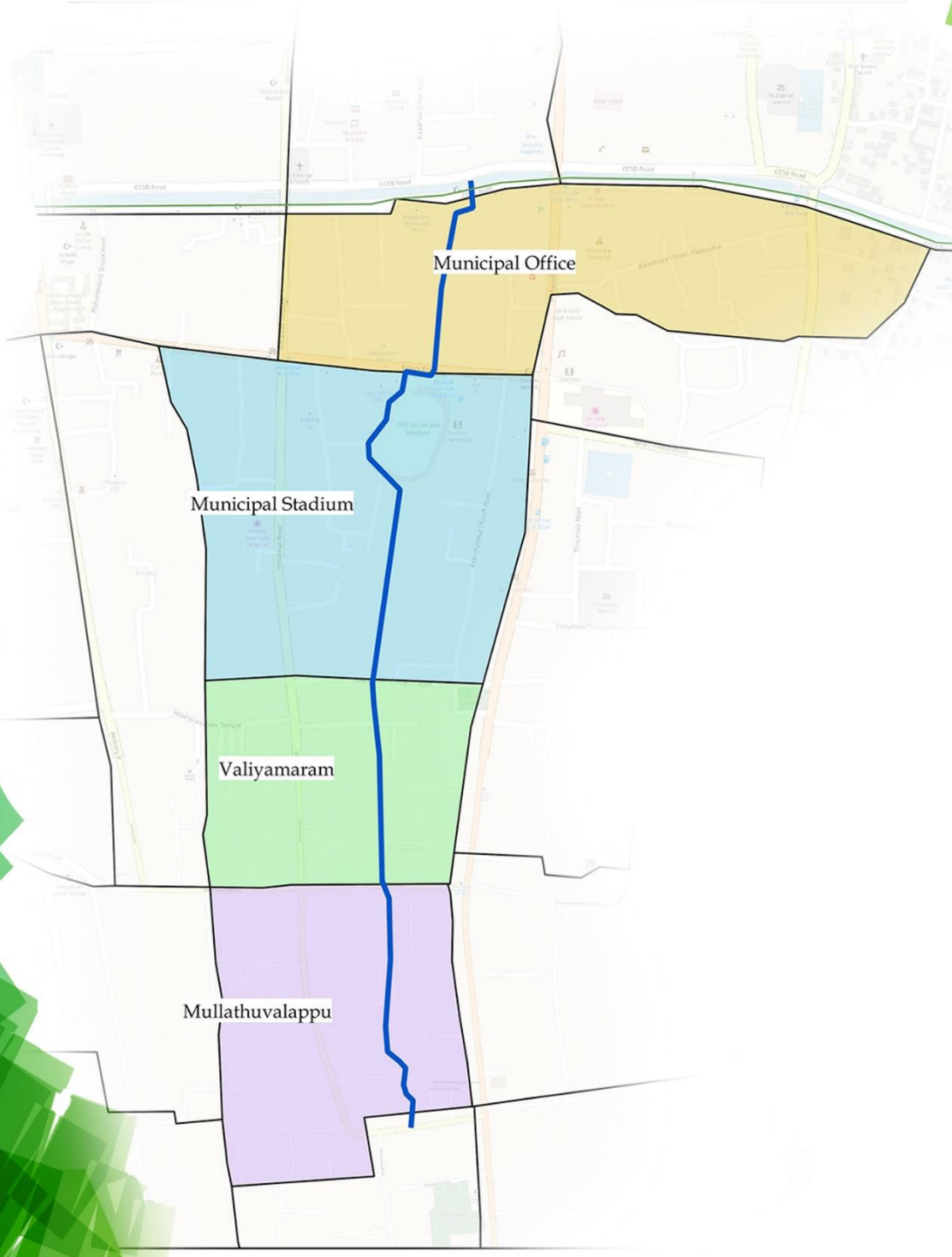
CANAL REJUVENATION BY INTEGRATED SANITATION PLANNING



INTEGRATED SOLID & LIQUID WASTE MANAGEMENT PLAN FOR SADAMANI CANAL

CALPY 2018

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

Abbreviations

APL	Above Poverty Line
ASCA	Alappuzha district Septic Tank Cleaning Contractor Association
BIS	Bureau of Indian Standard
BOD	Biological Oxygen Demand
BPL	Below Poverty Line
C& D waste	Construction and demolition waste
CDD	Consortium for Dewats Dissemination
CPHEEO	Centre Public Health and Environmental Engineering organization
CTARA	Centre for Technology Alternatives for Rural areas
DEWATS	Decentralized Waste Water Treatment System
DRDO	Defence Research and Development Organization
E- waste	Electronic waste
FRP	Fiber Reinforced Plastic
FSTP	Fecal Sludge Treatment Plant
GoI	Government of India
HDPE	High Density Poly Ethylene
HH	Household
IEC	Information Education Communication
IITB	Indian Institute of Technology Bombay
IRTC	Integrated Rural Technology Centre
JICA	Japan International Corporation Agency
KILA	Kerala Institute of Local Administration
KLD	Kilo Litter per Day
KMBR	Kerala Municipal Building Rule
KWA	Kerala Water Authority

LDPE	Low Density Poly Ethylene
LLDPE	Low Linear Density Polyethylene
LSGD	Local Self Government Department
MCF	Material Collection Facility
MCs	Main Canals
MRF	Material Recovery Facility
MSW	Municipal Solid waste
NSS	National Service Scheme
OBC	Other backward Class
ODF	Open Defecation Free
ODK	Open Data Kit
OSM	Open Street map
OSS	Onsite Sanitation System
PET	Poly Ethylene Terephthalate
PP	PolyPropylene
PPP	Public Private Partnership
PS	Polystyrene
PVC	Poly Vinyl Chloride
RA	Research Associate
RL	Reduced Level
SBM-G	Swachh Bharat Mission-Gramin
SC/ST	Scheduled Castes/Scheduled Tribes
SCs	Sub Canals
SLWM	solid and liquid waste management
SPI	Society of the Plastics Industry
SS	Suspended Solids

SWM	Sold waste Management
TSS	Total Suspended Solids
ULB	Urban Local Boby
UNEP	United Nations Environment Programme
WATSAN	Water And Sanitation
WC	Water Closet

SECTION I

SOLID WASTE MANAGEMENT

Chapter 1. Solid Waste Management

1.1 Study Area

Sadamani Canal which is having a length of about 2.11 km starting from Thumbaparmbil temple in Mullathuvalappu ward and ending in commercial canal. It passes through four wards namely, Municipal Office (ward no 25), Municipal Stadium (ward no 33), Valiyamaram (ward no 32), Mullathuvalappu (ward no 31).

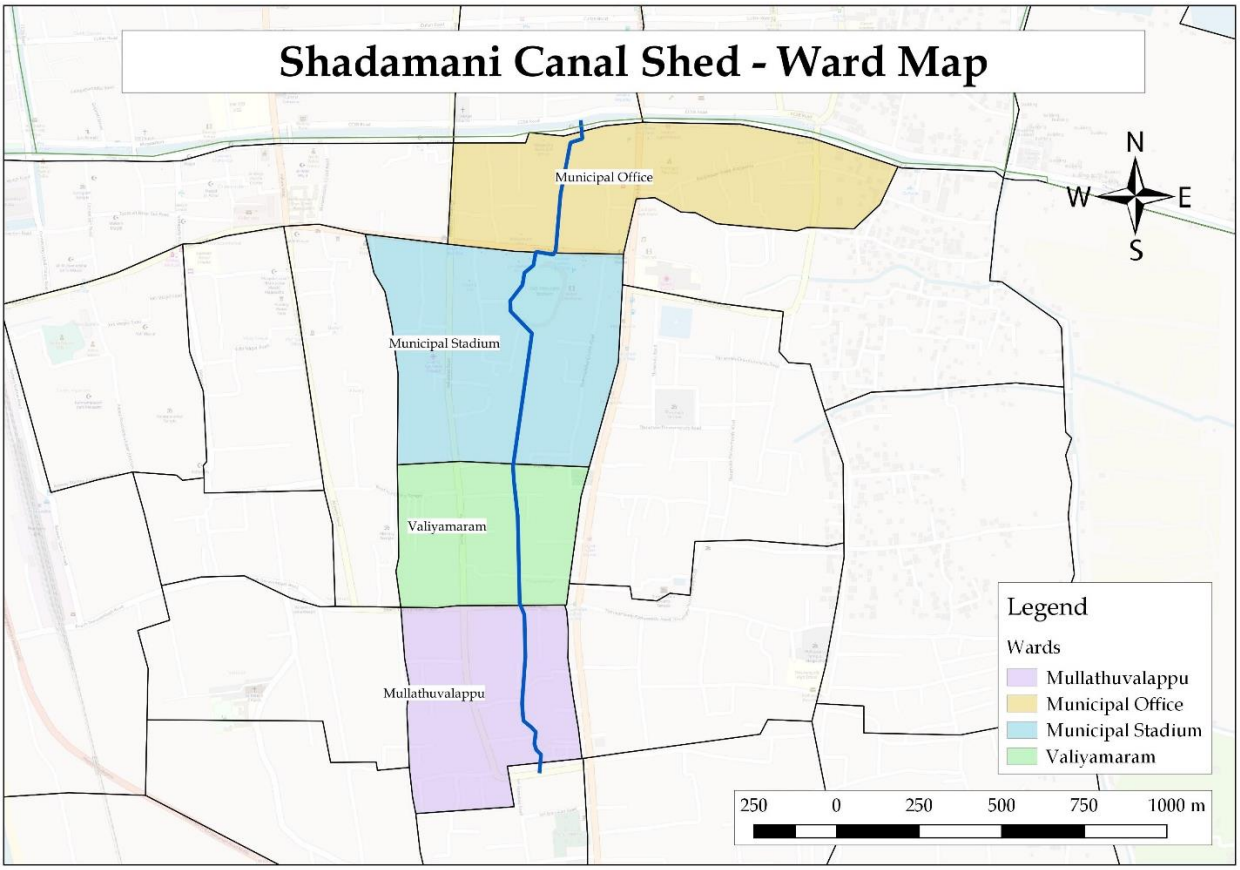


Figure 1.1 Shadamani Canal Shed Ward Map

Sadamani has a heterogeneous character with respect to the socio-economic parameters. By analyzing the land use characteristics, Valiyamaram and Mullathuvalappu wards predominant for residential land use and Municipal Office and Stadium wards for mixed

land use. For viability reasons, we have decided to conduct survey in the entire area of four wards comprising of about 3500 households.

1.2 RESEARCH METHODOLOGY

The overall research methodological approach for this study was mixed methodology. Both quantitative and qualitative approaches were used. Secondary data was collected from different sources such as articles, research papers, maps and detailed project reports (DPRs) from the Alappuzha Municipality. Primary data was collected mainly through surveys and interviews.

Two surveys were conducted to identify the current practices of solid waste management and also willingness to install new systems to manage solid waste in both individual and community level. Liquid waste and solid waste questions were both included in the survey questionnaire. Survey I was conducted through the CANALPY interns along the canal stretch and it covered all the 232 households along both sides of the canal. Survey II was part of Winter School, 2018, which was looking into various technological options and for knowing about the people's willingness to install new systems. Survey II was a sample survey, conducted in four wards excluding canal stretch. The Winter School participants were divided into four groups of 12 teams, each having two members. And each group were assigned to each ward. The survey was conducted using ODK application. In the team, at least one member should have a smart phone. The surveys were done in four wards, Municipal Office, Municipal Stadium, Valiyamaram and Mullathuvalappu.

In addition to survey, key stakeholders such as municipal officials, sanitation workers, and service providers were interviewed. Existing services and proposals of waste management were obtained through interviews of Alappuzha Municipal officials. Data regarding the operation of community level aerobic composting unit were obtained through interviews of municipal sanitation workers. For obtaining the details about various technological options for solid waste management, an IRTC service provider was also interviewed.

Conducting the surveys:

The steps followed for conducting the surveys are given below:

a) Identified volunteers for survey and divided them into groups of two members each, preferably with one male and one female member in each group.

b) For spatial representation of the surveys and for planning the logistics the study area was divided into polygons based on the distance based of the road networks. Google My Maps was also used as a tool for representing the polygons in a public domain.

c) Prepared the questionnaire for the survey taking into consideration the socio-economic survey data of households collected during Winter & Summer Schools and after analyzing them. Open Data Kit (ODK) was used for preparing the survey forms.

d) Prepared a shelf of technology options for households and community level management of solid waste with their specification, cost, space requirements, operation and maintenance etc.

e) Prepared brochures showing the various technological options need for solid waste management etc. to be used during training of volunteers and surveys.

f) Trained the volunteers on conducting household level survey using the survey questionnaire in ODK. Also, the details of various technological options in waste management and made them aware of the good waste management practices.

g) Divided the volunteers into groups of two members each, preferably with one male and one female member in each group. 12 groups were assigned to each polygon.

h) Conducted socio economic surveys of households by the volunteers with objectives of spreading awareness on best practices and various technological options in solid waste management.

Chapter 2. Situational Analysis of Solid Waste Management in Study area

2.1 Study Approach

In order to find out the present solid waste management scenario of study area detailed surveys were conducted. The survey was conducted in two phases and the analysis part was combined.

Phase 1: Canal stretch (Conducted along with liquid waste management survey).

Phase 2: Entire four wards (Municipal Office, Municipal Stadium, Valiyamaram, Mullathuvalappu)

Table 2:1General details of survey

Sl. No.	Details	Ward			
		Municipal Office	**Municipal Stadium**	**Valiyamaram**	**Mullathuvalappu**
1	Total no of houses	685	874	1042	965
2	No of houses surveyed	297	377	526	498
3	APL	200	250	313	304
4	BPL	97	127	213	194
5	Total population	813	542	2374	2230
6	No of Adults	677	461	2073	1926
7	No of children	113	81	301	304
8	House ownership -				
	Own	216	303	414	411
	Rented	81	74	112	87

2.2 GENERATION OF SOLID WASTE

2.2.1 Calculation of Solid Waste Generated in the Study Area

As per a study done by National Environmental Engineering Research Institute (NEERI), per capita waste generation ranges between 0.2 kg and 0.6 kg per day in Indian cities. As per this study, cities with population between 0.1-1 million produce 0.25 Kg per capita per day, the corresponding number for cities with population between 1-5 million is 0.27-0.35 Kg per capita per day and for cities with population over 5 million is 0.5 Kg per capita per day.

The population of Alappuzha municipality is 176164 (Census, 2011) and thus we can take the per capita waste generation as 0.25 kg per day. The quantity of waste generated in the four wards are estimated in table 2.2.

Table 2.2 Calculation for Solid Waste Generation in the four wards

Sl.No.	Ward	Population	Estimated solid waste generation (Kg/day)
1	Municipal Office	2762	690.5
2	Municipal Stadium	3357	839.25
3	Valiyamaram	3474	868.5
4	Mullathuvalappu	3662	915.5

2.2.2 Generation of Sanitary Waste

In all the four wards, most of the households are using sanitary pads rather than cloth napkins. About 538 households do not use any kind of sanitary napkins out of the 1698 households surveyed in all the four wards. From the number of bed patients we can identify the quantity of sanitary napkins generated from the household level. The number of households having bed patients in Municipal office, Municipal stadium, Valiyamaram and Mullathuvalappu wards are 6, 17, 26 and 21 respectively.

Table 2.3 Usage of sanitary napkins/diapers in the four wards

Sl. No	Sanitary napkins/Diapers	No: of households			
		Municipal Office	**Municipal Stadium**	**Valiyamaram**	**Mullathuvalappu**
1	Cloth napkin	7	7	7	11
2	Diaper	1	16	4	7
3	Sanitary pad	163	188	250	289
4	Diaper, Sanitary pad	31	27	40	34
5	Sanitary pad & Cloth napkin	4	8	45	5
5	Diaper, Sanitary pad & Cloth napkin	2	1	10	2
6	Nil	89	130	169	150

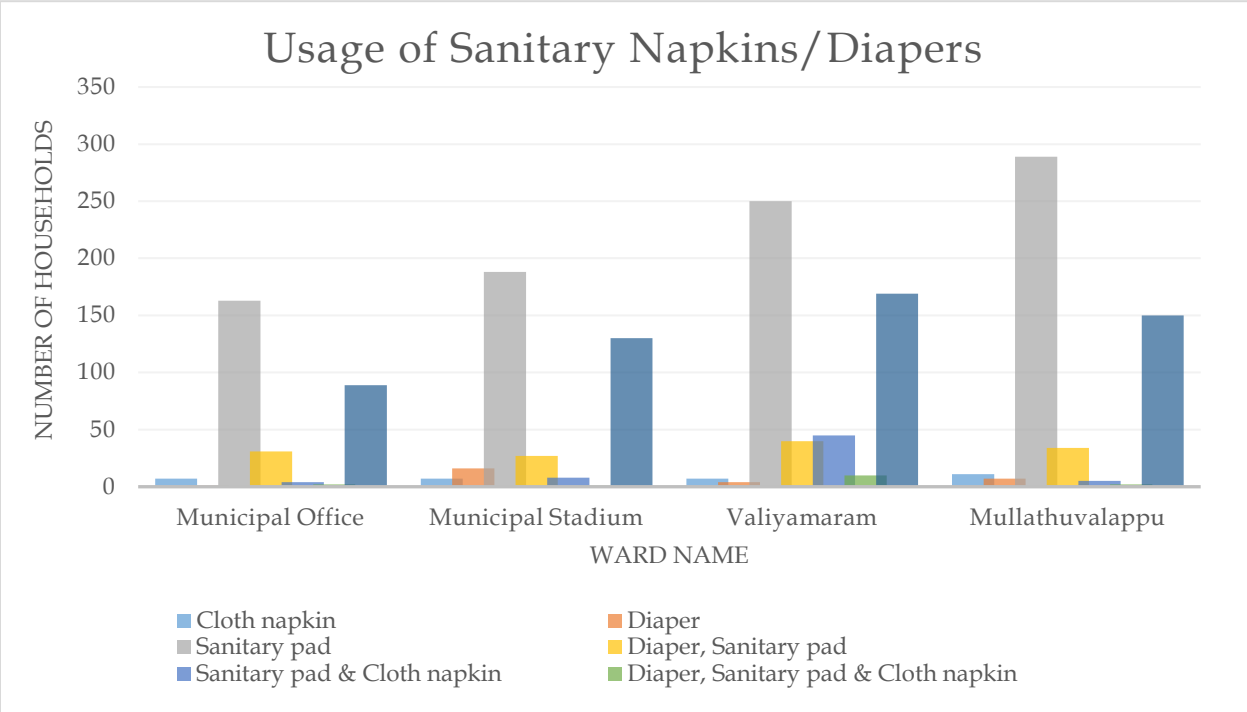


Figure 2.1 Graphical representation of usage of sanitary napkins/diapers in the four wards

2.2.3 Generation of Plastic Waste

By analyzing the frequency of buying parcel foods & grocery shopping, we calculated the amount of extra non-biodegradable waste produced in a household. If linked with the socio-economic data of the households generating the plastic waste, interesting insights could be obtained. This could not be done using this present study, as the socio-economic data was not collected.

Among the 1698 households surveyed in the four wards, majority of the households in the municipal office ward are buying parcel food once in a month whereas in all other wards' majority of the households rarely or doesn't buy parcel foods. Only few households are buying parcel foods daily in all the four wards. Out of the four wards surveyed, households in the Municipal office ward (71%) buy parcel foods more.

Table 2.4 Frequency of buying parcel food in the four wards

Sl. No	Frequency	No: of households			
		Municipal Office	**Municipal Stadium**	**Valiyamaram**	**Mullathuvalappu**
1	Daily	6	2	9	3
2	Weekly	15	33	31	20
3	Twice a week	12	21	19	11
4	Once in two weeks	30	35	45	31
5	Once in a month	148	104	142	108
6	Others	86	182	280	325

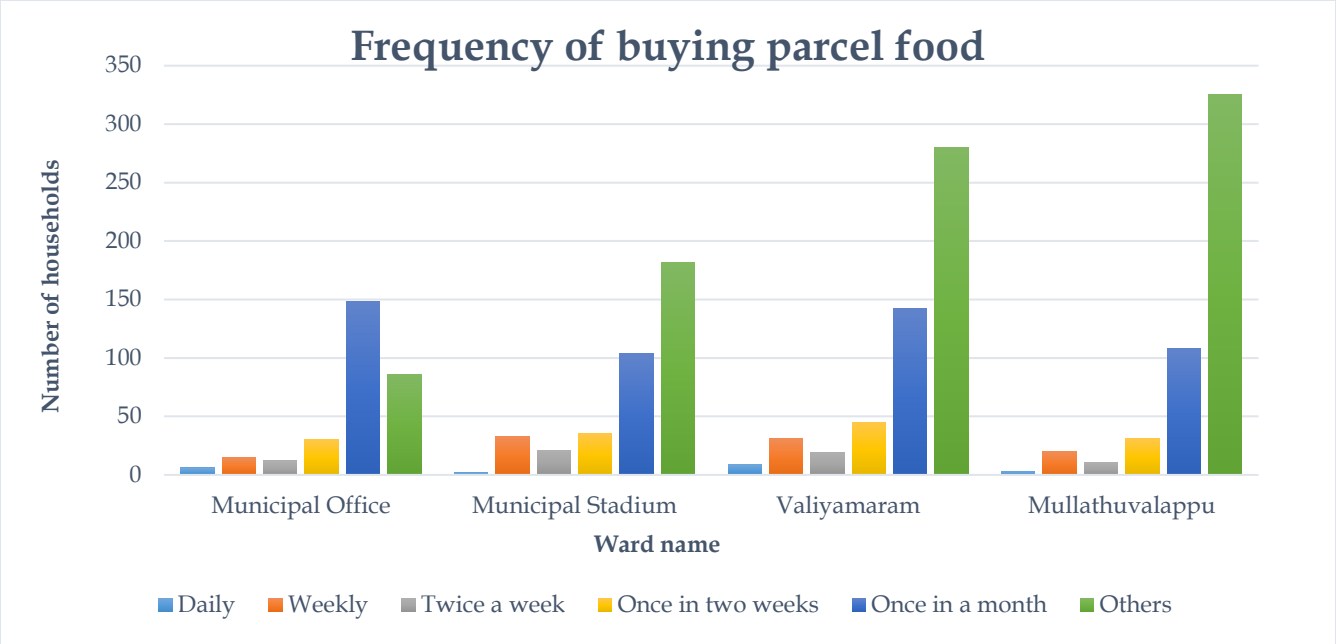


Figure 2.2 Graphical representation of frequency of buying parcel food in the four wards

Among the 1698 households surveyed in the four wards, majority are doing grocery shopping once in a week. In the Mullathuvalappu ward, there are a noticeable number of households (30%) who do grocery shopping daily whereas in Valiyamaram ward, there are a noticeable number of households (24%) who do grocery shopping once in a month.

Table 2.5 Frequency of grocery shopping in the four wards

Sl. No	Frequency	No: of households			
		Municipal Office	**Municipal Stadium**	**Valiyamaram**	**Mullathuvalappu**
1	Daily	24	64	88	149
2	Weekly	176	149	221	199
3	Twice a week	26	62	42	28
4	Two weeks	11	19	41	23
5	Once in a month	55	65	124	50
6	Others	5	18	10	49

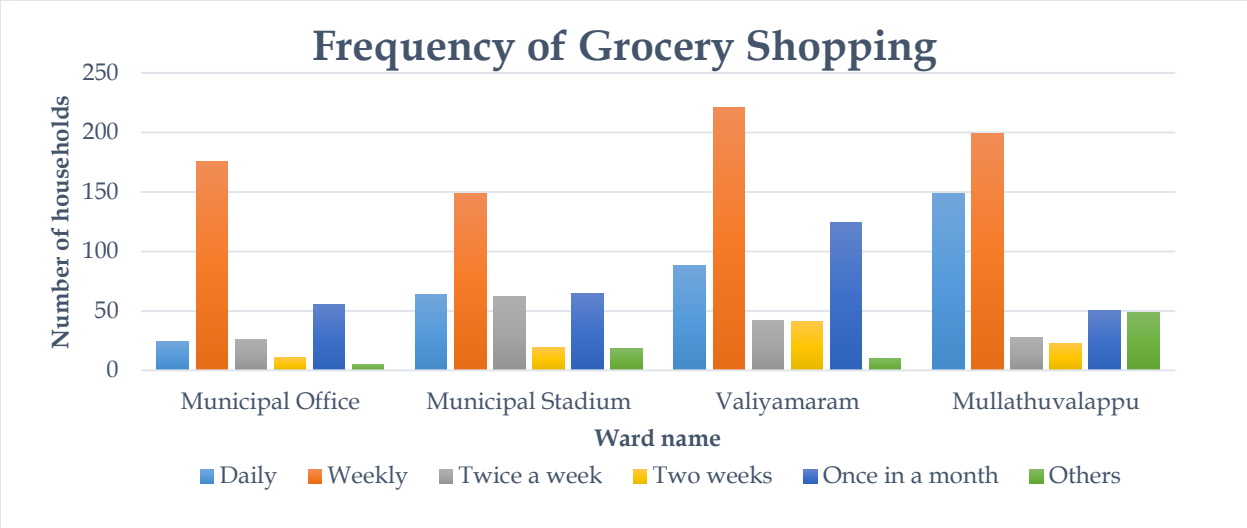


Figure 2.3 Graphical Representation of Frequency of Grocery Shopping

2.2.4 Small Scale Enterprises in Households

Different kind of enterprises produces different types of wastes. Also, there is a possibility to produce large amount of solid waste. 14 small-scale enterprises are there in the canal stretch passing through the four wards. The total number of small-scale enterprises in the four wards is given in Table 2.6. Among them majority are burning or littering their waste. There are households in Municipal stadium, Valiyamaram and Mullathuvalappu ward who give their waste to material collection facility.

Table 2.6 List of small-scale enterprises in the four wards

Sl. No.	Ward	No. of small-scale enterprise	Major waste management practice
1	Municipal office	11	Burning, littering
2	Municipal Stadium	29	Burning, littering and giving to plastic collection facility
3	Valiyamaram	28	Burning, littering and giving to plastic collection facility
4	Mullathuvalappu	56	Burning, littering and giving to plastic collection facility

2.3 SEGREGATION OF SOLID WASTE

2.3.1 Segregation of waste

Based on the present study, among the 1698 households surveyed in the four wards, about 1223 households (72%) practices segregation of waste, out of these 784 households are APL and 439 households are BPL. The practice of segregating waste seems to be high in the Municipal office ward (52%) and low in the Valiyamaram ward (41%). Among the four wards, APL households' practices segregation more than BPL households.

Table 2.7 Segregation practices in households in the four wards

Sl. No	Parameter	No: of households							
		Municipal Office		**Municipal Stadium**		**Valiyamaram**		**Mullathuvalappu**	
		APL	**BPL**	**APL**	**BPL**	**APL**	**BPL**	**APL**	**BPL**
1	Segregating waste	155	71	191	84	214	145	224	139
2	Not segregating waste	45	26	59	43	99	68	80	55

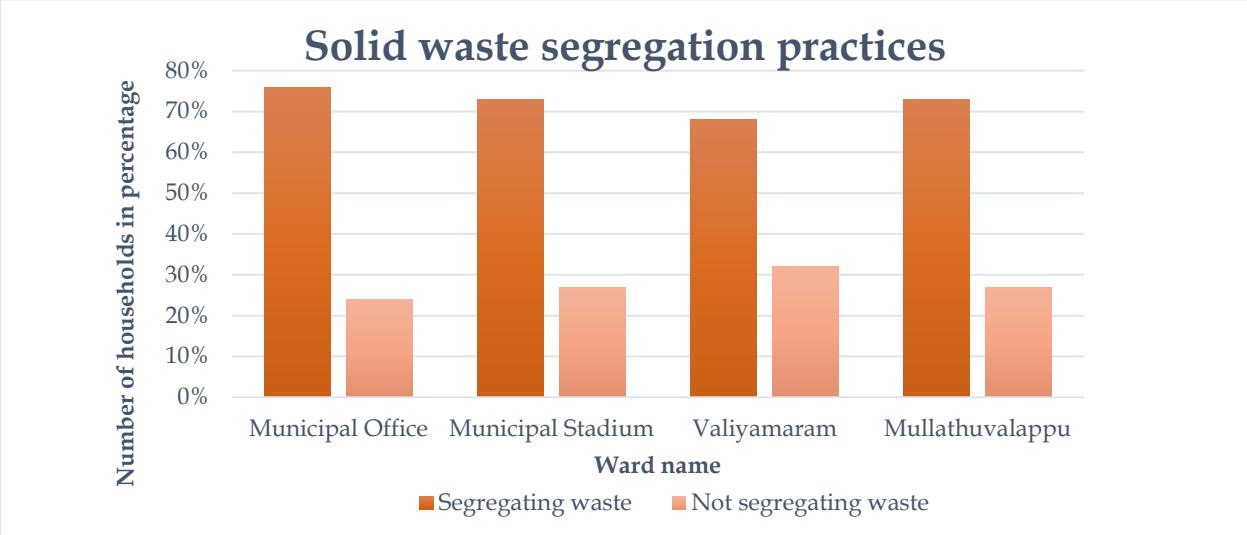


Figure 2.4 Graphical representation of solid waste segregation practices

The different types of waste segregated in the households of all the four wards are shown in Table 2.8. Among the four wards, majority of the household's segregates food waste and plastic waste. The practice of segregating paper waste seems to be high in the Municipal office ward and Valiyamaram ward. The practice of segregating sanitary, electronic and hazardous waste is found to be less in all the four wards.

Table 2.8 Type of waste segregated in the four wards

Sl. No.	Type of waste segregated	No. of households			
		Municipal Office	**Municipal Stadium**	**Valiyamaram**	**Mullathuvalappu**
1	Food waste	220	274	348	346
2	Plastic waste	219	264	347	342
3	Paper waste	179	190	299	240
4	Sanitary waste	126	76	68	79
5	Electronic waste	116	76	45	59
6	Hazardous waste	125	71	82	117

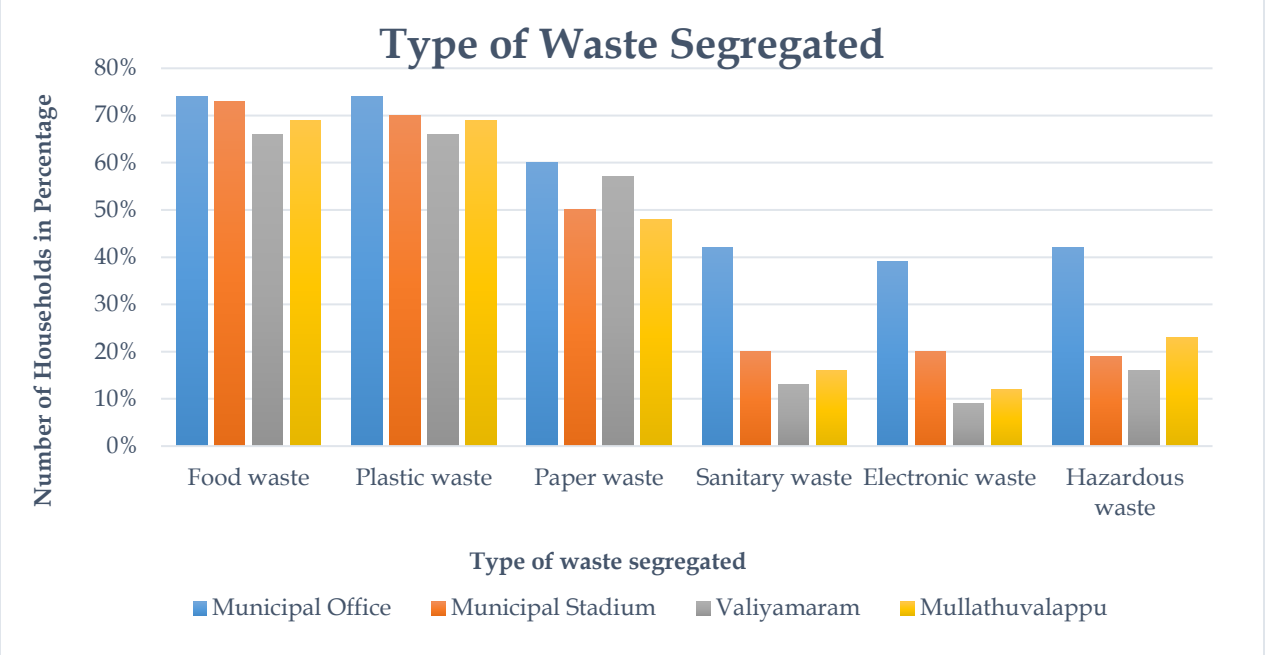


Figure 2.5 Graphical representation of type of waste segregated in the four wards

2.4 COLLECTION OF SOLID WASTE

Alappuzha municipality promotes "Your Waste Your Responsibility" for biodegradable waste and thus there is no door to door collection for wet waste. For non-biodegradable waste, there are plastic collection drives.

2.4.1 Plastic Collection

Of the total municipal waste in Alappuzha, plastic makes up 4-5 percent. All the wards in the municipality conduct plastic collection drives once in 2 to 3 months**.** (CSE) Most of the plastic waste is collected by the representative of the Clean Kerala Company, formed under the LSGD of the Gov. of Kerala.

2.4.2 Swap Shop

The concept Swap Shop, based on the principle of Reuse in waste management, aims at providing a public system for exchanging reusable goods that could be useful to others. In Alappuzha municipal area, there is a swap shop operating in municipal bus stand.

Among the total households surveyed, 284 households are aware of the swap shop and 1414 households do not know about the system. Thus, majority of the households are not aware about swap shop. The interns gave an idea about the swap shop to the people whom they surveyed. 1225 households (72%) are interested in using swap shop and the remaining 473 households are not interested.

Table 2.9 Awareness about swap shop

Sl. No.	Parameter	No of Households			
		Municipal office	**Municipal stadium**	**Valiyamaram**	**Mullathuvalappu**
1	Know about swap shop	26	64	87	107
2	Don't know about swap shop	271	313	439	391

2.5 DISPOSAL/ TREATMENT

2.5.1 Existing Biodegradable Waste Management Practices

The data regarding existing biodegradable waste management practices was collected from the four wards. A sample of 1698 households was surveyed.

Among the 297 households in Municipal office ward 25 households (8%) have on-site waste management systems. In Municipal stadium ward 38 households (11%), Valiyamaram ward 34 households (6%) and in Mullathuvalappu ward 32 households (6%) have on-site waste management systems. Among the 1698 households from all the four wards majority of households 945 (55%) are dumping their kitchen waste in land, 116 households are dumping into canal and 334 households are giving their kitchen waste to aerobic composting units.

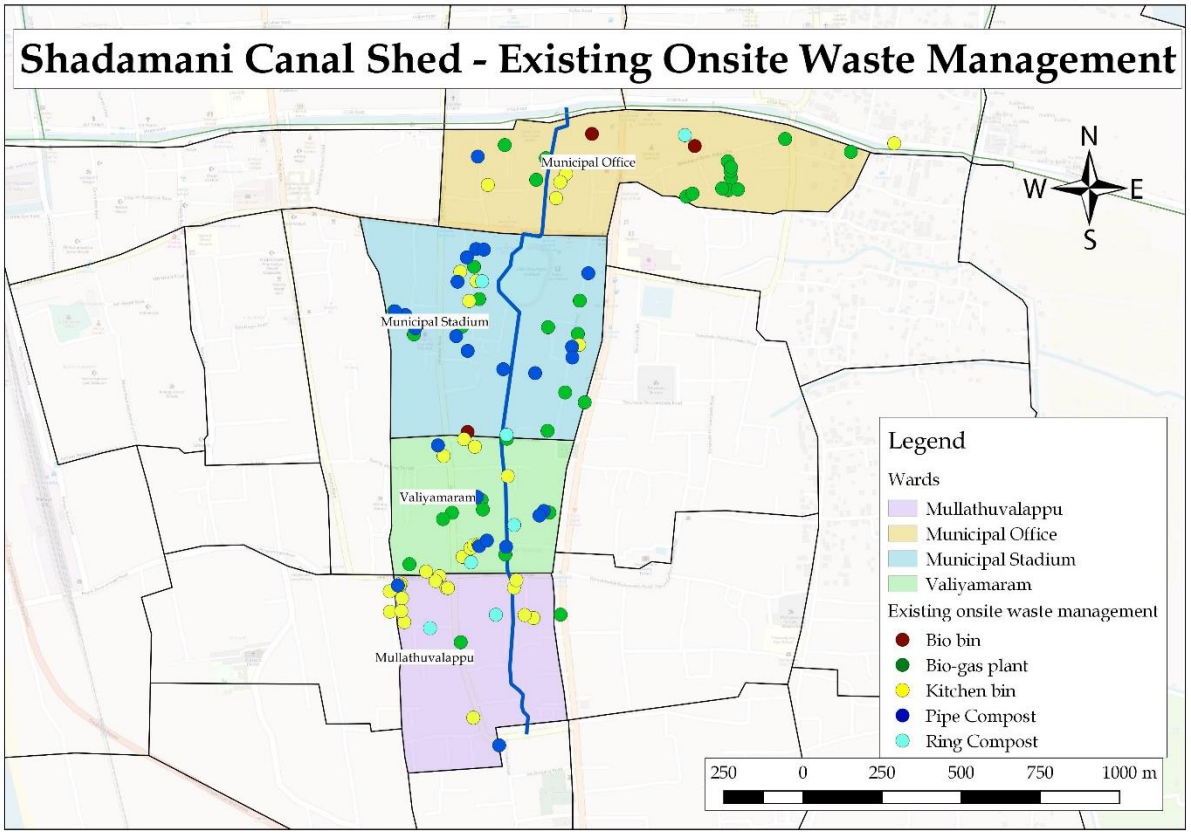


Figure 2.6 Existing Onsite Management Practices

Table 2.10 Kitchen waste management practices

Sl. No.	Kitchen waste management practices	No. of households			
		Municipal office	**Municipal stadium**	**Valiyamaram**	**Mullathuvalappu**
1	Biogas plant	14	12	8	2
2	Biobin	2	2	0	0
3	Pipe compost	4	16	12	11
4	Kitchen bin	4	7	10	16
5	Ring compost	1	1	4	3
6	Aerobic bin	62	52	109	111
7	Dumping in land	78	256	305	306
8	Dumping into canal	7	24	46	39
9	Others	35	33	70	55

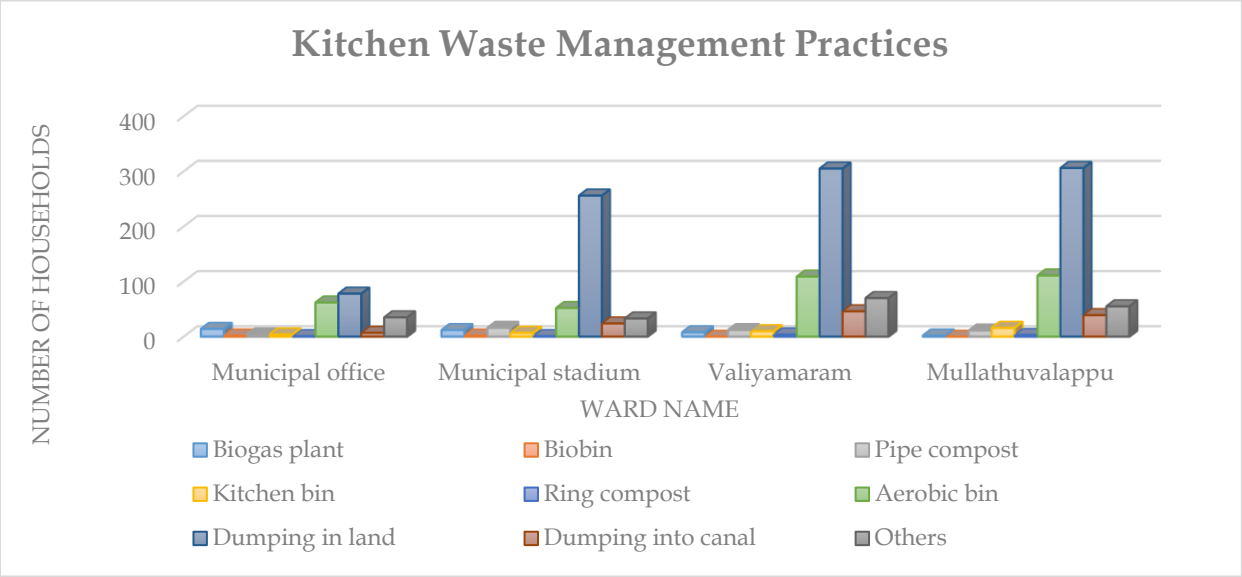


Figure 2.7 Graphical representation of kitchen waste management

Among the 35 Biogas plants installed in the four wards, 27 plants are in good working condition, 4 plants are in average working condition and 4 plants are not working due to faulty system.

2.5.2 Findings

From the analysis, got an idea about the existing solid waste management practices in the area and those includes biogas, kitchen bin, pipe compost, ring compost and bio bin. Regarding the existing solid waste management practices, a total of 1698 households has been covered and among that 129 households have on-site waste management systems. The chart shows the percentage of households having on-site solid waste management systems. The list of households having on-site waste management system is given in Annexure II

2.5.3 Location of Community Level Aerobic Composting Unit

Accessibility of community level system is an important factor in deciding the location. Following table shows the preferred distance to locate the community level Aerobic composting unit. Majority are preferring distance below 500m.

Table 2.11 Preferred distance

Sl. No.	Preferred distance	No of Households			
		Municipal office	**Municipal stadium**	**Valiyamaram**	**Mullathuvalappu**
1	0-500m	198	250	398	396
2	Above 500m	24	42	31	10

2.5.4 Dry Leaves Management

In all the four wards majority of the households (84%) are burning dry leaves in their premises. 3% are dumping dry leaves in land and few of them are giving it to aerobic composting units. 51% of the total households are willing to give the dry leaves to aerobic composting units. It is estimated that about 125kg of dry leaves from households are reaching Aerobic composting units on a weekly basis.

Table 2.12 Dry leaves management practices

Disposal practices	No of Households

Sl: No		Municipal office	Municipal stadium	Valiyamaram	Mullathuvalappu
1	Giving to Aerobic composting unit	2	5	16	4
2	Burning	249	337	458	380
3	Dumping in land	14	10	13	22
4	Others	32	25	39	92

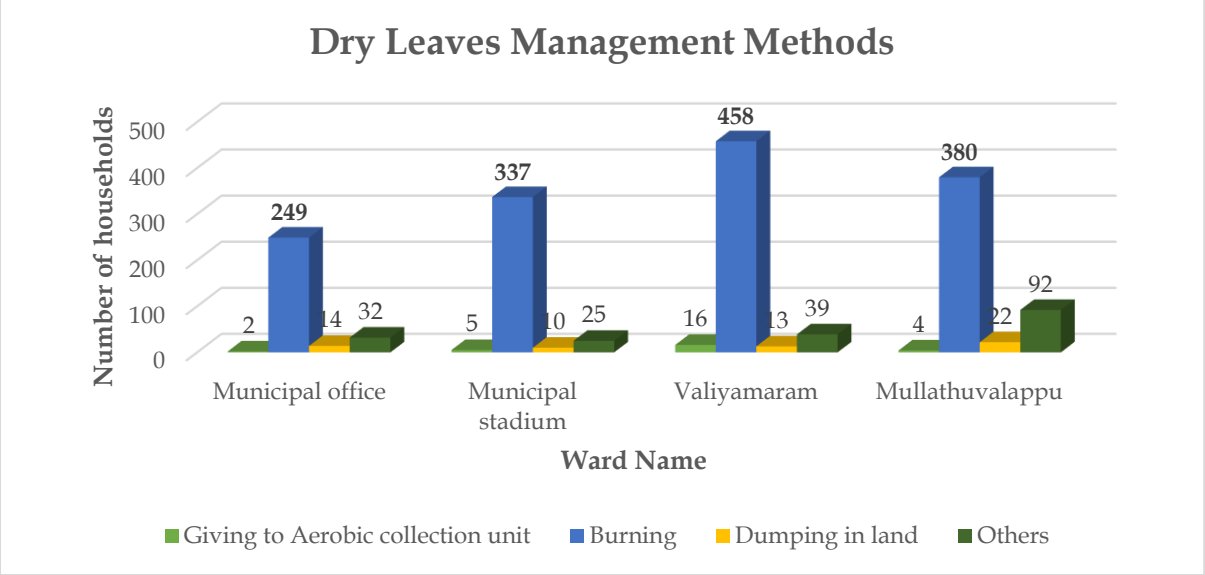


Figure 2.8 Graphical representation of dry leaves management practices

2.5.5 Plastic Waste Management

In all the wards, except Municipal office majority of households are burning their plastic wastes. In Municipal office ward majority are giving their plastic waste to Material collection facility. Rest of them are littering, storing their plastic wastes in home, dumping into the canals, selling together etc.

Table 2.13 Plastic waste disposal practices

Sl: No	Disposal practices	No of Households			
		Municipal office	**Municipal stadium**	**Valiyamaram**	**Mullathuvalappu**
1	Giving to Plastic collection facility	126	143	223	177
2	Burning	124	189	231	268
3	Littering	7	30	28	3
4	Dumping into canal	0	1	2	3
5	Stored in home	24	30	41	7
6	Sell together	6	10	17	8
7	Others	20	18	19	43

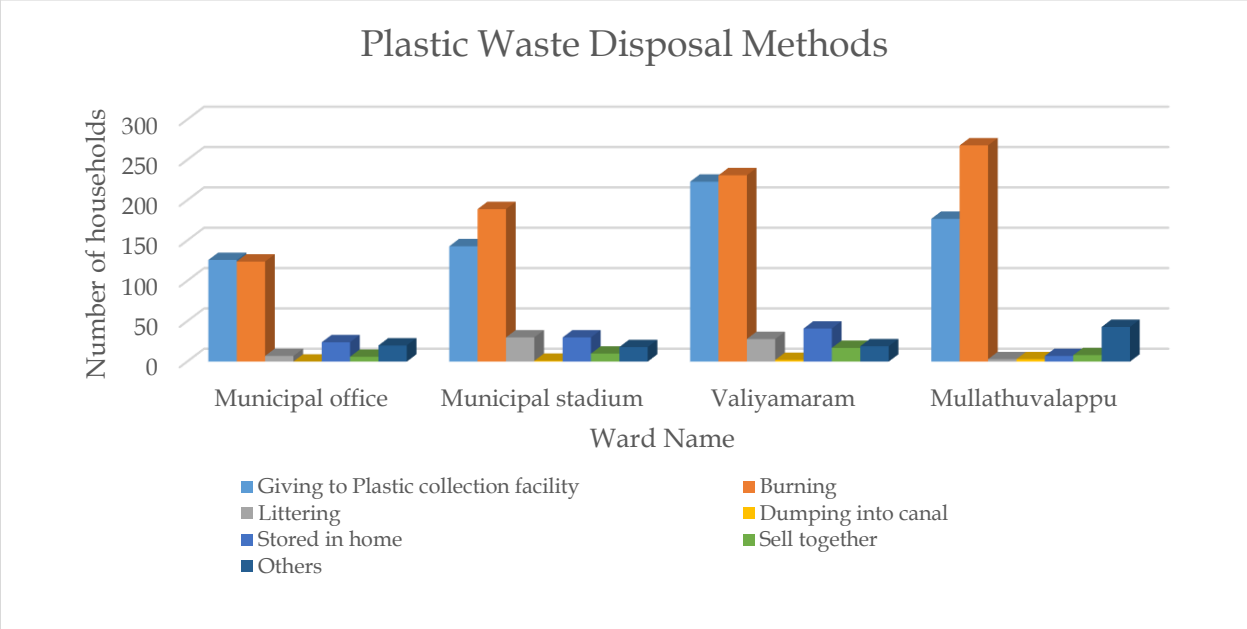


Figure 2.9 Graphical representation of plastic waste disposal methods

2.5.6 E- Waste Management

From this data, we will get an idea of how Electronic wastes are managed. Majority of the households (79%) are giving their E-waste to scrap dealers. 6% are dumping their E-waste

in land, 3% are storing in home. Rest of them are giving it to swap shops, dumping into canal etc.

Table 2.14 E-waste management

Sl. No	Disposal methods	Municipal office		Municipal stadium		Valiyamaram		Mullathuvalappu	
		APL	**BPL**	**APL**	**BPL**	**APL**	**BPL**	**APL**	**BPL**
1	Scrap dealer	167	83	158	83	254	176	251	169
2	Dumping in land	5	4	25	27	17	17	8	3
3	Dumping into canal	0	0	2	1	2	2	2	0
4	Stored in home	4	2	20	4	11	4	1	0
5	Swap shop	0	0	5	0	6	4	0	0
6	Others	24	8	40	12	23	11	42	21

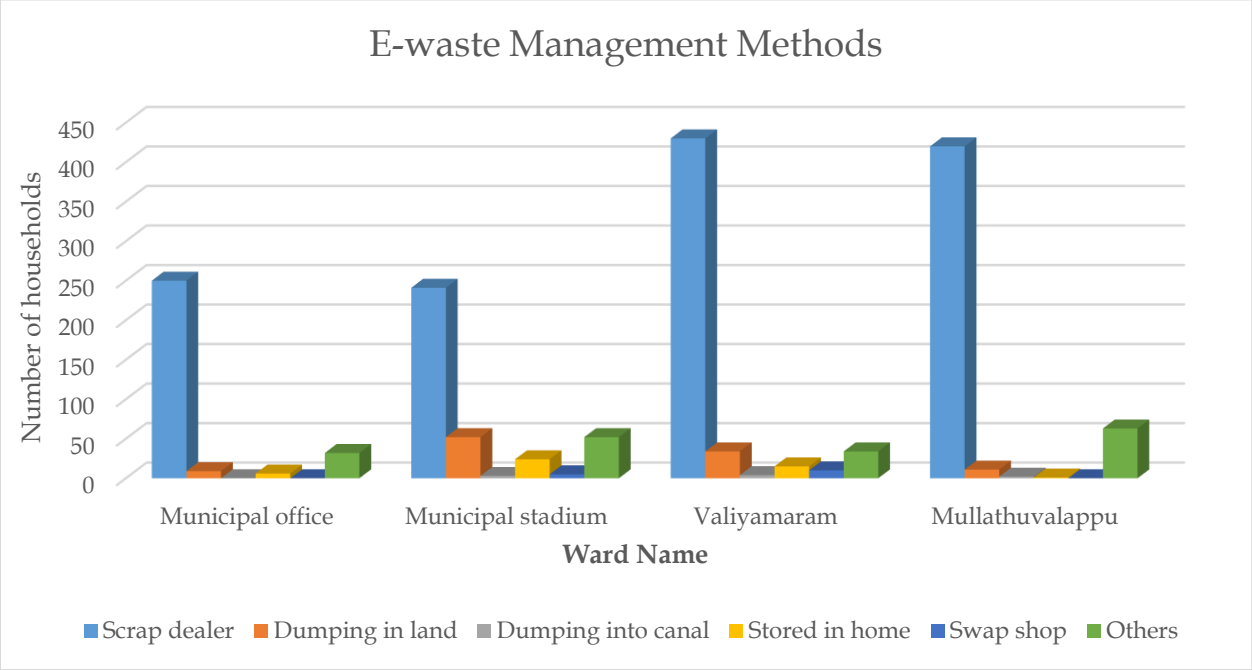


Figure 2.10 Graphical representation of E-waste management methods

2.5.7 Management of Sanitary Pads/Diapers

From the survey it is found that majority (60%) of the households are burning the sanitary napkins, while others are either burying, flushing, dumping in nearby places etc. 23% are not using sanitary napkins.

Table 2.15 Management of sanitary napkins

Sl. No	Disposal methods	No of Households			
		Municipal office	Municipal stadium	Valiyamaram	Mullathuvalappu
1	Burning	191	193	331	300
2	Burying	2	28	15	8
3	Flushing	1	1	0	0
4	Do not use napkins	81	91	121	95
5	Dumping on nearby place	6	5	12	3
6	Others	16	59	47	92

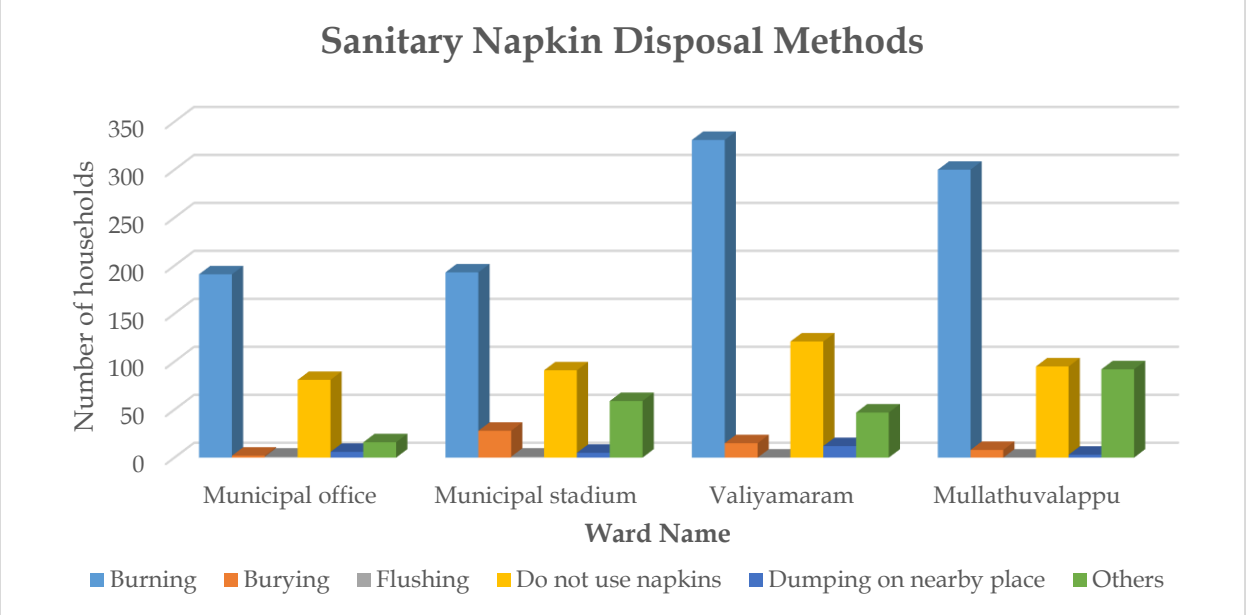


Figure 2.11 Graphical representation of sanitary napkin disposal methods

We also collected data about willingness to transport it to the incinerator to be installed at community level. The number of households that are willing to use the incinerator, if installed in Municipal office, Municipal stadium, Valiyamaram and Mullathuvalappu wards are 174, 201, 257 and 288 respectively.

Paper carry bags can be provided to dispose sanitary napkins and the same can be taken to the incinerator while disposing wet waste in aerobic bins.

2.5.8 Proposal for New Solid Waste Management Systems in Individual and Community Level

The data regarding willingness to install new on-site waste management system and also to use community level Aerobic composting unit was collected. List of various technological options are given in Annexure III. In Municipal office ward, among the total households (289) covered, about 150 households (52%) are interested in installing new on-site waste management systems like Biogas, Bio bin, pipe compost etc. In Municipal stadium ward, among the total households (289) covered, about 154 households (44%) are interested. And for Valiyamaram and Mullathuvalappu about 260 households (59%) and 185 households (48%) are interested respectively. Majority of the households prefer biobins.

Table 2.16 Technological options

Sl. No.	Technological options	Biogas plant (Fixed)		Biogas plant (Portable)		Bio bin		Pipe compost	
		APL	BPL	APL	BPL	APL	BPL	APL	BPL
1	Municipal office	17	4	19	9	58	38	4	1
2	Municipal stadium	13	4	10	2	22	61	20	22
3	Valiyamaram	10	6	27	17	106	74	15	5
4	Mullathuvalappu	5	1	21	6	80	51	15	6

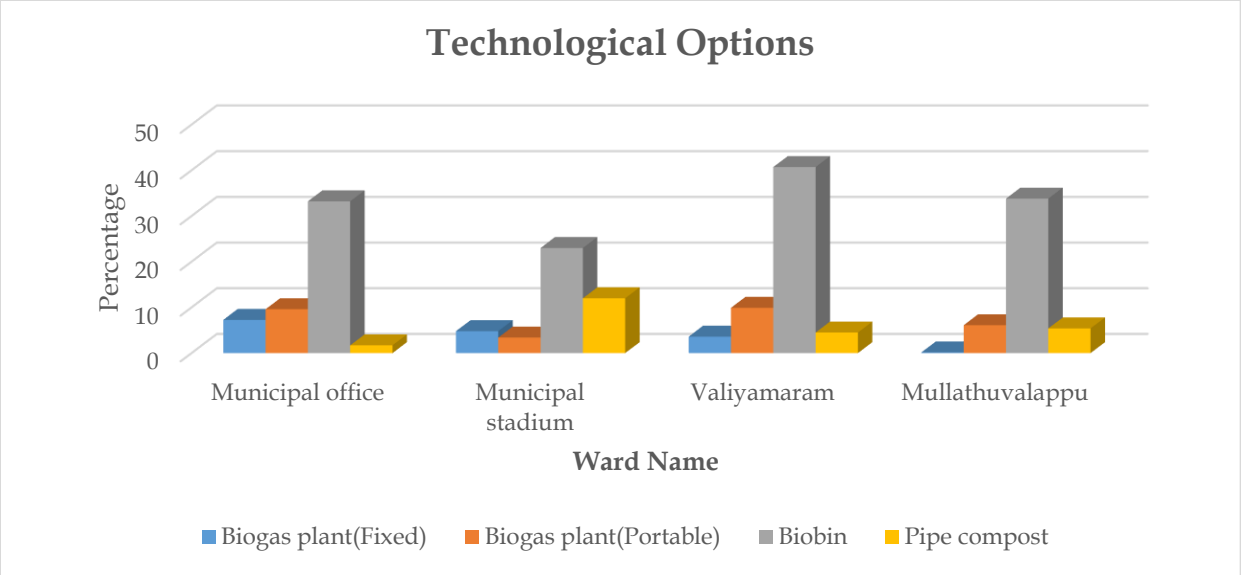


Figure 2.12 Graphical representation of willingness to install new system

2.5.9 Proposed Projects by the Municipality for Solid Waste Management

Alappuzha Municipality has proposed some projects to deal organic and inorganic waste. The different methods and its estimate are given in the table below.

Table 2:17 Proposed projects by municipality

Sl No	Description	Methods	Nos	Capacity	Unit Cost	Total Cost
1	**Household level SWM Plants**	Bio bins	1000	2kg/Day	1800	Rs. 1800000
INSTITUTIONAL LEVEL						
2	**Community Level SWM plants**	**Methods**	**No of Bins**	**No of Locations**	**Capacity**	**Total Cost**
		Aerobic Compost Units	125	25	2 Tons/Bin	Rs. 15000000
3	**Non-Biodegradable Waste Management**	**Methods**	**Area**	**No of Locations**		**Total Cost**
		Material Collection Facility **(MCF)** (Various Wards In Municipality)	6250 sqft	25		Rs. 8313600

Technological options for managing solid waste can be provided to the beneficiaries after sorting the willingness list (Annexure IV) and proposed projects by the municipality.

2.5.10 Proposed Location for Aerobic Units in Pilot Area

Based on the suggestion from people, identified locations in each ward are Karukayil junction and Graveyard in Mullathuvalappu ward, land near Municipal Office and Vazhichery in Municipal Office ward, near EMS Stadium and P&T Quarters in Municipal Stadium ward, Kongini burial ground in Thiruvambady junction and near Guru Mandiram in Valiyamaram ward. But for finalizing the location, land availability should be considered and for that further study should be conducted.

2.6 ACTION PLAN

Action	Responsible Authority	Time Frame		
		Short term	Medium term	Long term
ORGANIC WASTE				
Finalize the beneficiary list for installing new onsite waste management systems, based on the estimate prepared by the municipality and socio-economic status	CANALPY Team	✓		
Install new on-site systems to beneficiaries	ULB		✓	
Repair the non-functional on-site waste management systems	IRTC		✓	
Finalize the locations for installing new community level aerobic bins	ULB	✓		
Install new community level aerobic bins at finalized locations	ULB		✓	
Investigate the possibility of pre-composting at homes before it is given to community level composting units thereby improving its efficincy	CANALPY Team		✓	
Provide training in implementation and monitoring of the systems to be installed to the members of Canalkara committee	CANALPY Team		✓	
Assign responsibility for the follow-up support in maintenance of new as well as existing systems	ULB		✓	
INORGANIC WASTE				
Conduct a detailed study to identify plastic collection points	CANALPY Team	✓		
Organize IEC campaign among the people on plastic collection system	CANALPY Team	✓		
Fix the user fee for collecting plastic waste	ULB	✓		
Assign responsibility of conveyance of collected plastic waste from the collection points to the municipality	ULB	✓		
Commission new plastic shredding units as per need	ULB		✓	

Explore the technological options and methodology for managing E-waste, Biomedical waste & Hazardous waste	ULB			✓
Organize IEC campaign among the people on managing E-waste, Biomedical waste & Hazardous waste	ULB			✓

SECTION II
LIQUID WASTE MANAGEMENT

Chapter 3. Liquid Waste Management

3.1 INTRODUCTION

Domestic liquid waste is considered to have two components, viz; waste originating from kitchen and bathroom together called as grey water and waste originating from toilets called as black water. In cities of the developed world, both these streams of wastewater are collected together through sewers and treated at a centralized sewage treatment plant (STP). Critiques also call it 'end of the pipe' solution. However, such centralized systems are expensive to build, which is more pronounced in small cities and towns due to economies of scale. In India, the city governments have to rely on grants from the State and Union government to finance such expensive infrastructure. Only two cities in Kerala, viz; Thiruvanthpuram and Kochi have established sewer systems and yet they serve only part of the respective city.

Smaller towns like Alappuzha rely mostly on on-site systems (OSS) like septic tanks and pits. Besides being less capital intensive, they separate black and grey water at source. This is a big advantage since managing and treating them separately is much simpler than treating the mix. Various standards like BIS, CPHEEO also suggest that they be managed separately (BIS, 1995; CPHEEO & JICA, 2012).

In either case, the sanitation service chain includes user interface, collection, conveyance, treatment and disposal/reuse and can be represented as shown in Figure 3.1. The National Urban Sanitation Policy (NUSP) requires city governments to manage the entire chain for the entire city.

Figure 3.1 The Sanitation Service Chain

To have a proper liquid waste management system in place, it is invariably important to understand the chain starting off with the individual user or household. Analysis of the current practices and infrastructure will aid in developing a contextual understanding of current liquid waste management practices. This situational analysis helped in developing a comprehensive liquid waste management plan for Alappuzha. The current section attempts to highlight the various activities that were carried out in connection with liquid waste management in past one year. These activities have eventually culminated into an action plan discussed at the end of this report.

3.2 STUDY AREA

Sadamani Canal which is having a length of about 2.11 km starting from Thumbaparmbil Temple in Mullathuvalappu ward and ending in commercial canal. It passes through four wards namely, Municipal office (ward no 25), Municipal stadium (ward no 33), Valiyamaram (ward no 32), Mullatuvalappu (ward no 31).

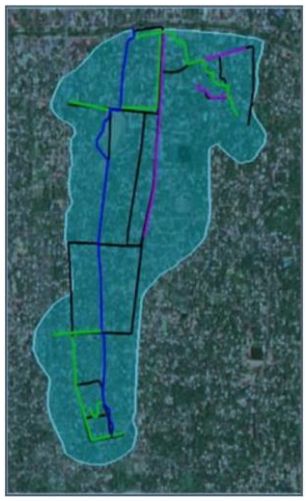


Figure 3.2 Sadamani Canal Shed

Table 3.1 Demographic Profile of Canal Shed

Total no. of houses in the canal stretch area	258
No. of houses surveyed	232
Not surveyed	26
Total population	1045
No. of adults	878
No. of children	167
Household size	4.05

As explained in section (Introduction) Sadamani canal shed was selected as the second stage after the study of pilot area. The canal shed delineation and demarcation was performed by analyzing the drain maps created using OSM tracker during IIT Bombay – KILA Summer School 2018 (Figure 3.2).

As per the previous studies (winter school 2017 and summer school 2018) it is clearly identified that the two rows of houses on both side of the sub canals are major contributors of liquid waste. So, the liquid waste management in the Sadamani sub canal is concentrated only on these houses. The two rows of houses on both side of canal are called the canal stretch and these are the critical areas of the Sadamani sub canal. The data collection and analysis are done through the 8 days' workshop called Winter School 2018.

3.3 METHODOLOGY

In order to propose a suitable liquid waste management plan for the pilot area, it is essential to understand

The physical characteristics of the Shadamanisub canal,

The socio-economic characteristics and liquid waste management practices of the households, and

To check the feasibility of various technological options for treatment of liquid waste and feacal sludge in the current context.

The strategy employed for attaining the aforementioned objectives is detailed in the flow chart below (Figure 3.3).

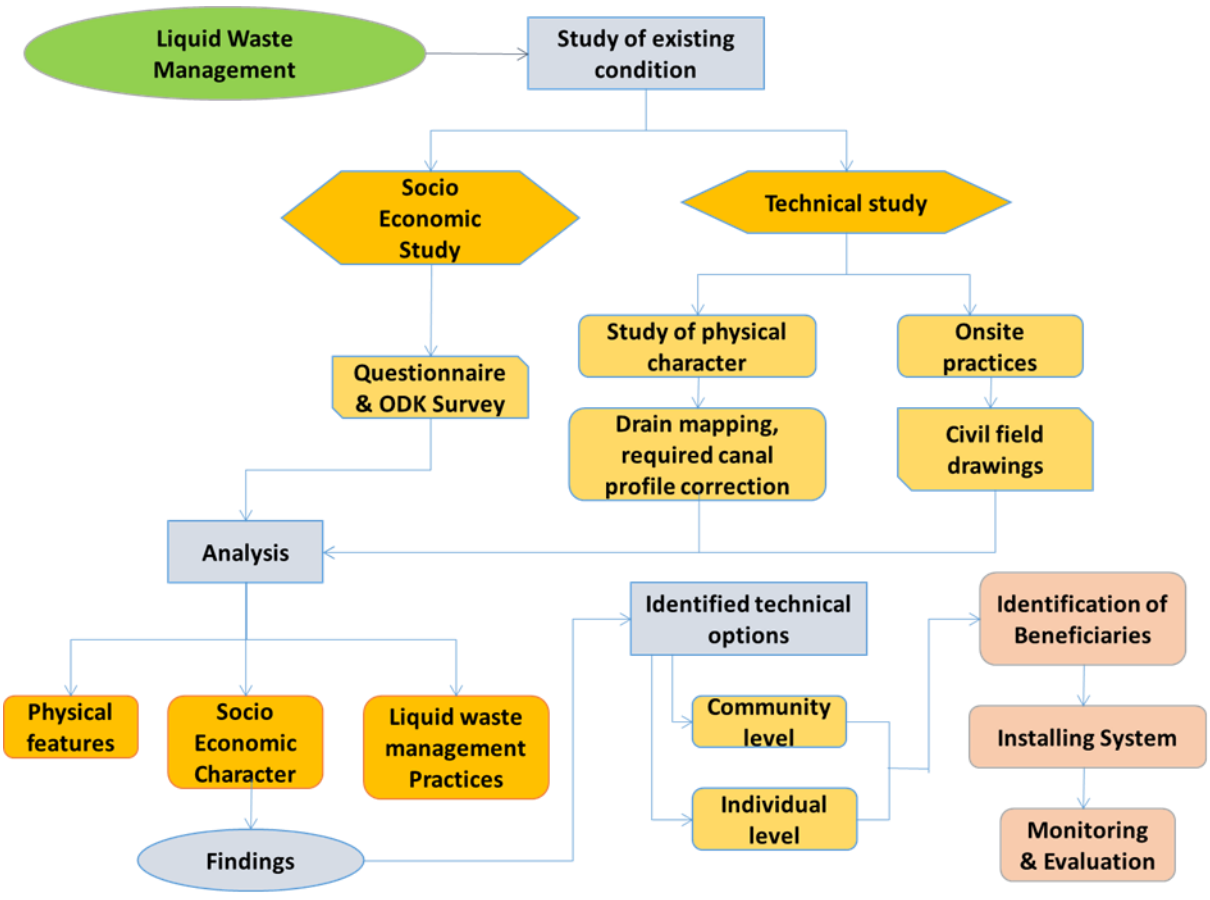


Figure 3.3 methodology flow chart of liquid waste management

3.4 SOCIO ECONOMIC STUDY

The main objective of this study was to identify the liquid waste management practices and socio-economic characteristics of households who are involved directly or indirectly in polluting the Shadamani sub canal due to their unscientific liquid waste management practices. This was done in Dec 2018 during the IITB- KILA Winter School 2018. Findings from the report of IITB- KILA Summer School 2018 indicate that the majority of the waste water discharges into the canal is from the adjacent houses near the canal. Hence it was decided that consequent studies can focus on two rows of houses on both the sides of the canals. The unit of analysis was at household level.

3.4.1 Methodology

Household survey along with key informant interview was the main method used to understand the various dimensions of the problems identified in the objective. To map the household practices in liquid waste management, a structured questionnaire was used complimented with semi-structured interviews to get specific details. A questionnaire was developed on 'ODK build' and data was collected using a mobile app called 'ODK collect'.

Design of the Questionnaire- The questionnaire evolved after a series of pilot and actual surveys over the last year. The following table shows the different elements of the questionnaire and the relevant information which each element provides.

Table 3.2Elements of the Questionnaire Survey.

Parameter	Utility of the parameter in this study	Relevance in the Action plan
Family composition	To calculate per-capita water consumption To calculate quantity of waste water generated	Helps to design the size of system to be implement
Source of water	To determine the method of quantification of water consumption	Aids in design of the system

	To know the probability of pollution	
Current liquid waste disposal practices	Existing situation analysis	To suggest suitable technological options
Age of septic tank	For correlating with cleaning frequency of septic tank to understand the operational efficiency of septic tank	To assess need for replacement of the system
Bottom sealed or not	To know whether there is seepage	
Material used for construction		
Shape of septic tank	To check whether it is a septic tank or leach pit	
No. of chambers in septic tank		
Presence of vent pipe	To know whether the design is as per BIS	
Outfall condition		
Frequency of cleaning	To know whether optimal anaerobic biodegradation process is taking place in the septic plant To estimate faecal sludge generated in a household	
Agency employed to clean the septic tank	To know whether the agency is empanelled with the municipality To know the collection, transportation and disposal mechanism	Helps in the proposal of FSTP and design of plant
Frequency of using toilet cleaners	To know the efficacy of anaerobic biodegradation process in the septic tank	Can be included in the Canal Shed Committee campaign
Width of approach road	To check accessibility for installation of new system	Helps in transportation of materials
Land occupied by existing system	To design size appropriate system for retro-fitting and quantification of demolition waste	Aids in design of new system and estimation of quantity of demolition waste
Land available for new system.	To design size appropriate system and to install temporary toilets.	Helps in design of system

Willingness to install a new system	To estimate the total number of systems to be retro-fitted or replaced	To finalize the beneficiary list

The questions asked in the survey are attached in Annexure I

Data Collection through Household Survey: Data Collection was conducted by CANALPY interns over the course of 8 days starting from the 8th December 2018. The interns were given training on the data collection tool (ODK collect) with a detailed explanation of the questionnaire including the way to approach the households by the KILA Research Associates team. The purpose of survey, the larger objectives of the Canal rejuvenation project and evolution of CANALPY was explained at the beginning by the CANALPY team. The interns were divided into 9 two-member teams. Each team was assigned a certain stretch of the canal and was asked to approach the two rows of households situated along the canals. The finalized forms containing household data were then sent by students from their mobile app (ODK collect) to a host google drive. The data thus collected was later collated and analyzed on excel and QGIS/ArcGIS to identify the trend of liquid waste management practices and overall socio- economic background of the inhabitants. This data was later used in technology selection and prioritization in technology implementation

3.5 TECHNICAL STUDY

To understand the characteristics of the canal and check the feasibility of installation of appropriate technological options to manage liquid waste, it is imperative to conduct an in-depth technical study. The study undertaken over the course of 10 months starting off in December 2017 focused on tracking and mapping Shadamani sub canal, understanding its physical features, noting the status of onsite systems in the households and ascertaining the feasibility of installation of proposed technical options if needed.

3.5.1 Study of Physical Characteristics of the Canal

Delineation of canal shed -

Preparation of Base Map: The first step was creation of a base map of the canal system in Alappuzha. The map collected from the Municipality did not have the complete network of sub canals. Hence an exercise was undertaken during IITB – KILA Winter School 2017 to map all the drains and sub – canals of Alappuzha. Drain maps were prepared for 14 main inlets (sub canals/drains) to the Vadai and Commercial canals. An open source application called OSM (Open Street Map) Tracker was used to map the drains. Encroachments and eutrophicated stretches with the canal sheds and pollution hotspots were marked on GIS platform, methodology for these activities are detailed out in Winter School Report 2017.

Drain maps to canal sheds: The drain maps transferred into GIS platform. The order of the drains was also marked while tracking which were depicted using different colours. The approach roads/ways were also tracked for future needs. Using elevation tool, the canal-sheds along the drains were delineated. The different canal-sheds were demarcated using the Elevation plugin in QGIS software. The boundaries of each of the canal sheds were drawn connecting the highest points around each canal.

Mapping Physical Features of the Canals -

Length, width, encroachments: Apart from mapping the canals the exercise also measured the physical features of the canals including their length, variation in width along the canals and marked encroached areas. The details regarding the same have been recorded in the Summer School report.

Estimating Variation of Reduced Level (RL) Of Canal Centre Bottom with Length: Encroachments as well as accumulation of solid waste dumped in intermittent intervals in the canal have led to reduced level of the canal bottom. The sub canals vary abruptly in their width along their topographical layout and it has been observed that much of this variation, more precisely reduction in width is due to encroachment in the canals. This has considerably affected flow of water in the canals and results in flooding during the

monsoon and silting during non-monsoon seasons. Data pertaining to the variation of canal width and RL (Reduced Level) of centre of canal bottom along with length was collected during IITB -KILA Summer School 2018. The methodology for the same can be found in Summer School-2018 report.

Household level mapping of On-Site Sanitation Systems

The next phase of data collection was a household level plot mapping aimed towards identifying the status of onsite systems currently functioning in the households, discharge points of households, measuring plot dimensions and dimensions of existing systems and demarcating space for alternate systems if needed.

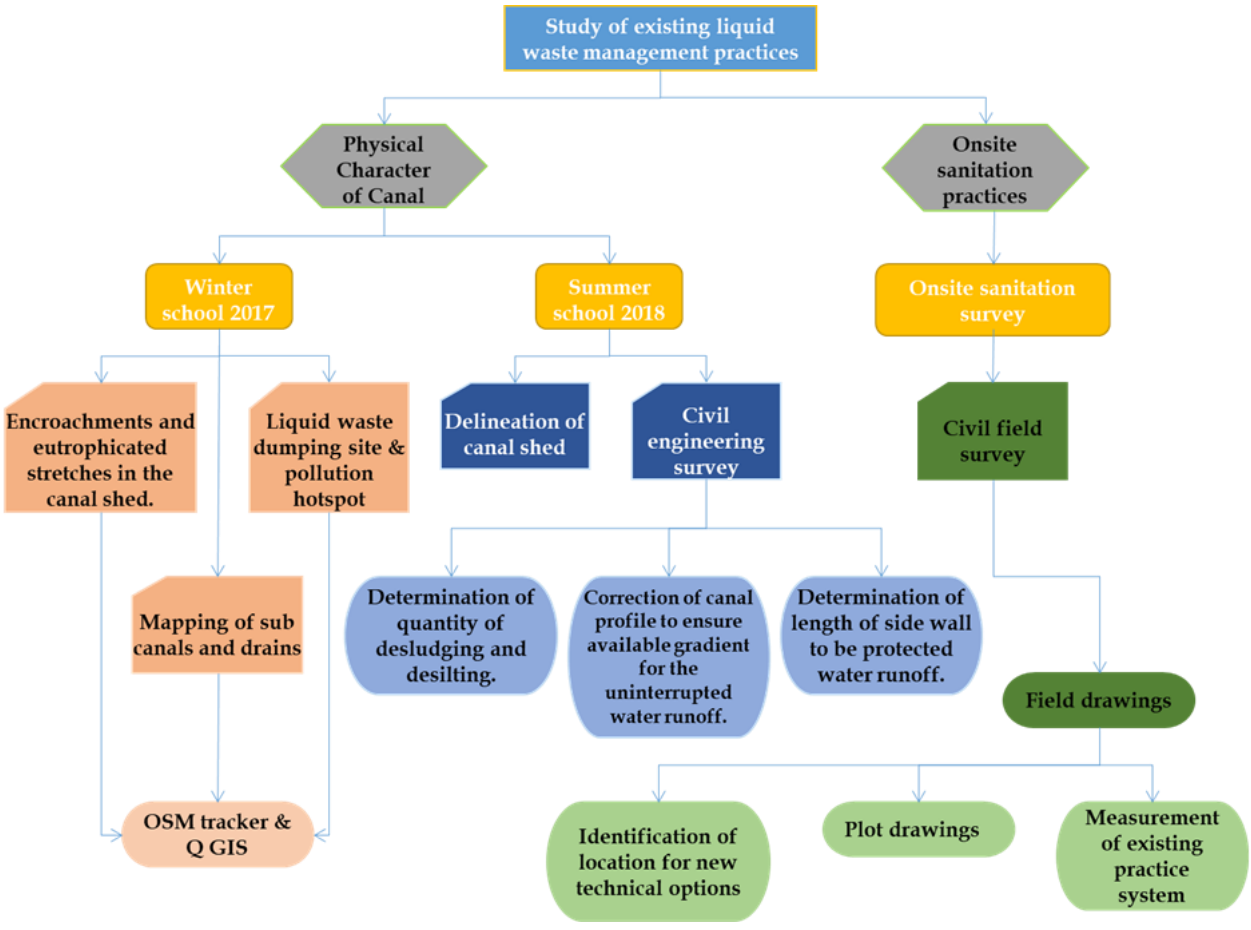


Figure 3.4 Methodology Flow Charts for Technological Options for Onsite Sanitation System

3.6 HOUSE HOLD LEVEL PLOT MAPPING SURVEY

The survey was conducted simultaneously with the socio-economic survey. They were given four-day training on drawing site plan and service plan of each plot by KILA Research Associates team. This was in addition to the earlier sessions on the socio-economic questionnaire and project background. The training included both class room sessions and site visits.

The team was provided with a survey kit which had the following items - measuring tape- 30m, water level, template of drawings, drawing sheet-A4, pen & pencil. Template of the drawings was added to aid the survey team in the measurements and to serve as a checklist. After completing the questionnaire for the socio-economic survey, the team recorded the dimensions of the plot and the existing OSS in the A4 sheets. After the survey they converted each drawing into an AutoCAD file which was later printed into A3 sheets. These sheets will be used for analysis and for construction of alternative systems if needed.

The following are the design parameters which were considered during the site visit

1. Approach Road:
2. Distance between boundary wall and house (setback)
3. Position of well within the plot.
4. Position of septic tank
5. Distance between well and septic tank
6. Distance between approach road and plot boundary
7. Levels from the ground to the inlet and outlet of black and grey water.
8. Position of water meter within the plot
9. Position of storm water drain (covered/ uncovered)
10. Household water supply distribution diagram

11. Slope of terrain

These parameters give a comprehensive overview of the plot dimensions, open spaces, built-up areas, positio55n of existing septic tank and vegetation (trees and plants). The output of the following parameters can be used to find out the most appropriate position for technical options.

The template used for field drawing is attached in Annexure V.

3.7 PRIMARY DATA ANALYSIS

3.7.1 Background – Sadamani Canal

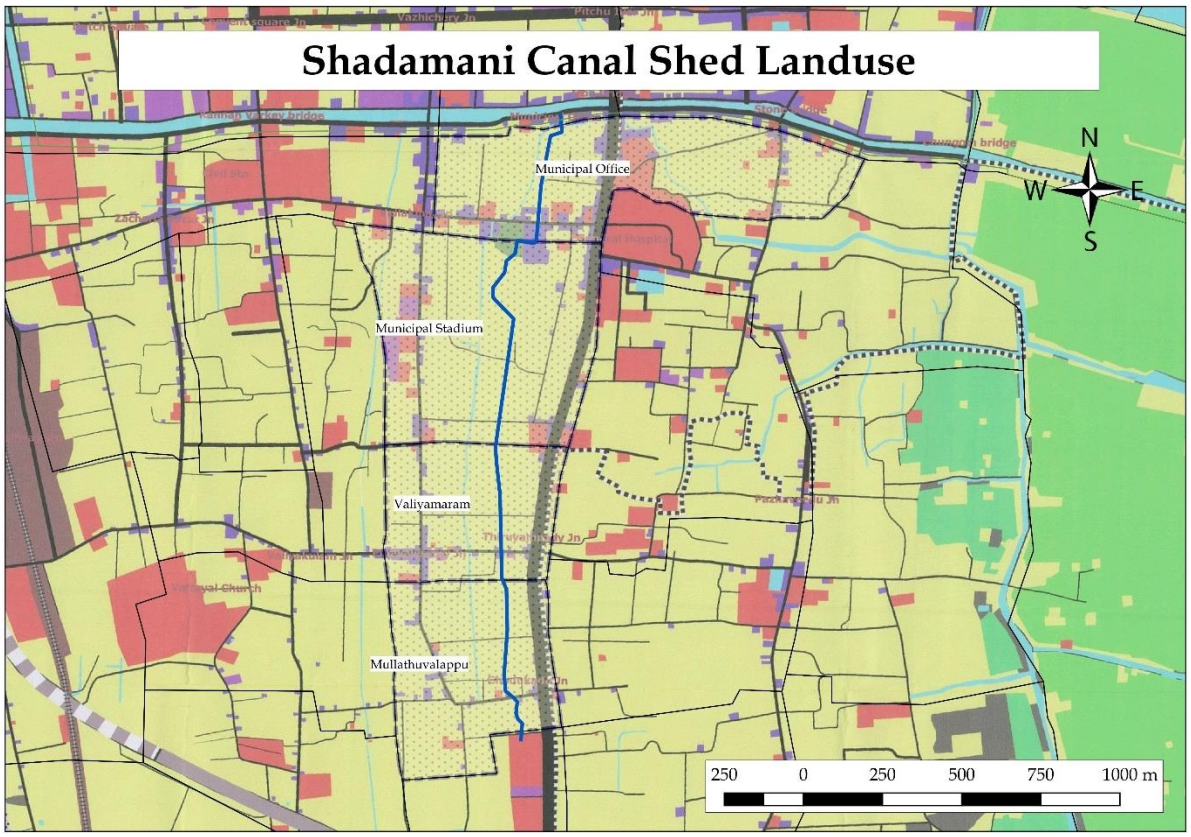


Figure 3.5Landuse Map of Shadamani Canal Shed

In sadamani canal stretch, two rows on both sides of the canal has about 232 households, having a population of 1052 with a sex ratio of 1114. sadamani flows through four wards, among this two wards (Valiyamaram and Mullathuvalapu) are the densest wards in alappuzha municipality. Sadamani has a heterogeneous character with respect to the socio-economic parameters. By analyzing the landuse characteristics Valiyamaram and Mullathuvalappu wards predominant for residential land use and Municipal office and Stadium wards for mixed landuse.

The data obtained from the Household Survey has been analyzed in detail to identify the trend of liquid waste management practices and overall socio-economic background of the inhabitants. This data analysis is crucial for identifying the technological options

appropriate for the intervention area. For the installation of any technological alternatives for the liquid waste management practices, house ownership status could be a proxy indicator to understand the willingness of the households for the installation of new system. The socioeconomic survey reveals that out of 232 HHs surveyed, 197 houses are own, 34 rented and 1 leased.

The other main parameters that are considered for the data analysis are as follows.

3.7.2 Physical Analysis

Physical Analysis includes measurements regarding length, width, profile correction, and volume of desludging. The following figure shows the variation of width with respect to length. It has been observed that much of this variation, more precisely reduction in width is due to encroachment in the canals. This has considerably affected flow of water in the canals and results in flooding during the monsoon and silting during non-monsoon seasons.

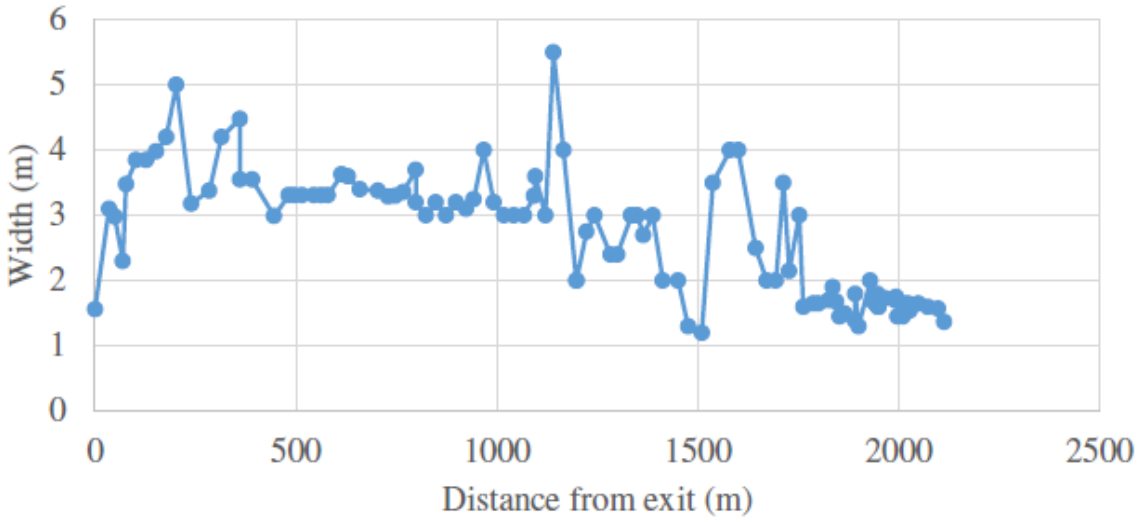


Figure 3.6 Variation of canal width Vs Length: Shadamani Sub Canal[1]

[1]Source: Summer School Report 2018

The current canal profile is depicted in Figure 3.7. However, this has resulted in uneven flow and there is a need for profile correction. The corrected profile can be deduced by estimating the corrected reduced level of canal centre bottom. This was done by levelling survey and the quantity of desilting to be undertaken has been calculated. An estimated value of 1402.2 m^3 is required to be desilted in Sadamani Sub Canal for ensuring proper flow. The Figure 3.8 shows the corrected profile of the Sadamani Sub Canal.

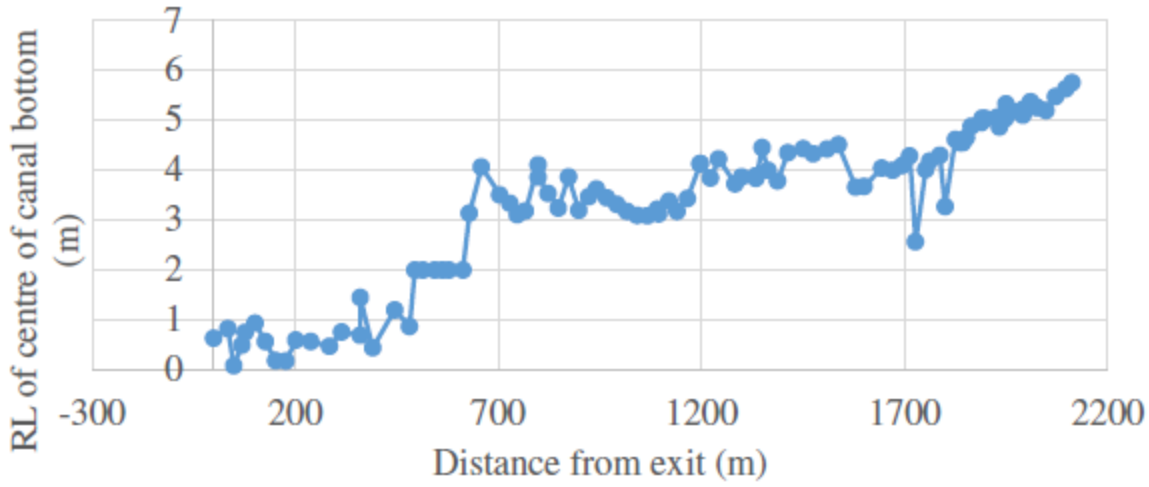


Figure 3.7 Measured Reduced Level (RL) Of Canal Centre Bottom

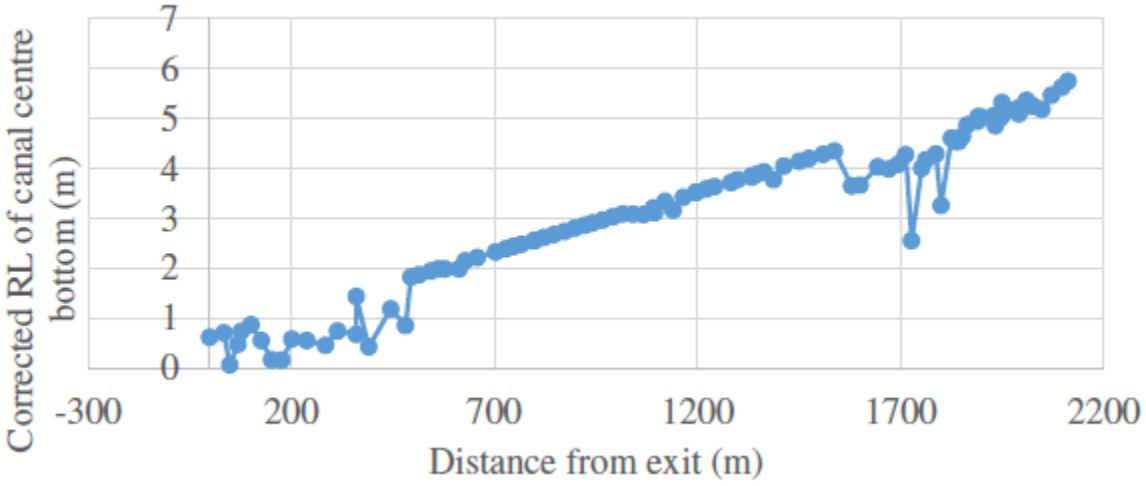


Figure 3.8 Corrected Reduced Level (RL) Of Canal Centre Bottom

3.7.3 Primary Source of Water

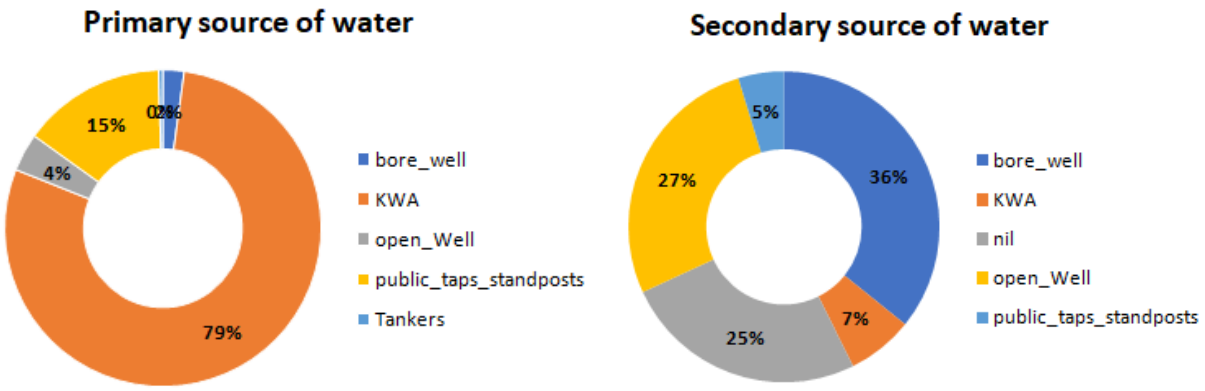


Figure 3.9 Source of Water in Pilot Area

The survey reveals that about 94% of the households rely on KWA (Household connection and Public Taps) as primary drinking water source. About 36% of the households use ground water as secondary water source, with KWA being their primary source.

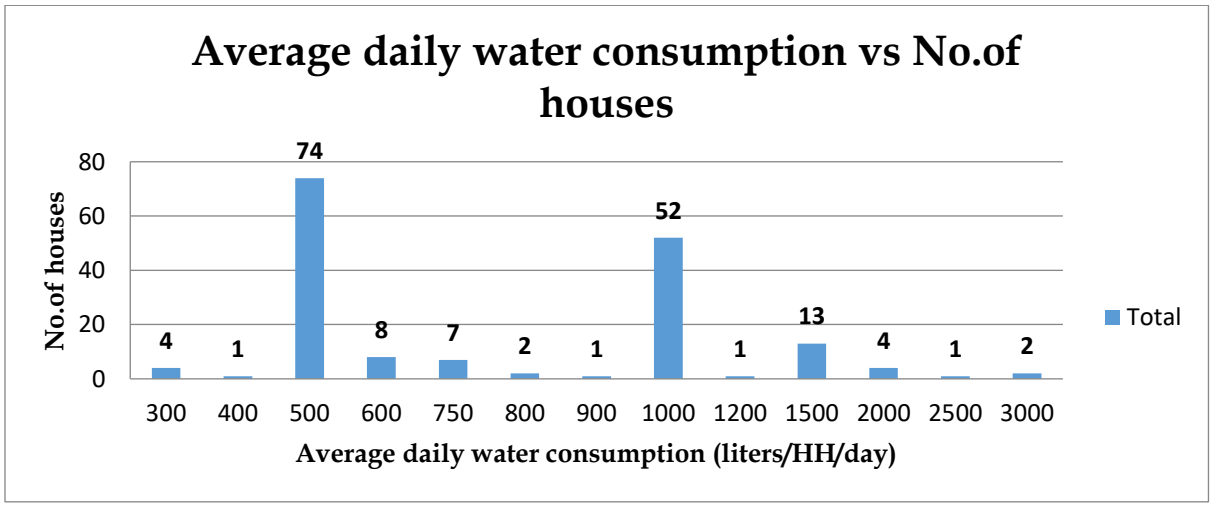


Figure 3.10 Average Daily Water Consumption Vs No. of Houses

The quantity of water used per HH can be determined by taking overhead tank capacity and frequency of pumping. The figure shows the variation of daily water consumption of HHs in the Pilot Area. From the figure, 52 HHs uses a maximum of 1000 litres per day and 74 HHs uses 500 litres per day. Four families use a minimum of 300 litres per day.

Out of this 80% of the water can be assumed to be converted to wastewater. The data on volume of wastewater generated per household can be used for designing alternate Onsite Sanitation Systems if the current systems are found to be unsatisfactory.

3.7.4 Black Water Management

In Alappuzha two methods are generally in practice for management of black water namely septic tank and soak pit. According to BIS 1993 and Kerala Municipality Building rules (1999) it is mandatory that every household is either connected to sewerage network or have a septic tank in their premises. From the 232 HHs surveyed, all households have individual household latrines. However, our findings show that only 15% of the households have a septic tank and the rest of the households dispose the black water into soak pit. Two houses discharging their black water directly into nearby drains.

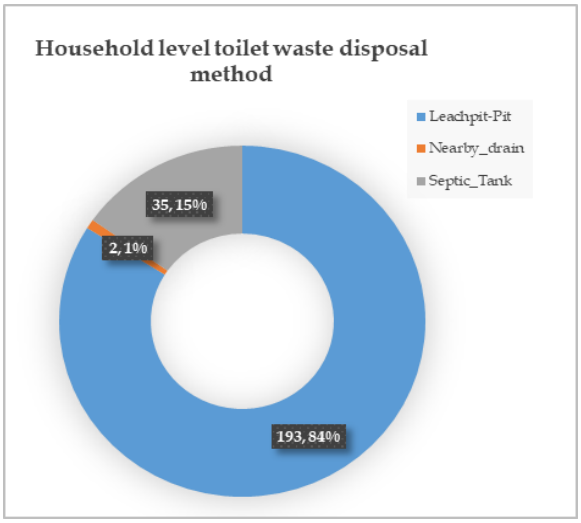


Figure 3.11Household level toilet waste disposal method

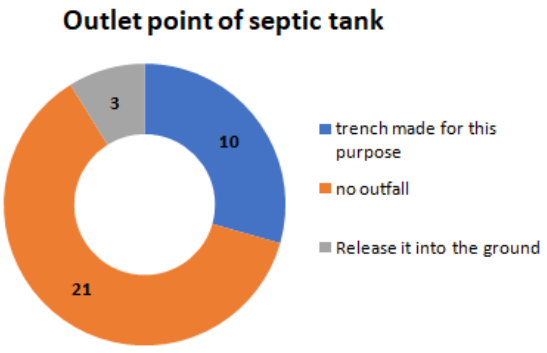


Figure 3.12 Outlet Point of Septic Tank

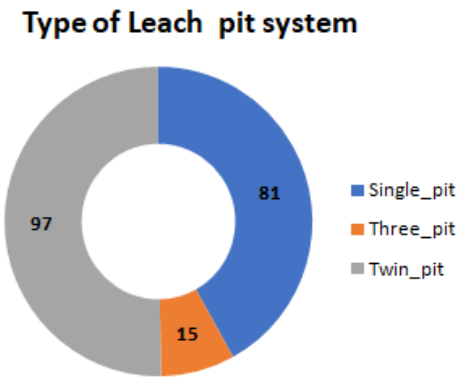


Figure 3.13 Type of Leach Pit System

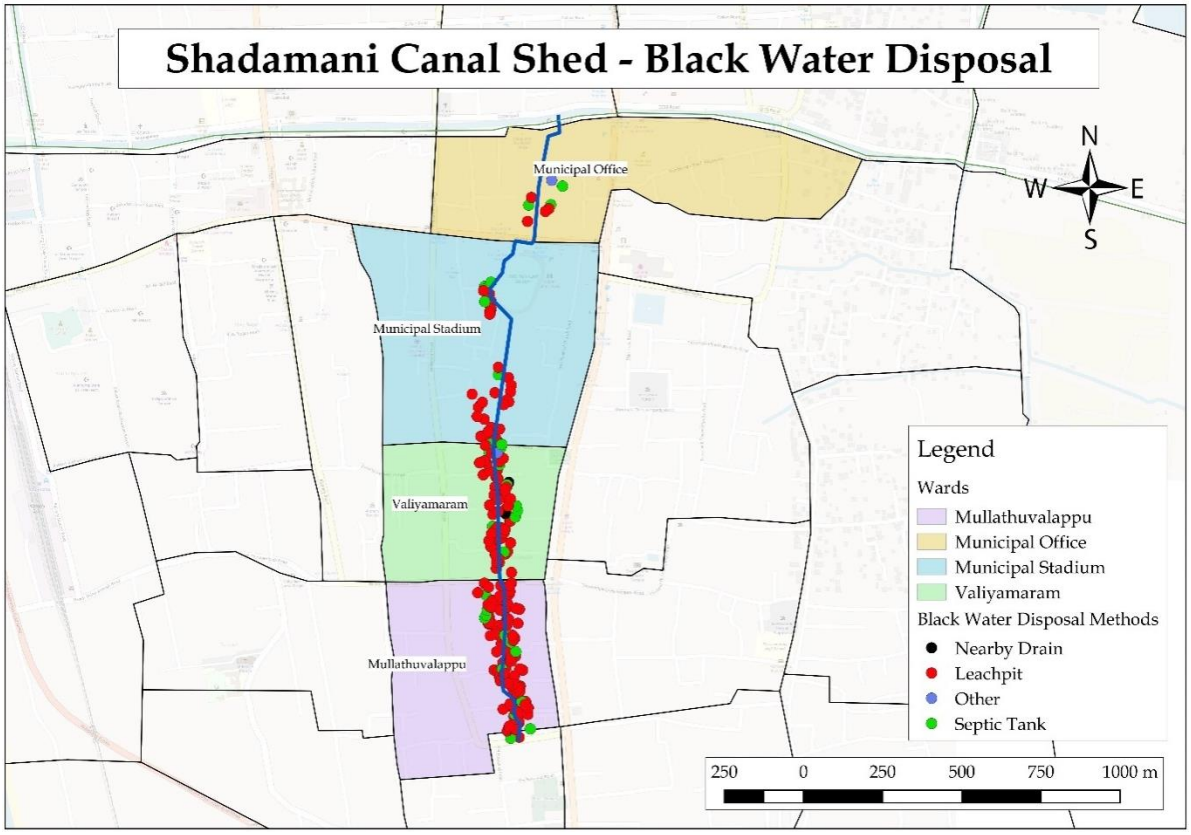


Figure 3.14 Map Showing Black Water Disposal Methods Adopted in Shadamani Canal Shed

From the analysis, all septic tanks which are found to be unscientific (side wall is not impervious, has no bottom or has no outfall) is considered a leach pit. Thus, as is evident from the Figure 4.7, only 15% of the households have a septic tank. However, out of the 35 only 10 of these have an outfall. Presence of an outfall ensures operational efficiency of septic tank and maintains its structural integrity. Thus, it has been established that out of 232 households only 10 households have a proper system in place for management of black water. The spatial representation of the black water treatment system is given in Figure 3.14. From the figure, it is clear that most of the households have a leach pit for managing their black water.

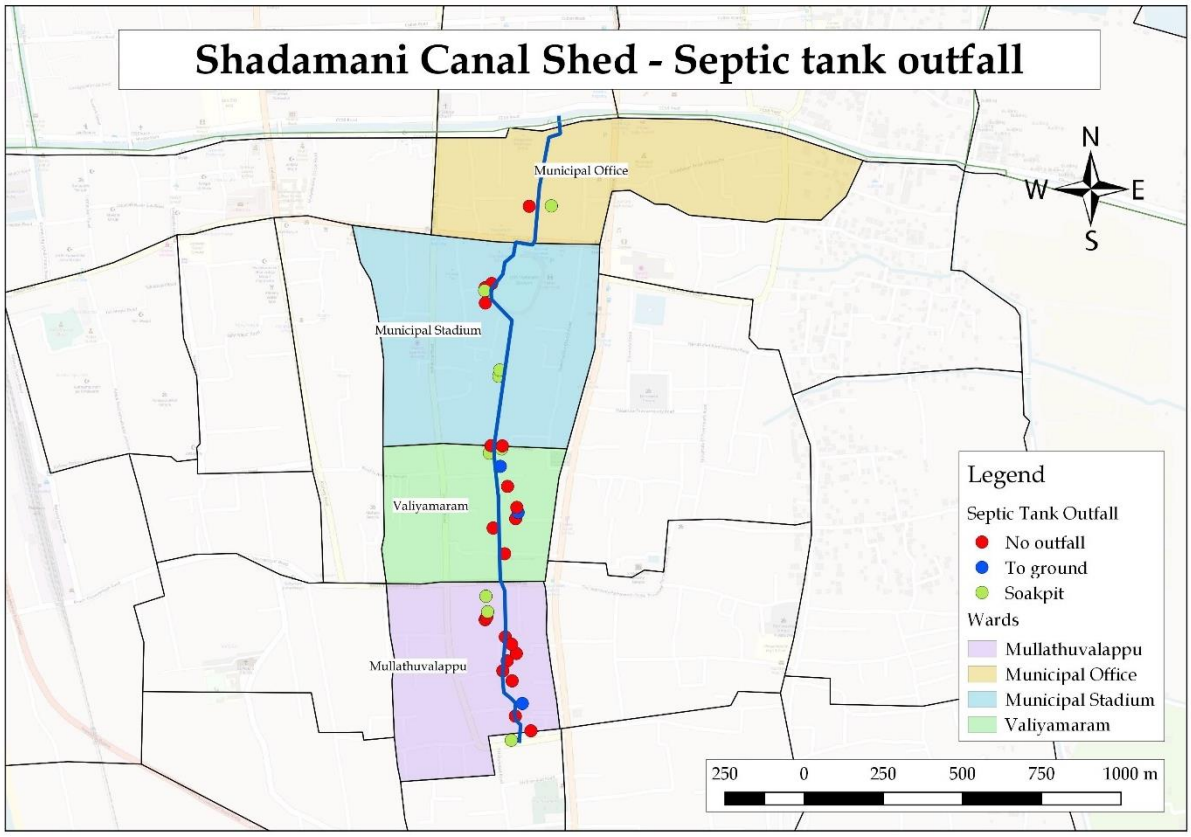


Figure 3.15 Map Showing Septic Tank Outfall in Shadamani Canal Shed

Figure 3.15 is the map which shows the outflow conditions of the identified septic tanks. The red colour represents septic tanks without an outflow and the green colour represents the septic tank with proper soak pit system. Thus, from the map it can be concluded that there exist septic tanks without an outflow which is the clear indication that the same cannot be considered as scientific.

3.7.5 Grey Water Management

Grey water is the major contributor of waste water in the Alappuzha canal systems. Almost every HH has an individual black water treatment system within their premise – either a septic tank or a leach pit. But the grey water management is considered to be of lower priority as compared to the black water.

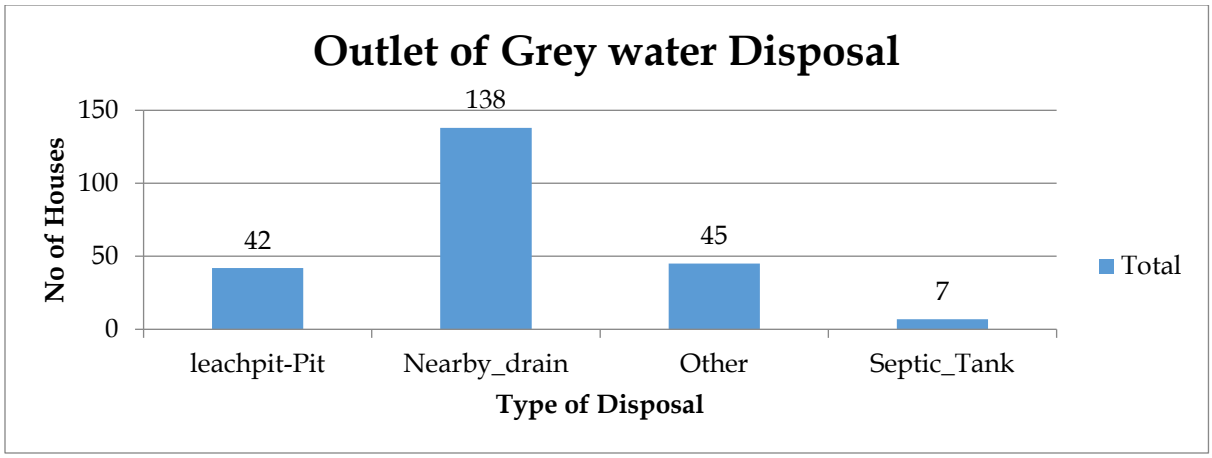


Figure 3.16 Outlet of Grey Water

Figure 3.16 shows the characteristics of grey water treatment systems adopted in the HH level. Out of 232 HHs surveyed, 138 HHs are directly discharging grey water to drains, which is about 60% of total HHs. And 87 HHs discharge grey water to ground without any treatment.

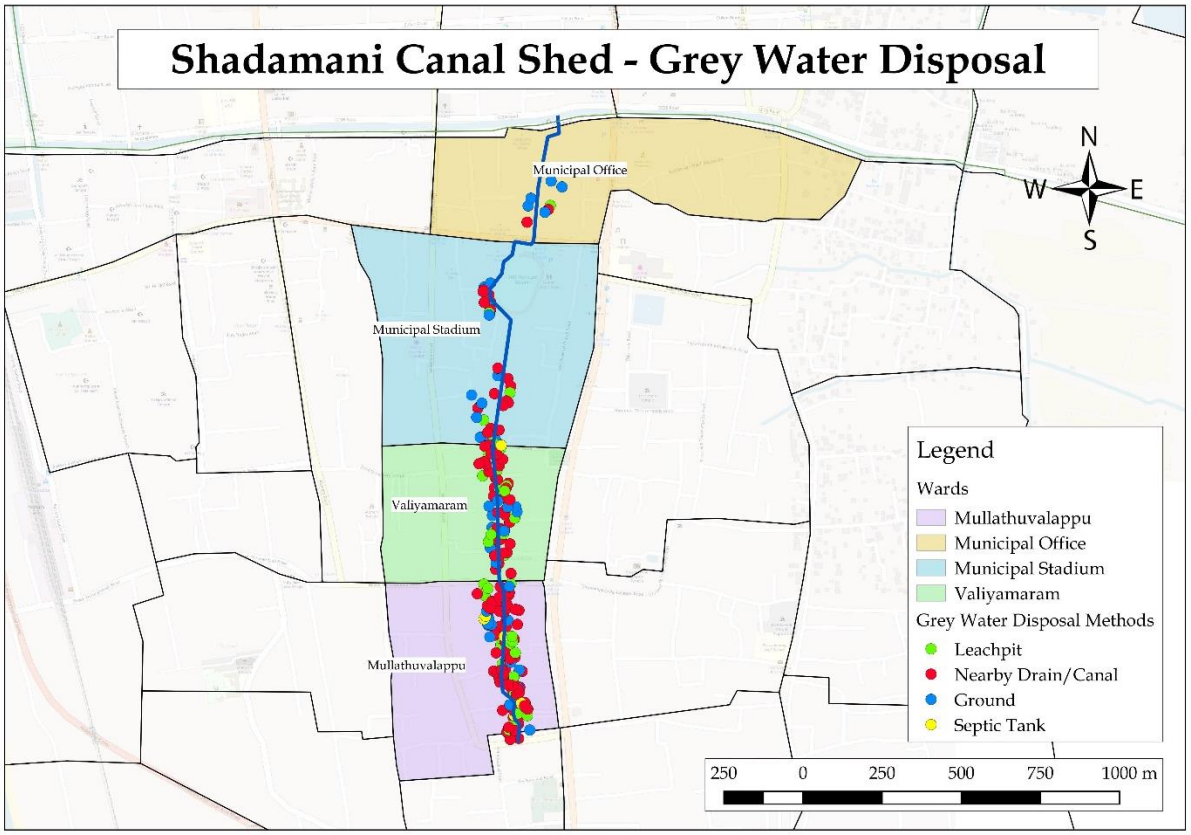


Figure 3.17 Map Showing the Grey Water Disposal Methods in The Pilot Area

The map (Figure 3.17) illustrates the distribution of grey water treatment methods along the canal.

3.7.6 Combined Grey and Black Water Management

As per various standards like BIS, CPHEEO the black and grey water should be managed separately (BIS, 1995) and (CPHEEO & JICA, 2012). All the households in the pilot area have an individual household latrine and an onsite treatment system for black water, however there are no systems adopted for grey water management (refer previous section). Figure 3.18 shows the distribution of HHs with combined grey and water management. Only 57 HHs manage waste water combined and the rest have separate systems for management of both the streams.

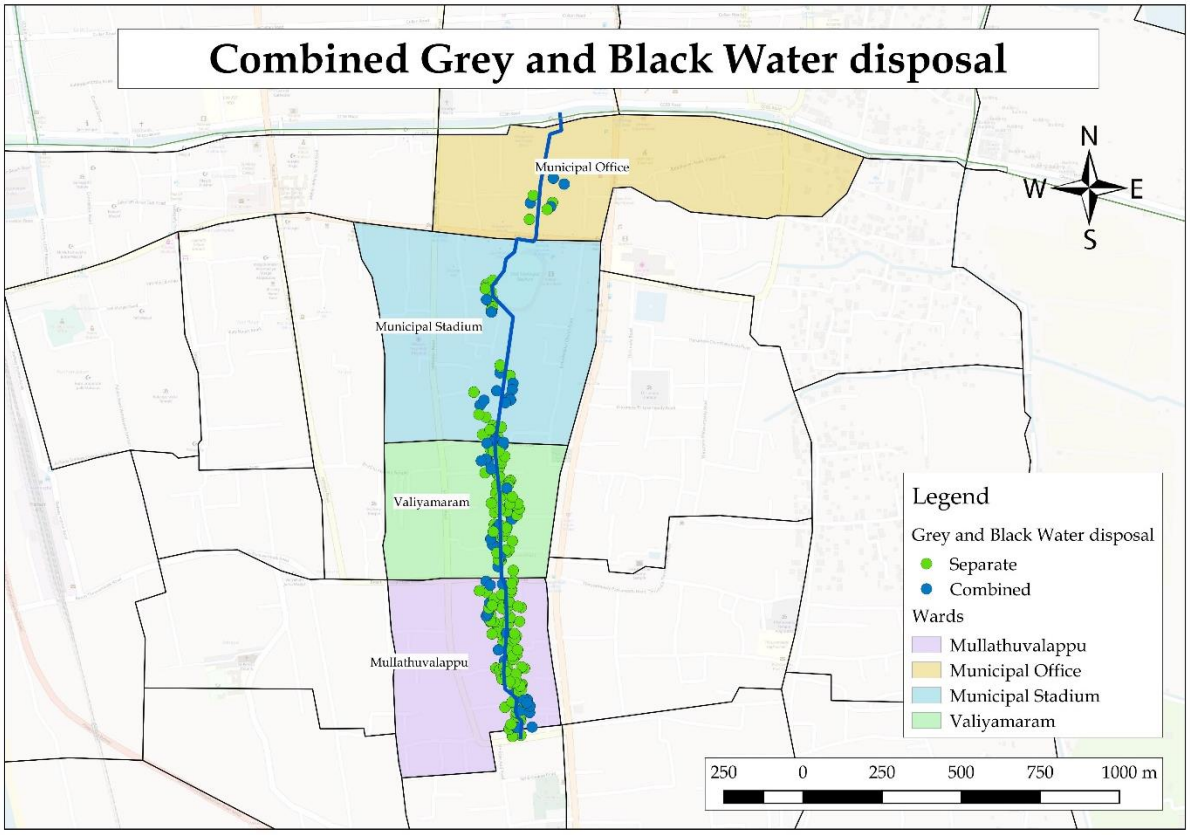


Figure 3.18 Map Showing HHS with Combined Grey & Black Water Disposal in Shadamani Canal Shed

The survey data was further analysed to determine the problems associated with the septic tanks and soak pits and how these might affect the performance and efficiency of the same. In case of septic tanks which are performing sub-optimally, there is a need to replace the current system. The parameters against which the septic tanks and Soak Pits were assessed is presented in the Table 3.3.

Table 3.3 Onsite Sanitation Systems: Relevance of results and insights

Parameters	Relevance	Results
Septic tanks with ventilation pipes	If not maintained, can affect the efficiency. Important for safety.	Out of 35 HHs with septic tank only 12 HHs has ventilation pipe.
Though it may not affect the structural integrity of a septic tank, it is always advisable to have a ventilation pipe while constructing a septic tank-soak pit system.		
Presence of separate system for grey & black water	If not separated, can affect the efficiency of tank	57 HHs are managing the black and grey water together.
There is a need to identify these 23 households and divert grey water from the black water stream to be treated separately		
Size appropriateness of septic tanks for 4-5 family size household	If not maintained, can affect the efficiency of tank	an average HH size of 4
As per our analysis the pilot area has septic tank of standard size and is size appropriate		
Presence of mosquito proofing	It's a measure of epidemic diseases	Out of 12 HHs with vent pipe, only 7 HHs have mosquito proof.
Awareness should be provided about the health implications of not mosquito proofing the system		
frequency of using toilet cleaners	Over usage may affect the proper biological process of septic tank	Almost 85% of the HHs cleans the toilet every week
Instead of using the chemical cleaners, natural cleaners should be promoted		

Odour from ST/Leach pit	It's a measure of improper working mechanism of the system	Only 10 HHs having odour problems
Though most of the households do not have odour issues, the reason for odour emanation from septic systems in these 9 houses must be investigated		

3.7.7 Individual Household Plot Size

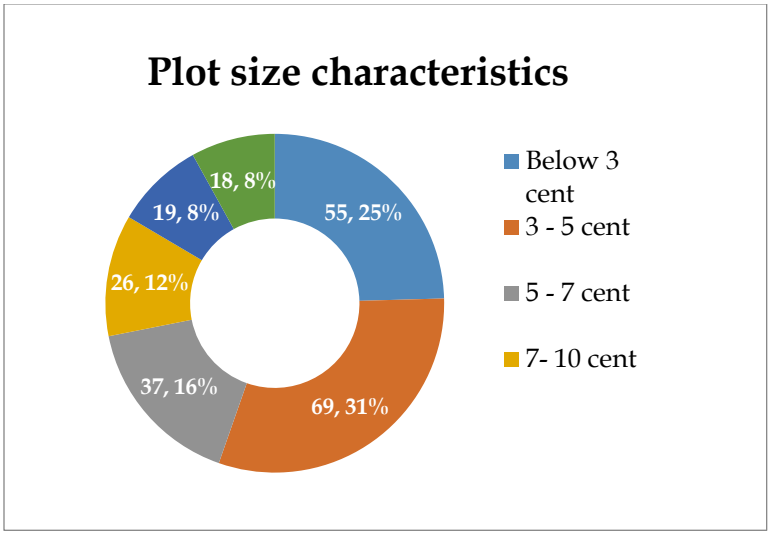


Figure 3.19 Individual Household Plot Size

The plot area can be used to demarcate the available space for installing a new system if necessary. This along with the AutoCAD drawings created as part of the civil survey can give an idea of the possible locations where the new system can be installed if necessary. Understanding the plot size distribution also will help us in identifying plots with smaller size as they are the ones which require immediate intervention. The Figure 3.19 shows the individual household plot size distribution of Shadamani canal shed area.

3.8 RECOMMENDATIONS

3.8.1 Introduction

This section presents output of the analysis presented above. The key ones include a discussion on appropriateness of the selected technical alternative, criteria used for identification of an initial set of beneficiaries, and the list of beneficiaries in the pilot area.

Surveys carried out during the winter schools 2018 found that the canals were polluted due to inadequate liquid waste management especially by households along the canals. Even visually, it is apparent that the canal water has high suspended solids. Surveys of households along the Sadamani sub-canal found that 75.5 percent households discharge black and grey water separately while the remaining disperse them together. More than 95 percent have their toilets connected to leach pits while only less than 4.3 percent (10 Nos) have septic tanks. 60 percent households discharge their grey water directly into the canal, 38 percent on open grounds and remaining disperse them through soak pits.

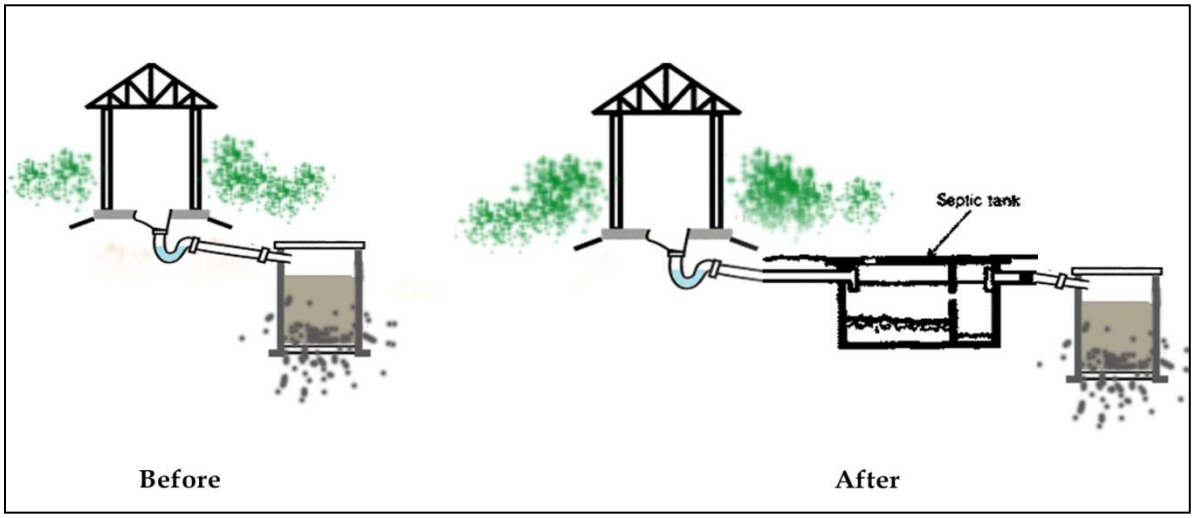


Figure 3.20 Current System and Proposed Intervention

Surveys of households along the Sadamani sub-canal found that 76 percent households discharge black and grey water separately while the remaining disperse them together. More than 84 percent have their toilets connected to leach pits while only less than 15

percent have septic tanks. Through the analysis it is clear that only 4% of the HH have scientific septic tanks. Two houses are directly discharge their black water into drains. These two household doesn't have leach-pit or septic tank. 138 HHs are directly discharging grey water to drains, which is about 60% of total HHs. And 87 HHs discharge grey water to ground without any treatment.

Out of 232 HHs surveyed, 10 of HHs were found to have scientific septic tanks while the rest of the 222 disposes of black water into a soak pit. Thus, these HHs have to be targeted and immediate action should be taken to replace/retrofit. **But out of 222 HH, only 151 HH have proper access and setback to install the septic tank. So 151HH are only considering as beneficiaries during primary stage. For remaining HH, need to find new design or other options for black water management. For grey water management, oil and grease trap with soak pit is the best option.**

3.9 ACTION PLAN

The action plan for Black water management in Sadamani sub canal is detailed in the table below.

Action	Responsible Authority	Status
Finalization of the beneficiary list for installing HH level septic tank for black water management.	CANALPY Team	Completed
Campaigning by Canal Kara committee for smooth operation and maintenance of the system installed as well as systems retrofitted.	CANALPY	Completed
Installation of septic tank for black water to the beneficiaries.	Municipality	To be completed by end of May 15
Calling Tender and providing work order to contractors for installing septic tank.	Municipality	To be completed by end of Feb 15
Inform the IIT Bombay for the formation of quality check team.	CANALPY Team	Work in progress
Finalization of the beneficiary list for installing HH level oil and grease trap for grey water management.	CANALPY Team	Completed
Installation of individual grey water system to the beneficiaries.	Municipality	To be completed by end of October
Design the new technology options for black and grey water for HH who are not having proper place to install septic tank or oil and grease trap	CANALPY Team, IIT Bombay	Work in progress
Evaluation and maintenance.	Canalpy Team	To be completed

ANNEXURE

Annexure I. Questionnaire Used for Socio-Economic and Solid Waste Management

GENERAL QUESTIONS:

- Name of house owner:
- House number:
- Ward number:
- Geo location:
- Total plot area:
- Area of house:
- Survey number of plots:
- House ownership:

  a) Own b) Rent
- Number of family members: ☐

  Male ☐ **Female** ☐ **Children (0-3yrs)** ☐
- Age group

  a) 10-15 ☐ **b) 15-25** ☐
- Are there any bed patients?

  a) Yes b) No
- Ration card

  a) APL b) BPL
- Primary source of HH Income

  a) private job b) govt job c) Abroad d) business

e) Agriculture f) house boat g) fishing h) House renting i) daily labour j) others

- Number of storey's

  a) Only ground floor b) Ground floor + one storey c) Ground floor + two storeys d) Ground floor + more than two storeys

- Floor Type

  a) Mosaic/Floor tiles b) Burnt Brick c)cement d) marble e) Mud f) other

- Roof type

  a) asbestos/metal sheet/galvanized iron b) burnt brick c) concrete d) handmade tiles e) machine made tiles f) stone/slate roof g) wooden/bamboo/mud h) other

- Household appliances:

  a) TV b) Refrigerator c) AC d) Washing machine e) Micro wave ovenf) Water heater g) Other

- No. of Vehicles

  a) Two wheeler ☐ b) car ☐ c) Auto rickshaw/Ape ☐ d) Heavy vehicles ☐

- Phone number:
- Gender of the respondent:

  a) Male b) female

SOLID WASTE DETAILS:

1. Do you segregate solid waste?

   a) Yes b) No

2. What all types of waste are segregated and stored separately?

a) kitchen waste b) plastic waste c) paper wastes d) hazardous wastes e) E-waste f) Others

3. How do you manage wet waste/kitchen waste?

a) Pipe compost b) Portable bio-gas plant c) Fixed bio-gas plant d) Ring composte) Kitchen bin f) Disposing in Aerobic bins g) Dumping in your own compound h) Dumping in canal i) Dumping in other places h) others

4. If biogas is installed, no of hours cooking gas is available

a) Less than half an hour b) half an hour to one hour c) 1- 2 hours d) More than 2 hours e) Gas not available f) Nil

5. Number of years since installed?

a) 0-2 years b) 2-5 years c) 5-7 years d) 7-10 years e) More than 10 years

6. Reason for opting it?

a) Upon personal interest b) Government mandatory c) Less land availability

7. Functional status of on-site system?

a) Good b) Average c) Poor

8. Can you explain the working method of this system? { Note down if issues any }
9. What is the reason for the poor condition of the existing system?

a) Flooding b) lack of knowledge c) poor maintenance d) faulty system e) Unable to get a person to repair e) others

10. Any issues faced in using this system?

a) Bad smell b) fly nuisance c) Leaching d) Worms in the pipes e) Issue with rats f) Non-availability of gas g) Others

11. Did you try to repair?

a) Yes b) No

12. Whom do you contact if there is any issue with the system?

a) No one b) Know a local person c) Call the maintenance team

13. Whether you are ready for repair/reinstallation?

a) Yes b) No

14. What do you do with the manure?

a) Use in own garden b) give it to others c) sell it

15. Any training undergone about the working method?

a) Yes b) No

16. Are you interested in installing on-site waste management system?

a) Yes b) No

17. Would you like to use community level treatment system (Aerobic compost units)?

a) Yes b) No

18. If yes, at what distance do you prefer?

a) 150 m b) 250 m c) 500m d) More than 500m e) less than 150m f) others

19. Suggest any suitable location for installing community level system?

20. How do you manage dry leaves?

a) Burning b) Dumping in your own compound c) Dumping in canal d) Dumping in other places e) used in compost unit f) Giving to aerobic unit g) others

21. Willingness to provide it for aerobic composting units for free?

- **Yes b) No**

22. How do you manage plastic waste?

a) Littering b) Giving to plastic collection facility c) Burning d) Dispose into canals e) others

23. Frequency of grocery shopping?

a) Daily b) weekly c) twice a week d) two weeks e) once in a month f) Others

24. Frequency of buying parcel foods?

a) Daily b) weekly c) twice a week d) two weeks e) once in a Month f) Others

25. How do you manage E-waste?

a) Dumping b) scrap dealer c) swap shop d) others

26. Do you know about the swap shop operating in the municipal area?

a) Yes b) No

27. Willingness to use swap shop?

a) Interested b) Not interested

28. Usage of sanitary napkins/ Baby diapers?

a) Sanitary pads b) Cloth napkins c) Diaper d) Nil

29. How do you manage sanitary napkins/ Baby diapers?

a) Burn (outside/inside plot premises) b) Bury (inside/outside plot premises) c) Dump into nearby place d) others

30. Opinion about installing incinerator at community level to manage sanitary waste?

a) Interested b) Not interested

31. Willingness for disposing sanitary napkins at community level by own if paper carry bags are given for disposing?

a) Interested b) Not interested

32. Are there any small scale enterprises attached to house?

a) Yes b) No

33. If yes, what kind of small scale enterprise?

a) Catering b) Stitching c) Pickling unit d) Others

34. If yes, how do you manage the waste generated?

a) Littering **b) Giving to plastic collection facility** **c) Burning**

d) Disposing into canals **e) composting** **f) others**

35. Do you feel pipe compost/biogas plant as beneficial?

a) Yes **b) No** **c) Not aware of**

36. How do you manage hazardous waste?

a) Littering **b) Burning** **d) Disposing into canals** **f) others**

37. Caste:

a) SC/ST **b) General** **c) OBC**

Annexure II. List of households having on-site waste management systems

House No.	House owner name	Ward name	Phone number	On site waste management system
963	Aap sayakan	Mullathuvalappu	9995536677	Kitchen bin
979	Muhammad	Mullathuvalappu	Dn	Kitchen bin
854	Salim	Mullathuvalappu	9846921316	Kitchen bin
865	Janamma	Mullathuvalappu	7025172811	Kitchen bin
Dn	George kutty	Mullathuvalappu	9947996715	Kitchen bin
856	Thajudeen	Mullathuvalappu	Dn	Pipe compost
Dn	Suneeer	Mullathuvalappu	Dn	Kitchen_bin
217	Jagadhesh Kumar	Mullathuvalappu	8289928711	Kitchen bin
683	Gopi das	Mullathuvalappu	9946417759	Pipe compost
115	Abdul atheif	Mullathuvalappu	9745717035	Kitchen bin
231	Deerija	Mullathuvalappu	8089247743	Kitchen bin
891	Thomas P M	Mullathuvalappu	9446064488	Ring compost
907	Philomina	Mullathuvalappu	9846880900	Kitchen bin
Dn	Jorge	Mullathuvalappu	8943824041	Kitchen bin
829	Saijappan	Mullathuvalappu	Dn	Kitchen bin
138	Babu	Mullathuvalappu	9847037711	Kitchen bin
DN	Aneesh	Mullathuvalappu	9447506250	Biogas plant
150	Xavior pv	Mullathuvalappu	9048400366	Bio gas plant
Dn	Joseph	Mullathuvalappu	Dn	Kitchen_bin
801	Tom	Mullathuvalappu	9846404523	Kitchen bin
836	Pol john	Mullathuvalappu	Dn	Kitchen bin
231	Thomas alexender	Municipal Office	9447432521	Biogas plant
312	Joni Sakriya	Municipal Office	9847960140	Pipe compost
Na	Leena	Municipal Office	9446917101	Biogas plant
247	Geroge Mathew	Municipal Office	9497512127	Biogas plant
508	Srikumar	Municipal Office	8281671999	biobin
295	Jayakumar	Municipal Office	9074953519	Kitchen bin
1260	Sakheer	Municipal Office	8089132711	Biogas plant
1284	Bala Krishna Kaimal	Municipal Office	9446164836	biobin
1202	NIYAS	Municipal Office	8129789567	Biogas plant
1251	Monichan Philip	Municipal Office	9400203304	Biogas plant
25/1250	Mathews j.	Municipal Office	9495442726	Biogas plant
1212	Rajamani	Municipal Office	9446374982	Biogas plant
1211	P C Mikal	Municipal Office	9947601381	Biogas plant

1358	Bijo K kunjariya	Municipal Office	9495241261	Biogas plant
25/1414 A	Abdul Kareem	Municipal Office	984750236	Ring_compost
33 118	Rafeeq	Municipal Stadium	9020333666	Biogas plant
33 117	Suhara kabeer	Municipal Stadium	7594943617	Pipe_compost
502	Pushpa	Municipal Stadium	4772262518	Biogas plant
424	K Naseeruddin	Municipal Stadium	9447505706	Pipe compost
280	Nazeer	Municipal Stadium	9526126218	Kitchen bin
662	Joseph	Municipal Stadium	9447292254	Biogas plant
532	Jacob mathew	Municipal Stadium	9495261408	Biogas plant
240	Najeem	Municipal Stadium	9746033691	biobin
33/115	Usha kailas	Municipal Stadium	9847658505	Pipe compost
33/198	Abdul Kabeer	Municipal Stadium	808944669	Pipe compost
33/112	Shivam pillai	Municipal Stadium	9497247585	Biogas plant
383	Shahul Hameed	Municipal Stadium	9744292233	Pipe compost
319	Sachi Dev	Municipal Stadium	8547254016	Kitchen bin
731	Mohd Hashid	Municipal Stadium	9747053075	Biogas plant
918	Jaswant k	Municipal Stadium	9846345721	Pipe compost
899	Anil	Municipal Stadium	9745007696	Pipe compost
494	Job thomas	Municipal Stadium	9495069755	Kitchen bin
455	Ajin	Municipal Stadium	9446923286	Biogas plant
467	Scindia	Municipal Stadium	9995837741	Kitchen bin
457	Sheriv p	Municipal Stadium	8547969285	Ring compost
33/705	P. Chandrashekaran nayar	Municipal Stadium	9847359150	Pipe compost
699	Jayan	Municipal Stadium	9400136889	Biogas plant
476	Muhammad koya	Municipal Stadium	9895412931	Pipe compost
Na	Nasar musthafa	Municipal Stadium	9446616652	Pipe compost
491	K j joseph	Municipal Stadium	0	Pipe compost
471	Moncy	Municipal Stadium	9037774675	Biogas plant
Dn	Nowshad	Municipal Stadium	8089887243	Kitchen bin
743	Jose zacharia	Municipal Stadium	9496794375	Pipe compost
390	Abdul Rasheed	Valiyamaram	9846343743	Ring compost
364	M baboo	Valiyamaram	9895875431	Kitchen bin
399	Ashraf	Valiyamaram	8089349368	Kitchen bin
384	Navshaad	Valiyamaram	8898144930	Kitchen bin
807	Sahanawaj	Valiyamaram	Na	Kitchen bin
123	Sony	Valiyamaram	8553794254	Kitchen bin
65	Anil Mon	Valiyamaram	9446249886	Pipe compost

551	Md yousuf	Valiyamaram	9947977233	Bio gas plant
Na	Francis K.P	Valiyamaram	9447132721	Bio gas plant
640	Appachan	Valiyamaram	9495163035	Pipe compost
405	M aseez	Valiyamaram	8089751282	Kitchen bin
383	Asarf	Valiyamaram	9061339046	Pipe compost
407	Sahul	Valiyamaram	9037270118	Pipe compost
76	Abdul samad	Valiyamaram	9447567122	Kitchen bin
589	Alex T.V	Valiyamaram	9846437944	Pipe compost
596 A	Naseema	Valiyamaram	9847459313	Biogas plant
290	Jayamma	Valiyamaram	9633481422	Biogas plant
589	Alex T V	Valiyamaram	9846437944	Pipe compost
596 A	Naseema	Valiyamaram	9847459313	Biogas plant
520	Sukumaran	Valiyamaram	4772261989	Biogas plant
521	Dinesh commeth	Valiyamaram	9447417921	Pipe compost
991	Me Hanif	Valiyamaram	7012984322	Kitchen bin
1288	Unnikrishnan	Municipal Office	9446081539	Biogas plant
1365	Salim	Municipal Office	9446944009	Biogas plant
1366	K J Joseph	Municipal Office	8943772458	Biogas plant
854	NK balakrishnan	Municipal Stadium	9497721662	Biogas plant
531	Rajan	Municipal Stadium	9447896637	Pipe compost
819	Indu	Municipal Stadium	9495863527	Biogas plant
NA	Rahim	Municipal Office	9446340888	Biogas plant
369	Mohana Krishnan	valiyamaram	9495086550	Pipe compost
696	Afsal	municipal_stadium	9496828508	Pipe compost
128/A	Shaheer	valiyamaram	9061217049	Kitchen bin
789	Balakrishna Menon	valiyamaram	9447766259	Biogas plant
834	Haris	valiyamaram	8089537623	Ring compost
597	Kariyappq	municipal_office	Dn	Kitchen bin
602	Fazul	municipal_office	9447380616	Kitchen bin
46	Ponamma	mullathuvalappu	9387857760	Ring compost
331	Shajahan	valiyamaram	9447041960	Kitchen bin
464	Anirudhan	valiyamaram	9446102404	Ring compost
953	Sivakumar	municipal_office	Dn	Kitchen bin
325	Muhammed yusef	valiyamaram	9562553044	Biogas plant

Annexure III. Comparison of Technological Options

Beneficiary Type	Sl No	Technology Options	Factors for selection						
			Space/Land Requirement	Utility			Challenges during operation and maintanance	Cost	Remarks, Issues faced
				Waste to compost	Waste to energy	Others			
Organic waste management									
Household	1	Biogas plant (portable)	x	X	✓	Slurry obtained can be used as manure	Requires continous maintenance and care	Rs. 3375	Mosquito breeding
	2	Kitchen bin	x	✓	x	x	Less maintenance	Rs. 410	Need to maintain low moisture content
	3	Bio bin	x	✓	x	x	Less maintenance	Rs. 900	Need to maintain low moisture content
	4	Pipe compost	x	✓	x	x	Less maintenance	Rs. 890	Issues due to worms
	5	Vermi composting	x	✓	x	Leachate can be used as manure	Requires continous maintenance and care	Rs. 950	Degradation takes time and noticeable odour
	6	Ring composting	✓	✓	x	x	Less Maintenance	Rs. 2500	Fly nuisance and odour problems
Community	7	Aerobic composting unit	✓	✓	x	x	Requires continous maintenanace and care	Rs. 1.4 Lakhs	Fly and rodents nuisance

	8	Windrow composting	✓	✓	x	x	Requires continous maintenance and care		Fly nuisance and odour problems
Inorganic waste management									
Community	9	Incinerator	✓	X	✓	Can be used to manage sanitary napkins	Requires maintenance	Rs. 20,000 to 2.5 Lakhs	Fluegas produced must be cleaned before dispersed
	10	Material Recovery Facility	✓	X	x	Used for seperating and diverting recyclable waste	Requires maintenance	For 500 sqft MRF – Rs. 7.4 Lakhs	-
	11	Plastic shredding unit	✓	X	x	Used to Shred plastic waste	Requires maintenance	5.25 Lakhs	-
	12	Swap shop	✓	X	x	Used for exchanging reusable goods	Requires maintenance		-

Annexure IV. Liquid Waste Management Questionnaire

1. General Details
2. No. of permanent residents in house; no. of adults and no. of children.
3. Any home-based job such as pickle making or grinding units at home.?
4. Primary Source of water

    a. KWA **b. Public taps**

    c. Well **d. Others**

    e. Tankers

5. If tanker, specify capacity of water taken per day (in liters)
6. If KWA, specify bill amount every 2 months:
7. If well, specify capacity of tank and number of times filled per day:
8. If public taps specify quantity
9. Toilet Present at home or not
10. Disposal method of black water

    a. Septic tank **b. To drains**

    c. Leach pit **d. Others, specify**

11. Disposal of grey water

    a. Septic tank **b. To drains**

    c. Leach pit **d. Others, specify**

12. How do you dispose toilet waste? (select any one)

    a. **Septic Tank** **b. Community /shared septic tank/facility**

    c. **Leach pit/ Pit** **d. Other**

e. Nearby drain **f. Community /shared septic tank/facility**

8. How old is your Septic Tank/Pit (Year)? (select one)

a. Less than 1 yr. **b. 7-9yr**

c. 1- 3 Yr **d. 10-12yr**

e. 4-6 Yr **f. 13-15yr**

9. Where septic tank /leach pit is located? (select one)

a. Just under the toilet **b. Not under the toilet**

10. Shape of Septic Tank / Leach pit (Select any one)

a. Round / Cylindrical **b. Round / Cylindrical** **c. Round / Cylindrical**

11. Wall material of Septic Tank / Leach pit (Select any one)

a. Rings **b. Rings**
c. Perforated rings **d. Perforated rings**
e. Bricks/stone masonry **f. Bricks/stone masonry**
g. Perforated bricks **h. Perforated bricks**

12. Bottom material of Septic Tank / Pit (Select any one)

a. No bottom **b. No bottom**
c. Concrete **d. Concrete**

13. Does the Septic Tank / Pit has opening at top? (Select any one)

a. Yes **b. Yes**

14. What kind of opening does the septic tank / pit have? (select one)

a. Manhole with iron lid **b. Manhole with iron lid**

c. Manhole with cement lid **d. Manhole with cement lid**

e. Removable round cement lid **f. Removable round cement lid**

15. Number of chambers in Septic Tank/Soak pit? (select one)

a. 1 **b. 1**

c. 2 **d. 2**

e. 3 **f. 3**

16. Does the septic tank/leach pit have a ventilation pipe? (select one)

g. Yes **h. Yes**

17. Does the ventilation pipe have a mosquito proof wire mesh? (select one)

i. Yes **j. Yes**

18. Wastewater from septic tank/soak pits is released into? (Select any one)

a. It does not have outfall **b. It does not have outfall**

c. Outfalls into a nearby drain **d. Outfalls into a nearby drain**

e. Outfalls into pit/trench specifically made for this purpose **f. Outfalls into pit/trench specifically made for this purpose**

19. Have you cleaned septic tank/pit till date? (select one)

a. Yes **b. Yes**

20. Frequency of cleaning leach pit/septic tank (Select any one)

a. Once in 3 months **b. Once in 3 months** **c. Once in 3 months**

d. Once in 6 months **e. Once in 6 months** **f. Once in 6 months**

g. Once in 12 months **h. Once in 12 months** **i. Once in 12 months**

21. Specify the agency employed to clean the septic tank/pit most of the times (select one)

22. Material used for construction

a. Concrete **b. Concrete** **c. Concrete**

23. Bottom sealed or not:

a. Yes **b. Yes**

24. Cleaning Period:

a. Once in 3 years **b. Once in 3 years** **c. Once in 3 years**

25. Agencies involved for cleaning:

a. Private Agency **b. Private Agency** **c. Private Agency**

26. Usage of toilet cleaners:

27. Frequency of using toilet cleaners:

a. Weekly once **b. Weekly once**

c. Once in two weeks **d. Once in two weeks**

28. Is there be any odour from septic tank?

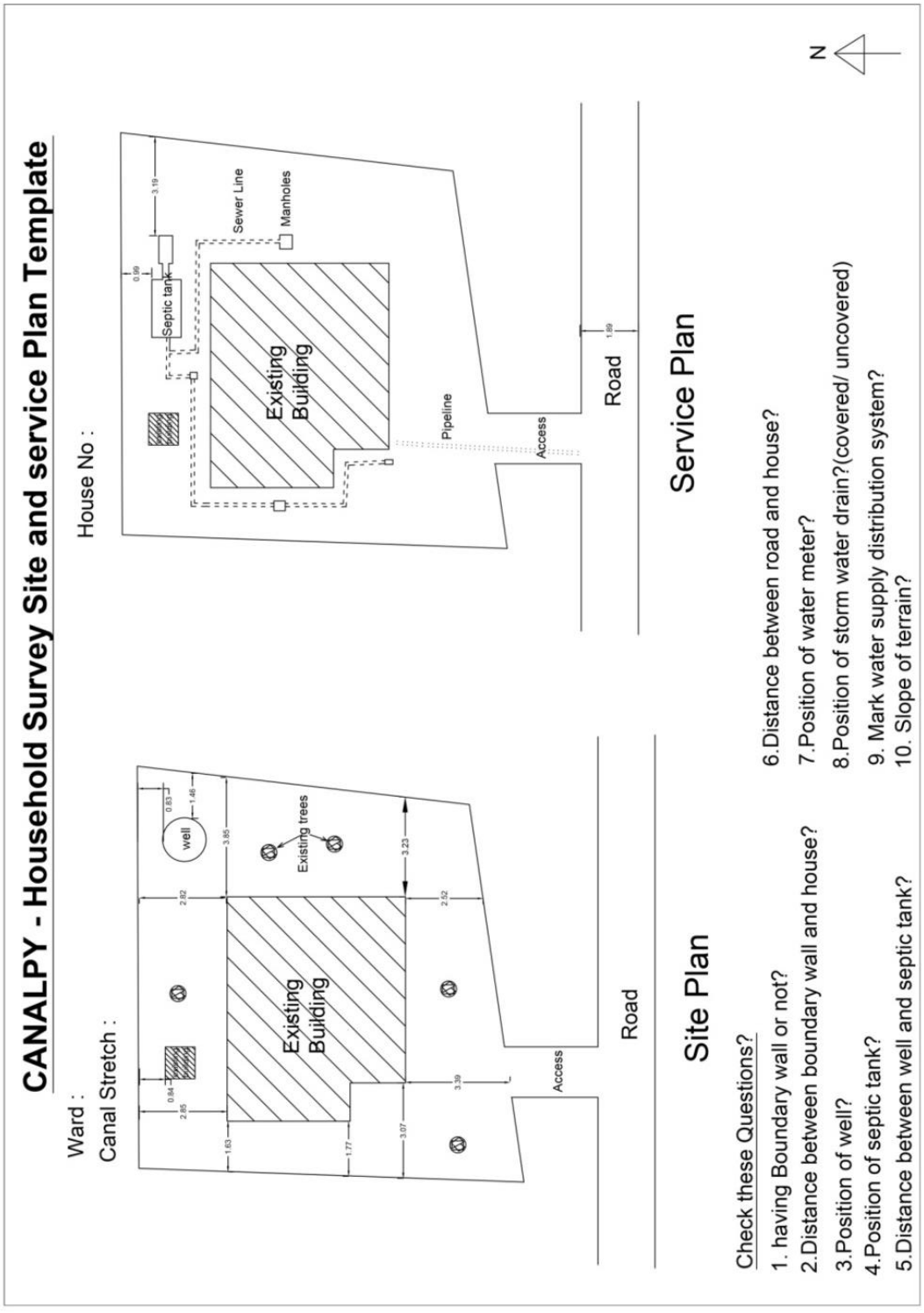
a. Yes **b. Yes**

29. Willingness to install a new system:

a. Yes **b. Yes**

30. Photos covering all sides

Annexure V. The template of field drawing which is needed to adopt for survey



Annexure VI. The different elements of the action plan

An action plan is a document that lists what steps must be taken in order to achieve a specific goal. The purpose of an action plan is to clarify what resources are required to reach the goal, formulate a timeline for when specific tasks need to be completed and determine what resources are required. Before begin an action planning process, the strategic framework for the work of project should be in place.

Action plan is based on time frame. Three type of action plan are adopted and they are:

Short term actions: The actions which needs to be done immediately can be listed as short-term actions. Ideally these are the actions which are targeted to be completed within 3 months.

Medium term actions: Typically, actions which require fair amount of pre planning or the ones for which funding options and legal provision are required are listed in medium term actions. They have to be targeted to be completed within 6 months.

Long term actions: Actions which require short-term and medium-term actions to be completed before initiating implementations can be listed here. They have to be targeted to be completed within 1 year.