ASSESSMENT OF SOLID WASTE MANAGEMENT PRACTICES, SYSTEMS AND COMMUNITY PERCEPTIONS IN ROHINGYA CAMPS

Implemented by:

Environmental Engineers Limited

Funded and supervised by:

Embassy of Switzerland in Bangladesh: Swiss Agency for Development and Cooperation (SDC)

Supported by Switzerland

In coordination with:

WASH Sector Cox's Bazar

MARCH 2022

PREFACE

The *Swiss Agency for Development and Cooperation (SDC), represented by the Embassy of Switzerland in Bangladesh,* has awarded the assignment to conduct the study titled "Assessment of SWM practices, systems and community perception in Rohingya camps" to *Environmental Engineers Limited (EEL)*. The study was carried out in the Rohingya camps of Cox's Bazar district from November 2021 to February 2022, the report was finalized in March 2022.

This report remains the property of SDC and the WASH Sector of Cox's Bazar but may be freely shared and reproduced with the relevant citations*. This report was prepared based on analysis of data collected by field inspections, household surveys, focus group discussions, interviews and information supplied by Implementing Partners (IPs), Area Focal Agencies (AFAs), DPHE Cox's Bazar and sector professionals.

The main objective of the study was the identification of some best practices in the field of Solid Waste Management (SWM) having a replication potential along with the documentation of some insights of community perceptions on SWM issues. Efforts have been made to analyze the existing systems with their functionalities, waste quantities, efficiencies, costs, integration of principles set by WASH sector, community feedback; and a summarized articulation is made on best practices, lessons learnt and conclusions.

This report was written by EEL, under the lead of Md. Shoriful Alam Mondal, with some inputs and review suggestions on the draft report provided by SDC (Mirco Keller and Manuel Krähenbühl).

Md. Shoriful Alam Mondal
(Lead Researcher)
Environmental Engineers Limited (EEL)
Bangladesh

*Citation:
Environmental Engineers Ltd. *Assessment of SWM Practices, Systems and Community Perception in Rohingya Camps*. Final Report, WASH Sector-Cox's Bazar, Embassy of Switzerland in Bangladesh, Swiss Agency for Development and Cooperation (SDC), Mar. 2022.

EXECUTIVE SUMMARY

This study on Solid Waste Management (SWM) practices, systems, and community perceptions in Rohingya camps was conducted by the consultancy firm Environmental Engineers Limited between November 2021 and February 2022. The study was funded and coordinated by the Swiss Agency for Development and Cooperation (SDC), represented by the Embassy of Switzerland in Bangladesh, and was carried out under the umbrella of the WASH Sector in Bangladesh with involvement of the relevant UN Agencies. The WASH Sector is responsible to coordinate the different Implementing Partners (IPs) working in the camps on WASH activities including SWM. The SWM services in the camps are generally carried out by segregating of waste at source, collection, transportation, value recovery and safe disposal of waste, including community engagement and monitoring activities.

The study looked at 5 SWM systems in different Rohingya camps (4 in Ukhiya and 1 in Teknaf) of Cox's Bazar districts and covered the following key objectives:

(1) Description of each of the 5 SWM systems;
(2) Analysis of effectiveness of different SWM systems and waste quantities;
(3) Analysis of efficiency and costs of the different SWM systems;
(4) Analysis of adherence to the 7 working principles of SWM Strategy set by WASH Sector;
(5) Collection and analysis of feedback on community perceptions;
(6) Compilation of best practices and lessons learnt from the comparisons of SWM systems;

In addition to the analysis of the 5 SWM systems, the study also tried to analyze other innovative SWM projects in the camps, in particular a large Omni Processor project which is under construction.
The study was carried out through document reviews, Key Informant Interview (KII), In-depth Interviews of IP officials, Field Inspections, Household surveys (n=336) and Focus Group Discussions (n=10) for both male and female camp dwellers, with qualitative and quantitative data collected and analyzed.

The 5 systems have the following key characteristics and differences:

- All the SWM systems try to cover the full SWM value chain of from the point of waste generation to the final disposal or reuse.
- All the systems include a Material Recovery Facility (MRF) which consist of composting plants, segregation units, storage facilities for recyclables and residual waste, etc.
- The waste collection is carried out in two different ways:
    - Door-to-door waste collection (2 systems) where the waste collection volunteers collect the waste directly from households and then transport it to the MRF. The waste is normally collected from the households on a daily basis, due to the steep slopes in both areas this is done manually.
    - Communal collection of waste (3 systems) where the household members bring their waste to communal bins or pits (common waste discharging point for around 10 households) and afterwards the waste collection volunteers transport the waste to the MRF. The waste from the communal points is collected less frequently than for the door-to-door systems. As the topography is less steep, the waste is transported to the MRFs with hand trolleys, wheelbarrows and vans.
- In all the systems the IPs have introduced two colored bins at the household level for waste segregation and are making efforts to maximize source segregation of waste.
- Additional segregation takes place in all MRFs to segregate the waste into organic material (for composting), recyclable materials and residual waste (neither recyclable nor compostable).
- The sizes of MRFs, household coverage, waste amount managed per day, volunteers deployed etc. are smaller in door-to-door systems compared to communal system.
- There are different composting methods used in the MRFs, such as box, windrow composting, and barrel composting. The operators regularly monitor and follow the composting field protocols set

by IPs. These include mixing the organic matter and preparing the pile, checking temperature and moisture, turning or shifting the pile, sun drying, maturing, screening, bagging, storing etc. Compost distributions patterns or usages are diverse, as for example plantation campaigns, agricultural projects, interested volunteers or camps dwellers for gardening as well as for use by camp authorities' offices.

- While all the 5 MRFs sell the recyclable materials to local vendors, many of the camp dwellers also segregate recyclables at home and sell them to local vendors or to floating buyers. In addition, one of the SWM systems has their own plastic recycling plant on site, where single layer plastics are recycled into useful materials such as latrine slabs, drain covers or pit slabs.
- All the SWM systems located in Ukhiya use the official sanitary landfill for the disposal of residual waste, while the SWM system located in Teknaf has their own disposal facility (although not considered as 'sanitary').
- All systems ensure adequate supply and use of safety gears and hygiene kits to maintain occupational health and safety of volunteers.

The key findings in relation to the analysis of the type of waste collection system (door-to-door collection vs. the communal collection) are:

- Door-to-door systems are generally being operated in smaller coverage areas
- The waste collection rate of door-to-door systems is less (23% on average) compared to communal systems (60% on average).
- The labor productivity for the waste collection is lower for door-to-door systems (40 kg/volunteer/day) as compared to communal systems (80 kg/volunteer/day) due to longer collection distance and time required for waste collection and transport from households.
- The allocation of households per waste collection volunteer is very similar for both systems (202 in door-to-door vs. 209 in communal system). Considering the fairly low waste collection rate, the authors came to the conclusion that the number of waste volunteers is too low (for both systems) and should be increased and optimized.
- The average costs for waste collection (per 100 households) are nearly similar, while the costs for door-to-door collection are even a bit lower than for communal collection (133 vs. 158 BDT respectively).
- The MRFs of the communal collection systems are generally larger and also more expensive to run (partially due to larger coverage areas) and also have a higher compost production rate.

The key findings in relation to the cleanliness of surroundings and community perceptions are:

- The general cleanliness of surroundings is better in door-to-door collection systems compared to communal collection systems; scattering of waste has rarely been observed around the HHs, shops or in drains in door-to-door systems. The reasons for this are likely the controlled waste collection, effective on-site storage and neighborhood cleaning, and the effective and regular monitoring by hygiene promotion volunteers at the doorsteps collection.
- The source segregation of waste (at the household level) is achieved much better in door-to-door systems (as reported 97% to 99%) compared with communal systems (as reported 57% - 90%). A major reason for this is the fact that a hygiene promotion volunteer often supports each waste collector for checking the status of source segregation at the time of collection, keeps the record and correct the anomalies instantly if possible. In case of improper/insufficient segregation, the HP volunteers can instruct the households directly and regularly to improve the segregation at household level.
- The existence of two color-coded bins is slightly higher in door-to-door systems (from 48% to 63%) as compared to communal systems (from 30% to 45%).
- Special cleaning programs are being organized frequently in door-to-door systems which enhances improved general cleanliness of surroundings.
- The satisfaction with the SWM system in place is higher for door-to-door systems compared with communal systems as the generated waste is being collected regularly from their households.
- Camp dwellers of communal SWM systems seemed to be less satisfied due to the following reasons:

  - (1) waste is not regularly collected, but only every 3-5 days on average,
  - (2) occurrences of uncollected or overloaded waste in communal bins,
  - (3) It is not easy for women (> 50% of dischargers are women), children, and elderly people to discharge waste in the communal bins, particularly in rainy seasons,
  - (4) the location of bins/pits are not in easily accessible or comfortable locations.
- The rate of involvement in different IEC/BCC[1] activities is higher for people living in door-to-door collection system (67%) compared to those living in communal systems (24%).
- The willingness to use compost has also shown to be higher for door-to-door systems (62% average) as compared to communal systems (30% maximum).

The **analysis of 17 environmental and occupation health risks** (probabilities) showed that some of the risks are addressed well while others need immediate attention such as waste pile being placed above an MRF, the absence of water connection and fire extinguisher at each MRF, the presence of waste in drains hindering the flow of water and also creating breeding grounds for mosquitoes.

While the **adherence to the working principles of the SWM strategy** of the WASH Sector could not be fully established, it requires more time and collaborative effort from all stakeholders (viz. AFA, IPs, and camp dwellers). However, all IPs are making different efforts to maximize the promotion of 3R (reduce, reuse, recycle) principles with full chain SWM systems, and controlling/limiting the leakage of waste from collection system, and conducting IEC and BCC activities.

In terms of the **analysis of planned innovative SWM projects**, very limited information was available and therefore no conclusive findings could be determined. As the Omni-Processor project is still under construction and its commissioning date has been significantly delayed, the exact mode of operation is unclear at the moment. Furthermore, the sustainability and integrity of the technology could not be determined due to insufficient information available. However, it is clear that the plant will require skilled manpower for its operation and maintenance and that proper institutional arrangements will have to be set up to ensure its long-term operation and sustainability.

The most important **learning points and good practices identified** in this study are:

- The SWM systems are well adapted to the local conditions and topography and are using locally made and easily available transport equipment such as vans, trolleys, handcarts, etc. and some are using a manual chopping machine for organic matter to enhance composting.
- The source segregation of waste (at household level) works significantly better for door-to-door collection systems due the instant and regular feedback by the hygiene volunteer to the household members which leads to improved segregation at source. Furthermore, the waste from communal collection systems is often mixed again at the communal bin/pit, even if it was previously segregated, which leads to a reduced segregation of waste overall (and a reduced motivation to segregation by the households) for these systems.
- The door-to-door collection systems have a lower collection rate (overall and also per volunteer) than the communal system due to longer collection distance and time required for door-to-door systems. However, the average cost for waste collection is generally a bit lower for door-to-door systems as compared to communal systems.
- The cleanliness of surroundings of households is found better for door-to-door systems, as households are commonly cleaning the surroundings due to supplied brooms and special cleaning programs that are organized regularly.
- The satisfaction of households with the SWM system in place and the willingness to use compost was found to be significantly higher for door-to-door systems as compared to communal systems.
- In all the systems, the recyclable materials are segregated both at sources and MRFs, and then sold to local vendors / scrap dealer for recycling. One of the SWM systems has its own plastic recycling facility for single layer plastics recycling which produces a small quantity of usable materials for the camps.

[1] Information Education and Communication / Behavior Change Communication

- The occupational health and safety of the volunteers are generally well taken care of, and an adequate supply of safety gear and hygiene kits are ensured.
- This study concludes that the number of waste volunteers allocated is insufficient in some cases. It is necessary to be increased as well as optimized. Furthermore, the systems do not have detailed SWM plans with targets for performance achievements. However, all IPs are making efforts to maximize the performances of their systems (e.g., collection rate, labor productivity, general cleanliness, compost quality, etc.) through their regular operations.

ABBREVIATIONS & ACRONYMS

ACF	Action Against Hunger
AFAs	Area Focal Agencies
BCC	Behavior Change and Communication
BRAC	Bangladesh Rural Advancement Committee
Brown waste	Like dry leaves, brown papers etc. (study context)
cft	Cubic Feet, ft^3
CIC	Camp in Charge
DOE	Department of Environment
DPHE	Department of Public Health Engineering
DSK	Dushtha Shasthya Kendra
ECC	Environmental Clearance Certificate
FGD	Focus Group Discussion
FSTP	Fecal Sludge Treatment Plant
GHG	Green House Gas
HDPE	High Density Polyethylene
HH	Household
HP	Hygiene Promotion
IEC	Information, Education and Communication
Inorganic waste	Organic polymer, recyclables, compost rejects, residual etc. (study context)
IOM	International Organization for Migration
IP	Implementing Partner
KII	Key Informant Interview
LC	Letter of Credit
LDPE	Low-Density Polyethylene
MB	Majhi Block
MHM	Menstrual Hygiene Management
MRF	Material Recovery Facility (in this study, composting with segregation unit)
NGO	Non-Governmental Organization
NGOF	NGO Forum for Public Health
NOC	No Objection Certificate
NRC	Noyapara Registered Camp
O&M	operation & maintenance
OP	Omni Processor
Organic waste	Food, vegetable, and other green waste (study context)
PET	Polyethylene Terephthalate
PP	Polypropylene
PPE	Personal Protective Equipment
PPU	Pre-Processing Unit
PRA	Participatory Rural Appraisal
PS	Polystyrene
PVC	Polyvinyl Chloride
RCC	Reinforced Cement Concrete
SDC	Swiss Agency for Development and Cooperation
SHED	Society for Health Extension and Development
SWM	Solid Waste Management.
TFSTP	Traditional Fecal Sludge Treatment Plant
t/d	ton / day
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations International Children's Emergency Fund
US EPA	United States Environmental Protection Agency
WASH	Water, Sanitation, and Hygiene

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1. INTRODUCTION

Within the camps, the WASH Sector is coordinating the different implementing partners (IPs) involved in Solid Waste Management (SWM). The promotion of waste segregation at source (household level), waste collection, transportation, value recovery and safe disposal is implemented by the different IPs under different area focal agencies (AFAs) in the Rohingya camps. Cox's Bazar project office of Embassy of Switzerland in Bangladesh, Swiss Agency for Development and Cooperation (SDC) in collaboration with the WASH sector has sought a study on "Assessment of SWM practices, systems and community perceptions in Rohingya camps." The study is aimed at providing a compilation of some good SWM practices with description of systems, understanding efficiency and effectiveness along with analysis of community perceptions.

1.1 OBJECTIVES AND ACTIVITIES OF THE STUDY

This study will portray performances of the selected practices of SWM that may be applied by other organizations in the same/similar settings considering community perceptions, collection, transport, disposal/reuse / recycle and corresponding behavioral change activities and campaign. The pre-selected five (5) SWM systems have been surveyed and analyzed by this study as mentioned in Table 1. Pre-selection was made by SDC together with WASH Sector and 3 Area Focal Agencies (AFAs). The survey and research have been conducted to undertake the seven (7) objectives of the study as shown in Figure 1 as stipulation of the TOR.

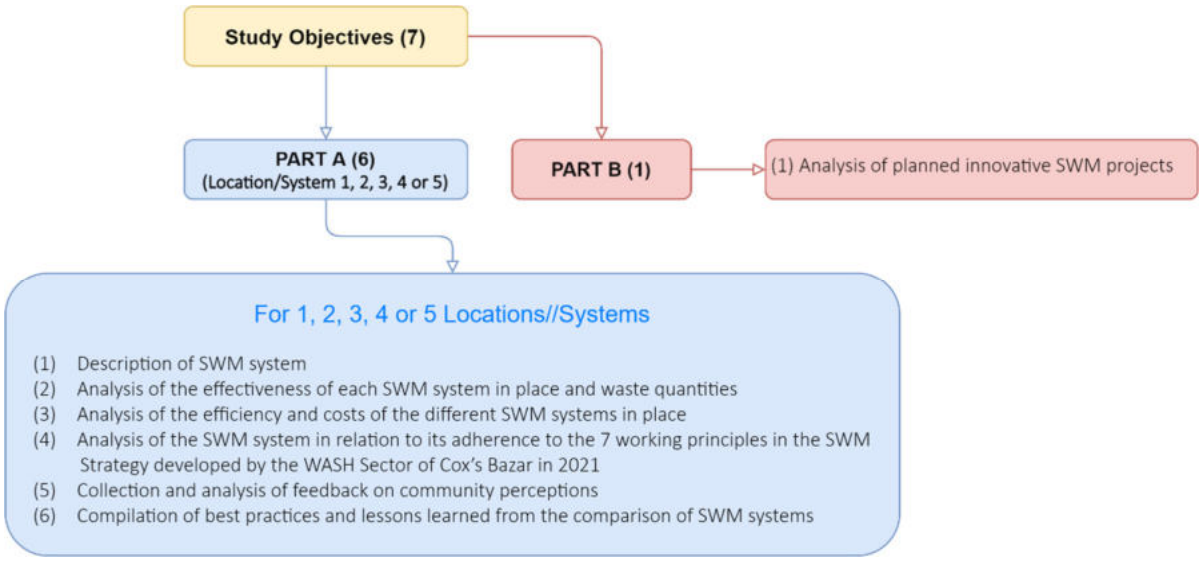


FIGURE 1: OBJECTIVES OF THE STUDY

1.2 STUDY SCHEDULE AND LOCATION

This study has been conducted between November 2021 and February 2022.

TABLE 1: STUDY AREA LOCATIONS

Country	District	Upazila (Subdistrict)	Camps (IPs)
Bangladesh	Cox's Bazar	Teknaf	NRC(NGOF)
		Ukhiya	1E(BRAC), 6(NGOF), 18(DSK), 20(SHED)

Note. NRC: Noyapara Registered Camp, IP: Implementing Partner

1.3 METHODOLOGY OF THE STUDY

A mixed of quantitative and qualitative methods have been applied in the fields' primary and secondary information collection from the target audiences and stakeholders. A conceptual framework for this study is shown in Figure 2.

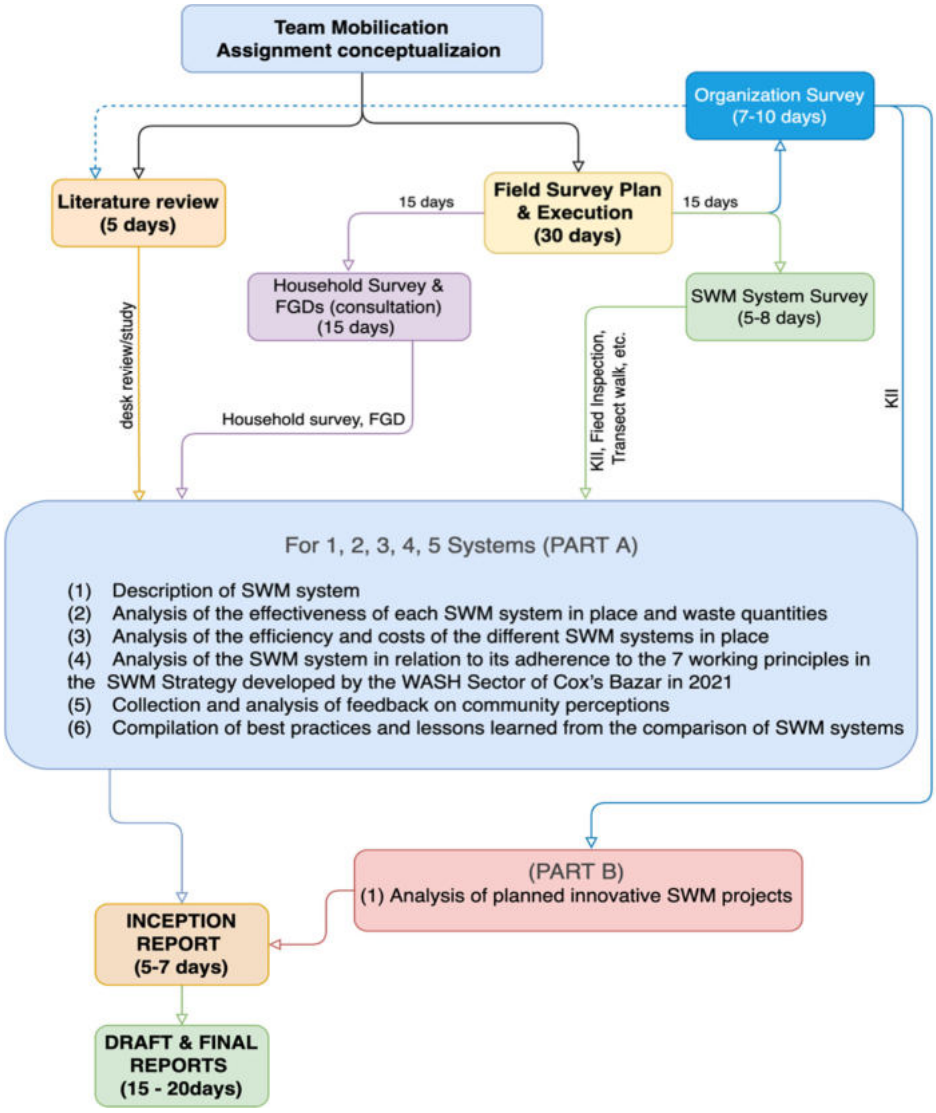


FIGURE 2: CONCEPTUAL FRAMEWORK OF THE ASSIGNMENT

1.3.1 QUANTITATIVE SURVEY

The face-to-face interviews have been conducted for households' survey by mobile device using Kobo toolbox. The pieces of information have been collected to understand the people's perception on the subject matter. **Questionnaire is attached as Annex I;** Kobo-link is https://ee.kobotoolbox.org/preview/DPrCbrzs. One of the main objectives of this current study is to understand the community perceptions on SWM related issues. Therefore, the study team has conducted a household (HH) level questionnaire survey. The heads of the households were respondents of the survey. The sample size for conducting the questionnaire survey at household is identified by using the common formula Eq. 1, considering the following assumptions and statistical parameters of Eq. 1:

- Entire households are homogenous in nature and exist in nearly similar cultural and social settings under five (5) SWM systems of three (3) AFAs in five (5) camps under four (4) NGOs as IPs.
- The households' incomes are nearly same in the 5-system supporting camps

- There are no major changes in the SWM system components towards which HH are exposed
- There are no significant changes in the perception on SWM among the household heads
- There are no significant changes in the perception on SWM among the shop owners

$$n = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + \left\{\frac{z^2 + p(1-p)}{e^2 \times N}\right\}} \quad ---------- (1)$$

Here,

n = the desired sample size, number of households interviewed
z = 1.65, Z-Score, at 90% confidence level
p = Standard of deviation, which is assumed as 0.5 or 50%
N = Number of households under the coverage areas of 5 systems of 3 AFAs
e = Assumed margin of error level, ± 0.052 or ± 5.2%

Therefore,

$$n = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + \left\{\frac{z^2 + p(1-p)}{e^2 \times N}\right\}} = \frac{\frac{1.65^2 \times 0.5(1-0.5)}{0.052^2}}{1 + \left\{\frac{1.65^2 + 0.5(1-0.5)}{0.052^2 \times 17{,}285}\right\}} = \frac{251.71}{1.064} = 236.6 \sim 240$$

However, it was planned to survey 300 households (*viz.* 5 camps *60 samples) but in the field total 336 samples have been surveyed. A systematic Random Sampling process was followed for the selection of a households with an approximation of picking one sample from 8-10 households in different blocks. We considered at equal sample number which had to be 60 assuming the homogenous condition, but actual samples are shown in Table 2.

TABLE 2: HOUSEHOLD SURVEY AND FGD DISTRIBUTION IN THE 5 STUDY LOCATIONS

Camps	NRC	1EAST	6	18	20
Area focal agencies (AFA)	UNHCR	UNHCR	UNICEF	IOM	IOM
Implementing partners (IP)	NGOF	BRAC	NGOF	DSK	SHED
Existing household[2]	4,263	8,464	4,998	6,226	1,615
Coverage households (17,285)	4,252	3,848	4,941	3,175	1,069
Household and shops samples total (336)	69	67	65	70	65
Male & Female respondents	11 & 58	27 & 40	30 & 35	24 & 46	23 & 42
Household survey dates	11th Jan 2022 and 12 Dec, 2021	5th Jan 2022 and 6 Jan 2022	6th Jan 2022 and 10 Jan 2022	18th Dec 2021 and 23 Jan 2021	20th Jan 2022 and 4 Jan 2022
FGD numbers (total 10)	1 for male, 1 for female	1 for male, 1 for female	1 for male, 1 for female	1 for male, 1 for female	1 for male, 1 for female
FGD participants	10-15	10-15	10-15	10-15	10-15
FGD dates	12 Dec, 2021	6 Jan, 2022	10 Jan, 2022	23 Jan, 2021	4 Jan, 2022

Note. UNHCR: United National High Commission for Refugees, UNICEF: United Nation Children Emergency Fund, IOM: International Organization of Migration, NGOF: NGO Forum for Public Health, BRAC: Bangladesh Rural Advancement Committee, DSK: Dushtha Shasthya Kendra, SHED: Society for Health Extension and Development.

1.3.2 SURVEY- RESEARCH TOOLS

The data collection tools were developed based on the given indications of TOR, through the introductory meetings with the SDC, and the relevant staff-members of 5 SWM systems. After reviewing the available secondary documents as supplied by SDC and other organizations, the necessary components have

[2] https://data2.unhcr.org/en/documents/details/86234

also been incorporated on different types of study tools those have been used in the fields. The tools have been used in Local-Native Language in the camps for Rohingya, Bengali & English have been used for others for ensuring collection of effective and useful information from the target audiences. The research tools are prepared for the study: Literature documents desk review, Questionnaire for the Household level Face-to-Face Interview, Guidelines for conducting the Focus Group Discussions (FGDs), Checklist for conducting the Key Informant Interviews (KIIs) and Site inspections.

Qualitative Survey: Under the qualitative method, Focus Group Discussion (FGD) and Key Informant Interview (KII) have been undertaken to collect the primary information related to study objectives. It has provided the opportunity to understand the real situation on the current SWM systems, effectiveness, adherence of seven (7) principle of SWM strategies, general cleanliness of the camps etc.

Focus group discussion: Two (2) FGDs (i.e., one for male and one for female) for each study location were carried out as an important process for capturing the perceptions of the community people on the subject matter using the following checklist:

- Perception on the importance of SWM for health and environment
- SWM flow in the respective camp and SWM inside household
- Satisfaction with the existing SWM and problems observed in existing SWM
- Knowledge on waste avoidance or reduction
- Any training or instructions on SWM
- Non designated disposal or scattering waste in the neighborhood
- Understanding on recycling waste
- Use of compost
- Suggestion for improvement

Key Informant Interview: The SWM system practitioners, sector expert and knowledgeable persons are considered under the Key Informant Interviews (KIIs) (Table 3). A total of more than 20 persons were interviewed under the KIIs and study team met them several times.

TABLE 3: KII PARTICIPANTS IN MODE OF ZOOM/MICROSOFT TEAM AND IN PERSON MEETINGS

Representative Organizations	Name	Designation
DPHE	Mr. Ritthick Chowdhury	Executive Engineer
WASH Sector	Mr. Damian Seal	Coordinator, WASH sector
UNHCR	Mr. Minhaz Uddin Ahmed	Asst. WASH Officer
NGOF (UNHCR)	Mr. Abu Rafat Siddique	Deputy Project Coordinator
	Mr. Asif Nur Dipto	Technical Officer
BRAC	Md. Iftiaz Ahammad	Assistant Technical Specialist
UNICEF	Mr. Mohammad Ashfaqur Rahman	WASH Officer
	Mr. Triqul Islam	Head of Program Operation
NGOF (UNICEF)	Mr. Sarwar Hossain	Technical Manager
	Md. Chanchal	Sanitation Engineer
IOM	Mr. Salahuddin Ahmed	National Programme Officer-WASH
	Mr. Rashed Rana	National WASH officer
	Mr. Mukhlesur Rahman	Project Assistant, Camp Coordination & monitoring
	Mr. Morshadul Alam Monna	Project Assistant, WASH
DSK	Mr. Saiful Hoque	Project Manager (WASH Team Leader)
	Mr. Zellur Rahman (DSK)	Project Engineer
SHED	Md. Abdul Aziz	Camp Manager, Camp 20
	Mr. Showkat Ali	Project Coordinator, WASH
All above organizations	-	Representative of HP staff and HP volunteers from collection, compost, recycling unit / MRF.
Ankur Scientific	Mr. Ankit Jain	Construction Company Representative

Note. Name of HP Officers, MRF operators, HP volunteers, and other volunteers were not recorded.

1.3.3 MONITORING MECHANISM

The facilitator/survey coordinator were responsible for checking of the filled-in questionnaires on kobo toolkit daily. Enumerators haven't uploaded any filled-in questionnaire to the system before quality check of the collected information. Any error or discrepancy were corrected on the spot. The filled data collections were supervised by the Task Coordinator/Task Advisor. Data collection team were comprised of the Enumerator, camp volunteer, IP's-camp level staff under the coordination of Facilitator/Survey Coordinator as shown in Figure 3.

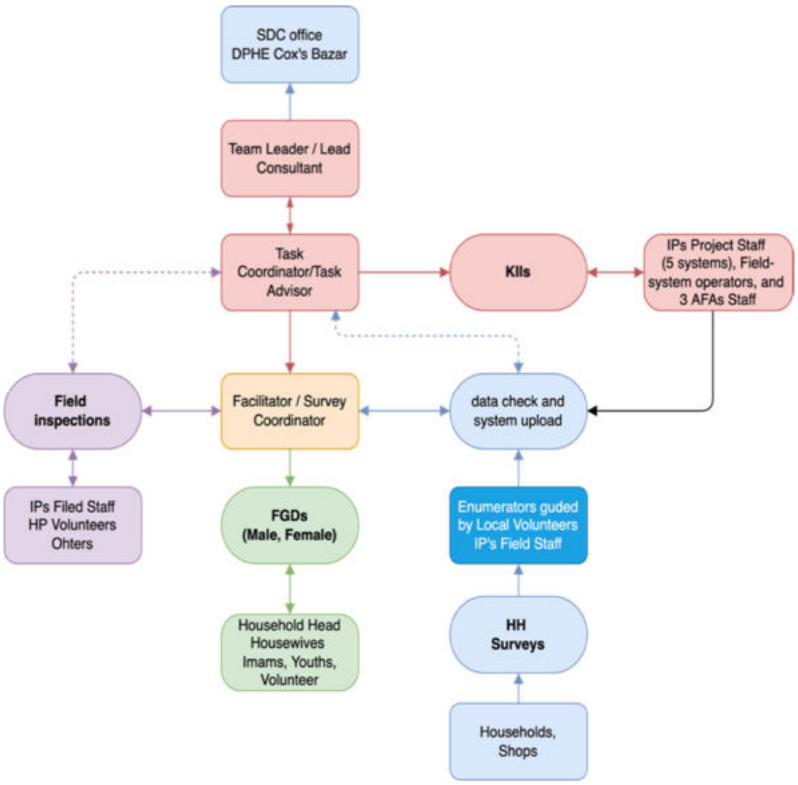


FIGURE 3: FIELD DATA COLLECTION AND MONITORING FRAMEWORK

1.3.4 DATA ANALYSIS METHOD

The study has collected primary and secondary information using both the qualitative and quantitative methods. All the relevant information were collected by following preset research tools. The study team has provided efforts to identify the required indicators based on the objectives, which have been addressed properly on the research tools. Analysis of the data were based on a simple table/matrix based on the indicators and objectives as set out in the TOR. However, for comparisons of systems' effectiveness and efficiency, as for example, labor productivity, generation versus management, costs etc. have been analyzed for uniform 100 HH in each camp as an average indicator. The contextual summary has been made based on the KII, HH survey, FGDs and direct document collected through internal group meetings.

CHAPTER 2. DESCRIPTION OF FIVE SOLID WASTE MANAGEMENT SYSTEMS

NGOF, BRAC, DSK and SHED are providing SWM services to the dwellers of camp NRC and 1 EAST, 6, 18 and 20 of the camps as shown in Figure 4, Figure 5, Table 2. Their systems are described in this chapter.

FIGURE 4 MAP OF STUDIED CAMP IN TEKNAF

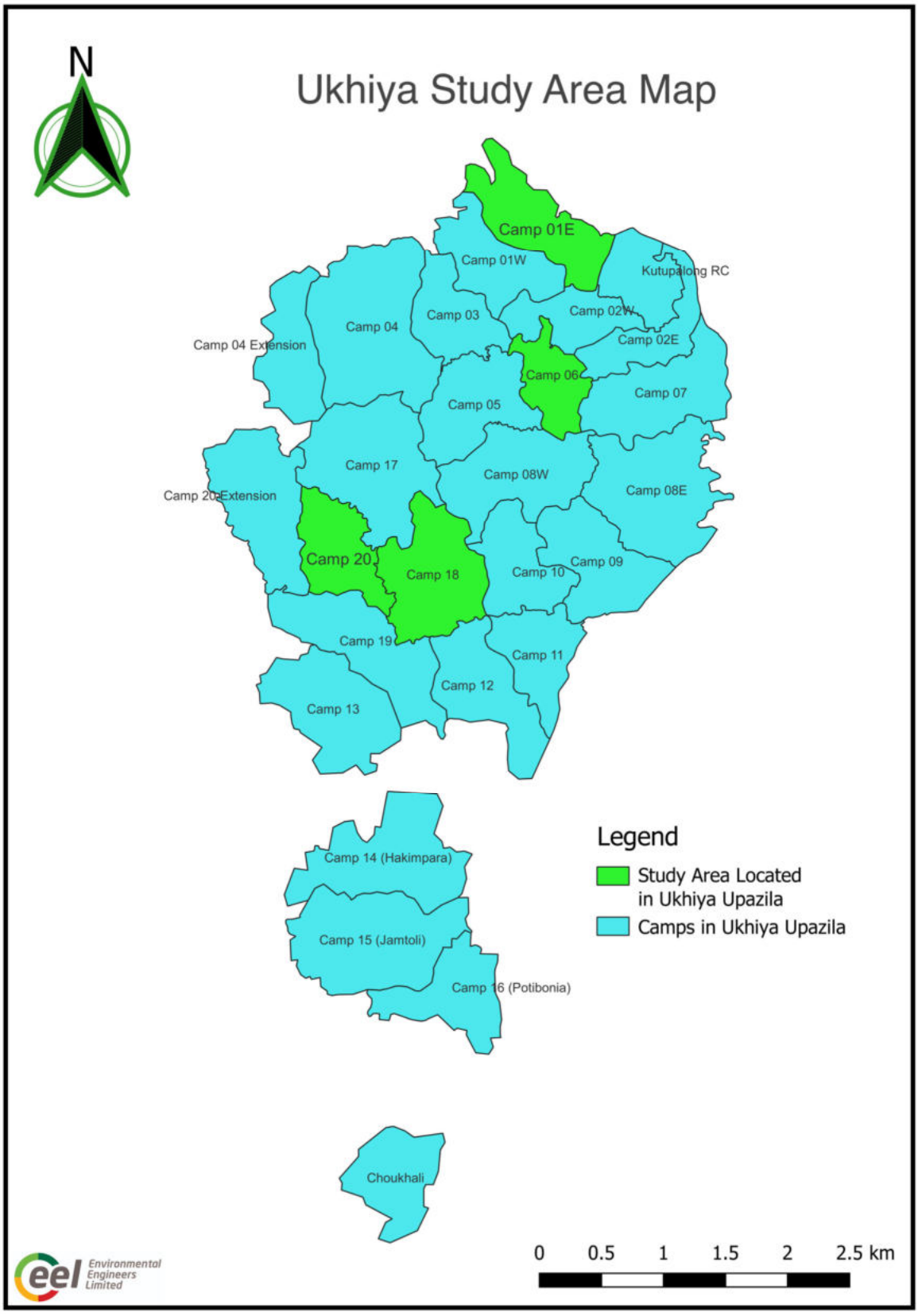


FIGURE 5 MAP OF STUDIED CAMP IN UKHIYA

2.1 NRC SWM SYSTEM

This SWM system is operated by implementing partner, NGOF under the area focal agency, UNHCR at NRC, located in Teknaf. The system seeks to ensure SWM services for around 4263 (Ref. October 21, UNHCR) households. The WASH team of NGOF is managing SWM system covering 4252 households. 21 waste collection volunteer, 4 MRF operator, and 23 hygiene promotion volunteers (i.e., Total 48 volunteers) provide overall SWM services collection, transport, MRF operation and community mobilization.

The estimated was generation is around 5687 kg /day and organic fraction is 52.4%. At NRC, there are seven blocks (B, C, D, E, H, I and P) and where C, and D blocks are under full coverage of MRF and E, P, B are under partial coverage of MRF. However, a new compost plant is under construction and expected to be operated from March covering blocks H and I.

Households and shops discharge their waste to the communal pits and volunteers' collect waste 2 times per week using hand trolleys to the MRF, and other temporary disposal locations located in C, H blocks. Manual segregation takes place in composting unit (MRF) into three types: organic, recyclable and residuals. Organic wastes are sent for composting, inorganic wastes which are recyclable are sent to recycling vendors, the inorganic wastes which are not recyclable are being disposed in their landfill site. Communal pits are housed of separate chambers for organic and inorganic waste. Typically, organic fractions come to compost plant and further separation is made. Finally organic matters are weighted, chopped, put in pre composting or pre storage chamber for 7-15 days after that they are loaded in Boxes for composting. Functional steps of the NRF SWM system are shown in Figure 6.

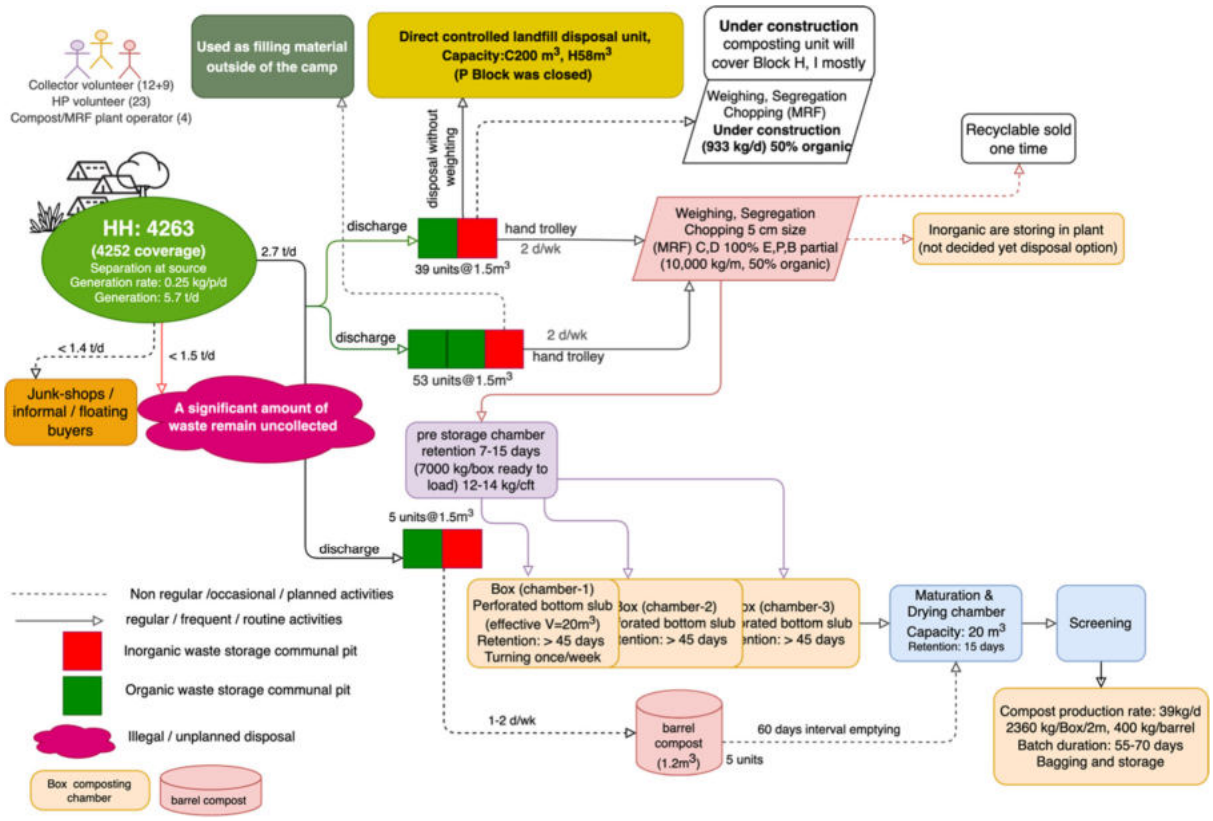


FIGURE 6: SWM SYSTEM AT NRC

2.1.1 GENERATION OF SOLID WASTE IN NRC

The wastes are being generated generally in households and shops situated at the NRC. Main organic wastes generated from the households are grass clippings, vegetable and fruit scraps, eggshells,

animal manures, woods, cloths, papers etc. and inorganic wastes are plastic bottles, iron, glass, polythene etc.

The NGOF WASH team has distributed 5440 pair of bins in 2020 (Figure 7). Green colored bin for organic waste storing and red-colored bin for inorganic waste storing. Also, they have provided waste bins to shopkeepers (Figure 5). The estimated was generation is around 5687 kg /day considering the waste generation rate 0.25 kg/person/day [3]. The generation rate is assumed by NGOF based on field experience and other reports.

FIGURE 7: WASTE BIN FOR HH AND SHOPS IN NRC

2.1.2 COLLECTION OF SOLID WASTE IN NRC

NGOF manages communal waste pits in different places in the blocks in the proximity of the households. These pits also have red and green color for separated storage of organic and inorganic waste; however, segregation is not up to the mark, it can be termed as nearly mixed discharge. There is total 97 communal pits where 44 communal pits (Figure 8) have been installed by the NGOF and rest 53 were previously installed by ACF, there is also few communal bins exist. The communal pits which have been constructed by NGOF has two boxes - one green and one red, and the pits which were previously made by ACF has three boxes - two green and one red. Volume of each pit is 1.5m^3. NRC system allows HH and shops to discharge waste at communal pits and volunteers collect waste from communal pits. They collect waste two days in a week typically. As reported, every day they collect around 2.7 tons of waste from household in which 70% of wastes is reported as organic and rests are inorganic. This system has two types of composting: box (i.e., single chamber system) composting and barrel composting.

FIGURE 8: COLORED WASTE COLLECTION COMMUNAL PIT AND COMMUNAL BIN IN NRC

2.1.3 WASTE TRANSPORTATION IN NRC

Waste collectors or community waste volunteers collect waste from communal pits and bins and take them using one-wheeler single trolley as manual carrying (Figure. 9) to temporary disposal site and MRF (compost plant with segregation unit). In addition to the waste collection from bins and pits, volunteers work for community connecting drains, streets, sometimes arrange special neighborhood cleaning campaign and dispose the waste to the temporary disposal sites. The transportation from temporary disposal to permanent landfill disposal has not established yet due long distance of landfill site, constructed by UNDP, therefore, NGOF considers the existing disposal sites as 'constructed landfill' and 'natural landfill' by their own definitions, however, provisions of landfills are missing there. It may be considered as controlled crude dumping.

[3] Officials proposed the generation rate considering previous 5 study findings e.g., 0.087, 0.11, 0.152, 0.245, 0.43 gm/capita/day of Terre des hommes (2018), SRC (2018), DSK (2018), Waste audit data (2019), NGOF (2019) respectively.

FIGURE 9: USING TRICYCLE TO CARRY WASTE FROM COMMUNAL PITS AND HUMAN CARRYING

2.1.4 ACTIVITIES AT MRF IN NRC

Segregation

The degree of segregation at communal bins or pits are not much it is almost mixed discharge. After the collection of waste and transported to the manual segregation place, waste workers segregate the waste to organic and inorganic waste (Figure 10). After segregation, leaves, and kitchen wastes are sent for pre storage chamber for composting, inorganic wastes are used for recycling (paper, plastics etc.).

FIGURE 10: WASTE SEGREGATION BY WASTE WORKERS

Box Composting

Generally, two types of organic wastes are put into the compost plant: Green organic wastes (e.g., food, vegetable waste, green leaf) and Brown organic wastes (e.g., paper, brown leaf). Before sending for compost, the organic wastes are manually chopped in 2 inches. Then they are stored in the pre-composting chamber for 15 days. The volume depends on the collected wastes. There are three boxes in the pre-composting chamber, when enough materials are stored in pre-composting chambers to load one composting chamber (box), the waste is transferred into the box. Every 7 days at first, manual turning is operated and afterwards, they turn in every 15 days. During the procedure, moisture content, and temperature are monitored regularly. It takes 45 days to compost the waste. Then the compost is sent to the maturation chamber by a partial sun-drying system. After 7 days, compost is screened, color checked, and bagged (Figure 11). They have under construction compost plant which is expected to be operated by receiving waste from H, I, P blocks.

FIGURE 11: COMPOST TEAM AT NRC

Compost distribution

Compost is being distributed in different ways based on needs of different entities. As for example, CIC is taking for own gardening, NGOF is using for gardening, community also collect in small quantity for home-front, back gardening. The volunteers are also provided based on their request but in limited amount for their household plants growing. Compost quality was checked in 2021 from laboratory which is attached in this report in chapter 3, Table 11.

FIGURE 12: COMPOST PLANT OF NRC

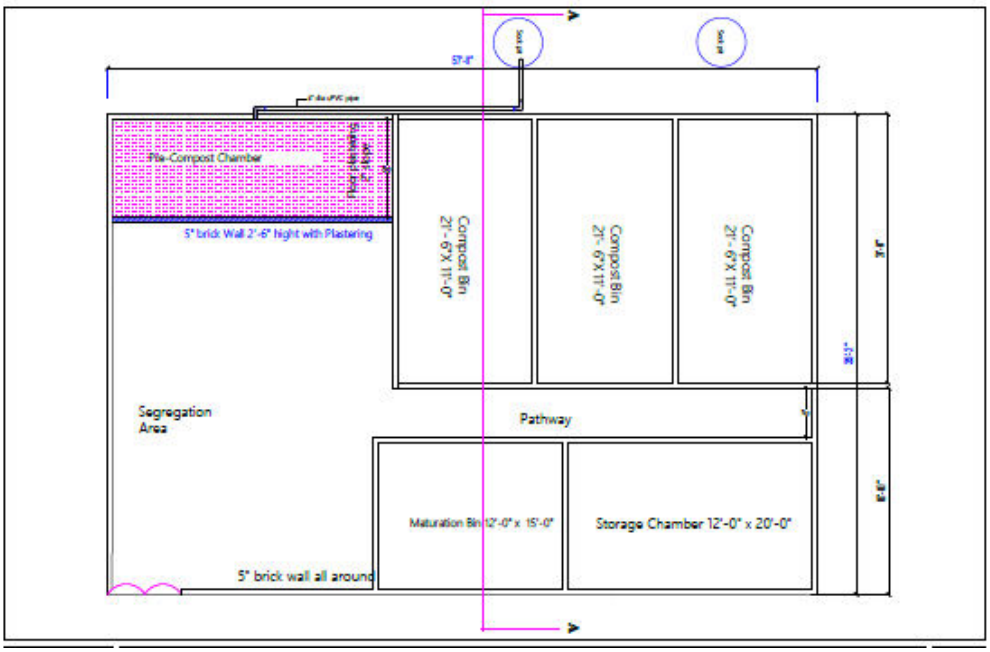


FIGURE 13: COMPOST PLANT PLAN OF NRC

Barrel composting

Barrels have been placed beside the communal pits in 5 different locations with the NRC. Capacity of these barrels is 1.2m^3. Waste collection volunteers shift the organic wastes into those barrels from nearby communal pits. The organic wastes remained there for 60 days and then turned into compost. That compost is taken to the compost plant, screened, and bagged. Waste volunteers frequently monitor the barrels and nearby pits, if there are sizable amount of organic accumulation in organic part of communal pits, they shift them from pits to nearby empty or partially empty barrels.

Resource recovery/ recycling

At the segregation place, inorganic waste which is recyclable is put separately. Private vendors who are known as local recyclers are contacted and the volunteers WASH team and volunteers sell the recyclable plastic bottles, iron, papers, rubber, and glasses to the local recyclers. According to a 2.5-month record of NGOF, 137 kg colored bottle @6 Tk/kg, 76 kg clear bottle @2.5 have been sold. However, recent data of recyclable recovery rate and value of selling are not found as they are taken away by the volunteers without maintaining any logs. It is estimated that among the collected wastes, 25% of wastes are recyclable and amount is 1421 kg/day.

FIGURE 14: CARRYING WASTES TO NRC LANDFILL

FIGURE 15: LANDFILL SITE OF NRC CAMP (LEFT H BLOCK, ROGHT MOCHONI)

Disposal of residuals

Along with residuals, mixed disposal also happens as shown in Figure 14. NGOF has disposed waste one time to the UNDP landfill site, however, they are now disposing within their constructed landfill site in C and H blocks. There are no environmental protections except fencing or wall to protect the waste from leaching out in H block. NGOF terms the landfills as "Constructed Landfill" and "Natural Landfill" located in H block and *Mochoni* respectively. Some of waste (i.e., non-recyclable) is used as filling materials outside of the camp occasionally. However, disposal needs to be guided and maintained as per specification of the regulation[4] of the government.

2.1.5 COMMUNITY ENGAGEMENT & BEHAVIOR CHANGE ACTIVITIES IN NRC

Stakeholders' engagement ensuring community participation through the *regular activities* of behavioral changes. NGOF has taken various initiatives as routine work, which are listed below and shown in Figure 16 & 17:

- HH SWM awareness campaign through miking on discharging waste on the designated places
- Regular HH visit and counseling for segregation of waste at source
- Block Cleaning Campaign to develop a sense of importance of cleanliness
- Frequently monitor households by HP using WASH monitoring sheet on the existence of bins, segregation etc.
- Volunteers keep an eye on SWM issue while roaming around the camp, e.g., if there are scattering of waste
- One to one counseling on onsite storage, propose segregation and segregated disposal to pits/bins
- Involvement of WASH/Camp Committee for mass people mobilization in special cleaning efforts
- Elite Person and Imam Involvement to disseminate message on proper waste discharge and stopping illegal discharge
- Leaflet distribution to each house and shops and warn not discharge waste to the drains.

NGOF has developed standard operating procedure (SOP) for this, and following the SOP, different groups are formed, as for example, "user group" from the community is used as an effective communication channel to reach outdoor-to-door and convey message in the indigenous language and tone to maximize sensitization towards an expected waste behave. NGOF has adopted 'no-littering' and 'Risk, Attitude, Norms, Ability Self-regulations' (RANAS) approach[5] for systematic behaviors change in other camps (26, Kutupalong) and trying to promote it. 'No littering approach' does not allow residents to through waste in places which are not designated for. Because of these undertaken initiatives, following changes have started reported by Ips: communities are using household bins, communities are getting habituated to clean the surroundings by themselves, Effort is made to Link local entrepreneurs, some dwellers have started using compost for agriculture purposes

[4] Solid Waste Management Rules, 2021, Ministry of Environment, Forest and Climate Change, Government of Bangladesh
[5] Methodological fact sheet 1, eawaq aquatic research,https://www.susana.org/_resources/documents/default/3-2397-22-1451899856.pdf

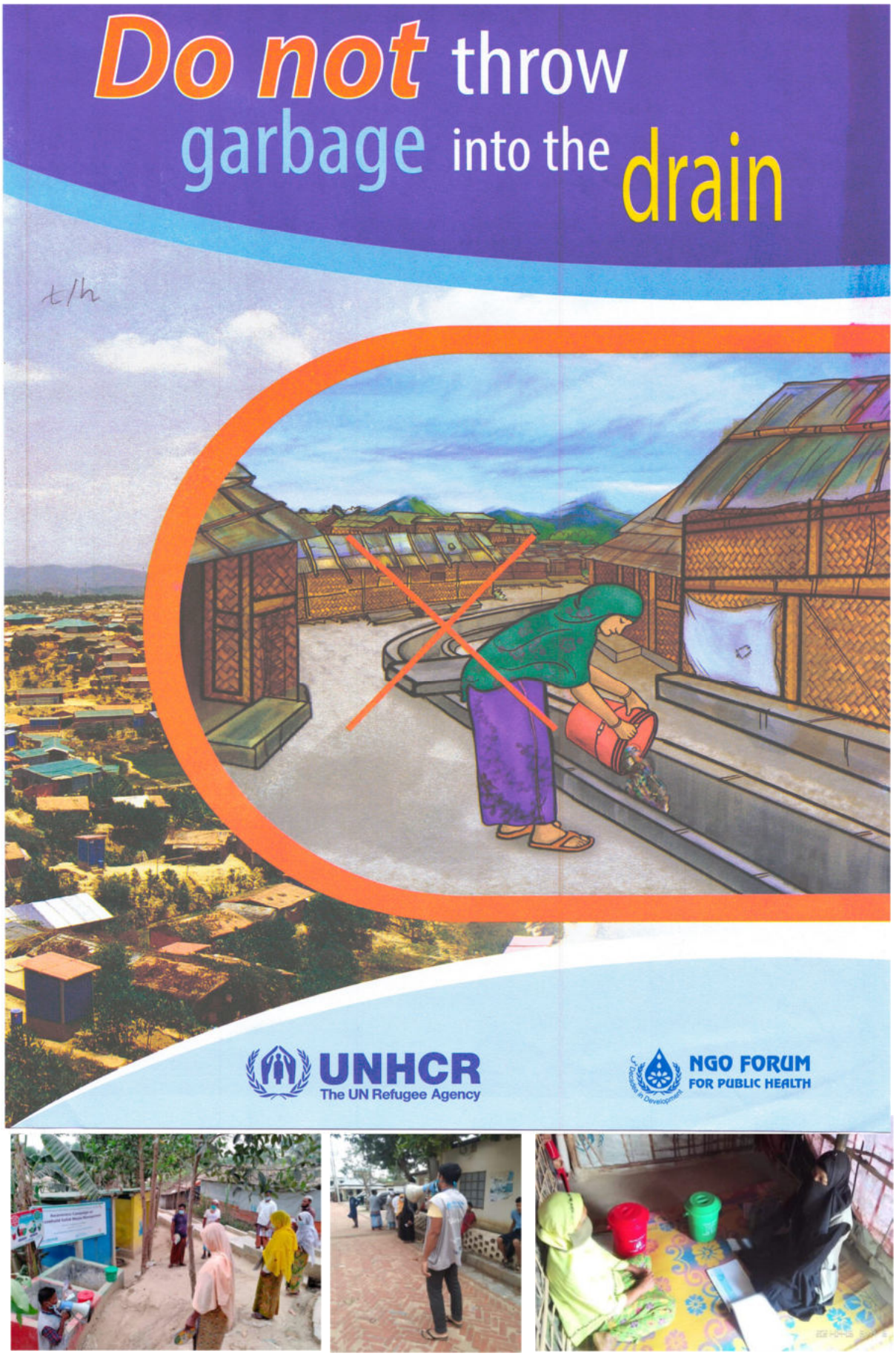
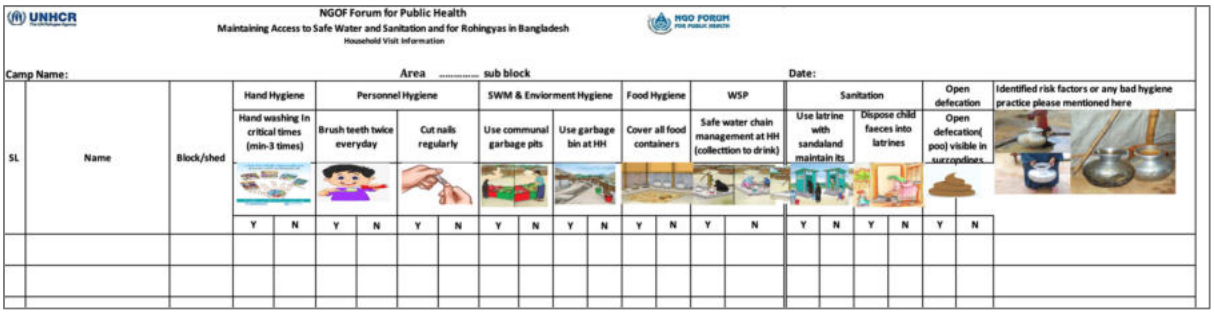


FIGURE 16: COMMUNITY ENGAGEMENT INITIATIVES TAKEN BY NGOF WASH TEAM



NGOF Forum for Public Health
Maintaining Access to Safe Water and Sanitation and for Rohingyas in Bangladesh
Household Visit Information

Camp Name: Area ..... sub block Date:

SL	Name	Block/shed	Hand Hygiene		Personnel Hygiene				SWM & Enviorment Hygiene				Food Hygiene		WSP		Sanitation				Open defecation		Identified risk factors or any bad hygiene practice please mentioned here
			Hand washing in critical times (min-3 times)		Brush teeth twice everyday		Cut nails regularly		Use communal garbage pits		Use garbage bin at HH		Cover all food containers		Safe water chain management at HH (collecttion to drink)		Use latrine with sandaland maintain its		Dispose child faeces into latrines		Open defecation(poo) visible in surroundings		
			Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	

FIGURE 17 HOUSEHOLD VISIT INFORMATION SHEET

2.2 CAMP 1E SWM SYSTEM

This SWM system is operated by implementing partner, BRAC under the area focal agency, UNHCR in camp 1E, located at Kutupalong, Ukhiya. There are approximately 8634 households are settled in the 7 blocks (i.e., from A to G) in camp 1E. However, BRAC WASH team serves SWM services to around 3848 households in 3 blocks (A, B and C), where about 2773.3 kg of solid waste is generated per day. BRAC is operating the SWM system with the help of 15 waste collection volunteers, 24 HP volunteers and 9 plant (MRF) operators. The MRF facility includes one compost plant with one temporary disposal site and recyclables storage facility, communal pits, communal bins, tricycle rickshaw van, hand trolleys, rental dumper, household paddle bins. System of camp 1E follows a SWM chain (Figure 18) from waste collection to composting wastes, distribution of compost to agriculture team, disposal residual to the landfill site of UNDP and usage of inert as filling or construction materials.

2.2.1GENERATION OF SOLID WASTE IN CAMP 1E

The coverage areas of the 3 blocks generate around 2773 kg of waste per day considering the rate 0.156 kg/person/day[6], all the households have been provided bins for onsite storage in 2020. The residents of camp 1E have been requested to store their waste in their household bins in a segregated manner.

2.2.2 COLLECTION OF SOLID WASTE IN CAMP 1E

Two types of waste bins have been provided at the household level. Green bins for organic waste discharging and red bins for inorganic waste storage. The WASH team also provided shared HH bin known as communal bins and constructed communal pits (Figure 19). They collect 1205 kg/day of solid wastes from communal bins and pits based on the average of data in last September and October of 2021.

Communal bins

Two colored (Green and Red) plastic bins have been distributed and positioned for about every 10 households. The capacity of these shared HH bins is 120 L. Green color is organic waste and red color is for inorganic waste. Total around 385 pair of communal bins were positioned at the commencement of the full chain SWM system. Collection frequency from communal bins is reported as 6 days per week as their working days. However, it is less when it is considered from each communal point.

Communal pits

Some places of camp 1E, BRAC has constructed 46 communal pits for waste discharging. 42 pits (*viz.* 9.63 m^3 1; 30.21 m^3 1; 35.40 m^3 1 and 2.10 m^3 39 numbers) have two chambers for organic and inorganic waste. However, there are 4 pits with single chamber (i.e., 2.10 m^3). The pits have been constructed in accessible location or beside the road. According to BRAC, volunteers collect from these pits on regular basis. The collection frequency is reported as 6 times per week as their working days. However, it is less when it is considered from each point.

[6] Officials proposed the generation rate considering previous 5 study findings e.g., 0.087, 0.11, 0.152, 0.245, 0.43 gm/capita/day of Terre des hommes (2018), SRC (2018), DSK (2018), Waste audit data (2019), NGOF (2019) respectively.

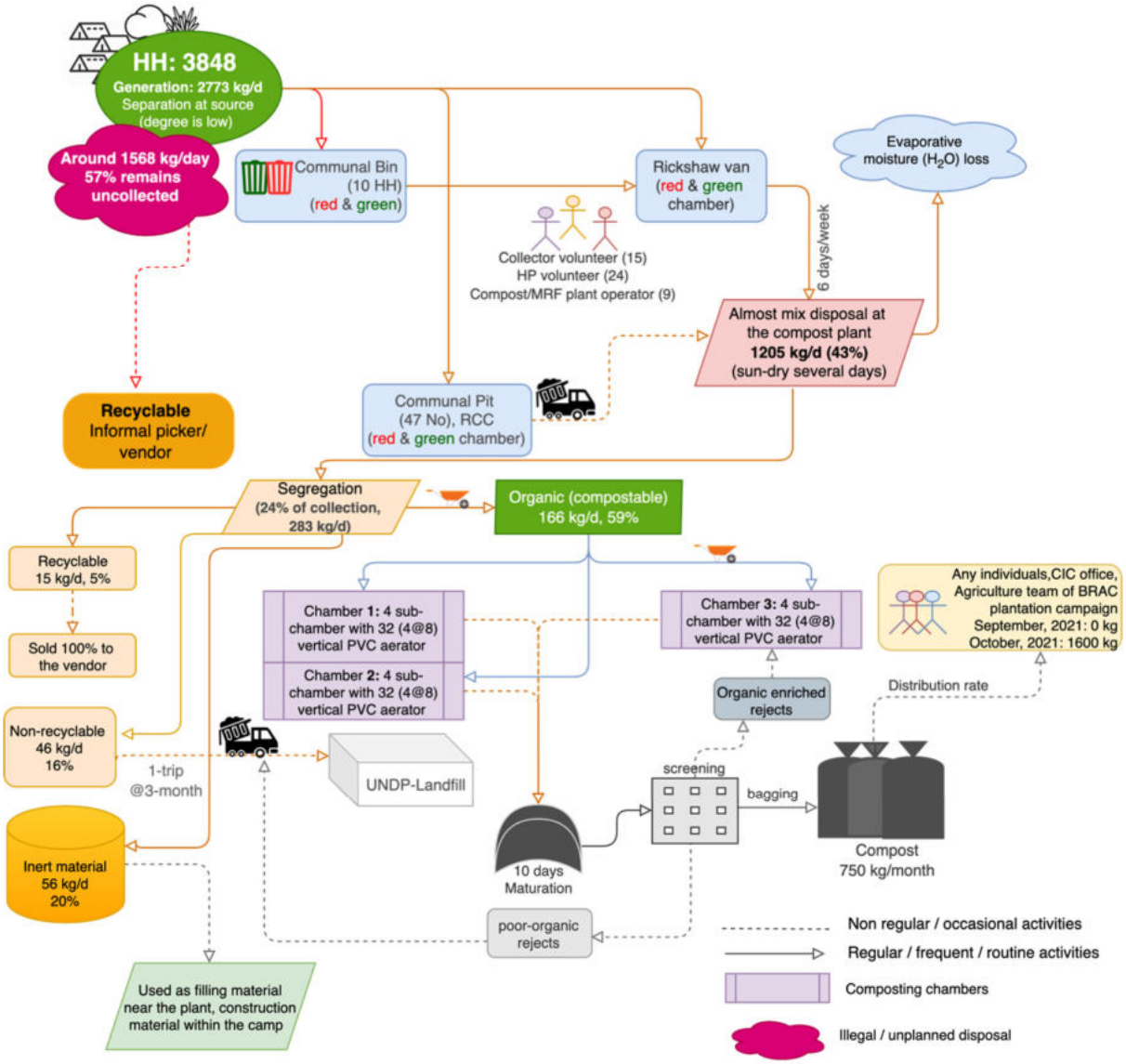


FIGURE 18: FLOW DIAGRAM SHOWING SWM AT CAMP 1E

FIGURE 19: COLORED COMMUNAL WASTE BIN AND PIT PROVIDED BY BRAC

2.2.3 WASTE TRANSPORTATION IN CAMP 1E

This SWM system shows waste collection in different sources such as collection from communal bins or pits, collection from special cleaning campaigns and shops, and collection from drain cleaning. After collection they take the waste to the MRF (Figure 20). Volunteers collect waste from all the difference sources carry the waste to the MRF through the tricycle or dumper and manually where segregation takes place. However, BRAC does not segregate all the daily collected waste. They store temporarily and intend to segregate after some drying. Eventually, a large heap of waste is created beside the MRF (Figure 21). There is no door-to-door collection in this system, operated by volunteers, but household member discharges their waste almost daily to the communal collection points.

FIGURE 20: TRANSPORTATION COLLECTION OF SOLID WASTE

2.2.4 ACTIVITIES AT MRF IN CAMP 1E

Waste segregation

As the dwellers of the camp were not used to this waste segregation system, the collected wastes from the communal pit or shared HH bins are found not segregated most of the time. So, the volunteers take all the collected waste to the compost plant. After drying for few days, volunteers segregate the waste (Figure 21). Organic wastes are put into the designated chambers. The recyclable inorganic waste i.e., PET plastics, etc. are put into the specified recycling storage areas and the local vendor or recycler buy this inorganic waste from BRAC. The non-recyclable fraction is kept in separate chamber temporarily so that they can be disposed at the planned sanitary landfill later. In last September and October 2021, MRF operation the collected mass contained 56-60% organic, 4-6% recyclable, 15-17% non-recyclable, 19-21% inert.

FIGURE 21: SEGREGATION OF ORGANIC AND INORGANIC WASTE

Compost plant (MRF)

The compost plant is located at block B of camp 1E (Figure 22). The GPS location of the compost plant is 21° 13' 58.77" and 92° 9' 13.67". Daily capacity of the compost plant is 2273 kg/day (Ref. BRAC). The design coverage population for the compost plant is 14,594 whereas it serves 17,778 (estimated). BRAC reported the method is *Windrow composting*. 9 workers (8 Volunteers and 1 Guard) usually operate this compost plant. Compost plant (i.e., with segregation unit and adjacent crude dumping site) has capacity of 7500 cft (i.e., 212.38 m^3) with three chambers (*viz.* each one is 334'x18'x4'), each chamber has 4 compost beds (*viz.* 12 beds, each dimension is 18'x8'x4'), 1 shorting chamber 22'x11' and 1 recycling chamber 10'x15'x6', inert material chamber 5'x8'x4'. Total facility area is around 70'x53'. Manual chopping, Handwashing device, compost & recyclables storage facility etc. are equipped with the MRF. This compost plant has facility of leachate collection with underdrainage networks and soak well.

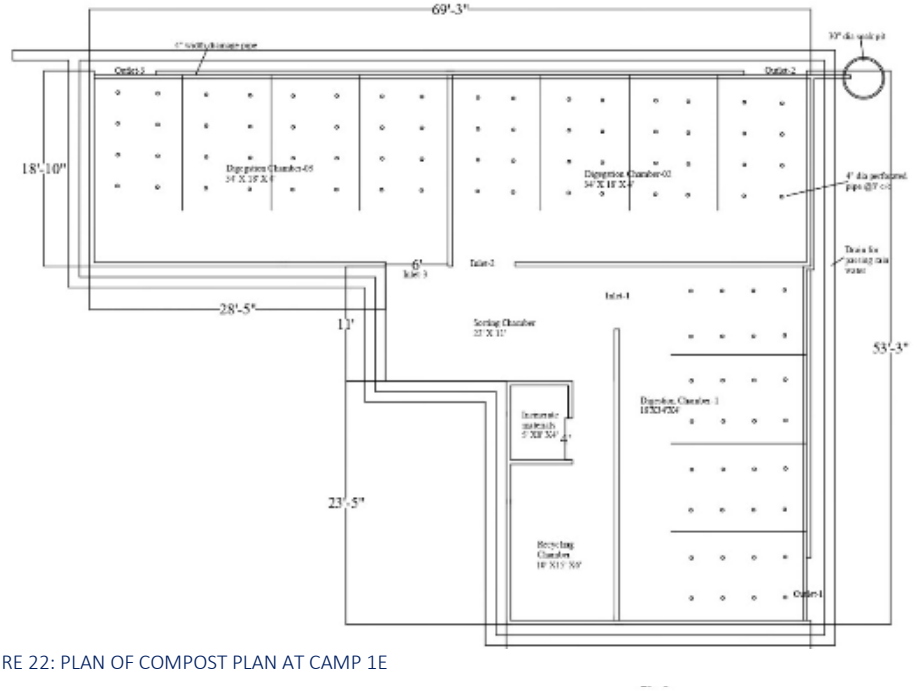


FIGURE 22: PLAN OF COMPOST PLAN AT CAMP 1E

Procedure of composting

Organic wastes are piled inside the chamber where vertical perforated pipes are installed to ensure proper aeration. Each stockpile of wastes is turned over manually using shovels after 15 days to maintain aeration and consistency of decomposition. A portion of water in the waste is passed away from the digestion chamber to the soak well which decrease the odors and fly nuisance (Figure 23). After 45-60 days the compost is released from beds and kept for maturation for about 10 days. After maturation screening is done and fine compost is bagged and stored for distribution. If the rejects from screenings are organic enriched, they are put in the composting bed again. If the rejects are not suitable for composting, they are stored or send for landfilling.

Compost distribution

Around 1600 kg of compost was distributed in last October 2021. Any individuals, several other organizations, site management office, CIC office, agriculture team of BRAC, plantation campaign within the camp or outside the camps are typically used to get the compost freely. Many organizations have received compost from BRAC plant in the past 2 years.

FIGURE 23: COMPOSTING PROCEDURES IN CAMP 1E

Recycling

Camp 1E does not have plastic recycling plant under the BRAC SWM system. Local vendors, floating buyers collect recyclable plastics and other materials from dwellers and MRF (Figure 24). The collection rate of recyclables is 14.73 kg/day in total collection.

Disposal of residuals

After composting, remaining wastes and non-recyclable wastes are being disposed in the landfill which is located at camp 20 extension. This landfill has been designed to collect all the non-recyclable inorganic wastes from all the camps in Ukhiya/Teknaf region. (Figure 25). As an average, safe disposal amount of residual (i.e., non-recyclable) is 26.37 kg/day and residual (i.e., inert) is 32.33 kg/day. However, they are not disposed unless a sizeable amount is accumulated. Inert materials are used as filling or construction materials.

FIGURE 25: LOCAL VENDOR BUYING RECYCLABLE MATERIALS FROM DWELLERS

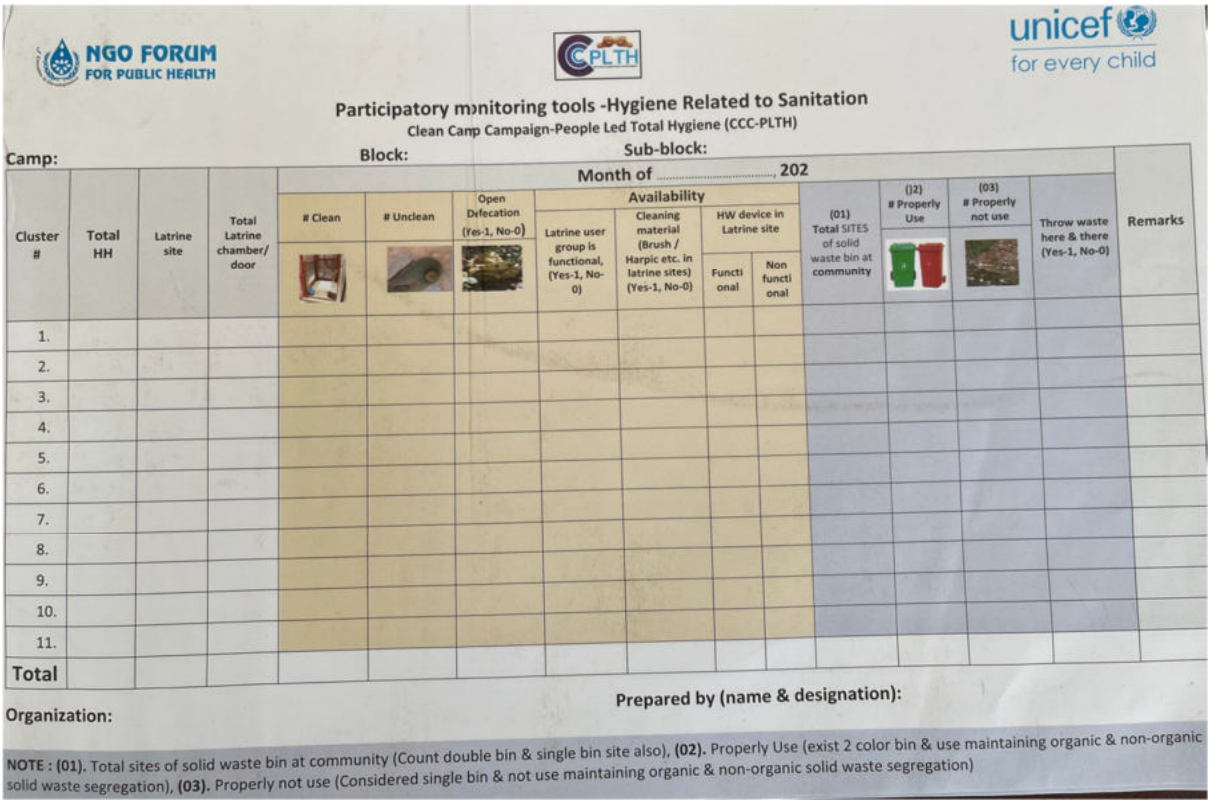
FIGURE 24: DISPOSING OF INORGANIC WASTE AT LFS (REF. UNDP)

2.2.5 COMMUNITY ENGAGEMENT & BEHAVIOR CHANGE ACTIVITIES IN CAMP 1E

HP staff and HP volunteers covers different topic of SWM while take sessions or facilitate different community meetings. They also use monitoring checklist regularly while visiting houses, monitoring tool covered SWM related issues (Figure 26). If any discrepancy is recognized, on the spot explanation and advocacy is made. BRAC hygiene team has been taking following initiatives among the stakeholders of Camp 1E as regular activities:

- Create awareness of attitudes and behaviors of the community through door-to-door meeting or group meeting on SWM and WASH components
- Developing skills and knowledge about SWM through group meeting and campaigning
- Developing coordination among stakeholders to strengthen SWM through combined effort on special cleaning
- Generating new activities to change behavior such as explaining the importance of waste segregation or waste discharge system
- Regular monitoring including SWM
- Assessment of public health risks
- Elite meetings and or awareness increase by Imam of the mosque sharing importance of cleanliness
- Food vendors meeting and share not to discharge wase on drains
- Facility poster distribution showing composting, communal bins etc.

BRAC has standard operation guideline for SWM, SWM facility poster (board), and one-page information summary for composting. 50% of HP volunteers of BRAC are female, aimed at maximizing mobilization of women members in effective participation of SWM.



NGO FORUM FOR PUBLIC HEALTH

CPLTH

unicef for every child

Participatory monitoring tools -Hygiene Related to Sanitation

Clean Camp Campaign-People Led Total Hygiene (CCC-PLTH)

Camp: Block: Sub-block:

Month of 202

Cluster #	Total HH	Latrine site	Total Latrine chamber/ door	# Clean	# Unclean	Open Defecation (Yes-1, No-0)	Availability				(01) Total SITES of solid waste bin at community	(j2) # Properly Use	(03) # Properly not use	Throw waste here & there (Yes-1, No-0)	Remarks
							Latrine user group is functional, (Yes-1, No-0)	Cleaning material (Brush / Harpic etc. in latrine sites) (Yes-1, No-0)	HW device in Latrine site: Functional	HW device in Latrine site: Non functional					
1.															
2.															
3.															
4.															
5.															
6.															
7.															
8.															
9.															
10.															
11.															
Total															

Organization: Prepared by (name & designation):

NOTE : **(01).** Total sites of solid waste bin at community (Count double bin & single bin site also), **(02).** Properly Use (exist 2 color bin & use maintaining organic & non-organic solid waste segregation), **(03).** Properly not use (Considered single bin & not use maintaining organic & non-organic solid waste segregation)

FIGURE 26 PARTICIPATORY MONITORING TOOL

2.3 CAMP 6 SWM SYSTEM

NGOF has been operating SWM system in camp 6 with the full coverage of 4 blocks (A-D) located at Ukhiya under UNICEF. NGOF operates a method of full-chain SWM system from the point of generation to the waste treatment (composting), recycling and final disposal. In camp 6, approximately 4998 HH are settled, however, NGOF reports existing entire HH of 4941 are under coverage which generate more than 4.6 t/d (estimated). NGOF is trying to safely manage the generated wastes through the operation of 3 composting units equipped with 3 segregation units.

It has operational logistics of manual waste carrying groups 22 numbers using half-of 100 L, hand trolley 3-wheeler 27 numbers which are being used only in the accessible roads. 29 collection volunteers, 12 MRF operators, and 53 HP volunteers are regularly severing for SWM in this system. The basic flow of the system is shown in Figure 27. This system is communal collection system wastes are being transported to the MRF or temporary dumping site using half-cut drums. This system uses UNDP landfill site for final disposal of waste.

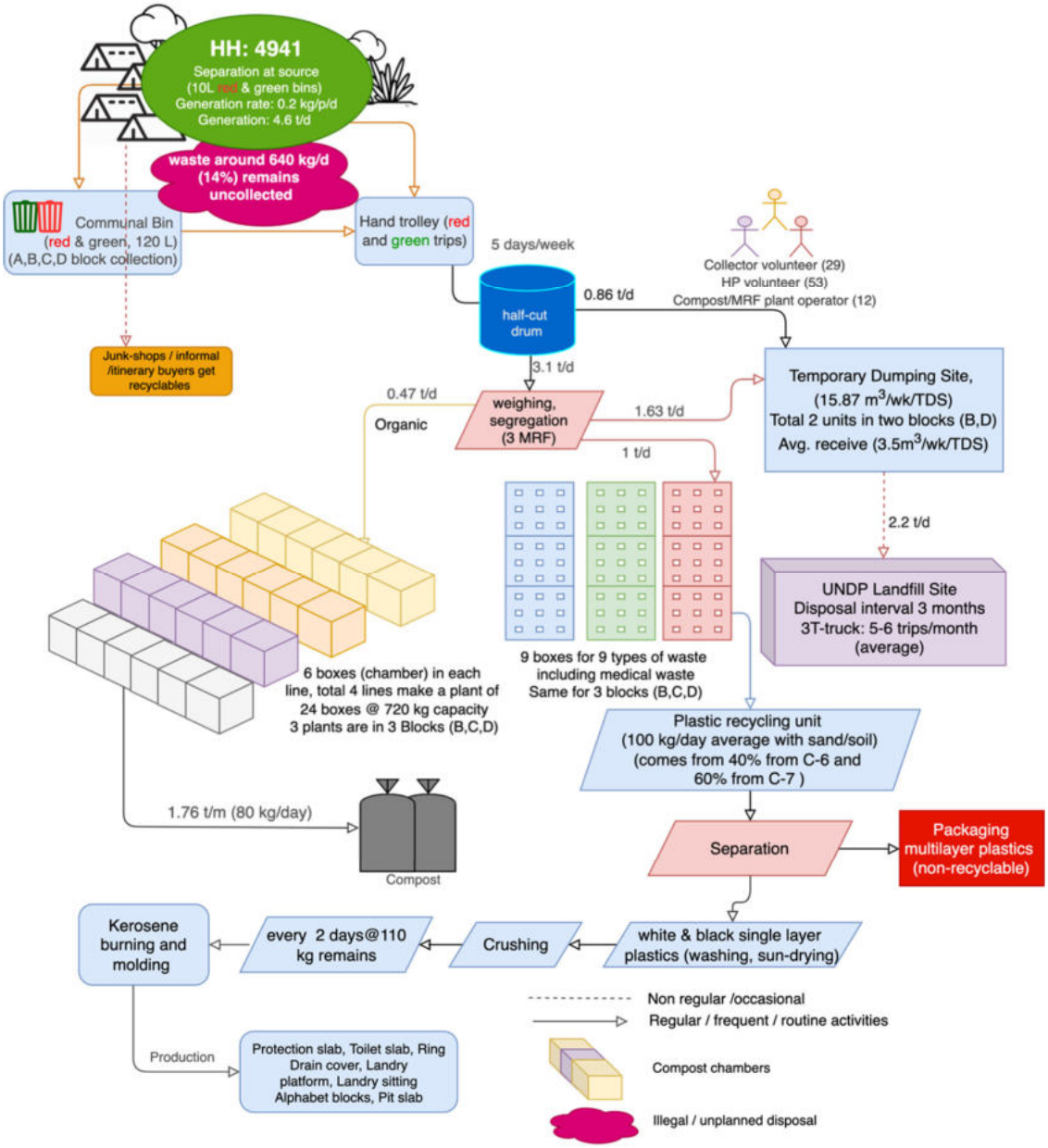


FIGURE 27: FLOW DIAGRAM SHOWING SWM IN CAMP 6

2.3.1 GENERATION OF SOLID WASTE IN CAMP 6

The waste generation rate in camp 6 is assumed 0.2 kg/person/day[7], total waste generation is estimated 4644.5 kg/day. Households discharge their waste from their household bins to communal bins (Figure 28). This system facilitates segregation of waste at sources in two categories: organic and inorganic. The wastes are being generated generally in households and marketplaces. Under the organic wastes, there are leftover of vegetables, fishes, chicken or meats, fruit peels etc. Under the inorganic wastes, a big portion of various types of recyclable polymer like PET, HDPE, PP, PVC, LDPE, PS etc. are found. Different types of plastic items are like single use bags, bottles, containers, food, and beverage packaging etc. are common.

FIGURE 28: WASTE GENERATION FROM HOUSEHOLD LEVEL TO COMMUNAL LEVEL

2.3.2 COLLECTION OF SOLID WASTE IN CAMP 6

The NGOF WASH team has distributed two types of waste bins to the entire households in 2020. Green colored bin for organic waste storage and red colored bin for inorganic waste storage (Figure 29). The capacity of these bins is 10 liters. Before handing over 2 bins to a family, the volunteers and staff sat down with the each of the household members and made them aware on the SWM and its relevant issues. There are pair of waste bins (communal bins) in different places very close to the households (Figure 29). These bins are also red and green color, made of plastic, and there are some constructed communal pits that are made of concrete for same purposes. The capacity of these bins is 120 liters. Households take their household-waste-bin to the communal bins or waste collectors collect those bin and discharge wastes in the communal bins sometimes. The waste volunteers collect waste generally from these communal bins. The average collection amount is 4005 kg/day.

FIGURE 29: WASTE COLLECTION BY COMMUNITY WASTE VOLUNTEERS

2.3.3 WASTE TRANSPORTATION IN CAMP 6

Households are responsible for disposing their daily generated wastes to the adjacent communal bins. Waste volunteers collect waste from the communal bins and transfer to the segregation place close to the compost plants through single wheel garbage hand trolley, small van or human carrying method (Figure 30). The waste collection system is designed considering terrain condition of the camps and accessibility to the communal bins. Half-cut drums are most common logistic for waste carrying to the compost plants.

[7] Officials proposed the generation rate considering previous 5 study findings e.g., 0.087, 0.11, 0.152, 0.245, 0.43 gm/capita/day of Terre des hommes (2018), SRC (2018), DSK (2018), Waste audit data (2019), NGOF (2019) respectively.


FIGURE 30: WASTE TRANSPORTATION BY COMMUNITY WASTE VOLUNTEERS

2.3.4 ACTIVITIES AT MRF IN CAMP 6

Segregation

After the collection of waste and transported to the segregation place adjacent to compost plants (MRF), waste workers segregate the waste to organic and inorganic waste. The segregation units are prepared to ensure safe storage and proper segregation of wastes. Since the residence of the camp 6 is not adapted with the segregation method, waste received from the waste bin are found mostly non-segregated as shown in Figure 31. There are 8 storage chambers (Figure 31) installed to store segregation inorganic waste which are (1) PET, (2) mixed plastics (3) paper & card boards, (4) metal waste, (5) soft plastics, (6) medical waste, (7) electrical waste and (8) other waste. After segregation, inorganic wastes are being used for recycling /reusing and other solid wastes are stored for landfilling. Among the collected wastes, 25% of wastes is recyclables, amount is 1161 kg/day.

FIGURE 31: WASTE SEGREGATION BY COMMUNITY WASTE VOLUNTEERS

Plastic recycling

NGOF operates a recycling plant adjacent to the camp no. 6. Only LDPE or plastic bags are used to produce different types of products. Daily 100 kg of plastic wastes feed to the plant from camp 6 and camp

7, where about 40% comes from camp 6. NGOF has appointed a team and build their capacities to manage the recyclable plastics received after segregation. Prime sources of plastics items other than polyethylene bags are bottles, containers, damaged pipes and sanitary fittings, food and beverage packaging, large polymer bags etc. Some of these are reusable and resalable.

Waste volunteers separate the *white and black single layer* plastics and *multilayered plastics* (Figure 32). *Multilayered* plastics are not recyclable. *White and black single layer* plastics are washed and sun-dried before crushing (Figure 32-33). After that the plastics are burnt & molded using kerosene. After molding, the recycling unit converts those plastics into different types of products such as toilet slab, latrine pit slab, ring drain covers, land dry platform, land dry sitting alphabet blocks (Figure 33) and mentioned in Table 4.

FIGURE 32: REUSING RECYCLABLE PLASTICS

FIGURE 33: WASTE VOLUNTEERS HAND SORTING THE PLASTIC BAGS AND CLEANING THE PLASTIC BAGS

FIGURE 34: WASTE VOLUNTEERS ARE DRYING THE PLASTIC BAGS AND USING MOLDING MACHINE FOR MAKING RING AND SLAB

The common produced items from recyclables plastics (e.g., black, and white single layered) and with specifications and usages are shown in Table 4.

TABLE 4: COMMON PRODUCED ITEMS FROM RECYCLING

Sl. No.	Product Name	Product dimension	Shape	Product weight (kg)	Usage
1	Protection slab	5'x2.5'	Rectangular	37	Land protection, slide protection
2	Toilet slab	30"	Circular	22	Latrine pit cover
3	Ring	30"	Circular	25	Toilet ring
4	Drain cover	2.5'x2'	Rectangular	22	Drain slab
5	Landry platform	2'x2.5x2'	Cube	40-42	Surface for cloth washing
6	Landry sitting	1'x1'x1'	Cube	13-14	Seat for washing
7	Alphabet blocks	0.5"x0.5"x0.5"	Cube	-	Toys and children learning material
8	Pit slab	1'x1'x5"	Rectangular	9	FSM inspection pit

Note: (') Feet, (") Inch

Composting

As reported, NGOF operating plants were constructed in 2019. The objectives of constructing the composting units were to safely manage the organic solid wastes for reducing the environmental pollution as well as to improve public health condition. The organic composted per day is 472 kg (Figure 35-36). There are 24 boxes in 4 lines with the capacity of accommodation of organic 51.84 ton (i.e.,720 kg, 24 pits, 3 plants). Compost production rate is 80 kg/day, and it takes around 70 days to get finished compost. The composting unit type is the pit-based unit. The capacity of storage of the Composting Unit is 12600 (i.e., 175*3*24) kg per month.

FIGURE 35: COMPOSTING OF ORGANIC WASTE

FIGURE 36: COMPOST PLANT AT CAMP 6

Distribution of compost

Volunteers use the compost and individual interested to take compost from the camp inform the volunteers and collect in limited amount for the home gardening i.e., vegetable plantation.

Final disposal of residuals

The non-recyclable and unusable waste segregated materials are taken to the landfill for final disposal. The residual fraction is 35% of the total collected wastes, while the household produce 1626 kg/day, and average disposal rate is reported as 1760 kg/day including street, drain, markets waste containing residuals.

2.3.5 COMMUNITY ENGAGEMENT AND BEHAVIOR CHANGE ACTIVITIES IN CAMP 6

Following activities are undertaken as regular or routine works by hygiene promotion volunteers and WASH Team.

- HP volunteers and staff use monitoring sheet of WASH regularly that covers SWM issues. Anomalies are discussed on the spot if found
- Each household receives session on SWM along with 6 other topics from the NGOF HP staff & volunteers.
- Group (Water user group, WASH committee, MHM group, Child leader group, Latrine user group) or individual household are directly or indirectly playing role in SWM in different activities such cleaning campaigns.
- Majhi Imam, community leaders are involved with awareness program along with Learning centers.
- UNICEF regularly provides leaflets and NGOF distribute them.

2.4 CAMP 18 SWM SYSTEM

In camp 18, approximately 6226 households are settled. Under IOM, DSK is operating the SWM service to 3175 households that generate solid waste more than 2207 kg per day. The NGOF WASH system follows full chain SWM system from waste collection to composting wastes, recycling plastics, community engagement, distribute compost to different entities etc. (Figure 37). Camp 18 system is door-to-door collection system. It is operated by 14 waste collection volunteers, 2 plant operators and 30 HP volunteers. However, waste volunteers after unloading the waste in the MRF provide some supports weighting and segregating.

The operational infrastructure this system includes compost plant with segregation spaces, storage spaces for recyclables and residuals, household bins, large bags or sacs for inorganic carrying, 80 litters of drums for organic carrying to the compost plants, sandbags, or sacs for brown waste (etc., leaf, eggshell, paper etc.) collection. This system allows door-to-door collection and directly taking them to the MRF without any intermediate (i.e., communal bins or pits) facilities. Segregated collection further separated, weighted, chopped, and composted in the plant as shown in the Figure 37. Recyclable inorganic wastes are sold to local vendors and residual inorganic wastes are disposed to the landfill.

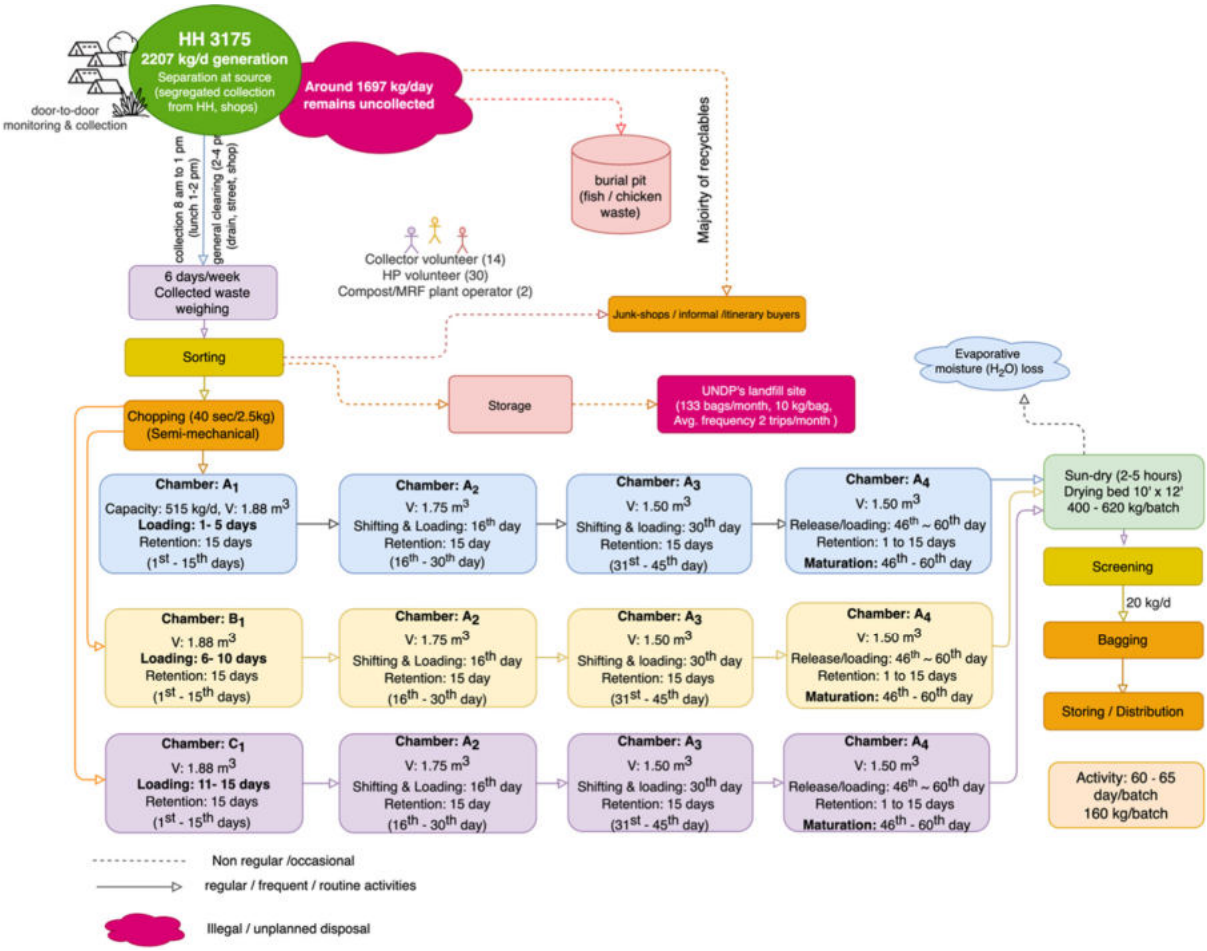


FIGURE 37: FLOW DIAGRAM SHOWING SWM AT CAMP 18

2.4.1 GENERATION OF SOLID WASTE IN CAMP 18

The wastes are being generated in households and marketplaces. The waste generation rate in camp 18 is 0.15 kg/person/day[8], and the total waste generation 2,207 kg of wastes daily.

[8] Officials proposed the generation rate considering previous 5 study findings e.g., 0.087, 0.11, 0.152, 0.245, 0.43 gm/capita/day of Terre des hommes (2018), SRC (2018), DSK (2018), Waste audit data (2019), NGOF (2019) respectively.

2.4.2 COLLECTION OF SOLID WASTE IN CAMP 18

The DSK team has distributed two types of waste bin to the household for onsite storage. Green bins are for organic waste onsite storage and red bins are for inorganic waste. DSK WASH team operates door-to-door waste collection system, collection frequency 6 days per week, collection time 8.00 AM to 1:00 PM. Volunteers collect waste from every household and shops in this time and bring them to MRF and help to segregate there also. After 2:00 PM volunteers work for street, road, drain, market cleaning. Average collection is 510.12 kg/day from households, in which 428.6 kg wastes are organic, 81.56 kg wastes are inorganic (Figure 38). This system rejects collection of fish, chicken waste or left over to avoid smell in composting plant by the provision of back yard burial seems better for minimizing disease vector growth or spreads.

FIGURE 38: GREEN AND RED COLORED BINS FOR HH

2.4.3 WASTE TRANSPORTATION IN CAMP 18

Waste volunteers manually bring the waste from households to the MRF as shown in the Figure 39. The do not use any trolleys or rickshaw vans because of steep slopes in hilly terrain. HP volunteers guide and monitor the door-to-door collection to oversee segregation source, rectify households and keeping the records. They also monitor to segregated collection by collection volunteers to avoid the chances of mixing again.

FIGURE 39 MANUAL TRANSPORT OF WASTE TO THE MRF FROM HH

2.4.4 ACTIVITIES AT MRF IN CAMP 18

Segregation

After the collection of waste, volunteers further segregate into organic and inorganic waste. At the segregation place, organic wastes are separated to green and brown waste. Inorganic wastes are separated to recyclable and residual. Composting quality is maintained following segregation guidelines to have proper nutrient ratio and active composting process (Figure 40-43).

FIGURE 40 SIGNBOARD OF BALANCING ORGANIC COMPONENTS AND QUALITY OF COMPOST

[9]

FIGURE 41: WASTE SEGREGATION, CHOPPING BY PLANT OPERATORS

Chopping

DSK has introduced a semi mechanical chopper to save labor and improve quality of waste size. It was reported to save time and labor. It has been newly introduced. Only this system has such chopping devise among the five.

Composting

Solid organic wastes are taken into the composting chamber unit after chopping the green and brown wastes. The green and brown wastes are mixed in 4:1 ratio. The compost plant has three (3) rows of chambers, A, B and C. Each raw has four (4) boxes. Volume of vox is shown in Figure 42. The composting follows a sequential cycle. At first, Chamber A_1 is loaded (in 5 days). After 5 days, chamber B_1 is loaded taking 5 days. After 10 days, chamber C_1 is loaded taking 5 days. Retention time in each chamber is 15 days after that, they are shifted to next chamber. Frequently, waste volunteers check the temperature and moisture to ensure the quality and record the data in register. After 60 days, organic wastes turn into compost. From each batch, 400 to 620 kg of compost (i.e., raw-moist) is released. In the subsequent, several days they are

FIGURE 42 4 CHAMBERS OF COMPOST IN A ROW (A)

[9] There are two plant operators, however, waste collection volunteers provide some help for segregation.

sundried, screened, bagged, and stored. The finished compost generation rate is about 160 kg/batch. Temperature and moisture are periodically checked in compost heaps throughout the process.

FIGURE 43 SCREENING AND MOISTURE CHECKING OF FINAL COMPOST

Compost distribution

Compost is distributed in various forms but there is no clear plan or course of action to distribute them. As for example, 2496 kg of compost was given to Transition and Recover Department of Social Cohesion project of IOM, CICs took 380 kgs in several times, site development, site management and visitors are used take the compost whenever they come to MRF. Around 4 to 5 kg of composts are given to the households or volunteers, whoever comes with bag to collect compost.

Recycling

This system does not have recycling plant. The recyclable plastics which were segregated from the segregation unit are sold to the recycler or local vendors. Total estimated generation of recyclable amount is 486.8 kg/day considering 22% as recyclable fraction. However, plant receives 25.8 kg/day (Ref. 7-days survey result by IP & AFA). A significant number of recyclables go to floating buyers within the camp, as households like to segregate at source level.

Disposal of residuals

The non-recyclable and unusable waste segregated from the segregation place are taken to the landfill for final disposal. As average about 242 kg of residuals have been safely disposed per day, however, typically send to the landfill site once in a month. Where, household residual is 55.79 kg/day and rests are street and drain cleaning waste generated residuals.

2.4.5 COMMUNITY ENGAGEMENT AND BEHAVIOR CHANGE ACTIVITIES IN CAMP 18

There are several approaches for community engagement and behavioral changes which are summarized below:

- Sometimes CIC participates session with Majhi, community leaders (e.g., imam), community groups (e.g., users' group, WASH committee block & MB level) on the topic of site management and site development including solid waste management.
- There is session / meeting on SWM including campaigns with the participation of community such as special cleaning. In special cleaning program, surrounding of households, shops etc. are cleaned with the involvement of Majhi, community leaders (e.g., imam), community groups (e.g., users' group, WASH committee block & MB level) 1 time in a month.
- HP volunteer visits door-to-door and convey messages to sensitize.

- Field visit at MB level is being done with the participation of HP volunteer, community mobilizer, Hygiene promotion officer etc. Majhi, HH representative, MB-WASH committee members also sometimes join in field visits.
- Whistle was previously used, and it was a good signal to make community ready to discharge waste to the collectors. However, due to CIC's instruction it is temporarily stopped now.
- All the waste collectors are accompanied by HP volunteer to see the status of segregation at households at the time of door-to-door collection and keep the record (Figure 44). In case of mix discharge or improper segregation, volunteers instruct and rectify households to have proper sorting at household level.

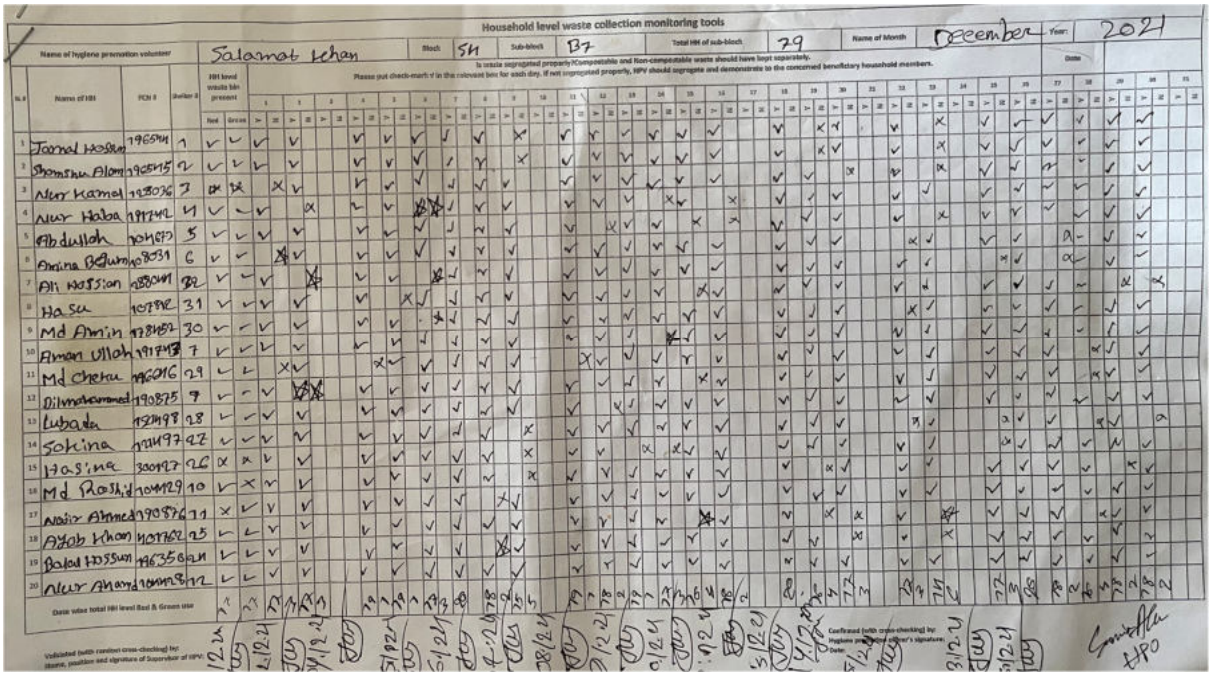


FIGURE 44 HOUSEHOLD WASTE COLLECTION MONITORING TOOL

2.5 CAMP 20 SWM SYSTEM

SHED operates a full chain SWM system in camp 20 covering 1069 out of 1615 households. It is door-to-door collection system without any intermediate storage or communal bin system. Segregated waste is collected from households and shops, afterwards, they are taken to the MRF where further segregation, weighting, composting is done. This system is operated by 6 collection volunteers, 6 HP volunteers, and 2 MRF operators. Operational logistics includes half-cut drums for organic collection, large bags or sacs for inorganic waste collection, sandbags for brown waste collection. This system does not operate any rickshaw vans, hand-trolleys, or wheelbarrows due to steep slope of the terrain condition. Collection is taken place manually. Figure 40 depicts the camp 20 SWM system of SHED.

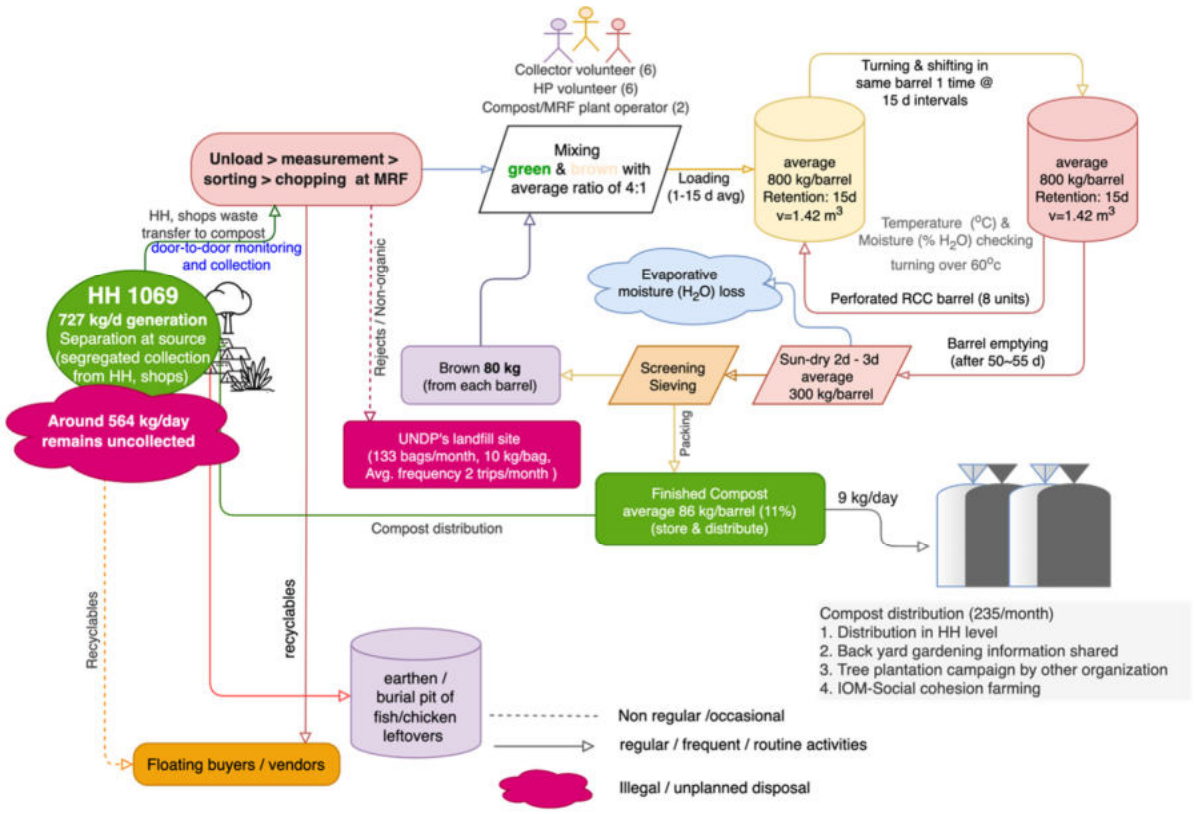


FIGURE 45: FLOW DIAGRAM SHOWING SWM AT CAMP 20

2.5.1 GENERATION OF SOLID WASTE IN CAMP 20

Generally, the wastes are being generated in households and marketplaces. The waste generation rate in camp 20 is 0.15 kg/person/day [10], and the daily total waste generation rate is 726.9 kg.

2.5.2 COLLECTION OF SOLID WASTE IN CAMP 20

The SHED team has distributed two types of waste bins to the households and shops. Blue bins are for organic waste storage and red bins for inorganic. Also, they have installed pair of waste bins (red and green) in few places in the blocks very close to the households. The residents of camp 20 store their waste in their household bins in a segregated manner. SHED WASH team follows the door-to-Door waste collection method. The community waste volunteers collect wastes from households and shops. The collection frequency is 6 days per week. Volunteers collect average 163.41 kg/day of solid wastes from every household in which 121.1 kg wastes are organic, 42.32 kg wastes are inorganic. Waste workers also collect waste from the local communal bins, but such bins are not used much, and their numbers are few (Figure 46-48). All the

[10] Officials proposed the generation rate considering previous 5 study findings e.g., 0.087, 0.11, 0.152, 0.245, 0.43 gm/capita/day of Terre des hommes (2018), SRC (2018), DSK (2018), Waste audit data (2019), NGOF (2019) respectively.

waste collectors are accompanied by HP volunteer to see the status of segregation at households at the time of door-to-door collection and keep the record. In case of mix discharge or improper segregation, volunteers instruct and rectify households to have proper sorting at household level. It is good practice which can be replicated. This system rejects collection of fish, chicken waste or left over to avoid smell in composting plant. And they are covered with soil in backyards.

FIGURE 46: BLUE AND RED COLORED BINS FROM HH

FIGURE 47: GREEN AND RED COLORED BINS FOR COMMUNITY

FIGURE 48: DOOR-TO-DOOR WASTE COLLECTION

2.5.3 WASTE TRANSPORTATION IN CAMP 20

Waste volunteers collect waste from the households and take to the segregation place at the compost plant using human carrying method (manual). HP volunteers guide and monitor the door-to-door collection to oversee segregation source, rectify households and keeping the records. They also monitor to segregated collection by collection volunteers to avoid the chances of mixing again.

2.5.4 ACTIVITIES AT MRF IN CAMP 20

Segregation

After the collection of waste and transported to the segregation place, waste workers further segregate the waste to organic and inorganic. Organic wastes are separated to green and brown waste. Inorganic wastes are separated to recyclable and residual.

FIGURE 49: WASTE SEGREGATION BY COMMUNITY WASTE VOLUNTEERS

Chopping

Segregated organic wastes are chopped manually before loading to the composting barrels (Figure 49).

Composting

Solid organic wastes are sent into the composting unit after chopping with the green and brown wastes. The green and brown wastes are mixed in 4:1

ratio. The compost plant operates the barrel composting methods (Figure 50). Every barrel has 1.42 m^3 capacity and retention day is 15 days for each barrel. After 50-55 days, barrels are emptied and sent for sun drying for 2-3 days. Each barrel can accommodate organic about 500-800 kg and generates 300 kg of raw and moist compost. Loading time for each barrel is about 15 days. SHED has 8 barrels with 2 of them are kept as factor of safety and 6 are typically used regularly. Finally, from each barrel, about 86 kg of finished compost can be obtained. Sometimes solid waste volunteers check the temperature and moisture to ensure the quality and record the data in register.

FIGURE 51: COMPOST PLANT OF SHED

FIGURE 50: PRODUCED COMPOST IN CAMP 20

Compost distribution

Compost is distributed in different ways. As for example 10 kg per person is given on master-roll basis who are willing to take and come to the camp office of SHED. HP volunteers and field facilitators provide information to the community about the compost. Many households are taking the compost from MRF and using for their household vegetable gardening.

Recycling

This system does not have recycling plant. The recyclable plastics which were segregated from the segregation unit are sold to the recycler or local vendors. Total estimated generation of recyclable amount is about 160 kg/day considering 22% as recyclable fraction. However, plant receives 19.7 kg/day (Ref. 7-days

survey result by IP & AFA). A significant number of recyclables go to floating buyers within the camp, as households like to segregate at source level.

Residual disposal

The non-recyclable and unusable waste segregated from the segregation place are taken to the landfill for final disposal. As average about 125 kg of residuals including household (22.56 kg/day), drains and streets etc. have been safely disposed per day, however, typically send to the landfill 2 trips in a month. About, 133 bags of residual waste carrying 10 kg per bag are disposed to the UNDP landfill per month

2.5.5 COMMUNITY ENGAGEMENT AND BEHAVIOR CHANGE ACTIVITIES IN CAMP 20

There are several approaches for community engagement and behavioral changes which are summarized below:

- Occasionally CIC joins session with Majhi, community leaders (e.g., imam), community groups (e.g., users' group, WASH committee block & MB level) on the topic of site management and site development including solid waste management.
- There is session / meeting on SWM including campaigns with the participation of community such as special cleaning. In special cleaning program, surrounding of households, shops etc. are cleaned with the involvement of Majhi, community leaders (e.g., imam), community groups (e.g., users' group, WASH committee block & MB level) 1 time in a month.
- HP volunteer visits door-to-door and convey messages to sensitize.
- Field visit at MB level is being done with the participation of HP volunteer, community mobilizer, H. promotion officer etc. Majhi, HH representative, MB-WASH committee members also sometimes join in field visits.
- Whistle was previously used, and it was a good signal to make community ready to discharge waste to the collectors. However, due to CIC's instruction it is stopped now.
  All the waste collectors are accompanied by HP volunteer to see the status of segregation at households at the time of door-to-door collection and keep the record. In case of mix discharge or improper segregation, volunteers instruct and rectify households to have proper sorting at household level.

2.6 SUMMARY OF FIVE SWM SYSTEMS

Among the five SWM systems operated by different implementing partners, NGOF (NRC and 6) and BRAC (1E) operate communal bin collection. On the other hand, DSK and SHED provide the door-to-door collection service in the camp 18 and 20. All implementing partners try to operate, to some extent, full-chain SWM, those are summarized in Table 5.

TABLE 5: SUMMARY OF FIVE SWM SYSTEMS

Camp	NRC	1E	6	18	20
AFA	UNHCR	UNHCR	UNICEF	IOM	IOM
IP	NGOF	BRAC	NGOF	DSK	SHED
Terrain condition (slope)	Mild slope (hilly)	Mild slope (hilly)	Mild slope (hilly)	Mild-steep (hilly)	Steep slope (hilly)
Existing HH in the camp (ref. UNHCR, 2021)	4263	8634	4998	6226	1615
HH covered SWM system	4252	3848	4941	3175	1069
Existence of SWM Plan[11]	No	No	No	No	No
Existence of SWM data	Yes	Yes	Yes	Yes	Yes
Onsite storage facility arrangement for separation of waste at sources	5440 pairs have been distributed in 2020 (all HH received 2 color bins)	All HH received 2 color bins in 2020	All HH received 2 color bins in 2020	• All HH received 2 color bins in 2021	All HH received 2 color bins in 2021
Waste collection equipment	• 24 wheelbarrows, capacity of 3.8 ft^3 • RV 2 nos, large one capacity 16 ft^3not in use	• Tricycle-van 4, capacity of 25 ft^3 • Rental dumber, capacity of 120 $ft^3$are used in need based, 15 wheelbarrow, capacity of 3.5 ft^3 • 10 L HH-paddle bins, 120 L communal bins	• Manual half cut drum (100 liter) for 22 groups • 27 Trolley (3-wheeler) are not in using much, occasionally used in accessible roads only	• Large bag/sacs for inorganic • Drum (80 liter with lid)- for organic • Sandbags, sacs for brown waste (leaf, eggshell, paper etc.)	• Large bag/sacs for inorganic • Half cut drums for organic • Bag/sacs for brown waste (leaf, eggshell, paper etc.)
Collection pattern	communal	communal	communal	door-to-door	door-to-door
Total waste generation (kg/day)	5687	2773.3	4644.5	2206.7	726.9
Total waste-collection (kg/day)	2667	1205	4005	510.12	163.41
Collection rate[12]	47%	44%	86%	23%	22%

[11] SWM Plan contains future direction of SWM with targets to achieve, resource requirement etc.

[12] Collection rate (%) = collection (kg/day) * 100/generation(kg/day), Collection per day is provided by the IPs as rough estimation. Not all the IPs measure all their daily collected waste.

Camp	NRC	1E	6	18	20
Uncollected (kg/day)	3020	1568	640	1697	563
Uncollected fraction, %	53%	57%	14%	77%	78%
Waste managed in MRF (kg/day)	424.0	282.9	3144	510.12	163.41
Organic generated in covered areas (kg/day)[13]	2,980.0	1,664.0	1,858.0	1,544.7	508.8
Organic composted (kg/day)	298	166	472	428.6	121.1
Inorganic (recyclable + residual) (kg/day) (collected)	7,359.0	482.0	3,324.0	81.56	42.31
Compost production (kg/day)	39	29	80	20	9
Compost production[14], %	13%	17%	17%	5%	7%
Method of composting	Chamber & barrel (no turning)	Windrow	Box,	Shifting chamber, semi-mechanized chopping	Barrel (with turning), manual chopping
Residual production (kg/day)	1285	693	1626	397	131
Total residual safely disposed (kg/day) (household, drain cleaning, market, etc.)	6428	102	2243	242	125
Recyclable produced (kg/day)	1422	416	1161	487	160
Recyclable processed (kg/day)	120	14.73	1081	25.8	19.7
Recyclable processed at MRF, %	8%	4%	-	5%	12%
MRF & facility information	• 1 composting unit (3 chambers, 20m^3 each), • 5 onsite barrel composting (1.2m^3 each), • 1 under-construction composting expected to commission in	• Compost plant with segregation unit 1 with landfill (crude dumping) capacity of 212.38 m^3 have 3 chambers (3@34'x18'4') • Each chamber has 4 compost beds (total 12 beds@18'x8'x4'), • 1 sorting chamber 22'x11' • 1 recycling chamber 10'x15'x6', • 1 inert chamber 5'x8'x4'. • Total facility area around 70'x53'.	• MRF 3 (compost 3+segregation unit3), • Area of each MRF: 112 m^2 (2019-2, 2020-1)	• MRF 1 (compost segregation unit), • Semi mechanical chopping (40 sec/2.5 kg, cutting & mixing)	• MRF 1 (compost segregation unit),

[13] Typically, organic fraction is 60% based on different studies have been shown to IPs so that organic generation is estimated. However, different IPs have proposed different organic fractions based on their experience of handling the waste which is sometimes lower than 60%

[14] Compost production % is estimation of mass reduction and final mass remained as compost. Estimated as = (Finished compost found) *(100)/ (organic composted)

Camp	NRC	1E	6	18	20
	Feb/Mar 2022, capacity will cover H, I block	• Manual chopping, compost & recyclables storage facility etc.			
Plastic Recycling Facility	No plastic recycling facility	No plastic recycling facility	• 1 plastic facility (outside of camp for 6 and 7) • Cleaning, Drying, molding facility	No plastic recycling facility	No plastic recycling facility
Temporary disposal sites	2 (H, C)	No but adjacent the plant (MRF premise) waste is stored (accumulated) to be segregated and composted	2 (each 6.8 ton, each area 56 m^2), 2018 constructed	0	0
Usage of Landfill site of UNDP	No (LFS is too far)	Yes	Yes	Yes	Yes
Recovery of recyclable materials by the systems	• In last 2.5 months total 137 kg colored bottle @6 Tk/kg • 76 kg clear bottle @2.5 TK/kg were sold • Recyclable collected 120 kg/day	• Volunteers enjoy the benefits as incentive only for plastics. Recyclable collected 14.73 kg/day • Compost is not sold but distributed among interested entities like CIC office, other project plantation campaigns (take data from recyclable, compost)	• Recyclables are stolen mostly • Value recovery priority is not felt by the IP officials • Recyclable collected 1081 kg/day	• No monetary information is maintained due to distributing compost and recyclables as free • Recyclable collected 25.8kg/day	• No monetary information is maintained due to distributing compost and recyclables as free • Recyclable collected 19.7 kg/day
HP volunteer number	23	24	53	30	6
Allocation HH/HP Volunteers	185	160	93	106	178
% HP volunteers' contribution on SWM[15] (assumed by IPs)	30%	15%	5%	15%	15%
Waste collection volunteer	21	15	29	14	6
Collection (Kg)/collection volunteer / day	127	80	138	36	27

[15] % HP volunteers' contribution towards SWM is assumed based on average each HP how much time they spend for SWM messaging, communication, SMW monitoring and so on activities.

Camp	NRC	1E	6	18	20
Allocation of waste volunteers/100 HH	0.49	0.39	0.59	0.44	0.56
HH coverage / Collection volunteer*	202	257	170	227	178
MRF operator	4	9	12	2+1	2
HH coverage / MRF operator*	1,063	428	412	1,058	535
Working days / week	5	6	5	6	6

Note. HH: Household, RV: Rickshaw Van, cft: cubic feet, *as per allocation

CHAPTER 3: ANALYSIS OF EFFECTIVENESS OF DIFFERENT SWM SYSTEMS

This chapter provides analyses of effectiveness of the five SWM systems providing services to the Rohingya Refugee camps. The chapter covers eight (8) distinct points: (1) coverage of the MRF, (2) determination of waste quantities, (3) effectiveness of waste segregation at source, or secondary segregation at MRF, (4) effectiveness of the behavior change / community engagement activities, (5) acceptance of produced compost by the recipients/users, (6) general cleanliness of the respective camps/blocks, (7) analysis of health and safety measures, and (8) analysis of the management of the environmental hazards and risks related to the SWM.

3.1 COVERAGE OF THE MRF

All five SWM systems have their own Material Recovery Facilities (MRF). Most of them cover all the households living in the respective camps. The MRF also covers the markets, shops, and restaurants most of the time. The following table provides the information on the coverage of MRF on HHs and Shops for the respective camps (Table 6).

TABLE 6: INFORMATION ON THE COVERAGE OF MRFS

Camp	NRC	1E	6	18	20
Total HH covered by collection system	4252	3848	4941	3175	1069
Coverage	100%	A, B, C 100% (D, E, F, G not targeted)	all, full 100%	A100%, B30%, C70%, D50%, E0%	Out of 21 sub blocks, 7 is done by Save the Children
Total population (served)	22,748	17,778	23,223	14,711	4,846
Markets, shops, and restaurant coverage status	Communal bins are provided in the marks and shops areas, and special cleaning cover the all-neighborhood cleaning. After communal bin collection, collection volunteers work on general drain and space cleaning			Bins are provided to the shops and households. First volunteers collect waste from the point of generation afterwards they work on drain and other place cleaning.	
Markets, shops, and restaurants' waste categories	chips/cookie/snack wrapping packs found typically, 2 times collection per week (2/7), bins found mostly in shops	chips/cookie/snack wrapping packs found typically, 6/7 collection, bins found mostly	chips/cookie/snack wrapping packs found typically, 5/7 collection, bins found mostly	chips/cookie/snack wrapping packs occasionally, 6/7 collection, bins found mostly	chips/cookie/snack wrapping packs found occasionally, 6/7 collection, bins found mostly

Note. HH: Household. 2/7, 6/7, 5/7 are collection frequencies from communal bins or doorsteps as times in a week.

3.2 DETERMINATION OF WASTE QUANTITIES

In these five systems, variation is observed between waste collection and waste processing. In one system, the processing of recyclables fulfills the expectation (Table 7). The highest collection rate is found in communal system of camp 6 which is highest number of labor allocation per 100 household for waste collection. On the other hand, it has found that where the labor efficiency (i.e., collection as kg/collection volunteer) is high, overall collection efficiency or collection rate of the system also high.

The lower the allocation or assigned jobs, the higher the efficiency in terms of achievement of the assigned work. System of camp 6, shows the lowest allocation of household waste to be collected per collection volunteer per day, it is 170 households/collection volunteer (Table 5). This system shows the coverage of household against each plant operator is less than any other systems, so recycling rate is higher. In addition, this system has a plastic recycling unit which triggers recycling materials flow to the plant. These figures can be good indicators for performance benchmarking that allocation of jobs should not be too small or too high when comparison is made with other system. Rationalization can be made by further time and motion study to optimize human resource deployment. System of camp 6 operate 3 MRF spread in different blocks while others operate one in their respective areas. This can be a reason for higher collection due to quick access to the nearby MRF.

TABLE 7: DETERMINATION OF WASTE QUANTITIES IN THE RESPECTIVE MRFS.

Waste quantity parameters	NRC	1E	6	18	20
Total **collection** vs expected production/day by MRF area[16]	47%	43%	86%	23%	22%
Total **organic** composted[17] vs produced per day by MRF area	10%	10%	25%	28%	24%
Total **recyclable**** processed vs produced per day by MRF area	8%	4%	93%	5%	12%
Total **residual** processed[18] vs produced per day by MRF area	9%	15%	138%*	61%	95%

Note.
*Data shows over 100% due to a significant amount of drain cleaning waste as residual. This cannot be estimated using generation rate as it is especial waste.
**Recyclables sold by households or out of collection stream is not managed by any MRF,

3.3 STATUS OF WASTE SEGREGATION

The status has been assessed in different viewpoints such as effectiveness on HH participation, effectiveness based on separate bin used or not. Also, the effectiveness for the segregated collection in the respective camps is also determined (Table 8). Though at household level a significant proportion of segregation observed but, at communal bins nearly mix discharged observed in most of the cases. Consequently, a MRF operators have make huge efforts to further segregate them. In the system of NRC, not all the collected waste is destined to MRF, and a significant proportion is discharged as mix waste in their disposal. To overcome this problem, NFOG is making additional MRF to cope the pressure of huge amount of waste, that is shown in Figure 6 as SWM system flow diagram.

TABLE 8: STATUS OF SEGREGATION

Camp	NRC	1E	6	18	20
Existence of 2 bins (observational data)	45%	30%	40%	63%	48%
Existence of 1 bin (observational data)	51%	48%	40%	37%	49%
Existence of no bins (observational data)	4%	22%	20%	0%	3%

[16] Waste collection rate= % of collection (kg/day) / generation of waste (kg/day)
[17] Organic processed in MRF =% of organic (collected, segregated, and put in compost heap)/organic generated
[18] Residual processed = residual stored and disposed properly (UNDP Landfill site, controlled deposal, and temporary disposal)

Camp	NRC	1E	6	18	20
Segregation in flow path	Nearly mix collection and transport and disposal at MRF and disposal site	Nearly mix collection and transport and disposal at MRF	Nearly segregated collection, segregated discharge at MRF		
Effectiveness of segregation at MRF (qualitative)[19]	All the wastes are not coming to MRF. But whatever comes segregated into, organic, inorganic, and residual categories	A significant portion of collected waste remains unmanaged and accumulated in MRF premise. They keep for drying in mix condition.	All the collected waste are segregated into organic and in-organic categories. There are 9 storage boxes for recyclables (inorganic)	All are segregated in green, brown, and inorganic and residual categories, 100% segregation made at MRF	
Total effectiveness of segregation at MRF[20]	16%	23%	79%	100%	100%

Note: Recyclable inorganics are also organic polymers and different plastics, many other recyclables materials

From the household observations, maximum rate (63%) of existence of two bins at household level is found in camp 18 (door-to-door system) and minimum (30%) found in camp 1E (communal system) (Figure 52). It is to be noted that 'no bin' or 'one bin' does not mean the HHs do not store waste or segregate waste. This fact is strengthened by an underlying situation that many households use plastic bags, one-time sacs etc. as an alternative of supplied bins for waste storage and discharge.

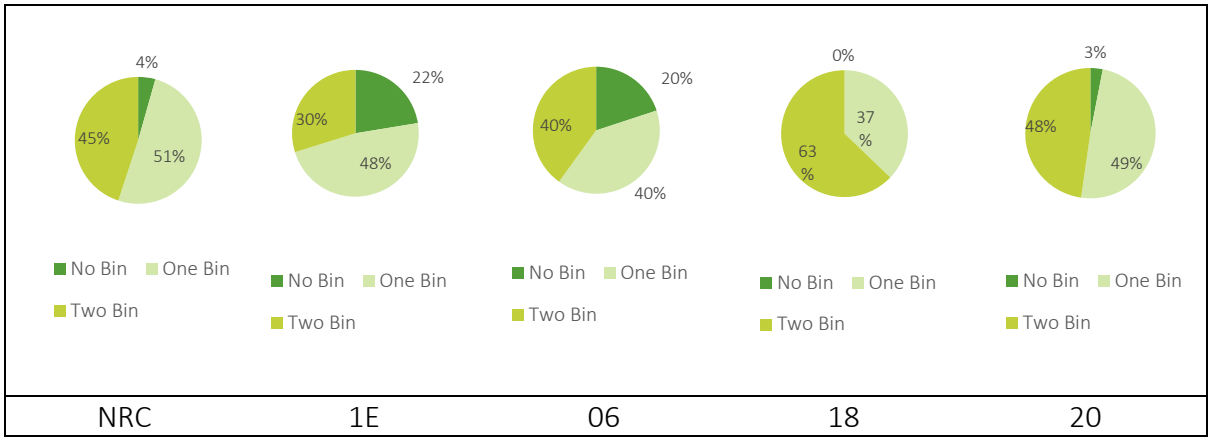


FIGURE 52: NUMBER OF BINS USED IN HH OF DIFFERENT CAMPS

Maximum percentage (99%) of households (i.e., who reported they segregate of waste at sources[21]) is found in camp 18 and minimum (57%) is reported for camp 1E (Figure 53)[22].

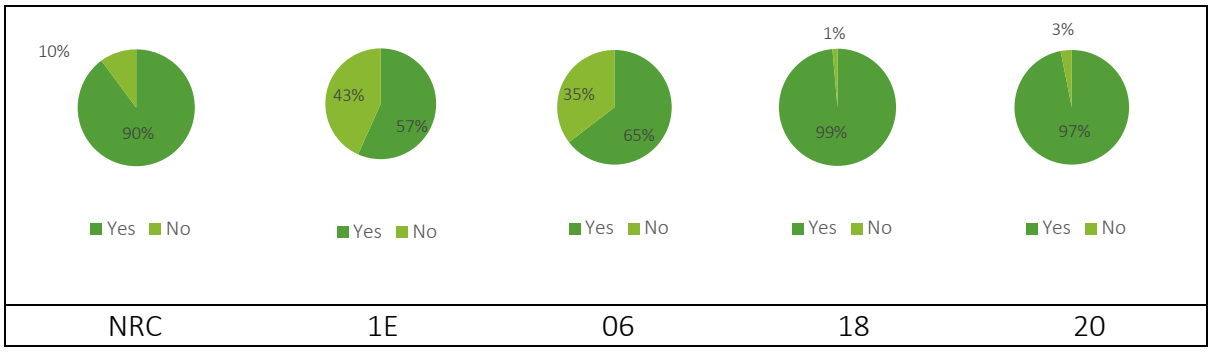


FIGURE 53: THE PERCENTAGE OF HOUSEHOLDS WHO SEGREGATE WASTES AT SOURCE

[19] Effective of segregation at MRF means how much of the waste of whatever amount is brought to the MRF is segregated by MRF operators
[20] Total effectiveness = waste amount managed in MRF (kg/day)/total amount of waste collected (kg/day)
[21] This figure may not match with actual situation as enumerators found mix discharges in communal bins, pits and MRFs and disposal sites.
[22] It was not possible to make it observational and evaluate the actual situation since at the time of surveys, waste collection was going on and empty households' bins were found. However, it is to be considered as limitation of the study as it could not recognize in field test.

3.4 EFFECTIVENESS OF THE BEHAVIOR CHANGE / COMMUNITY ENGAGEMENT ACTIVITIES

In two aspects effectiveness have been considered one is perception (e.g., conceptualization and convincing to the subject matter), and another is how to embody (e.g., changed behavior.) them in daily life as SWM practices. The perception is assumed as positivity rate as results of various BCC/Community engagement activities. The positivity rates have been determined by the responses of the respondents who received or came across some sort of efforts like awareness raising, behavioral change, and community engagement by any type of orientation: training, campaign, and IEC, BCC materials etc. (Table 9).

TABLE 9: POSITIVITY RATE OF THE RESPONDENTS WHO TOOK ANY KIND OF ORIENTATION AND TRAINING

Camp	NRC	1E	06	18	20
Do you use any waste bin/baskets at home for waste storage? (% of Y)	92%	100%	82%	100%	97%
Please, mention the color of the bins and what it represents? (% of C)	69%	57%	36%	98%	80%
Do you segregate waste based on the color? (% of Y)	85%	100%	91%	100%	97%
Do you know full-chain SWM from generation to onwards until composting, recycling etc. in camp? (% of Y)	46%	0%	18%	71%	80%
Do you throw waste in drains? (% of N)	96%	100%	100%	98%	100%
Do you throw waste in canals? (% of N)	96%	100%	100%	100%	100%
Do you throw waste in open water bodies? (% of N)	96%	86%	100%	100%	100%
Do you dispose waste at designated places? (% of Y)	65%	71%	36%	86%	70%
Do you know unmanaged waste can provide negative impacts on health and environment? (% of Y)	85%	71%	55%	83%	90%
Do you have any idea about waste avoidance? (% of Y)	31%	0%	18%	73%	53%
Do you have any idea about waste reduction? (% of Y)	23%	0%	27%	65%	50%
Do you have any idea about waste Reuse? (% of Y)	15%	0%	0%	67%	37%
Do you have any idea about waste recycle? (% of Y)	15%	0%	9%	67%	43%
Do you know about Materials Recovery Facility (MRF)? (% of Y)	12%	0%	0%	40%	30%
Do you know about Organic Compost? (% of Y)	23%	0%	18%	67%	77%

Note. Y: answered Yes, N: answered No, C: answered Correctly

At the household survey, dwellers of the respective camps were asked about receiving orientation on segregation from the NGOs. Maximum respondents of camp NRC agreed about receiving orientation while minimum percentage is reported for camp 1E (Figure 54). This result may support the observations of existence of two bins as found maximum camp 18 and reported maximum percentage of segregating households.

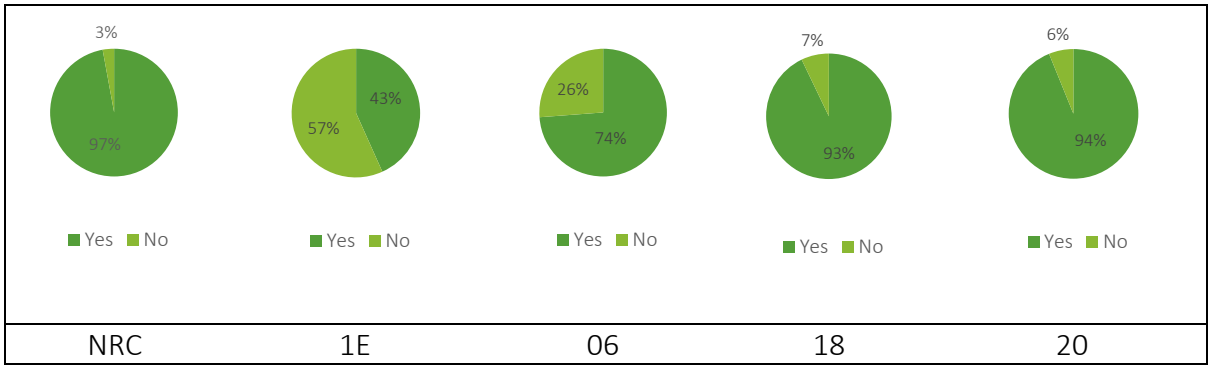


FIGURE 54: HOUSEHOLDS OF THE RESPECTIVE CAMPS WHO RECEIVED ORIENTATION ON SEGREGATION

3.5 ACCEPTANCE OF PRODUCED COMPOST

IPs (e.g., WASH Team) distribute the compost based on the demand. According to survey, the acceptance of compost among the residents of the respective camps are summarized in Table 10.

TABLE 10: TABLE SHOWING THE ACCEPTANCE OF PRODUCED COMPOST

Camp	NRC	1E	6	18	20
Compost acceptance information (field visit, meeting data)	• CIC is taking for own gardening, • NGOF gardening, • Community also collects in small quantity for home-front, back gardening, • Compost quality was checked in 2021 from lab	• Used in home-front, back gardening in camps but individual level distribution is not started yet. • Several organizations collect e.g., agriculture team, site management, CIC office, they are willing to accept more • Last 2 years many organizations have received compost	• Home-front, back gardening	• Transition and Recover department of social cohesion project took 2496 kg • CICs took around 380 kg in several times • site development, site management, and visitors take the compost	• CIC is taking for own gardening, • NGOF gardening • Community also collects in small quantity for home-front, back gardening, • Compost quality was checked in 2021 from lab
HH know about Compost	45%	25%	38%	71%	72%
Compost used by HH	30%	31%	46%	53%	62%
HH willingness to use compost	33%	39%	48%	64%	70%

Note. CIC: Camp in Charge, HH: Household

The proportion of compost users are not same in all study camps. Maximum percentage (62%) for compost users found in camp 20 and minimum (30%) found in camp NRC (Figure 55). Also, in NRC, camp 1E and camp 6, willingness to use the compost are found less than 50%. It might be partially a reason that the dwellers of these camps didn't have the idea (i.e., ≤ 45% know about compost) about compost and they might not have received the orientations on the use of compost (Table 10). On the other hand, who participated IEC/BCC efforts, their rate of understanding on compost as reported is high (>65%) in door-to-door systems compared with communal systems (<25%) (Table 9).

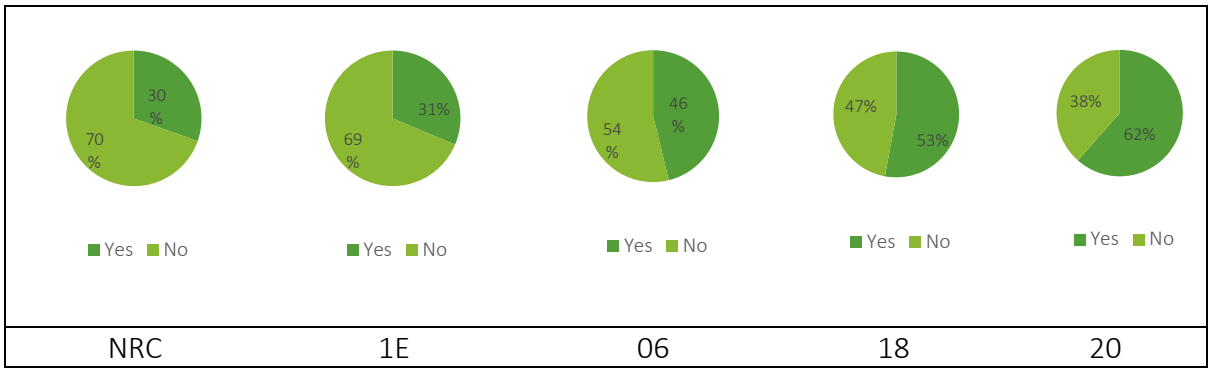


FIGURE 55: THE PERCENTAGE OF HOUSEHOLDS WHO ARE USING PRODUCED COMPOST

Only systems operated in NRC and camp 1E made laboratory test for the compost quality checking. Table 11 shows, the test results with the reference value of the government standards. There are about 24 quality parameters to be checked in terms of physical, chemical, and microbial constituents. Nearly all the parameters meet the quality set be government except moisture and phosphorus content. Phosphorus is one of the important nutrients of soil for the plants. Some of the food or vegetable waste has very high level of phosphorus naturally, and can be added to compost heap, as for examples, banana peels, shells of crab,

peels of shrimp, most grains, and nuts. On the other hand, waste meats, poultry, eggs, and dairy products are enriched with phosphorus, but it can be avoided.

TABLE 11: COMPOST TEST INFORMATION[23] WITH GOVERNMENT STANDARDS IN NRC AND CAMP 1E

Sr	Agency Location	NGOF NRC	BRAC Camp 1E	Government Standard[24]
1	As (ppm, dry wt basis)	2.617	2.602	
2	Cd (ppm, dry wt basis)	1.087	1.836	Maximum 5 ppm
3	Cr (ppm, dry wt basis)	20.139	27.021	Maximum 50 ppm
4	Cu (% dry wt)	0.002	0.002	Maximum 0.05%
5	K (% dry wt)	1.277	0.298	0.5-3.0%
6	Zn (% dry wt)	0.042	0.013	Maximum of 0.1%
7	Pb (ppm, dry wt basis)	12.433	16.056	Maximum 30 ppm
8	***Phosphorous (% dry wt)***	***0.295***	***0.122***	***0.5-3.0%***
9	Total nitrogen (% dry wt)	1.781	0.751	0.5-4.0%
10	pH (in 1:2.5 w/v water)	7.89	7.5	6.0-8.5
11	pH (in 1:10 w/v 0.01M $CaCl_2$)	7.47	7.2	-
12	***Moisture (% w/w)***	***48.49***	***25.29***	***Maximum 20%***
13	Total solids (% w/w)	51.51	74.71	-
14	Volatile solids (% w/w)	15.07	8.8	-
15	Fixed solids (% w/w)	36.44	65.9	-
16	E. coli (CFU/gm)	0	0	-
17	Helminth (Eggs/gm)	0	0	-
18	Organic Carbon	-	-	10-25%
19	Sulphur, S	-	-	0.1-0.5%
20	Nickel, Ni	-	-	Maximum 30 ppm
21	Color	-	-	Dark brown to black
22	Physical Condition	-	-	Non-granular form
23	Odor	-	-	Absence of foul odor
24	Inert Materials	-	-	Maximum 1%

Note. As: Arsenic, Cd: Cadmium, Cr: Chromium, Cu: Copper, K: Potassium, Zn: Zinc, Pb: Lead, ppm: parts per million, wt: weight, cfu/gm: colony forming unit/gram, w/v: weight/volume, ***Bold & italic*** components are not satisfying government standards.

3.6 GENERAL CLEANLINESS OF THE RESPECTIVE CAMPS/BLOCKS

The surrounding cleanliness condition for the respective camps have been determined through a field survey. The team of about 10 members (e.g., the enumerators, facilitators, surveyors) has followed transect walk method, took photographs, and looked around different roads and narrow streets. At the time of household survey, team has also looked the surrounding cleanliness. Surrounding cleanliness or general cleanliness are assessed in following viewpoints: (1) Household surrounding condition, (2) Shops surrounding condition, (3) Waste in the drains, (4) Scattering of waste around the community, (5) Left-over or accumulated waste in communal bins, (6) Left-over / accumulation in communal pits.

Members, who visited the study areas for at least 2 consecutive days for surveys, have given their ranking score on the general cleanliness for different viewpoints. Here, value '3' was assumed as *Very dirty / unclean (not satisfactory)*, value '2' assumed for *moderately clean (poorly satisfactory*, and value '1' for *apparently clean (Satisfactory)* (Table 12). According to this assumptions and ranking exercises, systems of camp 18 and 20 facilitate the cleanest areas among the studied systems as shown in Table 12.

However, though the camp 20 scored very high, but theoretical calculation from the data of baseline from IP & AFA shows, a significant amount of waste is remained uncollected (Figure 40).

[23] Compost laboratory test results are provided by UNHCR, CXB office
[24] Bangladesh Solid Waste Management Rules, 2021, Department of Environment, Ministry of Environment, Forest, and Climate Change, Government of Bangladesh

TABLE 12: GENERAL CLEANLINESS OF THE STUDIED CAMPS

Means of observations	Transect walk, Photograph, looking around while surveying households				
Means of verifications	Ranking is given based on voting of the enumerators and				
Observational indicators	NGOF (NRC)	BRAC (1E)	NGOF (6)	DSK (18)	SHED (20)
Household surrounding condition	2	3	2	2	1
Shops surrounding condition	2	3	2	2	1
Waste in the drains	2	3	2	2	1
Scattering of waste around the community	2	3	2	2	1
Left over / accumulation in communal Bins	-	3	2	-	-
Left over / accumulation in communal Pits	2	3	-	-	-
Overall observational benchmark indicators (lower the score, higher the cleanliness)	10	18	10	8	4

Note. This ranking is group work of team members, effort has been given to avoid personal biases, it may not be error free, but it can provide an overall picture roughly.

3.7 ANALYSIS OF HEALTH AND SAFETY MEASURES

All the NGO have taken initiatives for ensuring health safety by providing PPE and first aid boxes. The frequency of distribution of masks, gumboots, apron/vest, hand gloves are found sufficient. One system provides regular consumable health safety items every two weeks, while others provide whenever needed. Health and safety measures are summarized in Table 13.

TABLE 13: HEALTH AND SAFETY MEASURES TAKEN BY IMPLEMENTING PARTNERS

Items	NRC	1E	6	18	20
Gumboot	2 times/year/volunteer (i.e., 1 pair in six month)				
Gloves	2 times/year/V	2 pairs/year/V	2 pairs/month/V	6 pairs/3 months/V	2 pair/3 months/V
Masks	> 1pc/month/V	2 pc/month/V	1 pc/week/V	6 pc/3 months/V	6 pc/3 months/V
Apron or vest	2 times/year/volunteer				
First aid box[25]	Located at camp office regular fillings whenever need of primary healthcare items				Located at MRF, Regular filling
Sanitizer, soap, hygiene kit	More than 3 times/year/v				

Note. V: Volunteer, pc: piece, times: frequency

3.8 ANALYSIS OF THE MANAGEMENT OF THE ENVIRONMENTAL HAZARDS AND RISKS

Work environment, environmental conditions, occupational health, and safety issues are checked with pre-developed 17 indicators. Risk indicators are scored in three risk levels such as high (where the risk factor typically exists), moderate (where the risk factor is occasionally found) and invisible (where specific risk factor could not found or observed typically). They are scored based on the onsite observational assumptions. Findings are summarized in Table 14.

There are environmental and occupational health risks which need urgent attentions and precautions to be established as immediately as possible. Some of them are listed below as example:

[25] First aid box items are Hexisol, pain killer, bandage, burning ointment. Camp 1E system has pressure checking, sugar checking kits, several emergency medicines.

(1) MRF operated in camp 1E needs immediate removing of waste pile. It is highly likely to sliding down the whole mass of waste into the plant where several operators work regularly. This problem's probability will be intensified if monsoon starts.
(2) There is no fire extinguisher in any MRF, though risk of fire hazard always exists in combustible waste and methane gas formed in compost plant unless turning is ensured regularly. MRF zones to be declared as smoking free.
(3) There is no water connection in any of the MRF. To ensure the quality of compost, workers' occupational safety, protection against fire, water connection is evitable. Though MRFs are claimed to be equipped with hand washing devices, some cases hand washing devices are non-functional or absent.
(4) Existence of waste in drains are found in communal collection system. Such incidents typically not found door-to-door system. However, it is not only related collection system but also number of households, amount of waste generated, number of volunteers deployed, spread and number of communal bins etc. are related.
(5) Most of the drains and canals have non-biodegradable waste like plastics. This reduces water carrying capacity of the canal and hampers flow of water. Stagnant water is breeding ground of mosquitos. Downstream receiving water bodies are inundated with waste plastics, an alarming news from environmental journalists in different national TV channels. Authorities should work out plastic pollution minimization by stopping the leaching of waste. It can only be achieved if 100 % collection is ensured and brought to the collection and management stream.

TABLE 14: TABLE SHOWING ASSESSMENT OF ENVIRONMENTAL HAZARD IN THE RESPECTIVE CAMPS

	Env. Hazard and Risk Indicators	NGOF (NRC)	BRAC (1E)	NGOF (6)	DSK (18)	SHED (20)
1	Absence of Water Connection in MRF facility					
2	Absence of Handwashing facilities in facilities					
3	Lack of safety gears					
4	Lack of First Aid Box in MRF					
5	Lack of First Aid Box in office					
6	Scattering / uncollected of waste					
7	Unclean communal bins					
8	Brocken communal bins					
9	Left over/uncollected waste communal bin more than 2 days					
10	Left over/uncollected waste communal pit more than 2 days					
11	Water enters in communal pit/bin/muddy waste in rainy season					
12	Disposal of waste in drains					
13	Down stream drains chocked with waste and cultivated land inundated with plastic rich waste					
14	Prone to growth of desieas vector					
15	Waste slide / land slide in facility					
16	Absence of fire extinguisher					
17	Risk due to steepness of slope of collection route/street					

Qualitative risk benchmarking	Degree of risk	Interpretation
Risk level (observational assumption)	High	Typically exist
Risk level (observational assumption)	Moderate	Occasional found
Risk level (observational assumption)	Invisible	Not found

Note. This ranking is group work of team members, effort has been given to avoid personal biases, it may not be error free, but it can provide an overall picture roughly.

CHAPTER 4: ANALYSIS OF EFFICIENCY AND COSTS OF DIFFERENT SWM SYSTEMS

This chapter gives an overview of the efficiency of the five SWM systems and provide information about the costs of them. The chapter also describes the information on waste volunteers of five systems (Table 15), different costs information such as costs of MRF operation and waste collection, transportation, and costs of waste collector volunteers. The chapter will also cover the costs of segregating waste, transportation to landfill, costs of behavior change and monitoring the SWM system.

TABLE 15 CAMP WISE VOLUNTEERS NUMBER AND PRO-RATE SALARY IN BDT

Volunteers' information	NRC	1E	6	18	20
Number of HP volunteers	23	24	53	30	6
Number of waste collection volunteers	21	15	29	14	6
Percentage of HP volunteers work contributing SWM[26]	30%	15%	5%	15%	15%
Number of plant operators	4	9	12	2+1	2
Workdays per week	5	6	5	6	6
Salary of HP volunteer per day (TK/day)	480	404	250	308	277
Salary of Waste volunteer, plant operators per day (average) (Tk/day)	400	337	250	250	277

Note. figures are approximated from interview and data shared by IPs, HP: hygiene promotion

4.1 VOLUNTEERS' EFFICIENCY

The labor (i.e., volunteers) productivities have been seen in various angles, as for example, average coverage number of households by each collection volunteers (as per allocation), waste amount managed by each volunteer etc. The allocation of the number of waste collection volunteers, MRF operators and HP volunteers are different in different systems. Waste collection frequencies are not same in all studied systems or camps. Several prevailing efficiency indicators are shown in the Table 16 for the 5 studied camps.

TABLE 16: TABLE SHOWING THE INFORMATION ABOUT THE WASTE COLLECTOR VOLUNTEERS OF FIVE CAMPS

Efficiency indicators as per allocation	NRC	1E	6	18	20
HH covered /collection volunteer	202	257	170	227	178
HH covered/HP volunteer	185	160	93	106	178
HH covered / Any volunteer (including HP & collection)	97	99	60	72	76
Collection volunteer/100 HH covered	5	7	3	7	17
Frequency of collection per week (not all HH covered)	2	6	5	6	6
Working days per week	5	6	5	6	6
Kg of collection/collection volunteer/day	127.0	80.3	138.1	36.4	27.2
Kg of managed in MRF/volunteer/day	106	31.4	262.0	170.0	81.7

Note. HP: Hygiene Promotion

Due to more travel time, travel length, many collection points in door-to-door systems, the collection amount is much lower per volunteer per day than communal system. In communal systems, volunteers get accumulated mass of waste at communal collection points (e.g., communal bins, pits). Therefore, collection mass of waste per volunteer per day is higher in communal system than door-to-door system.

Number of MRF operators allocated, waste amount coming to MRF, waste managed at MRF are not same in all the systems. The system of camp 1E shows the lowest efficiency due to higher allocation of labors compared with amount of waste they segregate and load in waste heap. This system also does not manage all its daily collected waste at MRF. They keep for drying for some days.

4.2 COLLECTION COST

[26] It is the fraction of time HP volunteers spent on SWM related BCC, monitoring etc. activities (assumed as proxy estimator to quantify cost)

Among the five camps, households of camp 18 and 20 get the door-to-door waste collection service and other camps get the communal bin or pit collection service (Table 17). The operating collection cost for 100 households/day ranges from 110 taka to 198 taka. However, the average costs for waste collection from 100 households for door-to-door and communal systems are 133 and 158 respectively. It seems there is not significant difference between the average operating cost of collection from 100 households of two systems. Though door-to-door is apparently more labor-intensive collection service, but it is not more expensive apparently. However, this figure alone cannot give complete picture unless amount of waste managed by each volunteer is compared. In such viewpoint, operating cost for door-to-door is cheaper, but efficiency or labor productivity is lower than other systems.

Only cost data can give overall preference of a system. Both systems have different merits and demerits. The advantage of door-to-door collection is generators do not need to go somewhere to dispose their waste and collectors collect from doorsteps. However, its disadvantage is, collection volunteers need to visit each household. On the other hand, in communal collection, travel time to each household is saved and collection volunteers get accumulated waste for more than 10 households at one spot. In communal collection, each household should bring their waste to the nearby communal bins or pits in segregated manner which sometimes problematic for women or children, especially in rainy seasons, and this problem is intensified if the roads are unpaved and slippery in rainy days.

TABLE 17: COLLECTION COST PER 100 HH/ DAY (IN BDT)

Camp	NRC	1E	6	18	20
Collection Cost per 100 HH/day*	198	131	147	110	155
Average collection cost per 100 HH/day*			158		133
Type of collection	communal	communal	communal	household (door-to-door)	household (door-to-door)

Note. *This cost is allocation cost, and cost of cleaning street, drains etc. are inclusive, Fractional figures are rounded up, collection cost is estimated based on the operating allocation cost of waste collection volunteers.

4.3 COST OF OPERATING MRF

Every camp has their own Material Recover Facility (MRF), and their costs are different. Camp 1E system spends more than any other camps on MRF operation per month (Table 18). The approximate average cost for per ton waste managed in MRF ranges from 954 to 10,706 Taka. This cost varies with the changes of number of plant operators and the amount of waste managed in the MRF. There are no significant differences among the MRF operation costs including collection phase cost. However, it is to be noted that even though system of 1E cannot manage its all collected waste in MRF but shows the most expensive operation. It might be because of the labors' allocation is high with lower productivity. There are 12 plant operators in 1E.

TABLE 18: MRF OPERATING COST AT FIVE CAMPS (IN BDT)

Camp	NRC	1E	6	18	20
MRF operation cost (TK/Month)[27]	35,200	78,750	66,000	19,500	14,400
MRF operation cost (TK/ton/day)[28]	3,960	10,706	954	1,470	3,389
MRF operation cost (TK/ton/day/operator)[29]	990	1190	80	490	1695
MRF operation cost with collection (TK/100 HH/day)[30]	5,174	5,457	4,564	3,480	5,388
MRF operation cost per (TK/100HH) without collection[31]	828	2,047	1,336	614	1,347

Note. MRF operation costs are for processing, segregating, chopping, composting etc., but not collection cost. HH: Household

4.4 COST OF FINAL DISPOSAL

[27] Operation cost has been determined considering only the operators' numbers and their salaries
[28] It is calculated as (operator salary rate*operators' number*1000)/ (kg of waste managed in MRF)
[29] It is calculated as (operator salary rate*operators' number*1000)/ (kg of waste managed in MRF)/(total plant operator)
[30] Calculated as 100*{volunteers salary rate*(collection volunteers + operator volunteers)/ (coverage HH)}
[31] Calculated as 100*{volunteers salary rate*(operator volunteers)/ (coverage HH)}

Cost information for the disposal to the landfill or temporary site is shown in the Table 19.

TABLE 19: COST OF FINAL DISPOSAL OF NON-RECYCLABLE WASTES

Camp	NRC	1E	6	18	20
Cost of transporting to Landfill/final disposal	Have own landfill site*	UNDP Landfill free of charge			
Cost of final disposal operation	Have own landfill site*	UNDP Landfill free of charge			

Note. Cost of transportation to the own or UNDP landfill site could not secure. *Own landfill is apparently temporary disposal facility of NRC

4.5 COSTS OF BEHAVIOR CHANGE CAMPAIGNS/MATERIALS FOR THE COMMUNITY

The IPs organize campaigns for creating awareness on improving SWM systems and hygiene promotion on regular basis for their respective camps. Their costing amounts are different. Some IPs expenses for these campaigns depend on the hygiene promotion volunteers salary and numbers, and other allocates variable funds for various campaigns (Table 20). The operating BCC cost[23] for system in camp 6 shows the lowest. However, it has the highest number of HP volunteers (53), while the others have equal or less than 30 number of HP volunteers. On the other hand, on an average HP volunteers spend about 15% of their working effort for SWM but IPs of camps 6 system, assumed only 5%. If the assumption could be made like other systems, BCC cost would be 42 TK/HH/day in camp 6. Another way of thinking, the allocation efficiency of HP volunteers in camp 6 is much lower (i.e., 92 HH/HP volunteer), in terms of HH allocated/volunteer than other 4 systems (i.e., average is 157 HH/HP volunteer).

TABLE 20: COSTS OF IEC/BCC ACTIVITIES IN BDT

Camp	NRC	1E	6	18	20
Cost IEC/BCC material cost	Banner for cleaning 2000, Leaflet 7 TK/pc, distributed 4 times every household in past 1 year	• Special cleaning campaign is organized 1 time/2 months typically where budget 25,000 TK/time is fixed • Additional cleaning with the engagement of community's ultimate objective is creating mass awareness. Additional volunteers are mobilized in special cleaning campaigns.	-	• Signboard of 1400 TK, compost process displays board 500 TK	-
% HP volunteers spend on SWM (assumed by IPs)	30%	15%	5%	15%	15%
BCC cost[32] (TK/100 HH/day)	78	38	14*	44	24

Note. BCC: Behavior Change Communication, HP: Hygiene Promotion, IEC: Information, Education and Communication, Fractions are rounded up. * Assumption on HP volunteers time or effort % spend on SWM is much lower (one third) than other systems. It might need more rationalizations.

4.6 COSTS OF MONITORING OF THE SWM SYSTEMS

This cost has been determined from the HP volunteers number, their salary, HH covered for SWM for monitoring (i.e., campaign and monitoring SWM + WASH). From the following table, it has been determined that SHED spends the least amount for each 100 HH monitoring (Table 21). It shows, the higher the number of HP volunteer in a system, the higher the cost of monitoring per day for each 100 households. As shown, SHED has the least number of HP volunteers.

On the other hand, allocation of household compared to each HP volunteer is not uniform, there are deviations among they systems. As for example, though maximum number of HP volunteers work in system of camp 6, but the allocation of household against each volunteer are minimum in this system. And

[32] Calculated as HP volunteers' number*salary rate per day* % time spend on SWM*100/covered HH

in terms of general cleanliness this is not cleanest. It means rationalization of work forces number and their utilizations need to be standardized based on coverage, overall work volume, HP volunteers' number etc.

TABLE 21: COSTS OF MONITORING EACH 100 HH

Camp	NRC	1E	6	18	20
Cost of monitoring per 100 HH[33] (TK/100 HH/day)	260	252	293	291	155
Number of HP volunteers (persons)	23	24	53	30	6
Allocation HH/HP Volunteers (HH/HP person)	185	160	93	106	178

Note. Decimal places are rounded up

[33] Calculated as HP volunteers' number*salary rate per day*100/total coverage of HH

CHAPTER 5: ADHERENCE TO THE 7 WORKING PRINCIPLES OF SWM STRATEGY

The WASH sector of Cox's Bazar has set 7 (Seven) working principles for SWM. It has been found that it is yet to be adopted by the IPs and difficult to adopt to entire 7 principles. IPs are to some extent aware of this and still in planning stage on how to adhere them in their day-to-day activities of SWM in the camps. The 7 principles are listed below as per stipulation of the draft SWM Strategy[34]

(1) Waste avoidance (inorganic & non-recyclable)
(2) Establishment of complete system of waste which cannot be avoided
(3) Ensure adequate waste handling though awareness raising and BCC
(4) Source segregation of waste
(5) Reused of segregated waste
(6) Recycling of segregated waste
(7) Safe disposal of residual which cannot be avoided, reused, or recycled

Table 22 provides summarized information on the current state of adoption of 7 working principles in the studied 5 camps or systems.

[34] Solid Waste Management Strategy, WASH Sector Cox's Bazar, DPHE, Bangladesh (Draft, Version 6, July 2021)

TABLE 22: ADHERENCE OF 7 SWM WORKING PRINCIPLES IN DIFFERENT CAMPS

Camp	NRC	1E	6	18	20
(1) Waste avoidance	Not fully adopted yet as mainstream activity but few efforts are found such as MHM kit with a cloth napkin, avoiding single use pad	Not fully adopted yet as mainstream activity but few efforts are found such as MHM kit with a cloth napkin, trying to avoid pad but Community wants to use one-time Pad mostly, Hygiene KIT (non-packet, avoiding plastics, trying to introduce jute bag), Food packaging without polythene and use of paper packs. The self-reliance unit is trying to make jute bag, cloth napkin.	Not adopted yet as mainstream activity but few efforts are found such as MHM kit with a cloth napkin, avoiding single use pad	Not adopted yet as mainstream activity but few efforts are found such as MHM kit with a cloth napkin, avoiding single use pad	Not adopted yet as mainstream activity but few efforts are found such as MHM kit with a cloth napkin, avoiding single use pad
(2) Establishment of a complete system of waste which cannot be avoided	Yes	Yes, but some items are not acceptable to Landfills and incineration is discouraged	Yes, but few items are not sellable and not acceptable to UNDP landfill	Yes, but few items such as colored bottle speed, tiger etc. drinks, glass not sellable and not accepted by landfill	Yes, but few items such as colored bottle speed, tiger etc. drinks, glass not sellable and not accepted by landfill
(3) Ensure adequate waste handling through awareness-raising and BCC	Moderate	Efforts are made through IEC/BCC activities and community meetings as mentioned in the stakeholder's engagement effort	WASH HH monitoring template with SW, sorting, bins, etc. check, HH meeting (7 topic each topic one day)	Adequate monitoring by volunteers (HP) while collecting waste	Adequate monitoring by volunteers (HP) while collecting waste
(4) Source segregation of waste	Introduced with the distribution of 2 bins at households and installation of 2 communal bins/pits are community collection points			Introduced segregated door-to-door collection with the distribution 2 bins in each household.	
Reported segregating HH	90%	57%	65%	99%	97%
Existence two bins HH	45%	30%	40%	63%	48%
(5) Rieuse of segregated waste	Not identified	Not identified	Identified	Used old bag while shopping (few cases)	Used old bag while shopping (few cases)
(6) Recycling of segregated waste	Composting, recyclable to vendor	Composting, recyclable to vendor by volunteers and community	Composting, recyclable to vendor	Composting, recyclable to vendor	Composting, recyclable to vendor
(7) Safe disposal of residual which cannot be avoided, reused, or recycled	own landfill in NRC	UNDP Landfill	UNDP landfill	UNDP landfill	UNDP landfill

Note. MHM: Menstrual Hygiene Management,
Reported segregated households mean, households who opined that they segregate,
Existing of two bins does not mean this is actual segregating households, some households found has one bin, but they segregate using another plastic bag or sags or Brocken buckets etc. Some households have two bins, but they do not segregate well and use a bin for different purpose.

CHAPTER 6: ANALYSIS OF FEEDBACK ON COMMUNITY PERCEPTION

Focus group discussions (FGDs) and household surveys have been organized in these five camps and the responses from the dwellers have been collected. Analysis has been done on the feedback received from the camp dwellers. The chapter gives information about the perception of the camp dwellers towards SWM, and efforts has been made to understand the effect of the behavior changes activities. The checklist of the FGD is given in Chapter 1, and questionnaire of household survey is Annexed.

6.1 COMMUNITY PERCEPTION & EXPECTATION ON COLLECTION

One of the most common issues found in FGD of all camps, they need more bins for their households and community. Some dwellers have demanded brooms for their households so that they can clean their own households (Table 23) and surrounding areas. The residents of the camps were asked about their waste collection systems provided by the respective IPs. DSK and SHED provides the door-to-door collection system while rests provide communal bin or pit collection system (Table 23), and community people are aware of this. In terms of collection frequency, participants reported, camp 1E system collects waste from communal bin once in every 7-10 days interval. And NRC system collects once in 3-5 days.

Waste workers of the respective camps use different methods to carry the collected waste from HH or communal bin/pit. According to FGD, the common methods for handling wastes are door-to-door collection, human carrying, carrying by hand trolley but rickshaw van and dump truck are not common.

The demand of door-to-door collection and increase the collection frequency was very earnest and sincere particularly by the female participant.

TABLE 23: COMMUNITY PERCEPTION & EXPECTATION

Camp	NRC	1E	6	18	20
Community perception & expectation	More household bins and communal bins, demand for Door-to-Door collection method	Cleaner and more frequent collection, this year cleaner reduced from last year, bin lasts short, and more bins are necessary	More household bins and communal bins, volunteer increase	Cleaning the scattered wastes around the houses	Broom provides, lid for household bin
Mode of collection, location of bins	Communal pit collection method	Communal bin collection method	Communal bin collection method	Door-to-Door collection method	Door-to-Door collection method
Frequency of collection	3-5 days interval from communal	7-10 days interval from communal	3-5 days interval from communal	Daily	Daily
Transport mode	M, HT	M, HT, RV, DM	M	D, M	D, M

Note. M: Manual Transportation, HT: Hand Trolley, RV: Rickshaw Van, DM: Dumper, D: door-to-door manual collection

6.5 COMMUNITY PERCEPTION & EXPECTATION ON IEC/BCC

Different opinions have been collected during the FGD and HH survey (Figure 56). Most of the respondents of FGD said that they didn't attend any IEC/BCC training but at the HH survey respondents shared that many of them were engaged with IEC/BCC activities such as training, campaign, meeting session etc. (Table 24).

All the respondents agreed that the HP staff and volunteers have met with them individually or in a group and instructed them about the source separation of wastes, maintain cleanliness. The general cleanliness condition can be observed from Table 12 and segregation results can be observed in chapter 3.3.

From the HH survey, it has been found that maximum (81%) household heads participated in different IEC/BCC campaigns or activities in camp 18 and minimum (13%) participated in camp 1E as shown in Figure 56. It supports the statement that the higher participation in IEC/BCC activities, the higher degree of general cleanliness (Table 12 and Figure 56). However, it can also be easily argued that only IEC/BCC activities may not solve the problem of segregation and maintain cleanliness of the community unless more frequent collection, more labor, strong and regular monitoring can put in place.

TABLE 24: RESPONSES ON IEC/BCC ACTIVITY PERTICIATIONS (FGD)

Camp	NRC	1E	6	18	20
IEC/BCC activity participation	No Training received	No Training received but community meetings are arranged, special cleaning per 2 months, HP volunteers mobilize society	Residents received IEC/BCC training	Residents received IEC/BCC training	No Training received

Note. No training received does not mean that they have not participated any other efforts, but they were not spontaneously shared. It is clarified in HH survey.

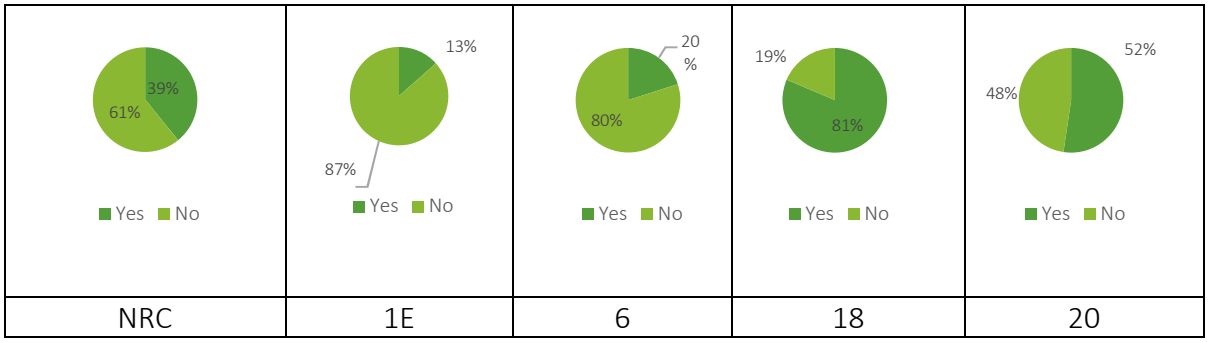
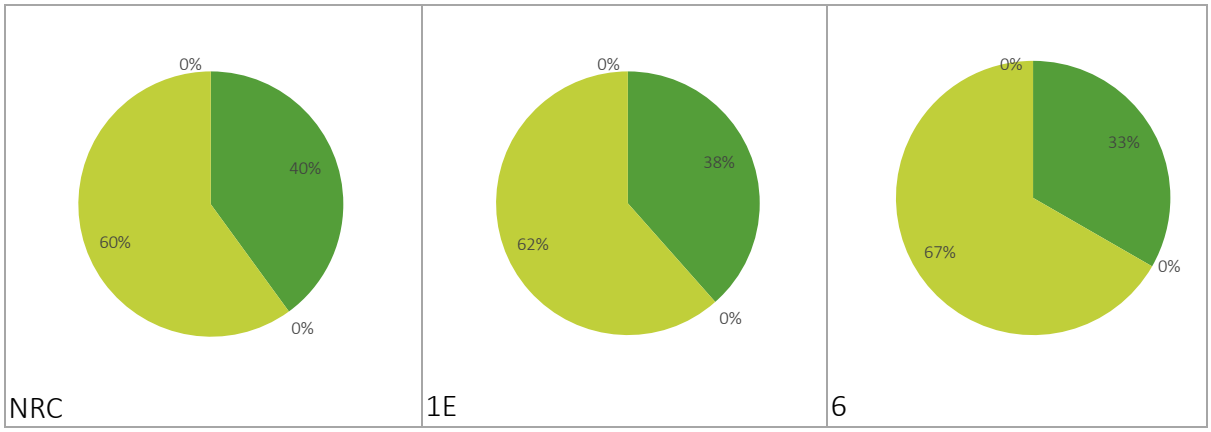


FIGURE 56: PARTICIPATION IN IEC/BCC ACTIVITIES

The respondent who attends the IEC/BCC activities is generally engaged with Community Engagement Campaign, Community Rally, Community Meetings, and others (Figure 57). Among the different types of IEC/BCC activities, maximum percentage of dwellers are engaged with community meetings on SWM.



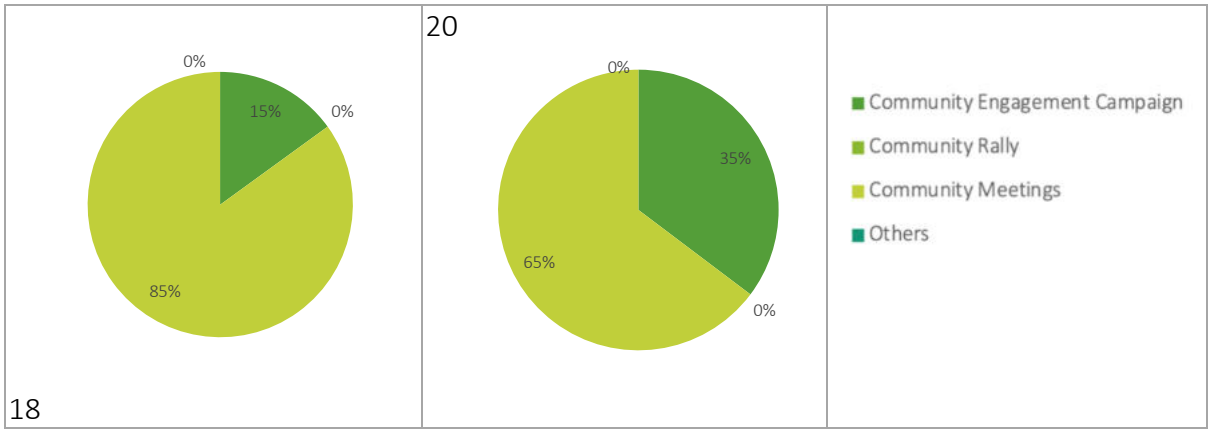


FIGURE 57: ENGAGEMENT WITH TYPES OF DIFFERENT IEC/BCC ACTIVITIES

In terms of IEC/BCC materials acquaintances, NRC, and camp 18 depict maximum positivity, 100% respondents opined they have seen at least any types of leaflets, posters, flip charts (Figure 58) but the participation rate in different activities and perception level are different in both systems. But when the general cleanliness ranking is observed, findings, e.g., NRC does commensurate (Table 12) this results. The reason might multifaced, as for example, households might not get a clear understanding on these leaflets and posters, or even they understood, they just do not follow. On the other hand, camp 18 shows better result on general cleanliness. It commensurate the fact that HP volunteers provided guidance according to the leaflets and posters and able to mobilize to a great extent.

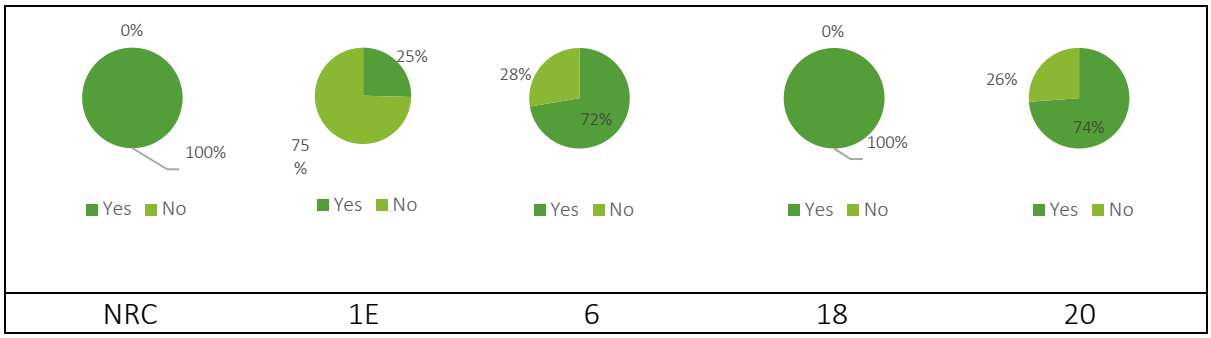


FIGURE 58: ACQUAINTANCE ON AWARENESS MATERIALS SUCH AS POSTER, LEAFLET, FLIPCHART

6.6 GENDER ISSUE

Roles of women or female household members are very important in segregation, on site storage, proper discharge and make the neighborhood clean. Therefore, the proportion of female HP volunteers for each IPs were calculated as shown in Table 25, who mostly interact with households.

TABLE 25: FEMALE HP VOLUNTEERS PROPORTION IN THE RESPECTIVE CAMPS

Camp	NRC	1E	6	18	20
Female proportion of HP volunteers	60 % HP volunteer female	50% HP volunteer females, Females for HH meetings and sessions.	60 % HP are female	26% HP volunteer female	19 % female collection volunteers, 62% female HP volunteers

In these five camps, one of the major findings is overall 49% of women are the waste discharger and highest percentage is observed for camp 18 and 20. A significant portion of waste discharger are adolescent boy or girl from the household members. The waste collection method should be designed correctly. In FGDs, maximum women wanted the door-to-door collection system or more communal bins at closer proximity of households, and it was found that women seemed to lose interest if the communal bins aren't in the closer proximity especially on the rainy days (Figure 59). It is advisable to increase the number

of communal bins and their positioning to be in close consultation with small neighborhood meetings. Otherwise, increasing number of communal bins always might not bring an efficient outcome.

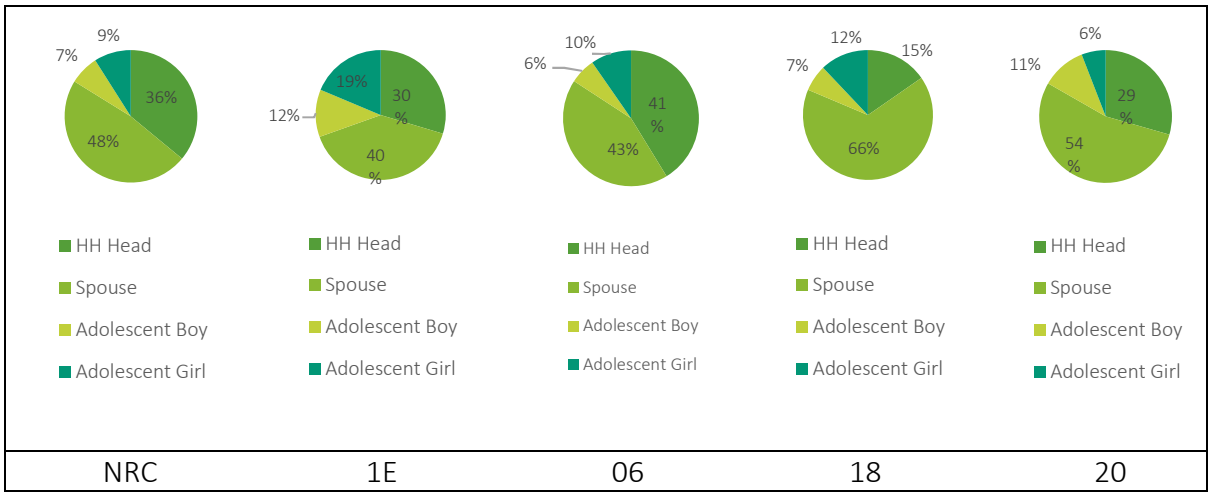


FIGURE 59: WASTE DISCHARGERS IN RESPECTIVE CAMPS

6.7 COMMUNITY PERCEPTION AND EXPECTATION (OTHERS)

6.7.1 SATISFACTION ON THE SWM SYSTEM

During the FGD and HH survey, camp dwellers were asked, if they were satisfied with the current SWM systems. Highest percentage of respondents were satisfied with the current SWM service in camp 18. At camp 1E, it has been observed that a major percentage aren't concerned with the satisfaction on the SWM system. From the FGD survey, the perspective of the camp dwellers has been tied to analyze and it has been found that the satisfaction level of the camp dwellers increases when the collection frequency of waste increases

In the filed inspection, it was observed that the contact frequencies among HH, HP volunteers, HP staff, waste collection volunteers are very high in door-to-door system. In case of improper segregation, or household surrounding cleanliness issues, advocacy and feed backs are spontaneous at the collection time. This system does not let issues pending on mobilizing households to expected behaviors, since demonstration on how to segregate, pick up the scattering waste from neighborhood or shops are done by actual doing of HP volunteers, whenever needs. And, studied operated areas of camp 18 and 20 are cleaner than other system operated areas. These might be the reasons higher satisfaction level (Figure 60).

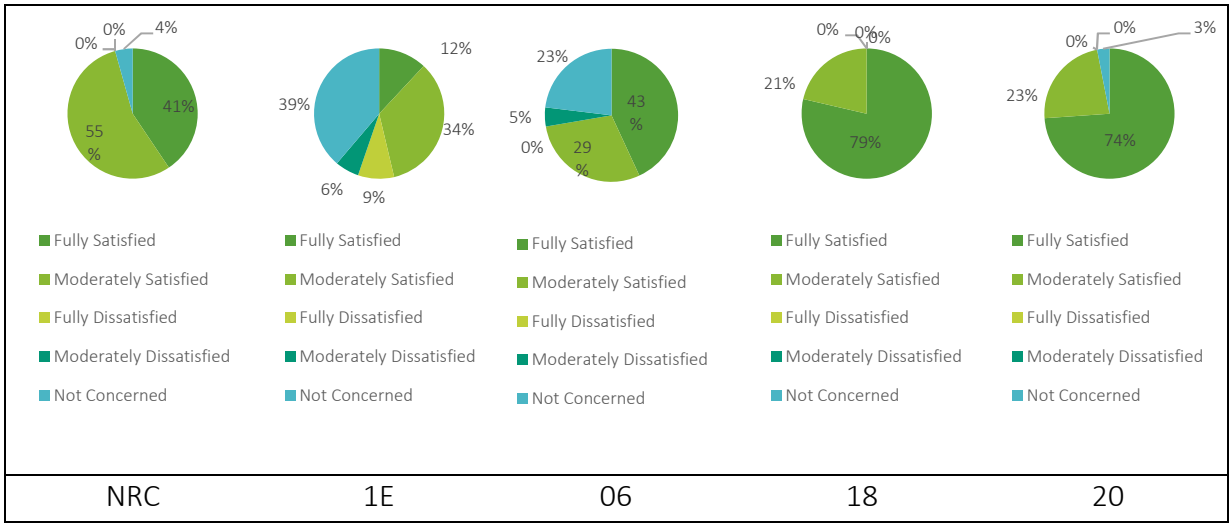


FIGURE 60: SATISFACTION LEVEL ON SWM SYSTEMS IN RESPECTIVE CAMPS

6.7.2 KNOWLEDGE ON THE IMPORTANCE OF PROPER SWM SYSTEM

Most of the camp dwellers are to some extent aware of the importance of SWM system as they know the harmful and negative effect of unmanaged solid wastes on the human body and surroundings (Figure 61). There are higher proportion of responded shows the knowledge on the importance of the proper SWM in door-to-door system than communal system on an average.

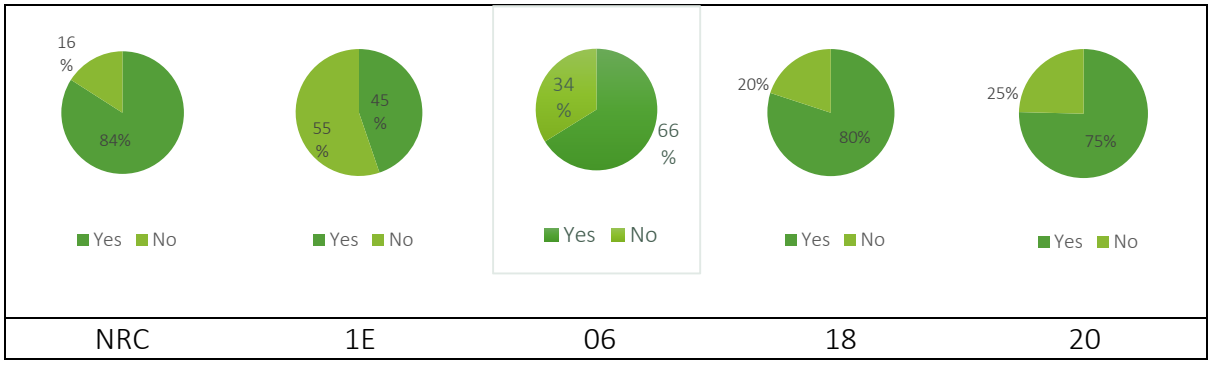
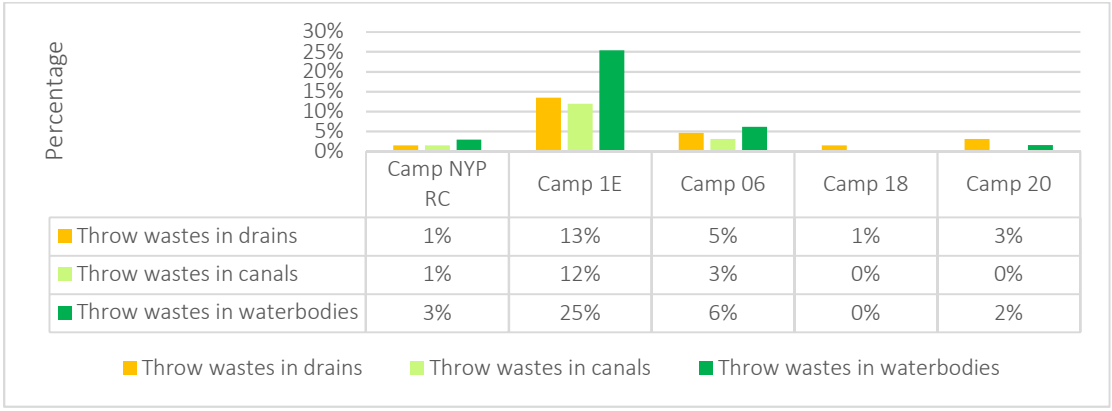


FIGURE 61: PERCENTAGE SHOWING KNOWLEDGE ON THE IMPORTANCE OF PROPER SWM SYSTEM IN DIFFERENT CAMPS

6.7.3 DISCHARGING WASTES IN DRAINS, CANALS, OR WATERBODIES

From the FGD and HH survey it has been found that some of the camp dwellers are not discharging their waste in the designated places, but in the local drains, canals, or waterbodies around them. Camp 1E shows a significant respondents threw waste in water bodies (Figure 62) at least for the time being. There are no water bodies found in camp 18. If the collection frequency decreases among the camps, camp dwellers are found to dump waste in non-designated places



	Camp NYP RC	Camp 1E	Camp 06	Camp 18	Camp 20
Throw wastes in drains	1%	13%	5%	1%	3%
Throw wastes in canals	1%	12%	3%	0%	0%
Throw wastes in waterbodies	3%	25%	6%	0%	2%

FIGURE 62: PERCENTAGE OF CAMP DWELLERS WHO THREW WASTES IN DRAINS, CANALS, OR WATERBODIES

6.7.4 KNOWLEDGE ON WASTE AVOIDANCE, REDUCTION, REUSE AND RECYCLE

One of the major findings of FGD and HH survey was how much knowledge the camp dwellers have about the waste avoidance, waste reduction, waste reuse, and waste recycle. Camp 18 and 20 respondents seemed to have knowledge about all four concepts (Figure 63). Compared to the other camps, camp 18 and 20 have a smaller number of households, and another point is door-to-door communication and monitoring is done regularly. These camp dwellers are more involved in different IEC/BCC activities where the HP volunteers share the information about waste avoidance, reduction, reuse and recycle. Waste generation rate will come to lower value if IPs take such initiatives for this purpose and will improve the overall waste management.

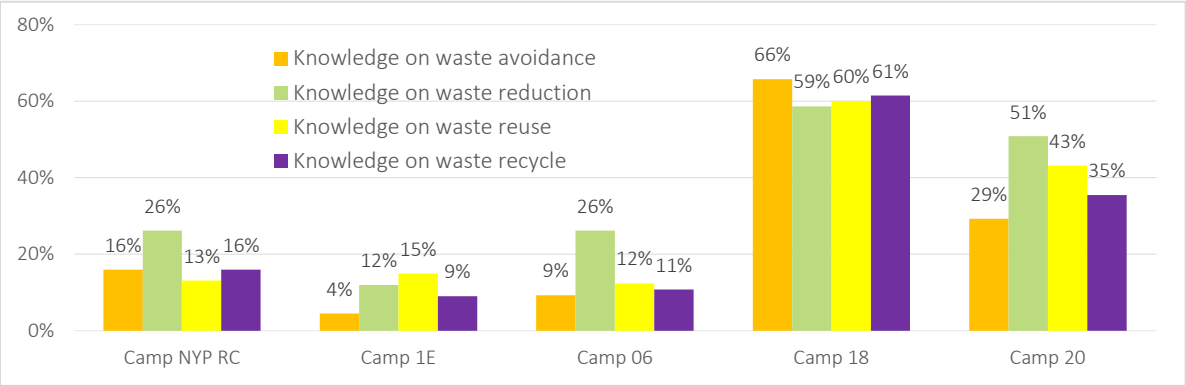


FIGURE 63: KNOWLEDGE ON WASTE AVOIDANCE, REDUCTION, REUSE AND RECYCLE BY RESPECTIVE CAMP DWELLERS

6.7.5 WILLINGNESS TO USE GENERATED COMPOST

From the FGD and HH survey, it has been observed that community people know about the compost and it's beneficial for household gardening. As a high percentage of the dwellers have front-back gardening, they want to use the generated compost (Figure 64). The communication frequency between SWM service provider and recipients are more frequent and vibrant in camp 18 and 20 as found in field inspection, it might be reason of willingness to use of compost.

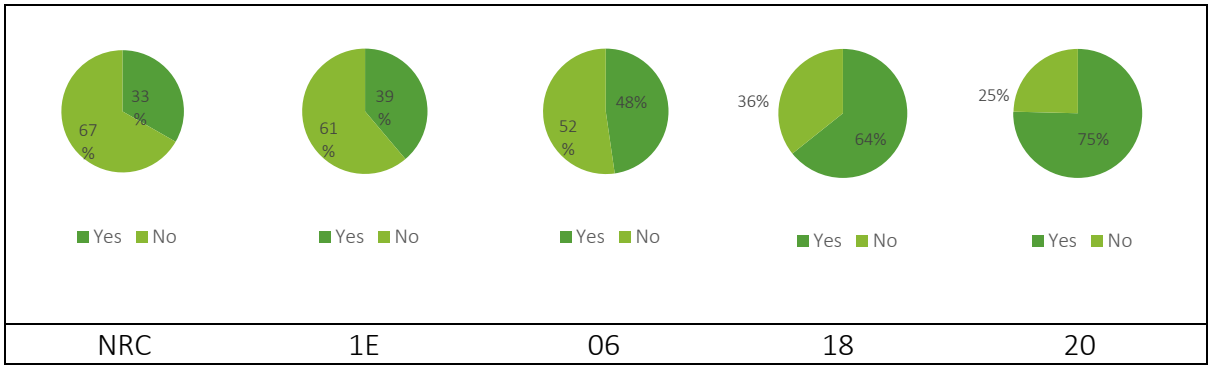


FIGURE 64: WILLINGNESS TO USE COMPOST BY RESPECTIVE CAMPS

CHAPTER 7: PART-B- OMNI-PROCESSOR

7.1 BASIC CONCEPTS OF OMNI-PROCESSOR:

The Bill & Melinda Gates Foundation envisioned (as shown in *Figure 65*) an Omni-Processor (OP) that can convert excreta (i.e., latrine waste) into beneficial products such as energy and soil nutrients with the potential to develop local business and revenue targeting the poor of developing countries. OP should be capable to *produce safe product that has value*, *support a sustainable business model*, *be adaptable to changing conditions*, *be community based*, and *use local skills and materials*[35].

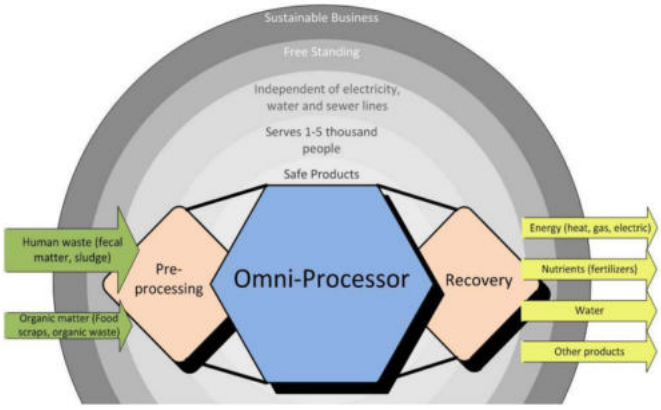


FIGURE 65 VISION OF OMNI-PROCESSOR

7.2 OMNI-PROCESSOR OF CAMP 4E, UKHIYA, COX'S BAZAR

The project is designed to consume daily 11.5 tons per day as input feedstock. The design parameters are stipulated in *Table 26*. However, according to the interview survey with plant construction official[36], plant can accommodate 11 to 22 tons of waste per day, and fluctuation of feedstock is possible which could be managed smoothly based on planned reserve of wastes. The facility will be comprised of 30 m^3 storage tank for sewage, screw press dewatering machine, skip charger, thermal gasifier, boiler with furnace, load bank for power storage, control room, office rooms, conference room etc.

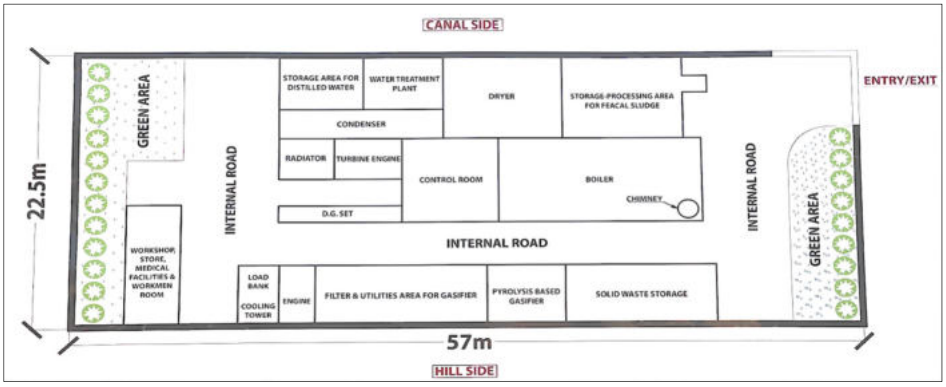


FIGURE 66 PLANT LAYOUT OF OMNI-PROCESSOR OF CAMP 4E (PHOTO: SURVEY TEAM AT SITE)

The plant layout is shown in

Figure 66. Solid waste will be thermally discomposed with limited, or absence of oxygen (O_2) and dried fuel would be possible to use in boiler furnace in different forms as mentioned by Ankur Scientific official[2]. Though this project is waste-to-energy type project; however, produced energy will not be sold to the national grid and no such objective is set. However, the limited energy produced whatever would be produced by the facility would be consumed by the system itself as found from survey interview (viz. technical details could not be studied), (Figure 67).

[35] R. D. Kuchenrither, L. Stone, and R. T. Haug, "Omni-Processor Landscaping Project," *Water Environment Research Foundation*, for the for Bill & Melinda Gates Foundation, p. 60, 2012, [Online]. Available : https://www.susana.org/_resources/documents/default/2-1640-werf6c11-omni-processor-final-report.pdf

[36] Mr. Anki Jain, Official, Ankur Scientific, India

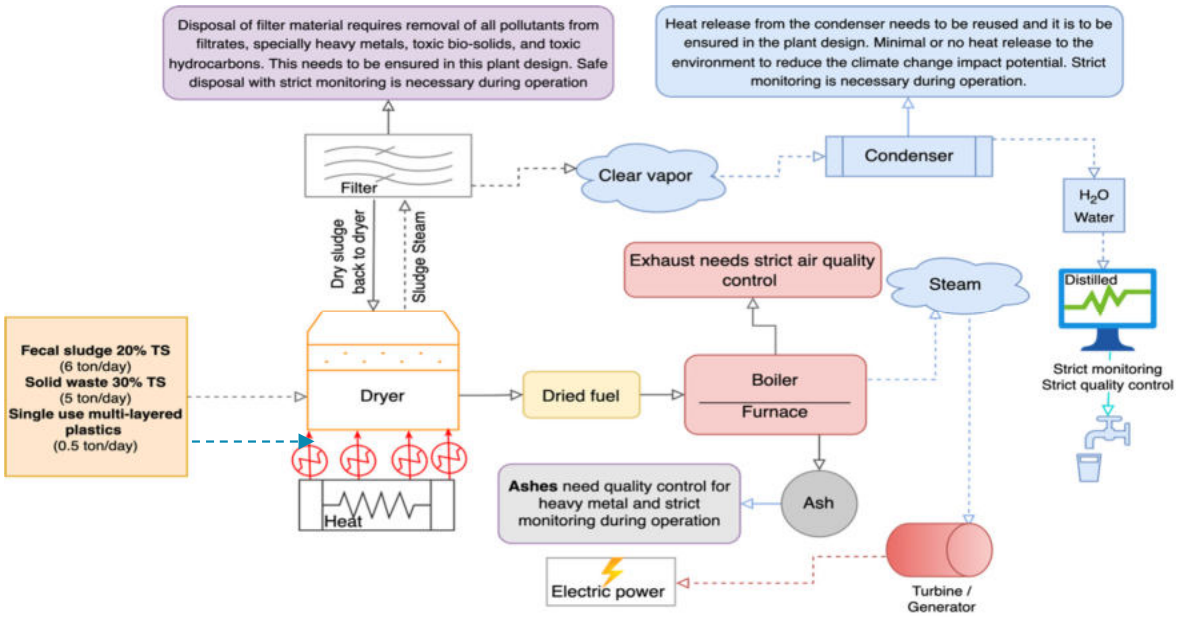


FIGURE 67 FUNCTIONAL STEPS OF OMNI-PROCESSOR WITH ANTICIPATED ENVIRONMENTAL ISSUES(OUTLINE)[37]

7.3 SCHEDULE OF INSTALLATION AND COMMISSIONING

It is already delayed, however, if DPHE would provide the access road and associated site infrastructure along with LC by December, Ankur Scientific hoped to complete commissioning and testing phase of the project before heavy rains start.

7.4 BASIC DESIGN PARAMETERS AS INPUTS AND OUTPUTS

Fecal matter, solid waste and plastics are planned requirements as per stipulation of Table 26. Energy, Biochar, distilled water, and other products such as gas, heat and ashes are expected to be generation from the plant as mentioned in Table 27.

TABLE 26 DESIGN PARAMETERS (TYPICAL / AVERAGE) OF OMNI-PROCESSOR IN CAMP 4E

Feedstocks	Fecal matter	Solid waste	Plastics
Quality	TS: 20%	TS: 30%, Moisture: 70%	Single use, multilayer
Feeding rate (t/d)	6	5	0.5
Feeding rate (kg/h)	250	208	20
Pre-processing	SP dewatering, no PPU	Storage facility, size reduction, compositions, no need PPU	Segregated plastics, may not need PPU

Note. TS: Total Solid, t/d: ton/day, 1 ton: 1000 kg, PPU: Pre-Processing Unit, feeding rate is average approximation.

TABLE 27 DESIGN OUTPUT OF OMNI-PROCESSOR OF CAMP 4E

Energy	Nutrient/conditioner	Water	Other products
60-70 kWh	Biochar[38]	Distilled H_2O, 1200 L/d (10-16 m^3/d)	Ash, Gas, Heat

Note: L/d: liter pre day, m^3/d: cubic meter per day.

[37] Adopted from EIA study presentation, ADB & DPHE, (2021)

[38] Biochar: Biochar is defined as carbonized biomass, sequestered in soils to sustainably enhance their agricultural and environmental value under present and future management. Biochar is a porous material, can help retain water and nutrients in the soil for the plants to take up as they grow. Due to its adsorption ability, some biochar has the potential to immobilize heavy metals, pesticides, herbicides, and hormones; prevent nitrate leaching and fecal bacteria into waterways; and reduce N_2O and CH_4 emissions from soils. Ref. What is biochar? (https://biochar.international)

7.5 EXPECTED OPPORTUNITIES / BENEFITS[39, 40]

The general benefits are Pollution control, disease control from Fecal matter due to heat induced disinfection. Since it will be equipped with controlled collection so scattering of solid waste or blockage of drains are expected to be minimized. This system does not require Pre-Processing Unit (PPU) and Traditional Fecal Sludge Treatment Plant (TFSTP). However, treated sludge can be feed in this plant. Energy, Biochar and Distilled water are reported as the byproducts and contribute to the sustainability of operations, however, system itself will consume nearly entire energy it produces. Already constructed FSTPs by different organizations can support OP by supplying dried fecal matters. But FSTP with plantation on top of the bed may not provide feedstocks within few years until the drying bed is complete.

A certain supply of feed stock would be given to the construction and commissioning company (i.e., Ankur Scientific) with a constant reserve of 3 days usage, and DPHE has purchased the vacuum trucks for this requirement. DPHE has already constructed sludge drying bed and waste segregation and composting unit just before the OP site they can support for feed stock of the OP plant (Ref. Ankur Scientific, DPHE Cox's Bazar). Its inflow is modeled but could not be studied.

7.6 POTENTIAL CHALLENGES[41]

The quality waste feedstock of plastics, FS and solid waste are considered as continuous inputs to make the plant operational and precursors for sustainability. However, how it will match with baseline situation could be studied. This plant may require highly skilled workforces with proper training and guidance. To materialize a sustainable operation in long run, careful handing over to expected operating entity with proper knowledge and skills from existing construction & commissioning company is inevitable.

The details of responsibilities and mode of operation of the facility (once fully constructed and operational) could not be studied due to lack of information. The commissioning was supposed to be in the last December 2021 and deadline of the project is June 2022; however, project might not be possible to end by then (Ref. DPHE Cox's Bazar office).

Though there are growing numbers of waste-to-energy plants, according to US EPA, several reasons contributed to failure of waste-to-energy plant across the globe. As for example, lack of skilled manpower, operational cost, problem with waste quantity and quality, poor plant management, inadequate institutional arrangement etc. Effort has been given to understand came 4E Omni-processor system in those aspects; however, pertinent information could not be secured due to time constraint.

[39] Presentation on Biomass and Waste Based Power Generation by thermal gasification
https://www.ankurscientific.com/pdf/pdf.brochures/Presentation_Biomass_Waste_based_Distributed_Power_Generation.pdf
[40] Interview meeting with the official of Ankur Scientific
[41] ADOPTED FROM ADB, DPHE EIA STUDY PRESENTATION (2021)

CHAPTER 8: BEST PRACTICES AND LESSONS LEARNT

This study covered five different SWM systems in five camps operated by different Implementing Partners. All the operated systems in five camps have adopted full chain SWM including on-site storage, segregation at sources, collection, segregation at MRF, composting, recycling, and final disposal. There are two types of collection systems exist: door-to-door collection and communal collection. Both the systems have introduced two colored bins at household level (about 10L capacity) for segregated onsite storage and segregated discharge. Their monitoring tools are also nearly same.

Door-to-door system allows generators to store their waste at households' bins since volunteers collect from doorsteps, whereas communal system requires generators going to the communal point (i.e., bins or pits) to discharge waste. From service recipients' perspective, door-to-door system is advantageous; however, collection volunteers need to visit each household which lowers the labor productivity. Labor productivity as waste collected amount per volunteer per day is less than 40 kg in door-to-door system, which is about half of the communal system (80 kg). It is due to the fact of traveling more distances and more pick up times to collect waste generated from certain number households when compared with communal system. In door-to-door system, 202 HHs are served by each collection volunteer per day by single human carrying method[42]. It might be difficult for a collection volunteer to serve 100% of assigned households per day due to more trips and trip times. However, due to special cleaning, more monitoring and controlled on site storage, the door-to-door operated areas are found cleaner than communal system areas. Door-to-door collection systems provides instant service quality improvement efforts with rectifying the anomalies (e.g., improper segregation) by HP volunteers accompanying the waste collection volunteers. Scattered wastes are hardly seen in this system operated areas.

On average 98% dwellers of door-to-door system have reported that they segregate waste at source. Regular guidance of HP volunteers has contributed to achieve this. The allocating cost for waste collection and monitoring is 133 and 223 taka/day/100 households respectively. Both costs are less in door-to-door system than the communal because of smaller number of volunteers are deployed in this system for a certain number of households.

In door-to-door system, the approaches of 'on-site feedback' at the time waste collection and monitoring is an excellent practice and can be considered as role model for wider replications. It contributes to improve the awareness of the dwellers and general cleanliness due to the fact of regular face-to-face communications, and monitoring. This system rejects collection of fish, chicken waste to avoid smell in composting plant by the provision of backyard burial. Another good practice, 'cleaning the surrounding households with supplied broom' is common in door-to-door system. This can easily minimize the overall cleaning burden of entire area and eventually maximizes benefits of clean environment. Because of more frequent collections and communications, the door-to-door service recipients are seemed satisfied, and they hardly discharge their wastes in non-designated places. Camp dwellers of door-to-door system have more willingness to use compost (62%) as they have attended (67% average) different IEC/BCC activities organized by the IPs. A portion of the community use the produced compost, and more are willing to get it.

In communal systems, there are also some pros and cons. In this system, each household brings their waste to the nearby communal bins or pits in segregated manner. Volunteers get accumulated waste (i.e., more than 10 HHs waste) at one spot. Labor productivity as waste collected amount/volunteer/day is more than 80 kg, which is more than double of door-to-door system. It is due to the fact of traveling less distances and thereby less time consumptions to collect generated waste from a certain number of households. Also, time consumptions are minimized by volunteers using equipment like three-wheeler trolley, van etc. and carry more wastes in one trip compared to door-to-door system. In communal system, 209 HHs are allocated to serve for each collection volunteer per day. The allocating cost for waste collection

[42] One collection volunteer is involved to make his trip

and monitoring per day for 100 households is 158 Taka and 268 Taka respectively. MRF operation cost for communal bin system varies from 35,200 to 78,750 BDT/month for managing large amount of waste in large area involving greater number of plant operators and volunteers than door-to-door system. Regardless the operational efficiencies, costs, or size of MRF; usually the general cleanliness is higher in smaller coverage areas than larger coverage areas.

Communal system sometimes becomes problematic for women or children, especially in rainy seasons, and this problem is intensified if the roads are unpaved and slippery in rainy days. Because of the less involvement of the HP volunteers, waste collectors found unsegregated waste in the communal bin most of the time. Also, from the field survey, HHs from the communal bin system responded that many of them (39% on average) didn't segregate waste at their home. Though the waste collection proportion is higher in communal system compared with other system, the general cleanliness under communal system not higher than door-to-door system. Several reasons are observed in this case. The collection proportion of waste doesn't show the full result. The communal system is being operated in large areas, a huge number of HH remained uncovered by the MRF. Special cleaning programs to cover entire areas and on regular basis is difficult. Collection frequency interval is also lower, which results overloading of communal bins/pits, scattering of waste around community areas and discharging waste in non-designated places.

All the five systems are equipped with MRF comprising compost plants and segregation units, one system has plastic recycling plant. One of the MRF uses semi mechanical chopper for cutting the organic waste which has been reported more efficient and time saving. Three types of composting operation found: Box Composting, Barrel Composting and Windrow Composting. Compost production rate is 3 to 4.5 Kg/day/volunteer for Barrel and Windrow composting, and 6.5 to 10 Kg/day/volunteer for Box composting. In door-to-door system, MRF operation cost for varies from 14,400 to 19,500 BDT/month which is less than communal system because of number of plant operators and volunteers are less. Existing operation of five camps does not shows that the entire waste generated daily could be collected, transported, and treated daily by existing manpower. For the residual waste, 4 out of 5 areas use the official sanitary landfill. It can still be mentioned that 1 system is not using the landfill due to transport distance and existing disposal facility may not be categorized as safe, and the site is not a "sanitary landfill".

In communal system, the camp dwellers are less satisfied with the current system specially, the women. Nearly 50% of waste dischargers are female and it was found that women seemed to lose interest if the communal bins aren't in the closer proximity especially on the rainy days. So, the location of communal bins to be optimized based on community level meetings in such a way, so that gender aspects are properly addressed to use them to discharge waste in all the seasons. However, such closeness or farness are to be determined by IPs applying PRA tools. Also, the waste collection frequencies are to be increased to avoid uncollected waste accumulation. In. this system, dwellers are less involved in different IEC/BCC activities than door-to-door system. Most of the camp dwellers have hardly known the usefulness of compost. In the communal system, dwellers seemed have less interest (30% maximum) in using compost where one of the reasons can be seen as less participation (24% on average) in the IEC/BCC activities.

One of the common characteristics for both systems demonstrate to ensure health safety. Safety gears and first aid boxes are provided with sufficient number and frequencies including gumboots, gloves, masks, aprons, sanitizers, primary medicines etc. Nearly all the working volunteers are habituated to use them regularly.

Conversion of plastic waste to usable materials improve recycling rate at the same time help to make daily life easier. Among the five systems, one has adopted recycling plant for single layer plastics, and overall recyclable segregation rate is also higher in this system. However, typically, segregation takes place at households, communal points, at MRF and informal disposal sites and the benefits are enjoyed by generators and volunteers.

Though the camps are operating full-chain SWM system and making effort to improve the general cleanliness; however, still there are issues, where more efforts are needed. Emphasis to be given on the area

specific labor (i.e., volunteers) productivity optimization. Operational allocation of volunteers for a certain number of households are different in different camps though there are not significant waste transport distances apparently. Even they are different within similar collection system in almost similar terrain conditions. There were missing of weighing scales at disposal phases in few camps, and waste-mass-flows were difficult to develop. Data base on recyclable collection, management and selling are not well established in different camps. Many of the systems' staff feel recycling data is less important than regular cleaning when they are facing difficulties to maintain cleanliness. Some of the non-recyclable items are not easily sellable and not acceptable to landfill as for example colored energy drinks. Those can be given to the vendor free of charge or with monetary incentive to find a solution in the recycling sectors. A uniform waste auditing system may be circulated by sector. Adoption of uniform database, and monitoring with various efficiency indicators, risk indicators, general cleanliness indicators are advisable. However, waste measurement (i.e., weighing) must be ensured to have complete waste auditing data at least for several weeks in different seasons. Security needs to be tightened for compost plant, recyclable storages in several systems to minimize the losses as reported by IPs.

In existing systems, to have optimum combinations among operational efficiencies, effectiveness and costs, adjustment of volunteers is must. Therefore, camp specific, *time & motion study* on volunteers' activities in different seasons are advisable to the IPs. Though IPs are making huge efforts for full chain SWM, however, still there are lots of scopes of improvement particularly in separation, collection efficiency, MRF operation and controlled disposals.

The Planned innovation, the Omni -processor is under construction, and it is going to be delayed from planned commissioning date. Skilled manpower will be required to operate and maintain the facility, existing contractor company may not run the facility for long time. The proper arrangement of acquisition and transfer of knowledge and skill to the local company or operating entities is necessary. And how it will be harmonized with existing systems of waste (e.g., solid waste and fecal sludge) collection and treatment could not be figured out, but DPHE and construction company is very positive towards its successful operation.