in near future.

2.6 Technology	
Type	Anaerobic Digestion, Biogas
Capacity	1000 m^3
Components	Segregation processing, Inlet, Biogas Plant, Compost Pit etc.
Gas production	465 m^3 of biogas per day
Liquid slurry production	18473 kg per day
Solid slurry production	868.6kg per day (as compost)
Remarks	As per initial demand of local people, total gas can be used for the thermal purpose in surround community.

2.7 Waste from the project implementation	**Yes**	**No**
Generation of solid waste? If yes, slurry can be managed as compost	Yes	
Are any wastes required to be stored on-site either for reuse or off-site disposal? If yes,	Yes	
Are effluents required to be discharged to a sewer or combined drainage system? If yes,	Yes	
2.8 Health and Safety Issues	**Yes**	**No**
a. Does project intervention affect health and safety condition?	Yes	
b. List out likely health and safety issues during construction period • Construction related accidents • Pollution due to frequent movement of vehicles **c. List out likely health and safety issues during implementation period** • Bad smells • Chances of water contamination from waste storage and slurry/compost pit • Accidents associated with firing and explosion • Chances of mosquitos, flies or other spreading diseases due to large volume of waste and by-product after implementing the project		
2.7 Other observations		
Can vector disease spread to the adjoining settlements?	Yes (Possible)	

Can foul odour affect the adjoining settlement?	Yes (Possible)
Slurry use (proposed)	As provided information, they are planning to sell compost fertilizer because of the high demand

Recommendations

Environmental impacts of the proposed project are likely to have minimal significant effects on health as well as consume no action in the loss of agricultural land or other natural resources. Most of the identified and predicted impacts are of inconsequential and minor values. The main beneficial impact of the project is to increase the use of clean energy derived from municipal waste for cooking purposes replacing the use of LPG gas, which would save the cost of fuel sources and these are proven to be ensuring beneficial impact and sustainability in long terms conserving nature. These positive impacts accelerate the well-being of the urban community. Hence, the proposed project is recommended for implementation.

However, due to the large volume of the waste in Itahari SMC, it might prevail some antagonistic effects during construction and operation phase. The management and segregation of municipal waste is still a challenge for the SMC. The nature of MSW is heterogeneous and manual separation of anaerobically digested organic fraction may create problems and issues in long terms. The overall impact caused by the sub-project intervention can be classified as **"Category B"** project with negligible environmental impacts. Hence, the study team strongly recommends to conduct IEE while preparing the detailed project report in future. It is believed that, the application of design standard and specification on effective implementation of the proposed mitigation measures would avoid and minimize the adverse impact on the environment.

5. Relevant Photographs

6. Minutes prepared during consultative meeting