The Urban Unit
Urban Sector Planning & Management Services Unit (Pvt.) Ltd.

SWM REGIONAL DEVELOPMENT PLAN FAISALABAD

TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION 9

1.1 BACKGROUND 9

1.2 METHODOLOGY 11

1.3 EXISTING ORGANIZATIONAL STRUCTURE 13

CHAPTER 2. FAISALABAD DIVISION 15

2.1 DISTRICT FAISALABAD PROFILE 15

2.2 WASTE GENERATION: 16

2.3 CURRENT SWM PRACTICES IN FAISALABAD DISTRICT: 17

2.4 WASTE COMPOSITION 21

2.5 PROPOSED SWM SYSTEM FOR MC/URBAN AREAS OF FAISALABAD CITY 21

2.5.1 PRIMARY WASTE COLLECTION 21

2.5.2 SECONDARY WASTE COLLECTION SYSTEM 22

2.5.3 FINAL DISPOSAL 22

2.6 REQUIRED RESOURCES 23

2.7 FINANCIAL COSTING: 26

2.7.1 CAPITAL COST 26

2.7.2 OPERATIONAL AND MAINTENANCE COST OF THE PROPOSED SYSTEM 27

2.7.3 HR COST 30

CHAPTER 3. CHINIOT DISTRICT 31

3.1 DESCRIPTION 31

3.2 POPULATION: 31

3.3 WASTE GENERATION: 31

3.4 CURRENT WASTE MANAGEMENT IN CHINIOT 32

3.5 REQUIRED RESOURCES 36

3.6 FINANCIAL COSTING: 38

3.6.1 CAPITAL COST 38

3.6.2 OPERATIONAL AND MAINTENANCE COST OF THE PROPOSED SYSTEM .39
3.6.3 HR COST 41
CHAPTER 4. TOBA TEK SINGH 42
4.1 DESCRIPTION 42
4.2 POPULATION: 42
4.3 WASTE GENERATION: 42
4.4 CURRENT WASTE MANAGEMENT IN TOBA TEK SINGH 43
4.5 REQUIRED RESOURCES 46
4.6 FINANCIAL COSTING: 48
4.6.1 CAPITAL COST 48
4.6.2 OPERATIONAL AND MAINTENANCE COST OF THE PROPOSED SYSTEM .49
4.6.3 HR COST 51
CHAPTER 5. JHANG DISTRICT 52
5.1 DESCRIPTION 52
5.2 POPULATION: 52
5.3 WASTE GENERATION: 52
5.4 CURRENT WASTE MANAGEMENT IN JHANG 53
5.5 REQUIRED RESOURCES 57
5.6 FINANCIAL COSTING: 60
5.6.1 CAPITAL COST 60
5.6.2 OPERATIONAL AND MAINTENANCE COST OF THE PROPOSED SYSTEM .62
5.6.3 HR COST 64
CHAPTER 6. BUSINESS MODEL BY INTRODUCING WASTE RECOVERY FACILITY (MRF) 65
6.1 COMPONENTS OF STD 66
6.2 BENEFITS OF THE FACILITY 66
6.3 ENVIRONMENTAL BENEFITS 66

6.4 DETAILS OF ACTIVITIES OF STD FACILITY 67
6.5 PROCESS DESCRIPTION OF COMPOSTING 68
6.6 WINDROW COMPOSTING 69
6.7 CAPITAL COST OF MRF FACILITY 70
6.8 MAINTENANCE COST OF FACILITY 70
6.9 HR COST OF MRF FACILTIY 70
6.10 ECONOMIC MODEL OF WASTE TREATMENT FACILITY (MRF) 70

LIST OF TABLES

TABLE 1:1: TEHSIL IN EACH DISTRICTS OF FAISALABAD DIVISION 13
TABLE 2:1: EXISTING SWM RESOURCES IN FWMC 20
TABLE 2:2: REQUIRED ADDITIONAL RESOURCES URBAN AREA OF FAISALABAD 24
TABLE 2:3: TOTAL HR REQUIRED IN URBAN AREA OF FAISALABAD 24
TABLE 2:4: ADDITIONAL RESOURCES REQUIRED IN RURAL AREA 25
TABLE 2:5: ADDITIONAL HR REQUIRED IN RURAL AREA TEHSIL WISE 25
TABLE 2:6: CAPITAL COST FOR SWM IN FAISALABAD URBAN AREA 26
TABLE 2:7 :CAPITAL ONCE COST IN URBAN AREA OF FAISALABAD 26
TABLE 2:8: CAPITAL COST FOR SWM IN FAISALABAD RURAL AREA 27
TABLE 2:9; CAPITAL ONCE COST TEHSIL WISE IN FAISALABAD 27
TABLE 2:10: CAPITAL ONCE TEHSIL WISE IN FAISALABAD 27
TABLE 2:11: O&M COST FOR SWM IN URBAN AREA OF FAISALABAD 27
TABLE 2:12: O&M COST FOR RURAL AREA OF FAISALABAD DISTRICT SWM 29
TABLE 2:13: TOTAL HR COST IN CRBAN AREA OF FAISALABAD 30
TABLE 2:14: HR COST FOR RURAL AREA OF FAISALABAD 30
TABLE 3:1: EXISTING SWM RESOURCES IN MC CHINIOT 33
TABLE 3:2: REQUIRED ADDITIONAL RESOURCES URBAN AREA OF CHINIOT 36
TABLE 3:3: TOTAL HR REQUIRED IN URBAN AREA OF CHINIOT 37
TABLE 3:4: ADDITIONAL RESOURCES REQUIRED IN RURAL AREA OF CHINIOT 37
TABLE 3:5: ADDITIONAL HR REQUIRED IN RURAL AREA TEHSIL WISE 37
TABLE 3:6: CAPITAL COST FOR SWM IN CHINIOT URBAN AREA 38
TABLE 3:7 :APITAL ONCE COST IN URBAN AREA OF CHINIOT 38
TABLE 3:8: CAPITAL COST FOR SWM IN CHINIOT RURAL AREA 38
TABLE 3:9; CAPITAL ONCE COST TEHSIL WISE OF CHINIOT 39

TABLE 3:10: CAPITAL ONCE COST TEHSIL WISE OF CHINIOT 39
TABLE 3:11: O&M COST FOR SWM IN URBAN AREA OF CHINIOT.....39
TABLE 3:12: O&M COST FOR RURAL AREA OF CHINIOT.....40
TABLE 3:13: TOTAL HR COST IN URBAN AREA OF CHINIOT.....41
TABLE 3:14: HR COST FOR RURAL AREA OF CHINIOT.....41
TABLE 4:1: EXISTING SWM RESOURCES IN MC TOBA TEK SINGH.....45
TABLE 4:2: REQUIRED ADDITIONAL RESOURCES URBAN AREA OF TOBA TEK SINGH 47
TABLE 4:3: TOTAL HR REQUIRED IN URBAN AREA OF TOBA TEK SINGH 47
TABLE 4:4: ADDITIONAL RESOURCES REQUIRED IN RURAL AREA OF TOBA TEK SINGH.....47
TABLE 4:5: ADDITIONAL HR REQUIRED IN RURAL AREA TEHSIL WISE OF TOBA TEK SINGH..47
TABLE 4:6: CAPITAL COST FOR SWM IN TOBA TEK SINGH URBAN AREA.....48
TABLE 4:7 :CAPITAL ONCE COST IN URBAN AREA OF TOBA TEK SINGH 48
TABLE 4:8: CAPITAL COST FOR SWM IN RURAL AREA OF TOBA TEK SINGH 48
TABLE 4:9; CAPITAL ONCE COST TEHSIL WISE IN TOBA TEK SINGH.....48
TABLE 4:10: CAPITAL ONCE TEHSIL WISE IN TOBA TEK SINGH.....49
TABLE 4:11: O&M COST FOR SWM IN URBAN AREA OF TOBA TEK SINGH 49
TABLE 4:12: O&M COST FOR RURAL AREA OF TOBA TEK SINGH SWM.....50
TABLE 4:13: TOTAL HR COST IN URBAN AREA OF TOBA TEK SINGH 51
TABLE 4:14: HR COST FOR RURAL AREA OF TOBA TEK SINGH 51
TABLE 5:1: EXISTING SWM RESOURCES IN MC JHANG.....55
TABLE 5:2: REQUIRED ADDITIONAL RESOURCES URBAN AREA OF JHANG 58
TABLE 5:3TABLE 3: TOTAL HR REQUIRED IN URBAN AREA OF JHANG 58
TABLE 5:4 MECHANICAL RESOURCES REQUIRED IN RURAL AREA.....59
TABLE 5:5: ADDITIONAL HR REQUIRED IN RURAL AREA TEHSIL WISE 59
TABLE 5:6: CAPITAL COST FOR SWM IN URBAN AREA OF JHANG.....60
TABLE 5:7 :CAPITAL ONCE COST IN URBAN AREA OF JHANG.....60
TABLE 5:8: CAPITAL COST FOR ADDITIONAL RESOURCES SWM IN JHANG RURAL AREA 60
TABLE 5:9; CAPITAL ONCE COST TEHSIL WISE IN JHANG 61
TABLE 5:10: CAPITAL ONCE TEHSIL WISE IN JHANG.....61
TABLE 5:11: O&M COST FOR SWM IN URBAN AREA OF JHANG.....62
TABLE 5:12: O & M COST FOR RURAL AREA OF JHANG SWM.....63
TABLE 5:13: TOTAL HR COST IN URBAN AREA OF JHANG.....64
TABLE 5:14: HR COST FOR RURAL AREA OF JHANG.....64
TABLE 6:1: CAPITAL COST OF FACILITY (MRF) FOR FAISALABAD.....70
TABLE 6:2: MAINTENANCE COST OF MRF.....70
TABLE 6:3: HR COST OF MRF FOR FAISALABAD CITY 70

LIST OF FIGURES

FIGURE 1.1: GEOGRAPHICAL COVERAGE OF PROJECT AREA 10
FIGURE 1.2: SWM DESIGN METHODOLOGY FOR URBAN AREA OF FAISALABAD DIVISION 12
FIGURE 1.3: OPERATIONAL MODEL IN URBAN AREAS/MCS' OF FAISALABAD DIVISION 12
FIGURE 1.4: SWM OPERATIONAL MODEL FOR RURAL AREA FOR FAISALABAD DIVISION 13
FIGURE 1.5: HIERARCHY IN EACH DISTRICT OF FAISALABAD DIVISION 13
FIGURE 1.6: ORGANIZATIONAL STRUCTURE OF FWMC 14
FIGURE 2.1 POPULATION VS WASTE GENERATION OF URBAN AREAS FAISALABAD DIVISIONS 15
FIGURE 2.2: POPULATION VS WASTE GENERATION OF FAISALABAD DISTRICT.....17
FIGURE 2.3: WASTE GENERATION VS POPULATION OF FAISALABAD TEHSILS (RURAL).....17
FIGURE 2.4: FWMC TRANSFER STATION .....**ERROR! BOOKMARK NOT DEFINED.**
FIGURE 2.5: PRIVATE RIKSHAW BRINGING WASTE TO TRANSFER STATION 18
FIGURE 2.5: PRIVATE RIKSHAW BRINGING WASTE TO TRANSFER STATION .....**ERROR! BOOKMARK NOT DEFINED.**
FIGURE 2.6: FAISALABAD URBAN AREAS – LAND-USE & SWM CURRENT INFRASTRUCTURE .19
FIGURE 2.7: OPERATIONAL MODEL FOR SWM 22
FIGURE 2.8: WASTE DISPOSAL SYSTEM IN FAISALABAD DIVISION 23
FIGURE 3.1: POPULATION VS WASTE GENERATION OF CHINIOT DISTRICT.....31
FIGURE 3.2: WASTE GENERATION VS POPULATION OF CHINIOT RURAL AREAS 32
FIGURE 3.3: CHINIOT URBAN AREAS – LAND-USE & SWM CURRENT INFRASTRUCTURE.....33
FIGURE 4.1: POPULATION VS WASTE GENERATION OF TOBA TEK SINGH DISTRICT 43
FIGURE 4.2: WASTE GENERATION VS POPULATION OF TOBA TEK SINGH TEHSILS (RURAL) ...43
FIGURE 4.3: TOBA TEK SINGH URBAN AREAS – LAND-USE & SWM CURRENT INFRASTRUCTURE 44
FIGURE 5.1: POPULATION VS WASTE GENERATION OF JHANG DISTRICT 53
FIGURE 5.2: WASTE GENERATION VS POPULATION OF JHANG TEHSILS (RURAL).....53
FIGURE 5.3 JHANG URBAN AREAS – LAND-USE & SWM CURRENT INFRASTRUCTURE 55
FIGURE 6.1: WASTE MANAGEMENT HIERARCHY 65
FIGURE 6.2: COMPONENTS OF STD FACILITY 66
FIGURE 6.3: PROCESSING AND RECOVERY ACTIVITIES AT STD 67
FIGURE 6.4: PROCESS FLOW DIAGRAM OF STD 68
FIGURE 6.5: WASTE TO COMPOST.....68
FIGURE 6.6: WINDROW COMPOSTING 69

List of Acronyms

FWMC	Faisalabad Waste Management Company
HR	Human Resource
LF	Landfill
MC	Municipal Corporation
MSW	Municipal Solid Waste
MS	Mechanical Sweepers
MD	Mini dumpers
SWM	Solid Waste Management
SW	Solid waste
TS	Transfer Station
TPD	Ton per Day
WMC	Waste Management Company
KPI	Key Performance Indicators
TOR	Terms of Reference
RFP	Request for Proposal
EOI	Expression of Interest
CBC	Container Base Collection
DTD	Door to Door
TCs	Tehsil Councils
CO	Chief Officer
MRF	Material Recovery Facility
HTV	Heavy transport vehicle
LTV	Light transport vehicle

DISCLAIMER

Solid Waste Management Sector of Urban Sector Planning and Management Sector Unit (Pvt.) Ltd. has devised this report for Faisalabad division to clearly illustrates the current practices of solid waste management and provides the basis to design state of the art solid waste management system for Faisalabad Division including urban and rural areas. Urban Unit has prepared this report for Regional Solid Waste Management Plan in Faisalabad Division. Maximum care and caution have been observed while developing this document.

The opinions expressed in the document are solely those of the authors and publishing them does not in any way constitute endorsement of the opinion by the Urban Unit.

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Executive Summary

Waste production is eminent result of all human activities and requires an appropriate management system to avoid devastating impacts on environment and public health. In Punjab province, an estimated 40,000 ton/day of solid waste is generated which needs collection, transport and safe disposal. Along with efficient and safe waste collection and transport, waste disposal must also be done in accordance with international standards of waste disposal adopted by developed and developing countries according to their environment and available resources.

This plan proposes the pathway towards increasing waste collection efficiency, its transport and much safer disposal as compared to the present situation covering all settlements within Faisalabad division. In proposed plan we have established SWM plan for urban areas and in later part of the report rural areas are focused which are under administration of Faisalabad Division. Total population of urban areas in 2023 of all districts in Faisalabad division is calculated to be 4,621,292 (projected by 2017 census report). The proposed plan increases the waste collection efficiency through upgradation of solid waste management resources for urban and rural areas along with intermittent waste treatment facility which enhances the quality of segregated material to obtain higher calorific values as well as increases the life of landfill site by decreasing the waste quantity reaching the landfill site. This end to end system design will help the Waste Management Company and Municipalities to make them partially self-sustainable financially.

Currently, Faisalabad Waste Management Company and respective Municipalities are responsible for waste management within Urban areas/MCs' of Faisalabad Division. The operational practices adopted by FWMC are somehow good and they have successfully managed their solid waste with their jurisdiction but lacks human and financial resources for further upgradation. Furthermore, MCs' of Chiniot, Toba Tek Singh and Jhang needs to improve waste collection efficiencies, operational planning and capacity of staff involved in municipal waste handling. There is also need to introduce the waste management concept in rural areas under local conditions by exploring cost effective methodologies. The system has thoroughly been assessed and it was found that in order to have a successful waste management system, waste management company and municipalities should be strengthened institutionally. Additional HR and machinery is proposed for upgradation of existing SWM system in the overall Division along with business plan.

CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

The management of Municipal Solid Waste (MSW) is a global concern and becoming a great challenge in rapidly growing towns and cities of developing countries. Pakistan, being the fifth largest country in the world in terms of population[1], is facing the problem of poor MSW management which is getting worse with every passing day. The situation is even more challenging due to rapid urbanization, overexploitation of non-renewable resources and increase in diversity of waste composition which is no longer mainly food waste rather includes growing amounts of plastic, paper, leather, rubber, textile, and glass etc.

The matter is of grave concern particularly in Punjab Province as it is the most progressive province in terms of population density, urbanization, industrialization, and economic growth. According to population census report 2017, Punjab is home to about 53% of whole population of the country and the number is increasing with growth rate of 2.13% annually[2]. Correspondingly, the waste generation has reached to a level where it is imperative to undertake substantial steps in solid waste management (SWM) for an improved civic life in the province.

Rapid urbanization coupled with increasing economic activity in Faisalabad Division resulted in generation of high volumes of solid waste bringing solid waste management at the forefront of environmental concerns. Deteriorated condition of the cities and insufficient and obsolete SWM infrastructure underlined a greater need for effective measures to be taken in this regard.

The Faisalabad Waste Management Company (FWMC) desired to improve the system of Solid Waste Management in the urban centers/MC and found its existing organizational capability inadequate to achieve intended results to protect public health, safety and welfare through comprehensive and integrated solid waste management. Furthermore, there is no existence of waste management company in other MC's of Faisalabad Division. In rural areas of the division, waste management services is not in every street or at door step which creates lot of nuisance for the residents of that areas due to lack of waste management resources. This situation is going worse day by day, resulted in many of the shortcomings like poor quality of services, improper management of assets, and increased unnecessary financial obligations on the already poorly serviced sector.

There is a dire need to devise and implement an integrated SWM system that can manage waste collection, storage, its transportation, treatment and safe disposal to avoid over exploitation of existing resources and to save environment.

Keeping in view the rapidly increasing problem for the management of Municipal Solid Waste (MSW), The Urban unit has been given a task to devise a comprehensive SWM plan for Faisalabad Division

[1] World Population Data Sheet 2017, Population Reference Bureau.
[2] Population Profile Punjab 2017, Population Welfare Department GoP.

urban and rural areas which covers every aspect of integrated SWM including generation, collection, storage, transportation, treatment and disposal.

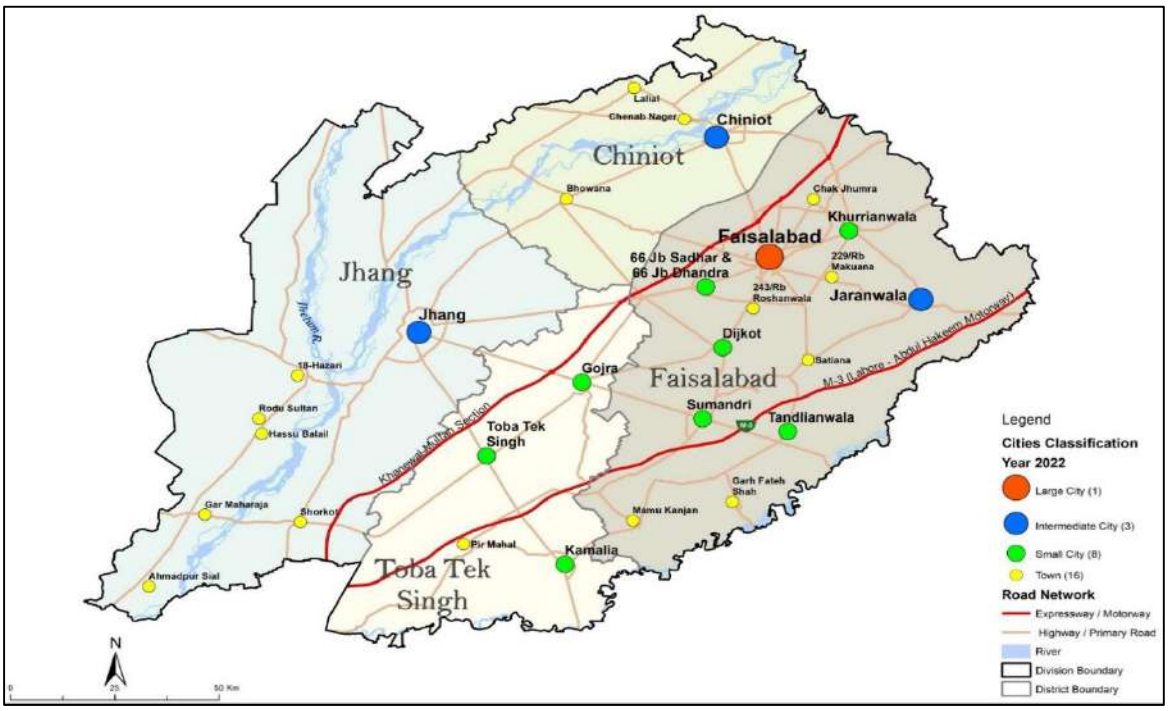


Figure 1.1: Geographical Coverage of Project Area

OBJECTIVE

The main objective of this project is to prepare a comprehensive solid waste management plan on the basis of field studies conducted for Faisalabad Division by SWM team of the Urban Unit in which the shortcomings of the existing system was assessed in each district of Faisalabad Division. This exercise will give a way forward to develop and implement an environment friendly and sustainable model for SWM services.

APPROACH

The approach to develop a suitable and pragmatic SWM plan for urban and rural areas of Faisalabad Division is based on the following principles:

- Design an integrated solid waste management system for urban and rural areas of Faisalabad Division.
- Select an appropriate design through analysis of different waste management system for waste collection and haulage, including Material resource recovery facility (MRF);
- Design and Implementation of SWM system in each district/ tehsils of Faisalabad urban and rural areas of the Faisalabad Division – Faisalabad (FWMC) & MCs of Chiniot, Toba Tek Singh & Jhang.
- Design a sustainable primary and secondary waste collection and transportation system;
- Recommend remediation approaches for existing unsustainable waste disposal methods;

- Develop capital and operational financial plan (i.e. POL & Human Resource). Revenue generation methods will also be discussed;

1.2 METHODOLOGY

SWM team has conducted a one-week field visit from December 5, 2022 to December 10, 2022 for the collection of primary data of Faisalabad Division. For this purpose, meetings with concerned representative of FMWC and MCs of Faisalabad division was carried out to get them familiar about the master planning project as well as to listen their issues and incorporating them at this planning stage to strengthen their existing solid waste management system. Important SWM sites were visited and assessed which include transfer stations, temporary collection points, existing dumping sites, workshops and parking lots. Primary data collected includes current human resources, equipment, expenditure, population, daily waste generation and existing SWM machinery. Secondary data was collected from previous SWM studies which include SWM regional plans and available data with respective MC's offices and official websites. Both type of data was gathered which was further used to identify the gaps in existing SWM systems of respective cities. Coordinates of existing SWM infrastructure / sites were also taken by the team for the mapping of existing SWM infrastructure in each city. Primary and secondary data collected was used to calculate additional resources required in each district for an efficient and sustainable waste management operations.

Based on collected data SWM plan is devised separately for urban and rural areas of Faisalabad division and resources are allocated accordingly.

The rural model is comparatively simple and economical while the model proposed in urban areas are more advanced where modes of primary and secondary collection is done using modern techniques. Door to door collection is suggested at primary level using mini tippers and hand carts. Secondary collection is done using compactors of different capacities. In rural area storage of waste is suggested in drums and trolleys; secondary collection is done using loader rikshaws. Whereas in urban areas storage is suggested in best suitable waste containers of different capacities designed for this purpose and transfer stations are also suggested before final disposal to the landfill/ dumping site. Open plots clearance is provided using loader and trolleys where waste is indiscriminately dumped by the residents of the area. Proposed waste management model will also prevent choking of drains due to waste in monsoon season and reduction of vector borne diseases. Moreover, a material recovery facility is also proposed in Faisalabad city for treatment of solid waste before final disposal. Propose model in urban and rural areas of Faisalabad division are depicted in figures below:

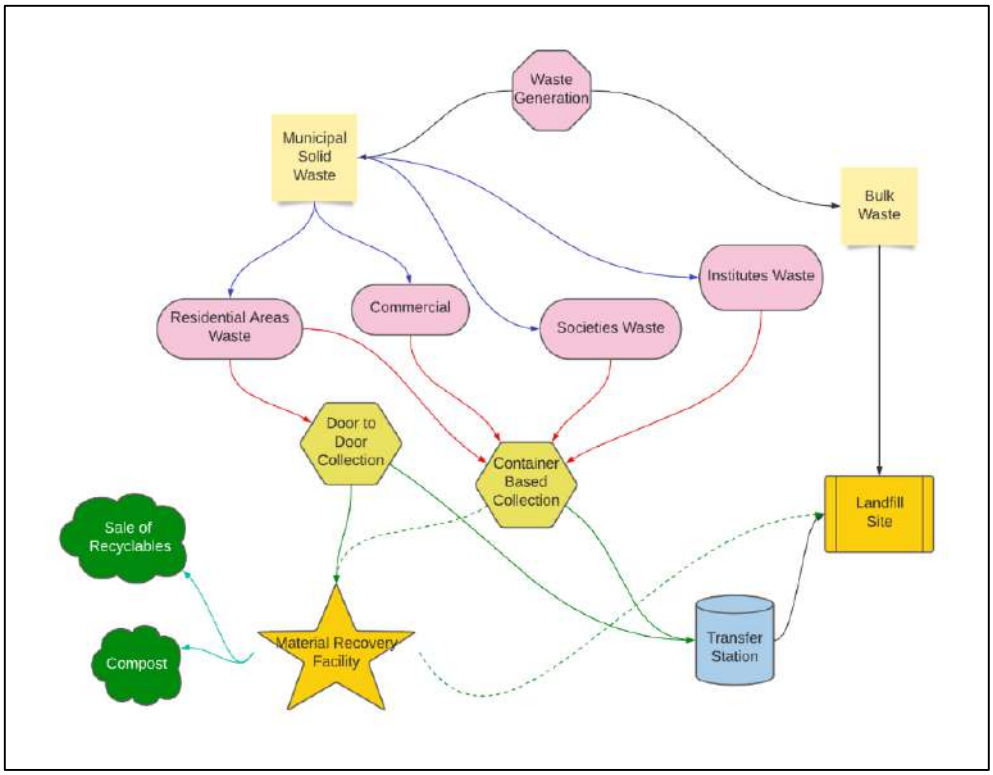


Figure 1.2: SWM design Methodology for Urban area of Faisalabad division

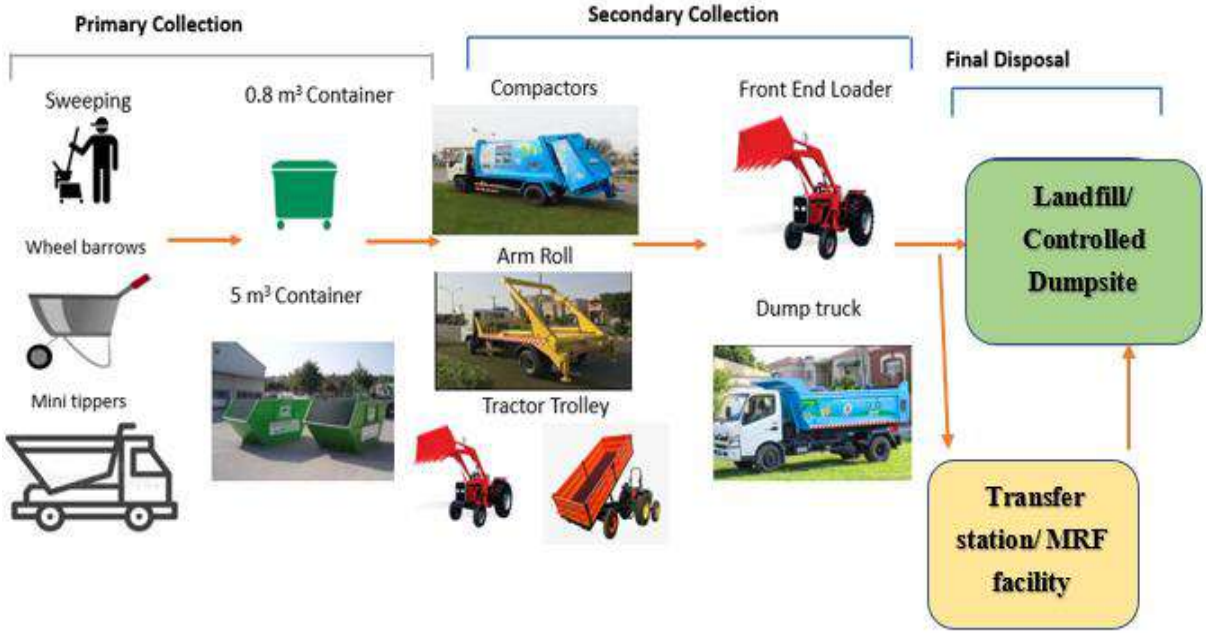


Figure 1.3: Operational model in Urban Areas/MCs' of Faisalabad division

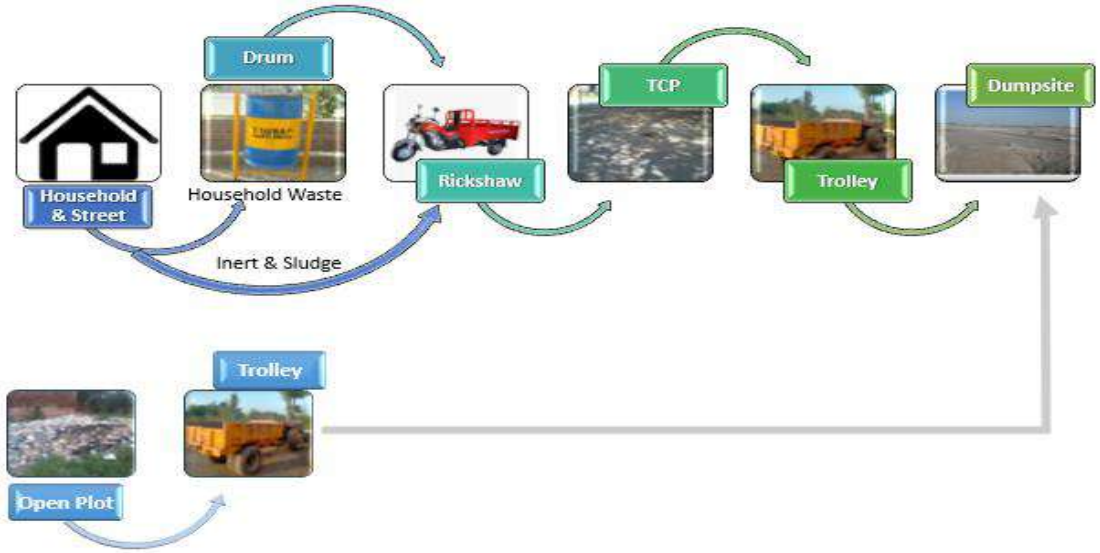


Figure 1.4: SWM Operational Model for Rural Area for Faisalabad Division

Tehsils of each district in Faisalabad division which are as following;

Table 1:1: Tehsil in each Districts of Faisalabad Division

Faisalabad District	Chiniot District	Toba Tek Singh District	Jhang Dist
Chak Jhumra	Chiniot	Gojra	Jhang
Jaranwala	Lalian	Kamalia	Shorkot
Tandalianwala	Bhowana	Pir Mahal	Ahmadpur Sial
Samundari		Toba Tek Singh	18-Hazari
Saddar			

1.3 EXISTING ORGANIZATIONAL STRUCTURE

Municipal Corporations (MCs) and Town/Tehsil Councils (TCs) are responsible to manage MSW at District and tehsil level. Each MC is headed by Chief Officer (CO) and Town Council is headed by Municipal Officer (MO). The following chart shows the existing solid waste management structure followed in FWMC & other District Level of Faisalabad Divisions.

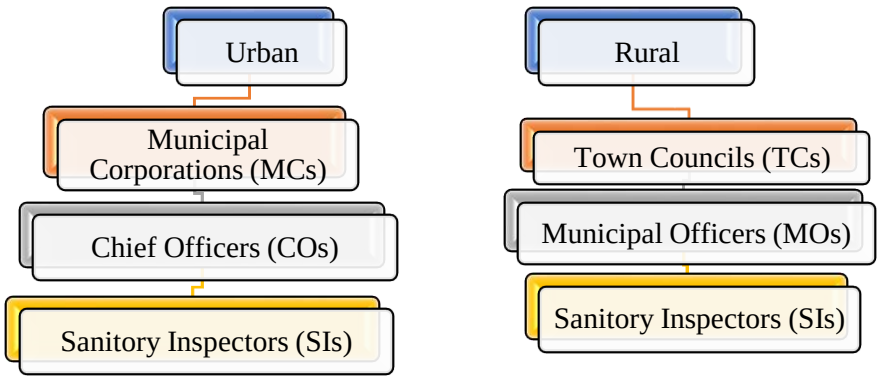


Figure 1.5: Hierarchy in Each District of Faisalabad Division

Existing organizational structure in FWMC are attached below:

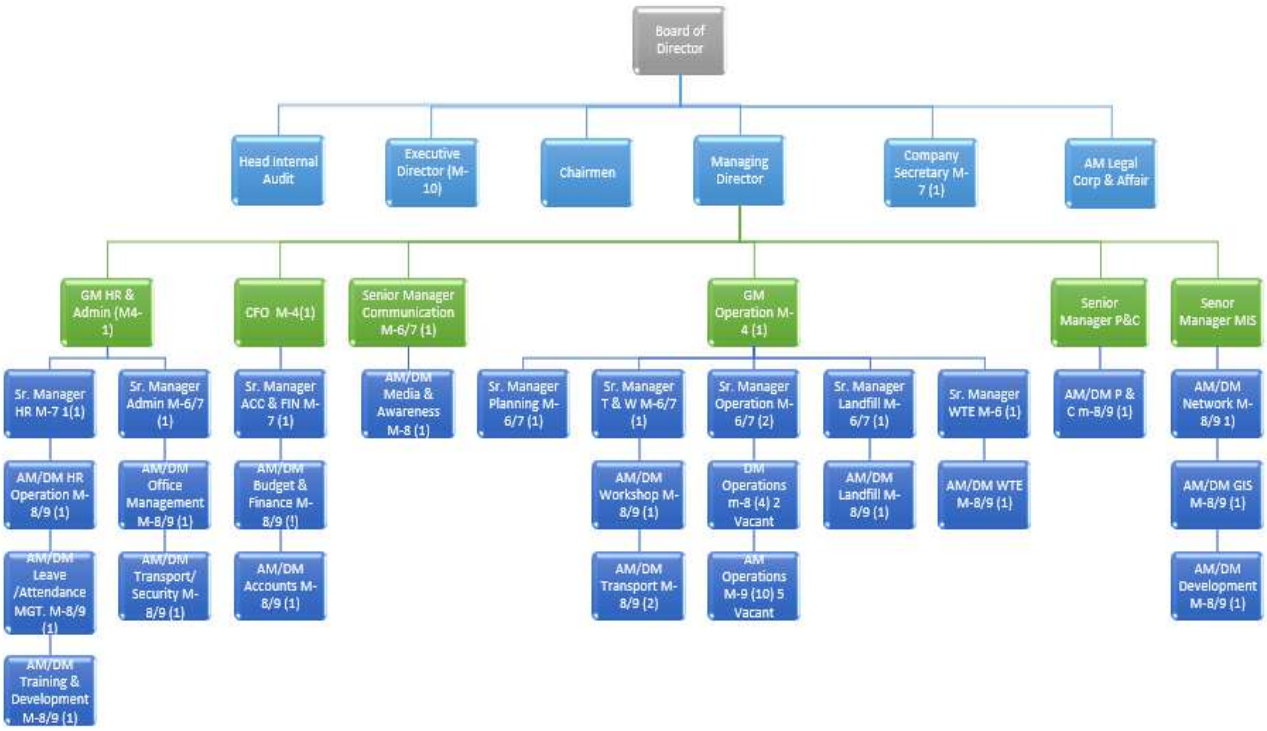


Figure 1.6: Organizational Structure of FWMC

CHAPTER 2. FAISALABAD DIVISION

Faisalabad, formerly known as Lyallpur, is the largest metropolis in Pakistan, the second largest in Province of Punjab and a major industrial centre in the heart of Pakistan. Faisalabad is one of the industrial divisions of Punjab. It is surrounded by Gujranwala and Sheikhupura districts in the North, in the East by Sheikhupura and Sahiwal districts, in the South by Sahiwal and Toba Tek Singh districts and in the west by Jhang district. Under Faisalabad division there are total four districts i.e. Faisalabad, Jhang, Chiniot and Toba Tek Singh. Each district is divided into their respective Tehsils/Towns and Union Councils (UCs). According to 2017 census, Faisalabad division had a population of 14,177,081, which includes 7,233,831 males and 6,949,921 females.

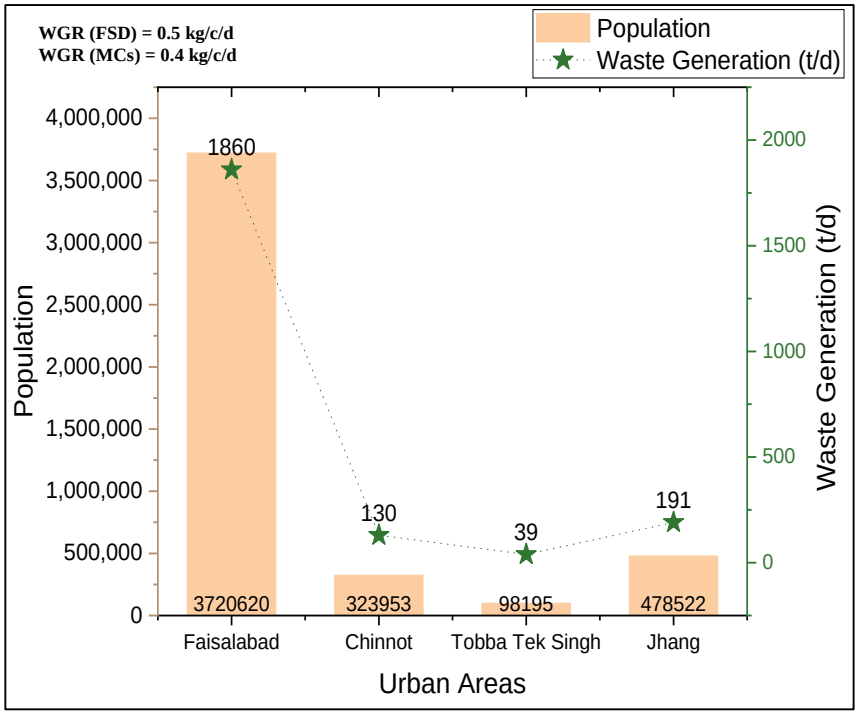


Figure 2.1 Population vs waste generation of urban areas Faisalabad divisions

2.1 DISTRICT FAISALABAD PROFILE

The district Faisalabad itself is currently divided into six tehsils. It has an area of 5,857 km^2 and a population of 7,882,444. Rural population is 4,115,578 while the urban population is 3,766,866. The districts has an annual growth rate of 1.98. The literacy rate is 69.83% at the time of census.[3] Faisalabad district has been endowed in both agriculture and industry. The river Ravi flows on the Eastern and the Chenab on the Western boundary of the district. Faisalabad district has made rapid strides in the field of industry after independence, often called the "Manchester of Asia" for its extensive development of textile industry. It is a progressive district with generations of entrepreneur's keen to support human resource development.

[3] Population Profile Punjab 2017, Population Welfare Department GoP.

1. Location

Faisalabad lies in the rolling flat plains of northeast Punjab, at 184 m above sea level. The city proper comprises approximately 1,330 km^2 while the district encompasses more than 16,000km^2.The Chenab River flows about 30 km and the Ravi River meanders 40 km to the southeast. The lower Chenab canal provides water to 80% of cultivated lands making it the main source of irrigation.

2. Geology

The district of Faisalabad is part of the alluvial plains between the Himalayan foothills and the central core of the Indian subcontinent. The alluvial deposits are typically over a thousand feet thick. The soil consists of young stratified silt loam or very fine sandy loam which makes the subsoil weak in structure with common cankers at only five feet. The course of the rivers within Faisalabad are winding and often subject to frequent alternations. In the rainy season, the currents are very strong. This leads to high floods in certain areas which do last for a number of days. Faisalabad is situated at the center of the lower Rachna Doab, the area is located between the Chenab and Ravi rivers. There is a mild slope from the northeast to the southwest with an average fall of 0.2–0.3 meters per kilometer (1.1–1.6 feet per mile).

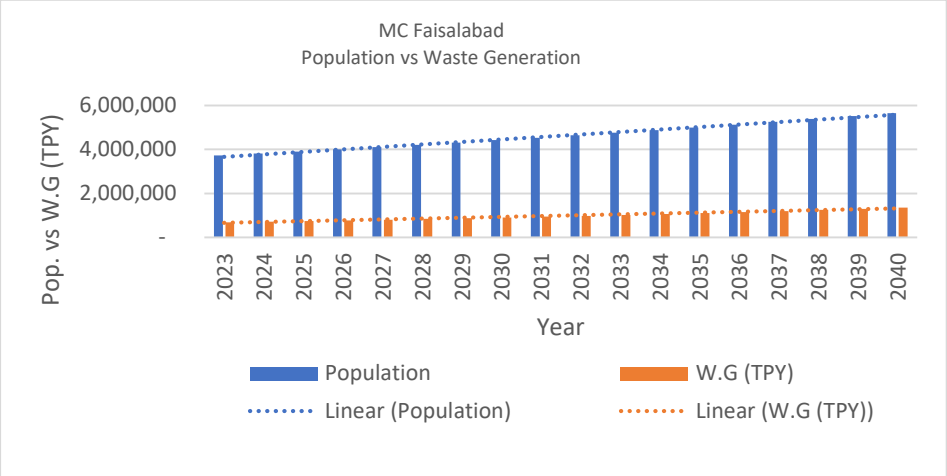
3. Population

The population is one of the most important factors for determining the waste amount produced in a region. For the current study, population data has been taken from the population census of Pakistan, as it is a prime source of relevant information. The population census of 2017, which is the latest in the sources of the population censuses was used for the current analysis of the city urban population. The current population data is taken by urban growth rate of 2.49, population of Faisalabad tehsil was 3,210,158 (population census 2017) and project population in 2023 is 3,720,620.

2.2 WASTE GENERATION:

Waste generation of Faisalabad has been calculated from the above-mentioned population. By conducting field visits and analysing the quantity of waste generated on a real-time basis, the waste generation rate (WGR) of 0.5 kg/cap-day is taken for Faisalabad. By using this WGR, the calculated waste generation is 1,860 tons/day of 2023 in which MSW generation is 1,302 tons per day with 70% and bulk waste is 558 tons per day with 30% of total solid waste generation.

Figure 2.2: Population vs waste generation of Faisalabad district



Faisalabad tehsils include Chak Jhumra, Jaranwala, Tandalianwala, Samundri, Saddar. Rural area waste generation is calculated for respective tehsils of Faisalabad districts. Waste generation in tons per day vs population details are explained below figure.

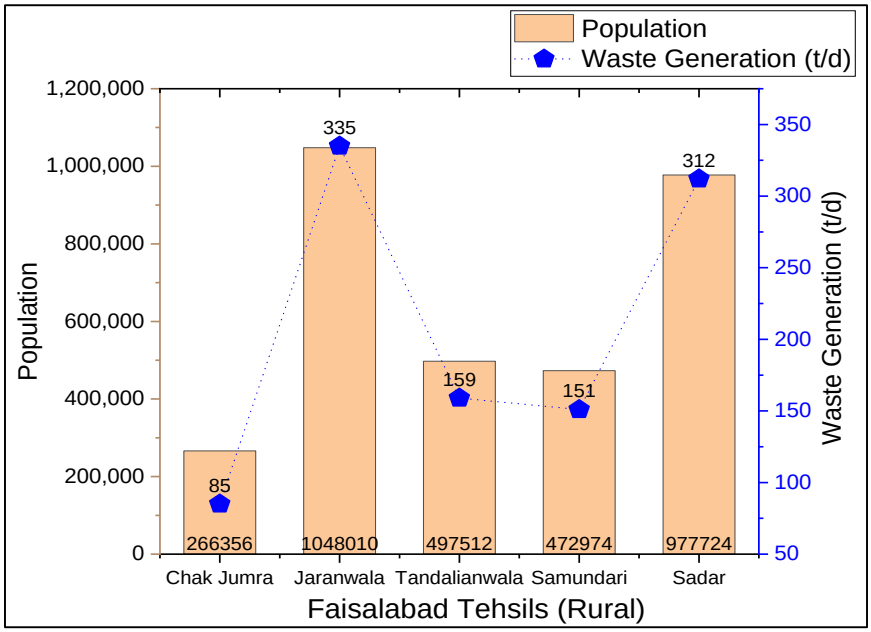


Figure 2.3: Waste generation vs population of Faisalabad Tehsils (Rural)

2.3 CURRENT SWM PRACTICES IN FAISALABAD DISTRICT:

In the existing SWM system of Faisalabad Division, Faisalabad Waste Management Company (FWMC) is responsible to Manage City's Waste. Faisalabad Waste Management Company (FWMC) was established on 13th July, 2013 under Section 42 of the Companies Ordinance, 1984, it started working under an agreement named as SAAMA (Services and Asset Management Agreement) which was executed on 11th December, 2013 between different stake-holders including CDGF, TMOs and FWMC. The company is responsible for the collection, transportation, and safe disposal of waste generated on daily basis. Before the establishment of the FWMC, the responsibility pertaining to solid waste management was lying with SWM wing which is working under CDGF.

Figure 2.4: Private Rikshaw bringing waste to transfer station

Faisalabad city is managed well by FWMC. SWM vehicles are working in Faisalabad in 1st shift and the areas of Faisalabad city. Markets and Bazars located around Ghanta Ghar are being swept at night due to high traffic and rush at day time. Scavengers, private Rikshaws are working very efficiently in the city and performing door to door collection in the streets also performing waste segregation at transfer stations. The sorted waste is then sold at scrap markets and recycling industries. Due to their vested interest private sector is also contributing towards waste collection and transportation in Faisalabad city which reduces burden of primary waste collection of FWMC as well. Waste Collection Efficiency of FWMC is approximately 80%. There are total number of 12 waste Transfer stations located inside the city. This system deploys sanitary workers and handcarts to collect waste from households and sweep related waste. The waste is then stored in containers of different capacities. Transportation of waste is done through Arm-roll trucks, tractor trolley, and container carriers. As far as disposal is concerned, the waste is being dumped indiscriminately in open space and open plots of Faisalabad districts. Waste is then disposed-off at the dumpsite which is located almost 20kms from the city center. FWMC also owns a workshop for repair and maintenance of vehicles and containers. All vehicles are weighed on a weigh bridge before it is sent to the dumping site. Existing locations of all FWMC sites are mapped and shown below:

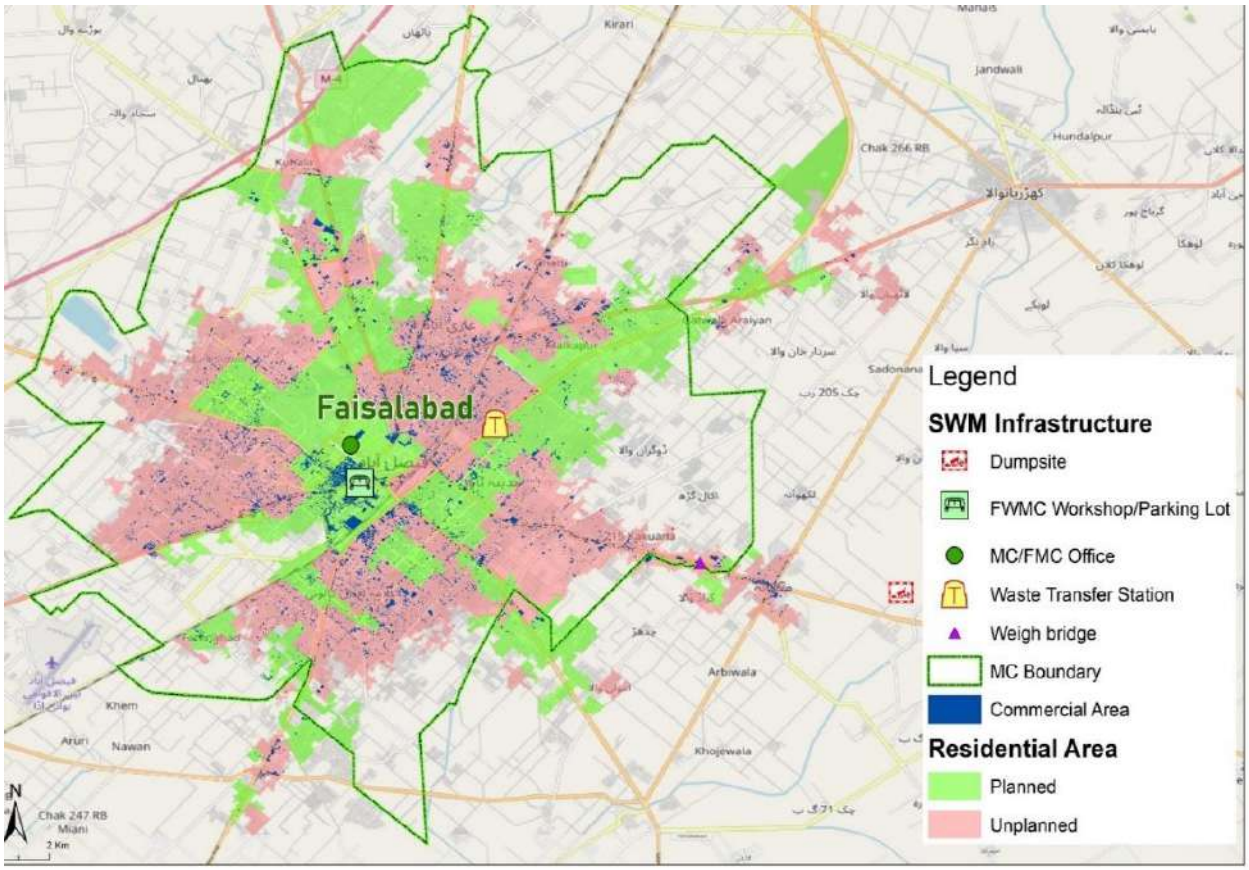


Figure 2.5: Faisalabad Urban Areas – Land-use & SWM Current Infrastructure

Existing resources available in FWMC are shown in table below:

Table 2:1: Existing SWM resources in FWMC

Human Resource	
Sanitary Workers	3539
Drivers	161
Primary Collection	
Hand Carts	1100
Mini dumper	40
Tractor Trolley	5
Secondary Collection Vehicles	
Arm Roll	28
Compactor 8m^3	8
Compactor 13m^3	8
Container carrier	Nil
Loader	17
Mechanical Sweeper	4
Water Bowzer	Nil
Storage	
Containers (10 m^3)	Nil
Containers (5 m^3)	105
Containers (0.8 m^3)	403

Departmental Meeting in FWMC

SWM Vehicles in FWMC

Primary Waste Collection Storage		
		

2.4 WASTE COMPOSITION

The waste composition studies was conducted previously by Faisalabad Waste Management Company which is tabulated below.

The major fraction of MSW is organic waste of the total waste, mostly consisting of kitchen waste, food and fruits remain spoiled and fermented food, leaves and garden waste. Second major part of MSW was paper waste (including cardboard, packing material, newspapers, magazines, empty cigarette case, match boxes) of the total generated solid waste. The construction and demolition waste was recorded to be 28.79%.

Components	Percentage (%)
Plastic & Rubber	6.60
Metals	1.00
Paper & Cardboard	7.67
Rags/ Textile waste	6.53
Glass ceramics	2.43
Bones	2.40
Food Waste	33.81
Animal Waste	2.34
Leaf, Grass & Straw	7.36
Wood	1.07
Dust, Dirt, Ash, Bricks, stone	28.79
TOTAL	**100.00**

2.5 PROPOSED SWM SYSTEM FOR MC/Urban areas of Faisalabad City

2.5.1 Primary Waste Collection

Primary Collection is the collection of solid waste at the primary level i.e. consumer/generator level. In the proposed SWM plan, Primary collection will be done through handcarts (HC) and Mini dumpers (MD). In Faisalabad urban area municipal waste, 15%-20% of the generated waste will be collected

by Mini-dumpers, 35% will be collected by handcarts and the remaining waste from will come directly to containers/collection points. Workers for primary collection will collect the waste from household's door to door base and transfer to containers. Waste from commercial area, societies, and institute will be container base collection.

For bulk waste, tractor trolleys and loader will be used to lift waste from respective tehsil open plots and collection points which will take the waste to the transfer station or landfill (if feasible). Sweeping of main road and inner streets will be improved by deploying sanitary workers.

The day-to-day duty of sanitary workers will include street sweeping, waste collection from households, de-silting, and scrapping works needed for streets and roads. In addition to a regular team of sanitary workers, there would be a special group of workers consisting of 10-15 sanitary workers in the Faisalabad City, who will work in a team and clean public places like grounds, parks, and graveyards twice a week.

2.5.2 Secondary Waste Collection System

Secondary collection system is the collection of solid waste from the secondary level. In this type of collection system, the waste collected from the community would be taken to the designated transfer station (TS)/ temporary collection point or directly to the landfill site (if feasible). Solid waste will be collected through compactors (having capacities of 8m^3) and arm roll vehicles, while remaining areas will be served through Arm roll vehicles and tractor-trollies. Community Containers of 5m^3 capacity are proposed along major streets and places of littering/bulk generators/un-serviced areas. While containers of 0.8 m^3 will serve secondary streets, roads, and localities. Mechanical Sweepers (MS) will be used to clean main roads while dumpers and excavators/loaders are proposed to clean plots and transport waste from TS.

2.5.3 Final Disposal

Final transport & disposal includes transportation of waste from locality/Transfer Station / temporary collection point to the Landfill site.

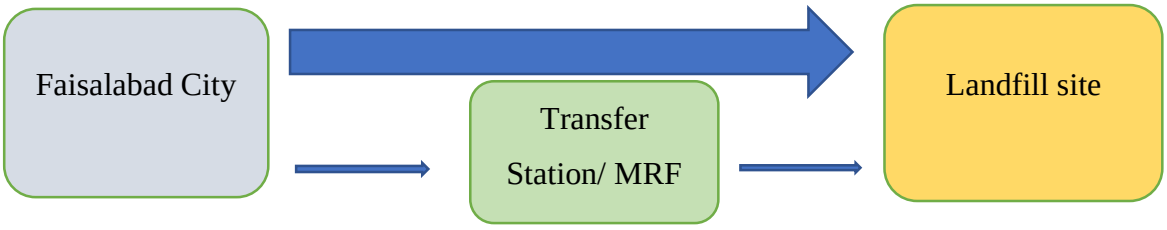


Figure 2.6: Operational model for SWM

The following combination of transfer stations and dumping sites would cater to all the waste coming in a day from human settlements lying within the vicinity of the dumpsite/transfer station.

The current landfill site and transfer station locations in Faisalabad division are mapped below.

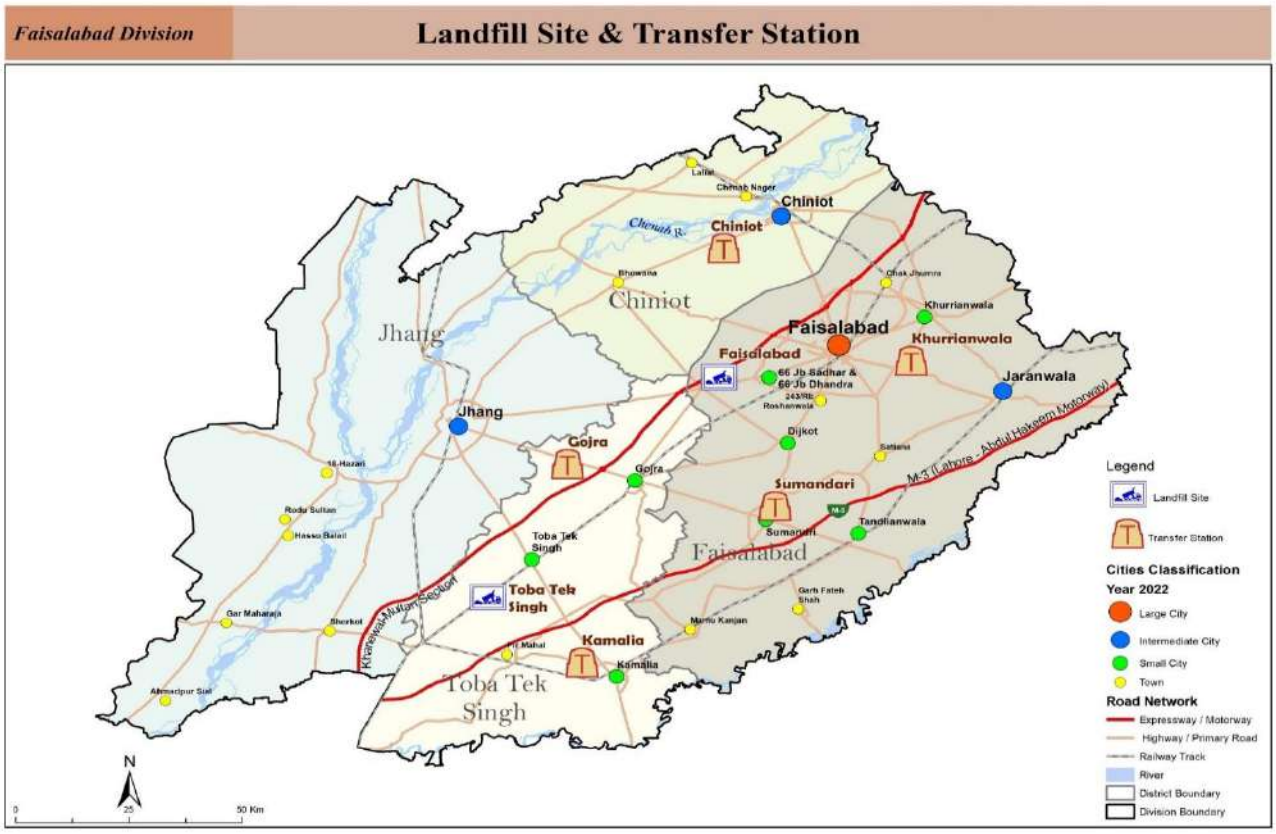


Figure 2.7: Waste disposal system in Faisalabad division

2.6 REQUIRED RESOURCES

In urban areas of Faisalabad resources allocation categorized depending upon mode of waste collection as Container Based Collection (CBC), Door to Door waste collection (DTD), commercial areas waste collection, private societies waste collection, bulk waste collection, TCPs/ transfer stations, mechanical sweeping & washing. Based on waste load, and area requirements, the number of compactors, arm rolls, mini dumpers, dumpers, loaders, collection containers (having capacities of $0.8m^3$/ $5m^3$), mechanical sweeper, and required human resources are proposed.

In rural area of Faisalabad, mechanical resources including riksha loader, tractor loader, tractor trolleys, drum bins, handcart and required human resources are calculated based on waste load and area requirement. The mechanical and HR resources required in urban and rural area of Faisalabad details are given in the table below.

Table 2:2: Required additional Resources Urban area of Faisalabad

Waste Category	Resources	Quantity
Container Based Collection (CBC)	Compactor 7cum	22
	Chain Arm Roll 5cum	13
	T Loader (4*4)	3
	Container 0.8cum	1112
	Container 5cum	67
	Handcarts	1378
	Drivers	38
	Helpers	57
	Workers	4134
Door to Door Waste Collection (DTD)	Compactor 13cum	7
	Compactor 7cum	16
	Mini Dumper 1cum	60
	Mini Dumper 2.5cum	36
	Drivers	119
	Helpers	46
Commercial Areas Waste Collection	Chain Arm Roll 5cum	3
	Compactor 7cum	2
	Container 0.8cum	116
	Container 5cum	16
	Drivers	5
	Helpers	10
Societies Waste Collection	Compactor 13cum	20
	Compactor 25cum	20
	Container 0.8cum	2849
	Drivers	40
	Helpers	80
Bulk Waste Collection	Dumper 5cum	19
	Dumper 10cum	7
	T Loader (4*4)	13
	Excavator (Small)	3
	Trolleys	12
	Frond End Loader	3
	Drivers	57
	Helpers	26
TCPs/ Transfer Stations	Dumper 25cum (MSW)	20
	Dumper 25cum (Bulk)	6
	Excavator (Large)	10
	Front End Loader	3
	Drivers	37
	Helpers	48
Mechanical Sweeping & Washing	Mech Sweeper 6m3	15
	Mech Washer 8000 lit	4
	Drivers	19
	Helpers	23

Table 2:3: Total HR required in Urban area of Faisalabad

Sr. No.	Name	Total Resources (HR)
1	Total Drivers	315
2	Total Helpers	290
3	Total Workers	4134

Table 2:4: Additional resources required in Rural Area

Tehsil	Workers	Drivers LTV	Driver HTV	Helpers
Chak Jumra	89	12.00	9.00	12.00
Jaranwala	349	46.00	33.00	46.00
Tandalianwala	166	22.00	17.00	22.00
Samundri	158	21.00	15.00	21.00
Saddar	326	43.00	32.00	43.00
Total	1088	144	106	144

Table 2:5: Additional HR required in rural area tehsil wise

Sr. No.	Vehicle Type	Quantity
1	Riksha Loader	144
2	Tractor Loader	36
3	Tractor Trolleys	70
4	Drum bins	5742
5	Handcart	218

2.7 FINANCIAL COSTING:

The total cost for primary and secondary waste collection for the whole district has been calculated using above mentioned resources. The following parameters were considered in costing

- Cost of mechanical resources handcarts, loader rickshaws, containers, compactors, arm roll vehicles, container carrier, Containers), front end loaders.
- Capital cost including R/M cost, registration cost and depreciation cost
- Operational and maintenance Cost.
- Cost of HR for primary, secondary
  The detail of each cost has been shown in tables below:

2.7.1 Capital Cost

Table 2:6: Capital cost for SWM in Faisalabad Urban area

Sr. No.	Vehicle Type	Quantity	Cost /Unit	Total Cost / Annual
1	Compactor 7cum	40	12,376,494	129,602,097
2	Compactor 13cum	27	15,476,986	106,930,455
3	Chain Arm Roll 5cum	16	11,376,217	47,078,036
4	T Loader (4*4)	16	4,506,549	18,251,145
5	Compactor 25cum	20	26,704,149	138,136,748
6	Mini Dumper 1cum	60	2,620,822	40,671,413
7	Mini Dumper 2.5cum	36	5,175,702	48,191,701
8	Dumper 5cum	19	7,751,494	37,290,555
9	Dumper 10cum	7	11,226,986	20,253,864
10	Trolleys	12	4,606,549	14,773,992
11	Frond End Loader	6	4,506,549	7,185,356
12	Dumper 25cum (MSW)	26	23,204,149	156,041,272
13	Excavator (Large)	13	20,000,000	68,098,509
14	Mech Sweeper 6m3	15	14,000,000	54,315,000
15	Mech Washer 8000l	4	24,204,149	25,040,921
TOTAL				**911,861,065**
***Note:** Total cost includes 2% registration cost, 10% R&M cost/year,2.5% insurance cost/year and depreciation / Year (10% Residual Value) cost as well.*				

Table 2:7 :Capital once cost in urban area of Faisalabad

Resources	Quantity	Cost per unit	Life	Cost/ month	Cost/ annum
Containers (0.8 cum)	4,077	42000	1	14268216	171218588
Containers (5 cum)	82	300000	2	1029131	12349569
Handcart	290	25000	1	604112	7249342

Table 2:8: Capital cost for SWM in Faisalabad Rural Area

Sr. No.	Vehicle Type	Quantity	Cost /Unit	Life (in Year)	Gross Cost
1	Riksha Loader	144	300,000	5	44,064,000
2	Tractor Loader	36	4,000,000	7	146,880,000
3	Tractor Trolleys	70	4,527,048	7	323,231,227
Total					**514,175,227**
**Gross cost included 2% of registration cost/unit as well.*					

Table 2:9; Capital once cost tehsil wise in Faisalabad

Faisalabad Tehsils	Drum				
	Qty.	Cost per unit	Life	Cost/ month	Cost/ annum
Chak Jhumra	469	12000	1	469000	5628000
Jaranwala	1,844	12000	1	1844000	22128000
Tandalianwala	876	12000	1	876000	10512000
Samundri	832	12000	1	832000	9984000
Saddar	1,721	12000	1	1721000	20652000
Total	**5,742**			**5,742,000**	**68,904,000**

Table 2:10: Capital once tehsil wise in Faisalabad

Faisalabad Tehsils	Handcart				
	Qty.	Cost per unit	Life	cost/ month	Cost/ annum
Chak Jumra	18	25000	1	37500	450000
Jaranwala	70	25000	1	145833	1750000
Tandalianwala	33	25000	1	68750	825000
Samundri	32	25000	1	66667	800000
Saddar	65	25000	1	135417	1625000
Total	**218**			**454,167**	**5,450,000**

2.7.2 Operational and Maintenance Cost of The Proposed System

Table 2:11: O&M cost for SWM in Urban Area of Faisalabad

Particulars	Per Month Cost	Per Annum Cost
Fuel Cost (POL)	46,035,198	552,422,382
Machinery Operational Cost	121,023,356	1,452,280,272
HR Manual work including Janitorial	138,249,482	1,658,993,786
Total Operational Cost	275,174,296	3,302,091,557
Monitoring Cost 4%	11,006,972	132,083,662
Total Annual Cost	286,181,268	3,434,175,219
Annual Tonnage	55,800	669,600
Cost per ton	5,129	5,129
Population	3,720,620	3,720,620
House Hold	589,639	569,773
Cost per Person	77	923

Particulars	Per Month Cost	Per Annum Cost
Cost per Household	485	6,027

Table 2:12: O&M Cost for Rural Area of Faisalabad District SWM

	Chak Jumra		Jaranwala		Tandalianwala		Samundri		Sadar		Faisalabad	
Particulars	**Per Month Cost**	**Per Annum Cost (PKR)**	**Per Month Cost (PKR)**	**Per Annum Cost (PKR)**	**Per Month Cost (PKR)**	**Per Annum Cost (PKR)**	**Per Month Cost (PKR)**	**Per Annum Cost (PKR)**	**Per Month Cost**	**Per Annum Cost (PKR)**	**Total cost per month**	**Total cost per annum**
Fuel Cost	2,560,948	30,731,376	9,455,359	113,464,312	4,843,271	58,119,256	4,843,271	58,119,256	9,144,126	109,729,516	30,304,560	363,654,720
Machinery Operational Cost	3,498,365	41,980,382	12,908,111	154,897,328	6,604,977	79,259,719	5,870,994	70,451,933	12,475,971	149,711,653	41,358,418	496,301,015
Operational Cost	7,593,461	91,121,536	28,863,274	346,359,284	14,234,326	170,811,906	13,090,277	157,083,327	27,407,329	328,887,948	91,188,667	1,094,264,001
Monitoring Cost	303,738	3,644,861	1,154,531	13,854,372	569,373	6,832,476	523,611	6,283,333	1,096,293	13,155,517.80	3,647,547	43,770,560
Annual Cost	7,897,200	94,766,397	30,017,805	360,213,655	14,803,699	177,644,383	13,613,888	163,366,660	28,503,622	342,043,466	94,836,213	1,138,034,561
Annual Tonnage	2,557	30,684	10,061	120,731	4,776	57,313	4,541	54,487	9,386	112,634	31,321	375,849
Cost per ton	3,088	3,088	2,984	2,984	3,100	3,100	2,998	2,998	3,037	3,037	3,028	3,028
Cost per Household	194	2,323	187	2,244	194	2,332	188	2,255	190	2,284	190	2,278

2.7.3 HR Cost

Table 2:13: Total HR Cost in crban area of Faisalabad

Sr. No.	Name	Total Resources (HR)	Per month Cost	Per Annum Cost
1	Total Drivers HTV	219	7,429,586	89,155,037
2	Driver LTV	96	7,429,586	89,155,037
3	Total Helpers	290	8,380,239	100,562,874
4	Total Workers	4134	119,473,256	1,433,679,074.67
Total			**138,249,482**	**1,658,993,786**

Table 2:14: HR cost for rural area of Faisalabad

Tehsil	Workers cost per month	Drivers LTV cost per month	Driver HTV cost per month	Helpers cost per month	Total Cost per month	per annum
Chak Jhumra	2,565,896	30,790,754	305,100	346,800	3,588,596	43,063,154
Jaranwala	10,095,830	121,149,956	1,118,700	1,329,400	13,965,330	167,583,956
Tandalianwala	4,792,699	57,512,387	576,300	635,800	6,684,599	80,215,187
Samundri	11,325,977	135,911,728	508,500	606,900	6,320,616	75,847,394
Saddar	23,751,129	285,013,547	1,084,800	1,242,700	13,074,941	156,899,294
Total					**43,634,082**	**523,608,986**

CHAPTER 3. CHINIOT DISTRICT

3.1 DESCRIPTION

Chiniot District is the 36th district of the Punjab province of Pakistan in February 2009. Chiniot is at the intersection of the Faisalabad-Sargodha and Lahore-Jhang roads. It is 158 km (98 mi) northwest from Lahore and 38 km (24 mi) north of Faisalabad. Chiniot district is spread over an area of 10 km2 (3.9 sq mi) with an average elevation of 179 meters (587 ft), Chiniot city lies on left bank of the Chenab River, and is located on a small rocky hill. Much of the surrounding area consists of alluvial plains, interspersed with rocky outcroppings of slate and sandstone that reach up to 400 feet in height around Chiniot. Chiniot has a hot semi-arid climate. The weather in Chiniot is variable. The important products of Chiniot includes silk, cotton, wheat, sugar, rice, milk, pottery, wooden furniture.

3.2 POPULATION:

The population is one of the most important factors for determining the waste amount produced in a region. For the current study, population data has been taken from the population census of Pakistan, as it is a prime source of relevant information. The population census of 2017, which is the latest in the sources of the population censuses was used for the current analysis of the city urban population. The current population data is taken by urban growth rate of 2.55, population of Chiniot tehsil was 278,528 (population census 2017) and project population in 2023 is 323,954.

3.3 WASTE GENERATION:

Waste generation of MC Chiniot has been calculated from the above-mentioned population. By conducting field visits and analyzing the quantity of waste generated on a real-time basis, the waste generation rate (WGR) of 0.4 kg/cap-day is taken for Chiniot. By using these WGR, the calculated waste generation is 130 tons/day of 2023 in which MSW generation is 104 tons per day with 80% and bulk waste is 26 tons per day with 20% of total solid waste generation.

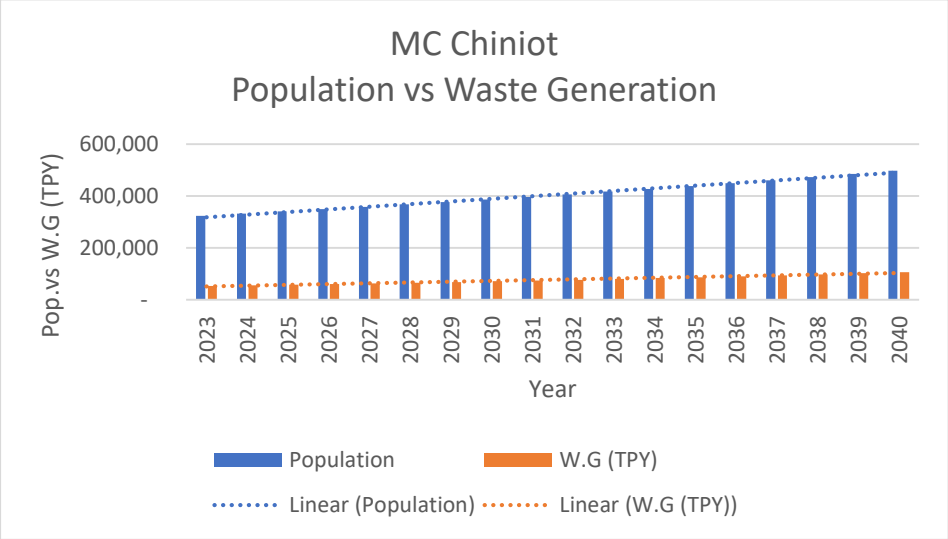


Figure 3.1: Population vs waste generation of Chiniot district

Chiniot tehsils include Chiniot, Lalian, Bhowana. Rural area waste generation is calculated for respective tehsils of Chiniot district. Waste generation in tons per day vs population details are explained below figure.

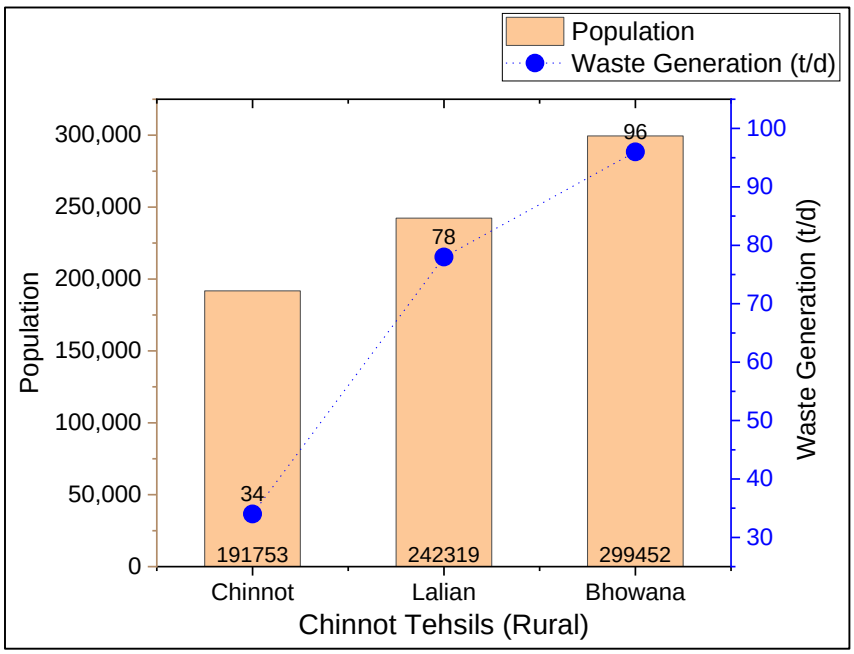


Figure 3.2: Waste generation vs population of Chiniot rural areas

3.4 CURRENT WASTE MANAGEMENT IN CHINIOT

The existing solid waste management system of Chiniot is being managed by the Municipal Committee. The existing solid waste collection in general is divided into primary and secondary collection system. However, there is no proper solid waste disposal system in the city. Previously, a controlled dumpsite was formed in Chiniot under PMDFC project and grant was provided from world bank for its development. The controlled dumpsite had leachate drainage system and covering layers of waste. This controlled dumpsite was formed on a pilot scale that is now completely filled. The existing dumping practices in Chiniot is open dumping at the same dump site where there is still much land is available for waste dumping. Once a controlled dumpsite is developed again on the same location much of disposal issues for Chiniot will be resolved. The current dumping site is located at distance of 10km from city center.

Consultation with MC staff during city profile survey revealed that still there will be a need to address the Solid waste management issues at primary and secondary level, which could be solved by providing more resources to MC. This would strengthen MC and solid waste management system in the city. Current Machinery and waste containers are out dated and obsolete. There is no proper workshop available and machinery is sent local workshops for repair and maintenance. Oil change workshop is owned by MC Chiniot and also has 12 acres of land available for establishment of workshop and parking lot.

There are several open waste collection points in the city where waste is dumped openly in plots where MC deputes its machinery for their clearance. These types of waste disposal practices cause nuisance

to the population living nearby and also adversely effecting environment. Open dumping also causes vector borne diseases as they serve as breeding places for mosquitoes and flies. MC Chiniot also has one transfer station which is located in center of highly populated area and also there is a religious site nearby.

Slaughter houses are situated in the interior portion of city creating great insanitary and unhygienic conditions for the public. Hospital waste is also being mixed with MSW which is causing health issues in sanitary workers. The lack of resources in terms of staff and machinery are resulting in collection and disposal of only 65% of waste generated.

Primary collection is done using handcarts. No door to door collection is present in Chiniot. Main roads are swept manually at early hours of the day, no mechanical sweeping is present. $5m^3$ containers are placed at points of bulk waste generation in the city which are lifted by arm roll vehicles in one shift daily. There are only 2 arm roll vehicles available with MC Chiniot for lifting of 25 waste containers of $5m^3$ Volume. The workforce is also not enough to cater daily waste generated at primary level. Existing SWM infrastructure present in MC Chiniot is shown mapped below:

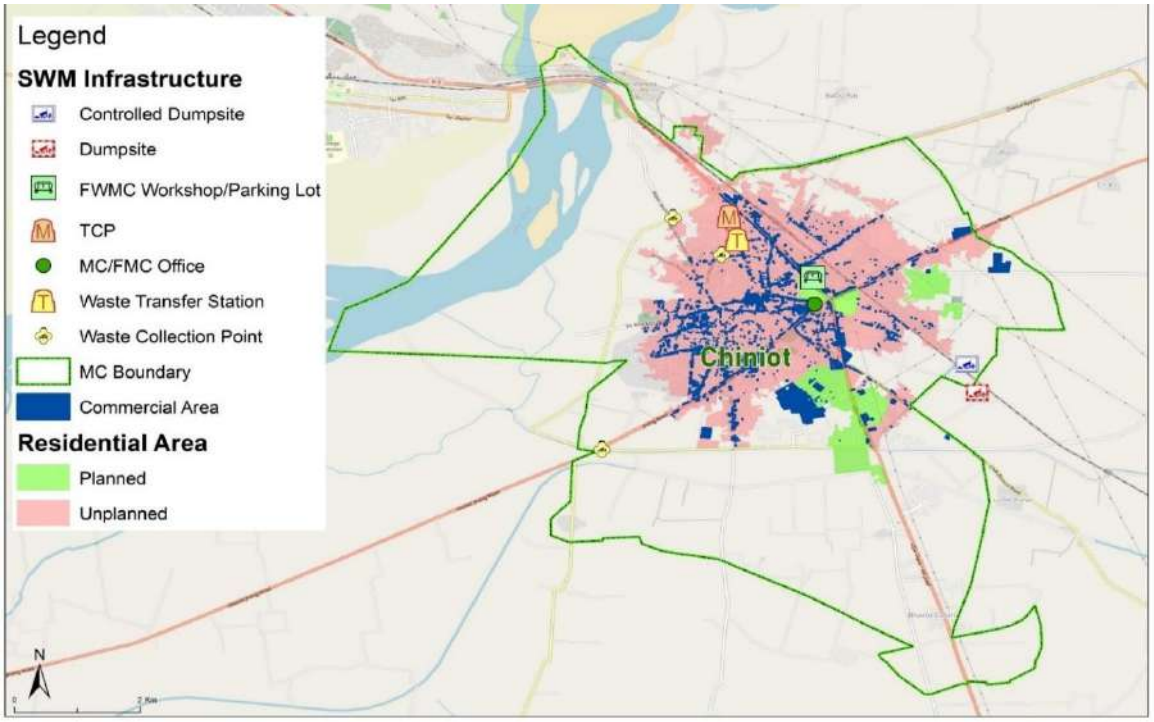


Figure 3.3: Chiniot Urban Areas – Land-use & SWM Current Infrastructure

Existing resources available in MC Chiniot are shown in table below:

Table 3:1: Existing SWM Resources in MC Chiniot

Human Resource	
Sanitary Workers	140
Drivers	12
Primary Collection	
Hand Carts	120
Mini dumper	Nil
Tractor Trolley	6

Secondary Collection Vehicles	
Arm Roll	2
Compactor $8m^3$	0
Compactor $13m^3$	Nil
Container carrier	Nil
Loader	2
Mechanical Sweeper	1
Water Bowzer	Nil
Storage	
Containers (10 m^3)	Nil
Containers (5 m^3)	25
Containers (0.8 m^3)	Nil

Primary Collection of MSW	Manual Sweeping at Main roads	Waste /Collection sweeping issues
		
Waste Storage Container	**Tractor Trolley in MC Chiniot**	**Arm roll Vehicle**
		

Closed controlled Dumping site/ Leachate drainage	Existing Dumping Site	Oil Changing workshop
		
Departmental Meetings with MC Chiniot	Field Visits	Transfer Station
		
Open Collection point	Waste Lying in open Plot	Waste Lying in underneath waste container
		

3.5 REQUIRED RESOURCES

In urban areas of Chiniot resources allocation categorized depending upon mode of waste collection as Container Based Collection (CBC), Door to Door Waste Collection (DTD), commercial areas waste collection, private societies waste collection, bulk waste collection, TCPs/ transfer stations, mechanical sweeping & washing. based on waste load, and area requirements, the number of compactors, arm rolls, mini dumpers, dumpers, loaders, collection containers (having capacities of 0.8m^3 / 5 m^3), mechanical sweeper, and required human resources are calculated.

In rural area of Chiniot mechanical resources including riksha Loader, tractor loader, tractor trolleys, drum bins, handcart and required human resources are calculated based on waste load and area requirement. The mechanical and HR resources required in urban and rural area of Chiniot details are given in the table below :

Table 3:2: Required additional Resources Urban area of Chiniot

Waste Category	Resources	Quantity
Container Based Collection (CBC)	Compactor 13cum	1
	Chain Arm Roll 5cum	2
	Container 0.8cum	87
	Container 5cum	12
	Handcarts	135
	Drivers	3
	Helpers	4
	Workers	405
Door to Door Waste Collection (DTD)	Compactor 13cum	7
	Mini Dumper 1cum	26
	Mini Dumper 2.5cum	7
	Drivers	40
	Helpers	14
Commercial Areas Waste Collection	Chain Arm Roll 5cum	1
	Compactor 7cum	1
	Container 0.8cum	52
	Container 5cum	4
	Drivers	2
	Helpers	4
Societies Waste Collection	Compactor 13cum	2
	Container 0.8cum	116
	Drivers	2
	Helpers	4
Bulk Waste Collection	Dumper 5cum	2
	T Loader (4*4)	1
	Trolleys	1
	Drivers	3
	Helpers	2
Mechanical Sweeping & Washing	Mech Sweeper 4m3	8
	Mech Washer 4500l	3
	Drivers	11
	Helpers	14

Table 3:3: Total HR required in Urban area of Chiniot

Sr. No.	Name	Total Resources (HR)
1	Total Drivers	61
2	Total Helpers	41
3	Total Workers	405

Table 3:4: Additional Resources Required in Rural area of Chiniot

Sr. No.	Vehicle Type	Quantity
1	Riksha Loader	32
2	Tractor Loader	8
3	Tractor Trolleys	15
4	Drum bins	1,290
5	handcart	49

Table 3:5: Additional HR required in rural area tehsil wise

Tehsil	Workers	Drivers LTV	Driver HTV	Helpers
Chiniot	64	8.00	6.00	8.00
Lalian	81	11.00	8.00	11.00
Bhowana	100	13.00	9.00	13.00
Total	**245**	**32**	**23**	**32**

3.6 FINANCIAL COSTING:

The total cost for primary, secondary, waste collection & transport for the whole district has been calculated using above mentioned resources. the following parameters are considered in costing.

- Cost of handcarts, loader rickshaws, containers, compactors, arm roll vehicles, container carrier, containers), front end loaders.
- Capital depreciation cost
- Operational and Maintenance Cost.
- Cost of HR for primary & Secondary waste collection system

The detail of each cost has been shown in tables below:

3.6.1 Capital Cost

Table 3:6: Capital cost for SWM in Chiniot Urban Area

Sr. No.	Vehicle Type	Quantity	Cost /Unit	Total Cost / Annual
1	Compactor 7cum	1	12,376,494	3,201,092
2	Compactor 13cum	10	15,476,986	39,529,742
3	Chain Arm Roll 5cum	3	11,376,217	8,827,132
4	T Loader (4*4)	1	4,506,549	897,933
5	Mini Dumper 1cum	26	2,620,822	17,624,279
6	Mini Dumper 2.5cum	7	5,175,702	9,370,608
7	Dumper 5cum	2	7,751,494	3,475,105
8	Trolleys	1	4,606,549	688,394
09	Mech Sweeper 4m3	8	14,000,000	28,968,000
10	Mech Washer 4500l	3	14,000,000	10,863,000
TOTAL				**911,861,065**
**Total cost includes 2% registration cost, 10% R&M cost/year,2.5% insurance cost/year and depreciation / Year (10% Residual Value) cost as well.*				

Table 3:7 :apital once cost in urban area of Chiniot

Resources	Qty.	Cost per unit	Life	Cost/ month	Cost/ annum
Containers (0.8 cum)	255	42000	1	892880	10714560
Containers (5 cum)	16	300000	2	205497	2465966
Handcart	41	25000	1	86424	1037083

Table 3:8: Capital cost for SWM in Chiniot Rural Area

Sr. No.	Vehicle Type	Quantity	Cost /Unit	Life (in Year)	Gross Cost
1	Riksha Loader	32	300,000	5	9,792,000
2	Tractor Loader	8	4,000,000	7	32,640,000
3	Tractor Trolleys	15	4,527,048	7	69,263,834
Total					**111,695,834**
**Gross cost included 2% of registration cost/unit as well.*					

Table 3:9: Capital once cost tehsil wise of Chiniot

Faisalabad Tehsils	Drum				
	Qty.	Cost per unit	Life	Cost/ month	Cost/ annum
Chiniot	337	12000	1	337000	4044000
Lalian	426	12000	1	426000	5112000
Bhowana	527	12000	1	527000	6324000
Total				**1,290,000**	**15,480,000**

Table 3:10: Capital once cost tehsil wise of Chiniot

Chiniot Tehsils	Handcart				
	Qty.	Cost per unit	Life	cost/ month	Cost/ annum
Chiniot	13	25000	1	27083	325000
Lalian	16	25000	1	33333	400000
Bhowana	20	25000	1	41667	500000
Total	**49**			**102,083**	**1,225,000**

3.6.2 Operational and Maintenance Cost of the Proposed System

Table 3:11: O&M cost for SWM in Urban area of Chiniot

Particulars	Per Month Cost	Per Annum Cost
Fuel Cost	6,082,161	72,985,937
Machinery Operational Cost	16,470,997	197,651,961
HR Manual work including Janitorial	14,882,176	178,586,108
Total Operational Cost	32,537,974	390,455,678
Monitoring Cost 4%	1,301,519	15,618,227
Total Annual Cost	33,839,492	406,073,905
Annual Tonnage	3,900	46,800
Cost per ton	8,677	8,677
Population	323,954	323,954
House Hold	52,675	49,610
Cost per Person	104	1,253
Cost per Household	642	8,185

Table 3:12: O&M cost for Rural area of Chiniot

	Chiniot		Lalian		Bhowana		Total Cost Chiniot Rural Area	
Particulars	**Per Month Cost (PKR)**	**Per Annum Cost (PKR)**	**Per Month Cost (PKR)**	**Per Annum Cost (PKR)**	**Per Month Cost (PKR)**	**Per Annum Cost (PKR)**	**Per Month**	**Per Annum**
Fuel Cost	1,707,299	20,487,584	2,314,932	27,779,180	2,593,556	31,122,676	6,615,787	79,389,440
Machinery Operational Cost	2,332,243	27,986,921	3,146,997	37,763,967	3,538,751	42,465,012	9,017,992	108,215,901
Total Operational Cost	5,225,347	62,704,168	6,869,670	82,436,044	8,074,639	96,395,663	20,169,656	241,535,875
Monitoring Cost 4%	209,014	2,508,167	274,787	3,297,442	322,986	3,875,827	806,786	9,681,435
Total Annual Cost	5,434,361	65,212,335	7,144,457	85,733,486	8,397,624	100,271,490	20,976,443	251,217,310
Annual Tonnage	1,841	22,090	2,326	27,915	2,875	34,497	7,042	84,502
Cost per ton	2,952	2,952	3,071	3,071	2,921	2,907	2,979	2,973
Cost per Household	177	2,119	184	2,204	175	2,086	178	2,134

3.6.3 HR Cost

Table 3:13: Total HR Cost in Urban area of Chiniot

Sr. No.	Name	Total Resources (HR)	Per month Cost	Per Annum Cost
1	Total Drivers HTV	28	960,783	11,529,390
2	Driver LTV	33.00	1,019,700	12,236,400
3	Total Helpers	41	1,198,868	14,386,420
4	Total Workers	405	11,702,825	140,433,898
Total			**14,882,176**	**178,586,108**

Table 3:14: HR cost for rural area of Chiniot

Tehsil	Workers cost per month	Drivers LTV cost per month	Driver HTV cost per month	Helpers cost per month	Total Cost Per Month	Total Cost Per Annum
Chiniot	1,847,221	247,200	203,400	231,200	2,529,021	30,348,247
Lalian	2,334,340	339,900	271,200	317,900	3,263,340	39,160,076
Bhowana	2,884,721	401,700	305,100	375,700	3,967,221	47,606,651
Total					**9,759,581**	**117,114,974**

CHAPTER 4. TOBA TEK SINGH

4.1 DESCRIPTION

Toba Tek Singh District is a district of Faisalabad Division in the Punjab province of Pakistan. It is located between 30°33' to 31°2' degree north latitudes and 72°08' to 72°48' Degree longitudes.

Toba Tek Singh Tehsil was formed in 1900 with Toba Tek Singh town as Tehsil Headquarter, under the administrative control of Jhang District. It was raised to the status of a sub-division in 1930 and district in 1982. After the implementation of the Punjab Local Government Ordinance 2001, the headquarter sub division was given the status of TMA.

Toba Tek (T.T) Singh is named after a Sikh saint Tek Singh who maintained a water pond and used to serve drinking water to the passers-by. He rendered a great humanitarian service to the community and gradually the pond came to be called as 'Toba Tek Singh' meaning the pond of Tek Singh. There was a small mandi (grain market) close to that pond which subsequently flourished and grew into a town that was named T.T. Singh after the name of the great benefactor of the area-Tek Singh.

Toba Tek Singh is also a colony district. The British from the beginning of the 20th century constructed an extensive irrigation network to bring the agricultural lands under cultivation that were lying uncultivated since long because of the non-availability of irrigation water. For this purpose, they also encouraged new settlements by attracting the people from other populous areas. These settlements are called colonies and such districts are called as colony districts. A forest park with the name of Manzoor Elahi Forest Park has been established by the Government of Punjab for the citizens of Toba Tek Singh. It is located on Jhang Road at a distance of approximately 1 Km from the old "Chungi"

Toba Tek Singh is one of the best producers of oranges, locally known as kenno. It contributes towards export standard quality of oranges produced in all Pakistan. The majority of people living in this district work in agriculture and the region produces several kinds of agricultural and dairy products, including meat, eggs, cotton, maize, several pulses, peaches, guava, tomato, melon, water melon, mangoes, tobacco, onion.

4.2 POPULATION:

The population is one of the most important factors for determining the waste amount produced in a region. For the current study, population data has been taken from the population census of Pakistan, as it is a prime source of relevant information. The population census of 2017, which is the latest in the sources of the population censuses was used for the current analysis of the city urban population. The current population data is taken by urban growth rate of 1.99, population of Toba Tek Singh tehsil was 87,246 (population census 2017) and project population in 2023 is 98,195.

4.3 WASTE GENERATION:

Waste generation of MC Toba Tek Singh has been calculated from the above-mentioned population. By conducting field visits and analyzing the quantity of waste generated on a real-time basis, the waste

generation rate (WGR) of 0.4 kg/cap-day is taken for Toba Tek Singh. By using these WGR, the calculated waste generation is 39 tons/day of 2023 in which MSW generation is 31 tons per day with 80% and bulk waste is 8 tons per day with 20% of total waste.

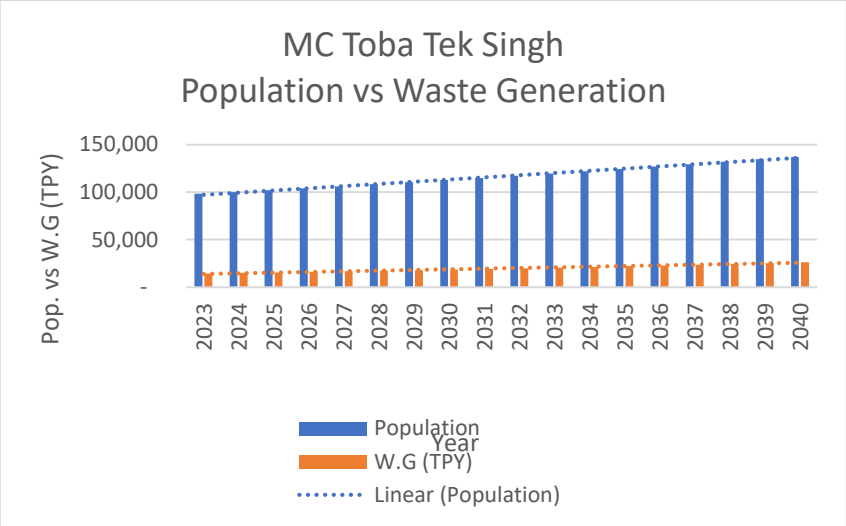


Figure 4.1: Population vs waste generation of toba tek singh District

Toba Tek Singh tehsils include Gojra, Kamalia, Pir Mahal and Toba Tek Singh. Rural area waste generation is calculated for respective tehsils of Toba Tek Singh districts. Waste generation in tons per day vs population details are explained in below figure.

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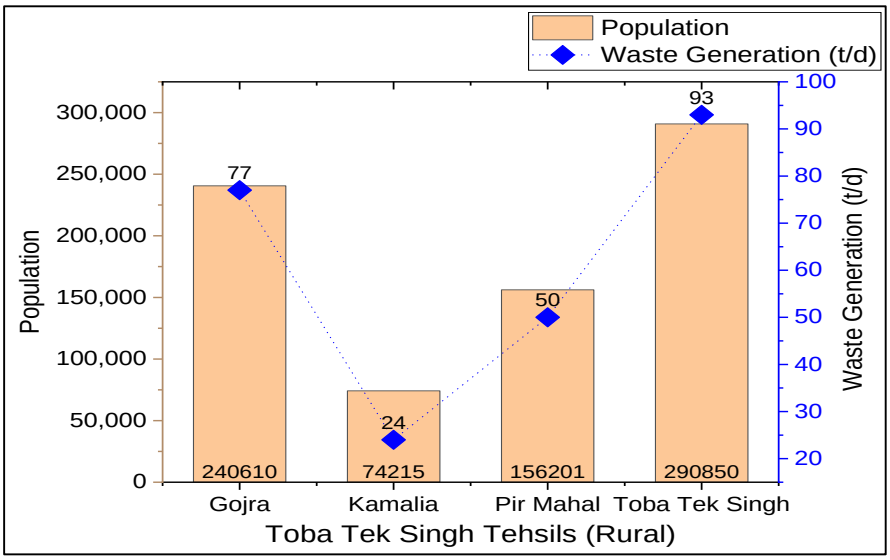


Figure 4.2: Waste generation vs population of Toba Tek Singh tehsils (Rural)

4.4 CURRENT WASTE MANAGEMENT IN TOBA TEK SINGH

The services of SWM are currently managed by the Municipal committee. MC is still using old methods of waste collection and transportation. There is no proper allocation of sanitary workers as the system is not established for SWM. Sanitary workers carry out sweeping of streets and roads and collect

the solid waste from small heaps with the help of brooms, wheel barrows etc. and store at permanent and temporary collection points. The system currently has poor collection efficiency, as it consumes more time and more manpower to collect and transport the solid waste to dumpsites. This system deploys sanitary workers, handcarts and tractor trolleys are used for collection of waste from households and clearance of open plots/ streets respectively. There is no door to door collection present in the city.

The secondary collection is accomplished through tractor trolleys and container carriers. The existing machinery is not sufficient for Toba Tek Singh. Toba Tek Singh has several open heaps, masonry enclosures/ collection points and covered steel containers for secondary waste collection. Collection from many of these collection points is being done on daily basis. The waste is then stored in containers of $5m^3$ capacities. Transportation of waste is done through container carrier vehicles; tractor trolley and loaders are used to clear open waste and temporary collection points. As far as disposal is concerned, the waste is being dumped in the city at designated collection points. There are several small collection points in the city where primary collected waste is dumped, from there waste is taken to dumping site or transfer station in trolleys and dumpers. TMA also has to collect wastes from debris-demolition of building structures; hospital wastes; slaughter houses wastes; vegetable market; dead animals etc. and those are mixed with municipal waste. Precise data of scavenging and for other hazardous wastes is not available with MC. The existing dumping site is present almost 5kms from the city center. However, there is only one transfer station present in the city at Gojra road islampura where waste is being dumped and transferred to dumpsite by loading it on dumpers and trolleys. There is no workshop present for repair and maintenance of vehicles and containers. However, a parking lot is available for MC vehicles. No proper covering of vehicle is done while transporting waste from city/ transfer station to the dumpsite. Existing SWM locations of Toba Tek Singh are mapped below:

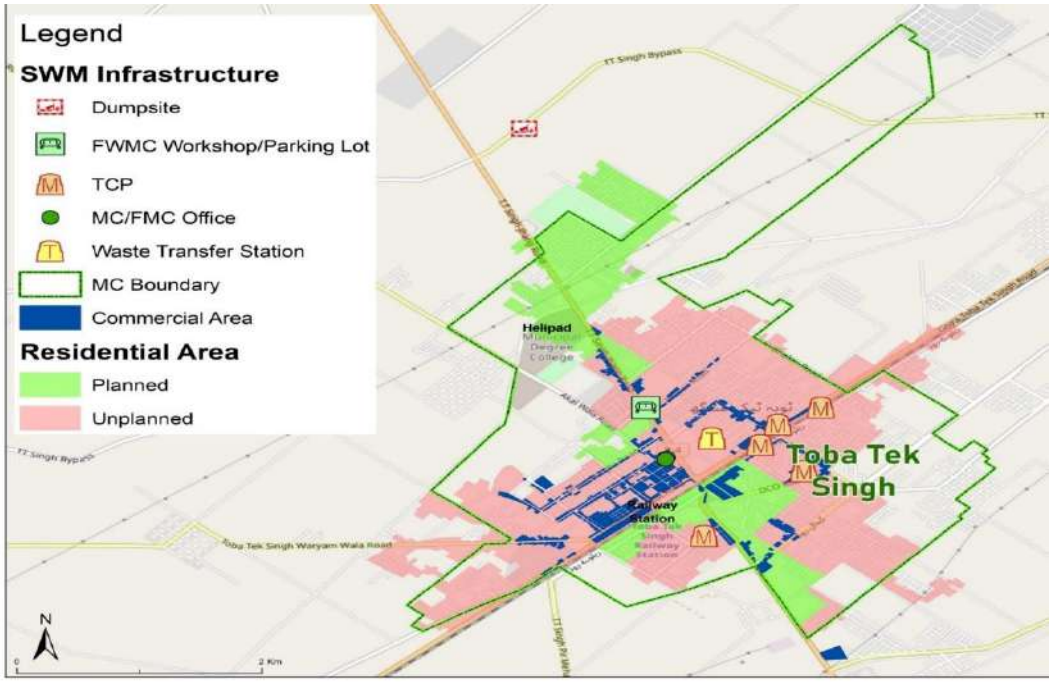


Figure 4.3: Toba Tek Singh Urban Areas – Land-use & SWM Current Infrastructure

Existing resources available in MC toba tek singh are shown in table below:

Table 4:1: Existing SWM resources in MC Toba Tek Singh

Human Resource	
Sanitary Workers	95
Drivers	7
Primary Collection	
Hand Carts	60
Mini dumper	Nil
Tractor Trolley	5
Secondary Collection Vehicles	
Arm Roll	Nil
Compactor 8m^3	Nil
Compactor 13m^3	Nil
Container carrier	2
Loader	3
Mechanical Sweeper	0
Water Bowzer	1
Storage	
Containers (10 m^3)	Nil
Containers (5 m^3)	17
Containers (0.8 m^3)	Nil

Primary collection and Manual Sweeping	Manual Sweeping	Existing Dumpsite
		

Waste storage container	Waste Enclosure/ collection Points	Waste Transfer Station
		
Vehicle Parking Lot	Meeting with MC officials	SWM Site Visits
		

4.5 REQUIRED RESOURCES

In urban areas of Toba Tek Singh resources allocation categorized depending upon mode of waste collection as container-based collection, door to door waste collection, commercial areas waste collection, societies waste collection, bulk waste collection, transfer stations, mechanical sweeping & washing. Based on waste load, and area requirements, the number of compactors, arm rolls, mini dumpers, dumpers, loaders, collection containers (having capacities of $0.8m^3$ / 5 m^3), mechanical sweeper, and required human resources are proposed. In rural area of Toba Tek Singh mechanical resources including rikshaw loader, tractor loader, tractor trolleys, drum bins, handcart and required human resources are calculated based on waste load and area requirement. The mechanical and HR resources required in urban and rural area of Toba Tek Singh are given in the table below.

Table 4:2: Required additional Resources Urban area of Toba Tek Singh

Waste Category	Resources	Quantity
Container Based Collection (CBC)	Compactor 7cum	1
	Chain Arm Roll 5cum	1
	Container 0.8cum	40
	Container 5cum	4
	Handcarts	41
	Drivers	2
	Helpers	3
	Workers	123
Commercial Areas Waste Collection	Compactor 7cum	1
	Container 0.8cum	13
	Drivers	1
	Helpers	2
Societies Waste Collection	Compactor 7cum	1
	Container 0.8cum	44
	Drivers	1
	Helpers	2
Bulk Waste Collection	T Loader (4*4)	1
	Trolleys	3
	Drivers	4
TCPs/ Transfer Stations	Dumper 25cum (MSW)	1
	Excavator (Large)	1
	Drivers	2
	Helpers	2
Mechanical Sweeping & Washing	Mech Sweeper 4m3	4
	Mech Washer 4500l	2
	Drivers	6
	Helpers	8

Table 4:3: Total HR required in Urban Area of Toba Tek Singh

Sr. No.	Vehicle Type	Quantity
1	Riksha Loader	34
2	Tractor Loader	9
3	Tractor Trolleys	16
4	Drum bins	1,341
5	handcart	50

Table 4:4: Additional Resources Required in Rural Area of Toba Tek Singh

Sr. No.	Name	Total Resources (HR)
1	Total Drivers	16
2	Total Helpers	17
3	Total Workers	123

Table 4:5: Additional HR required in rural area tehsil wise of Toba Tek Singh

Tehsil	Workers	Drivers LTV	Driver HTV	Helpers
Gojra	80	11.00	8.00	11.00
Kamalia	25	3.00	3.00	3.00
Pir Mahal	52	7.00	5.00	7.00
Toba Tek Singh	97	13.00	9.00	13.00
Total	**254**	**34**	**25**	**34**

4.6 FINANCIAL COSTING:

The total cost for primary, secondary, waste collection & transport for the whole district has been calculated using above mentioned resources. the following parameters were considered in costing.

- Cost of handcarts, loader rickshaws, containers, compactors, arm roll vehicles, container carrier, Containers), front end loaders.
- Capital depreciation cost
- Operational and Maintenance Cost.
- Cost of HR for primary, Secondary waste collection system.
  The detail of each cost has been shown in tables below:

4.6.1 Capital Cost

Table 4:6: Capital cost for SWM in Toba Tek Singh Urban area

Sr. No.	Vehicle Type	Quantity	Cost /Unit	Life (in Year)	Total Cost / Annual
1	Compactor 7cum	3	12,376,494	7	9,603,275
3	Chain Arm Roll 5cum	1	11,376,217	7	2,942,377
4	T Loader (4*4)	1	4,506,549	7	1,036,077
5	Trolleys	3	4,606,549	7	3,177,203
6	Dumper 25cum (MSW)	1	23,204,149	7	6,001,587
7	Excavator (Large)	1	20,000,000	7	6,322,381
8	Mech Sweeper 4m3	4	14,000,000	7	14,484,000
9	Mech Washer 4500l	2	14,000,000	7	7,242,000
TOTAL					**51,067,920**
**Total cost includes 2% registration cost, 10% R&M cost/year, 2.5% insurance cost/year and depreciation / Year (10% Residual Value) cost as well.*					

Table 4:7 :Capital once cost in urban area of Toba Tek Singh

Resources	Qty.	Cost per unit	Life (yrs.)	Cost/ month	Cost/ annum
Containers (0.8 cum)	97	42000	1	338505	4062066
Containers (5 cum)	4	300000	2	45000	540000
Handcart	17	25000	1	35417	425000

Table 4:8: Capital cost for SWM in Rural Area of Toba Tek Singh

Sr. No.	Vehicle Type	Quantity	Cost /Unit	Life (in Year)	Gross Cost
1	Riksha Loader	144	300,000	5	44,064,000
2	Tractor Loader	36	4,000,000	7	146,880,000
3	Tractor Trolleys	70	4,527,048	7	323,231,227
Total					**514,175,227**
**Gross cost included 2% of registration cost/unit as well.*					

Table 4:9; Capital once cost tehsil wise in Toba Tek Singh

Toba Tehsils	Drum				
	Qty.	Cost per unit	Life	Cost/ month	Cost/ annum

Gojra	423	12000	1	423000	5076000
Kamalia	131	12000	1	131000	1572000
Pir Mahal	275	12000	1	275000	3300000
Toba Tek Singh	512	12000	1	512000	6144000
Total	**1,341**			**1,341,000**	**16,092,000**

Table 4:10: Capital once tehsil wise in Toba Tek Singh

Faisalabad Tehsils	**Handcart**				
	Qty.	**Cost per unit**	**Life**	**cost/ month**	**Cost/ annum**
Gojra	16	25000	1	33333	400000
Kamalia	5	25000	1	10417	125000
Pir Mahal	10	25000	1	20833	250000
Toba Tek Singh	19	25000	1	39583	475000
Total				**104,167**	**1,250,000**

4.6.2 Operational and Maintenance Cost of the Proposed System

Table 4:11: O&M cost for SWM in Urban area of Toba Tek Singh

Particulars	**Per Month Cost**	**Per Annum Cost**
Fuel Cost	3,041,558	36,498,696
Machinery Operational Cost	7,297,218	87,566,616
HR Manual work including Janitorial	4,581,008	54,972,099
Total Operational Cost	12,297,148	147,565,781
Monitoring Cost 4%	491,886	5,902,631
Total Annual Cost	12,789,034	153,468,412
Annual Tonnage	1,170	14,040
Cost per ton	10,931	10,931
Population	98,195	98,195
House Hold	15,889	15,038
Cost per Person	130	1,563
Cost per Household	805	10,206

Table 4:12: O&M Cost for Rural Area of toba tek singh SWM

	Chak Jumra		Jaranwala		Tandalianwala		Samundri		Total Cost	
Particulars	**Per Month Cost (PKR)**	**Per Annum Cost (PKR)**	**Per Month Cost (PKR)**	**Per Annum Cost (PKR)**	**Per Month Cost (PKR)**	**Per Annum Cost (PKR)**	**Per Month Cost (PKR)**	**Per Annum Cost (PKR)**	**Per month**	**Per year**
Fuel Cost	2,314,932	27,779,180	821,041	9,852,492	1,461,282	17,535,388	2,593,556	31,122,676	7,190,811	86,289,736
Machinery Operational Cost	3,146,997	37,763,967	1,125,736	13,508,831	1,980,876	23,770,507	3,538,751	42,465,012	9,792,360	117,508,317
Total Operational Cost	6,850,207	433,202,483	2,263,191	27,158,285	4,369,545	52,434,543	7,974,689	95,696,272	21,457,631	608,491,583
Monitoring Cost 4%	274,008	3,288,099	90,528	1,086,331	174,782	2,097,382	318,988	3,827,851	858,305	10,299,663
Total Annual Cost	7,124,215	436,490,583	2,353,718	28,244,616	4,544,327	54,531,924	8,293,677	99,524,123	22,315,937	618,791,246
Annual Tonnage	2,310	27,718	712	8,550	1,500	17,994	2,792	33,506	7,314	87,768
Cost per ton	3,084	15,747	3,304	3,304	3,031	3,031	2,970	2,970	3,051	7,050

4.6.3 HR Cost

Table 4:13: Total HR cost in Urban area of Toba Tek Singh

Sr. No.	Name	Total Resources (HR)	Per month Cost	Per Annum Cost
1	Total Drivers HTV	16	542,400	6,508,800
3	Total Helpers	17	491,300	5,895,600
4	Total Workers	123	3,547,308	42,567,699
Total			**4,581,008**	**54,972,099**

Table 4:14: HR cost for rural area of Toba Tek Singh

Tehsil	Workers cost per month	Drivers LTV cost per month	Driver HTV cost per month	Helpers cost per month	Total HR Cost Per Month	Total HR cost Per annum
Gojra	2,317,876	339,900	271,200	317,900	3,246,876	38,962,516
Kamalia	714,938	92,700	101,700	86,700	996,038	11,952,454
Pir Mahal	1,504,736	216,300	169,500	202,300	2,092,836	25,114,036
Toba Tek Singh	2,801,855	401,700	305,100	375,700	3,884,355	46,612,260
Total					**10,220,105**	**122,641,266**

CHAPTER 5. JHANG DISTRICT

5.1 DESCRIPTION

Jhang District is a district of Faisalabad division in the Punjab province, Pakistan. The geography of the Jhang district can be divided into several regions, based on the course of its two major rivers. First is the Hithar, or lowland areas that get flooded annually by the rivers. Next, there are three distinct upland areas: the Sandal Bar, to the east of the Chenab, the Kirana Bar, between the rivers, and the Thal, which is to the west of the Jhelum.

The climate of Jhang District is the same as the climate for all of southern Punjab. At the start of June, the weather becomes intensely hot, and the kikar and ber trees lose all their leaves due to the heat. A hot wind blows consistently from the south and southwest throughout the month of June; the wind becomes more variable with the onset of the monsoon. Until the last few days in June, the nights are somewhat cooler than the days, and from that point on both day and night are very hot.

5.2 POPULATION:

The population is one of the most important factors for determining the waste amount produced in a region. For the current study, population data has been taken from the population census of Pakistan, as it is a prime source of relevant information. The population census of 2017, which is the latest in the sources of the population censuses was used for the current analysis of the city urban population. The current population data is taken by urban growth rate of 1.82, population of Jhang tehsil was 429,441 (population census 2017) and project population in 2023 is 478,522.

5.3 WASTE GENERATION:

Waste generation of MC Jhang has been calculated from the above-mentioned population. By conducting field visits and analyzing the quantity of waste generated on a real-time basis, the waste generation rate (WGR) of 0.4 kg/cap-day is taken for Jhang. By using these WGR, the calculated waste generation is 191 tons/day of 2023 in which MSW generation is 153 tons per day with 80% and bulk waste is 38 tons per day with 20% of total waste.

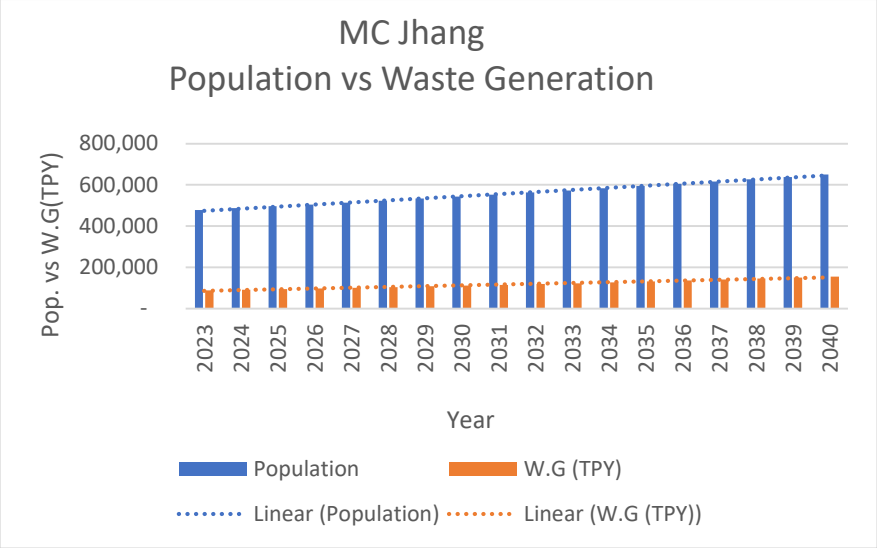


Figure 5.1: Population vs waste generation of Jhang district

Jhang tehsil include Jhang, Shorkot, Ahmadpur Sial and 18-Hazari. Rural area waste generation is calculated for respective tehsils of Jhang districts. Waste generation in tons per day vs population details are explained below figure.

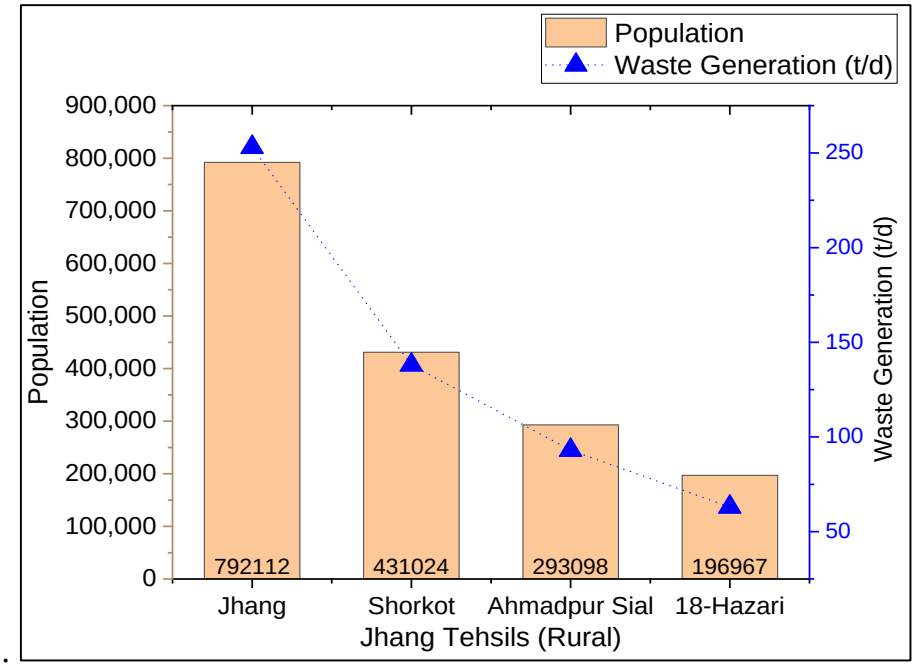


Figure 5.2: Waste generation vs population of Jhang tehsils (Rural)

5.4 CURRENT WASTE MANAGEMENT IN JHANG

The existing solid waste management system of Jhang is being managed by the Municipal Corporation (MC). The existing solid waste collection in general is divided into primary and secondary collection system. However, there is no proper solid waste disposal system in the Town and no sanitary land fill site exists. The current dumping site is located at distance of 20 kms from the city center. There are 3

main waste collection points which are located inside the city within the vicinity of residential settlements which cause nuisance. Collection points are open dumping grounds where huge amount of waste is being dumped whereas, limited machinery is available to clear those points. Due to this vector borne diseases among the citizens are spreading in the citizens living nearby.

For waste storage two types of containers are in use by the MC ($5m^3$ & $10m^3$) but only 5 container carriers are available for their lifting. Machinery is very scarce in MC Jhang for timely lifting of waste containers. Waste can be seen lying underneath the containers and open plots and MC is not equipped properly to clear these points. No door to door collection is present in the city and human resource is inappropriate. There is one model bazar present in Jhang where private workers are hired to ensure cleanliness inside. Manual/ Mechanical sweeping cannot be seen anywhere along main roads and link roads. There is an unofficial dumpsite present near Tibba Desert, Jhang rd and Yousuf wala, Chiniot road.

Major Issues

- Unauthorized dumping of household waste
- Unpaved roads generate dirt
- Poor areas have narrow access
- Sweepers depend on private work
- Inadequate equipment
- The SWM department lacks strategic direction, an under-developed workforce and poor management systems.
- Inadequate planning capacity, poor information and weak financial management.
- The administration is typically absorbed by its own internal procedures and processes, and largely deaf to the needs of citizens and communities.
- Information is still managed using a manual, paper-based system with a high level of inconsistencies, long outdated records and difficult access and retrieval.
- The equipment and machinery of the SWM department is also constantly being used for removing encroachment and debris from roads.
- Similarly, management complains that due the negligence and inefficiency of line departments their workload also increases.
- Existing institutional arrangements for SWM suffer from fragmentation, lack of clear division of responsibilities, and inadequate planning, management and enforcement capacity.
- The legal and regulatory framework for SWM has shortcoming that limits its effectiveness. The main weaknesses are fragmentation and lack of clear allocation of duties and responsibilities.

MC Chiniot is also looking to get machinery from world bank grant that include 17 Arm roll vehicles, 11 containers of $10m^3$ volume and 6 containers of $5m^3$ volume.

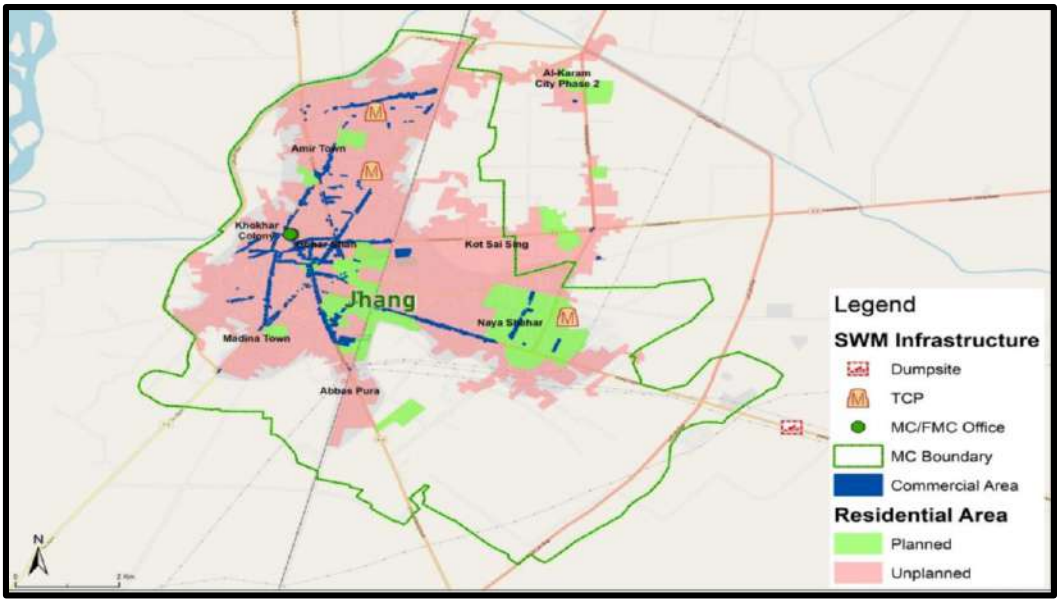
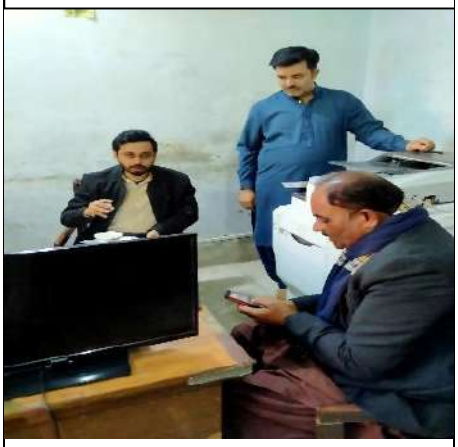


Figure 5.3 Jhang Urban areas – Land-use & SWM current infrastructure

Existing resources available in MC Jhang are shown in table below:

Table 5:1: Existing SWM resources in MC Jhang

Human Resource	
Sanitary Workers	352
Drivers	8
Primary Collection	
Hand Carts	20
Mini dumper	Nil
Tractor Trolley	11
Secondary Collection Vehicles	
Arm Roll	0
Compactor 8m^3	Nil
Compactor 13m^3	Nil
Container carrier	5
Loader	6
Mechanical Sweeper	0
Water Bowzer	0
Storage	
Containers (10 m^3)	75
Containers (5 m^3)	75
Containers (0.8 m^3)	Nil

Departmental Meetings		Site Visit
		
Waste storage container	Container carrier	Tractor Trolley
		
Dumping Site	Model Bazar Jhang	Open Waste Dumping
		

Collection point 1	Collection point 2	Collection point 3
		

5.5 REQUIRED RESOURCES

In urban areas of Jhang resources allocation categorized depending upon mode of waste collection as container-based collection door to door waste collection, commercial areas waste collection, societies waste collection, bulk waste collection, transfer stations, mechanical sweeping & washing. Based on waste load, and area requirements, the number of compactors, arm rolls, mini dumpers, dumpers, loaders, collection containers (having capacities of $0.8m^3$ / $5\ m^3$), mechanical sweeper, and required human resources are calculated.

In rural area of Jhang mechanical resources including riksha loader, tractor loader, tractor trolleys, drum bins, handcart and required human resources are calculated based on waste load and area requirement. The mechanical and HR resources required in urban and rural area of Jhang details are given in the table below.

Table 5:2: Required additional resources Urban area of Jhang

Waste Category	Resources	Quantity
Container Based Collection (CBC)	Compactor 7cum	27
	Compactor 13cum	1
	Chain Arm Roll 5cum	20
	T Loader (4*4)	4
	Container 0.8cum	1435
	Container 5cum	100
	Handcarts	1713
	Drivers	52
	Helpers	76
	Workers	5140
	Compactor 13cum	14
	Compactor 7cum	18
	Mini Dumper 1cum	90
	Mini Dumper 2.5cum	47
	Drivers	169
	Helpers	64
Commercial Areas Waste Collection	Chain Arm Roll 5cum	4
	Compactor 7cum	5
	Container 0.8cum	207
	Container 5cum	23
	Drivers	9
	Helpers	18
Societies Waste Collection	Compactor 13cum	24
	Compactor 25cum	20
	Compactor 7cum	1
	Container 0.8cum	3178
	Drivers	45
	Helpers	90
Bulk Waste Collection	Dumper 5cum	23
	Dumper 10cum	7
	T Loader (4*4)	15
	Excavator (Small)	4
	Trolleys	16
	Frond End Loader	4
	Drivers	69
	Helpers	30
TCPs/ Transfer Stations	Dumper 25cum (MSW)	21
	Dumper 25cum (Bulk)	6
	Excavator (Large)	12
	Front End Loader	3
	Drivers	42
	Helpers	54
Mechanical Sweeping & Washing	Mech Sweeper 4m3	17
	Mech Sweeper 6m3	18
	Mech Washer 4500l	8
	Mech Washer 8000l	4
	Drivers	47
	Helpers	59

Table 5:3Table 3: Total HR required in Urban Area of Jhang

Sr. No.	Name	Total Resources (HR)
1	Total Drivers	434
2	Total Helpers	391
3	Total Workers	5,140

Table 5:4 Mechanical Resources Required in Rural Area

Sr. No.	Vehicle Type	Quantity
1	Riksha Loader	144
2	Tractor Loader	36
3	Tractor Trolleys	70
4	Drum bins	5742
5	Handcart	218

Table 5:5: Additional HR required in rural area tehsil wise

Tehsil	Workers	Drivers LTV	Driver HTV	Helpers
Jhang	264	35.00	26.00	35.00
Shorkot	144	19.00	14.00	19.00
Ahmadpur Sial	98	13.00	9.00	13.00
18-Hazari	66	9.00	6.00	9.00
Total	**571**	**76**	**55**	76

5.6 FINANCIAL COSTING:

The total cost for primary and secondary waste collection & transport for the whole district has been calculated using above mentioned resources. the following parameters were considered in costing.

- Cost of handcarts, loader rickshaws, containers, compactors, arm roll vehicles, container carrier, Containers), front end loaders.
- Capital depreciation cost
- Operational and Maintenance Cost.
- Cost of HR for primary, Secondary waste collection system
  The detail of each cost has been shown in tables below:

5.6.1 Capital Cost

Table 5:6: Capital cost for SWM in Urban area of Jhang

Sr. No.	Vehicle Type	Quantity	Cost /Unit	Total Cost / Annual
1	Compactor 7cum	7	12,376,494	22,323,403
2	Compactor 13cum	2	15,476,986	8,006,024
3	Chain Arm Roll 5cum	18	11,376,217	51,785,840
4	T Loader (4*4)	2	4,506,549	2,477,951
6	Mini Dumper 1cum	4	2,620,822	2,711,428
7	Mini Dumper 2.5cum	4	5,175,702	5,354,633
8	Dumper 5cum	3	7,751,494	5,079,000
10	Trolleys	1	4,606,549	1,006,114
13	Excavator (Large)	1	20,000,000	6,628,921
14	Mech Sweeper 4m3	5	14,000,000	18,105,000
15	Mech Sweeper 6m3	3	14,000,000	10,863,000
16	Mech Washer 4500l	3	14,000,000	10,863,000
TOTAL				**911,861,065**
**Total cost includes 2% registration cost, 10% R&M cost/year,2.5% insurance cost/year and depreciation / Year (10% Residual Value) cost as well.*				

Table 5:7 :Capital once cost in urban area of Jhang

Resources	Qty.	Cost per unit	Life	Cost/ month	Cost/ annum
Containers (0.8 cum)	391	42000	1	1369268	16431216
Containers (5 cum)	20	300000	2	249997	2999962
Handcart	42	25000	1	88501	1062018

Table 5:8: Capital cost for additional resources SWM in Jhang rural area

Sr. No.	Vehicle Type	Quantity	Cost /Unit	Life (in Year)	Gross Cost
1	Riksha Loader	76	300,000	5	23,256,000
2	Tractor Loader	19	4,000,000	7	77,520,000
3	Tractor Trolleys	36	4,527,048	7	166,233,203
Total					**514,175,227**

**Gross cost included 2% of registration cost/unit as well.*

Table 5:9; Capital once cost tehsil wise in Jhang

Faisalabad Tehsils	Drum				
	Qty.	Cost per unit	Life	Cost/ month	Cost/ annum
Jhang	1,394	12000	1	1394000	16728000
Shorkot	759	12000	1	759000	9108000
Ahmadpur Sial	516	12000	1	516000	6192000
18-Hazari	347	12000	1	347000	4164000
Total	**3,016**			**3,016,000**	**36,192,000**

Table 5:10: Capital once tehsil wise in Jhang

Faisalabad Tehsils	Handcart				
	Qty.	Cost per unit	Life	cost/ month	Cost/ annum
Jhang	53	25000	1	110417	1325000
Shorkot	29	25000	1	60417	725000
Ahmadpur Sial	20	25000	1	41667	500000
18-Hazari	13	25000	1	27083	325000
Total	**115**			**239,583**	**2,875,000**

5.6.2 Operational and Maintenance Cost of the Proposed System

Table 5:11: O&M cost for SWM in Urban area of Jhang

Particulars	Per Month Cost	Per Annum Cost
Fuel Cost	7,208,581	86,502,975
Machinery Operational Cost	19,336,282	232,035,380
HR Manual work including Janitorial	16,424,251	197,091,010
Total Operational Cost	37,468,299	449,619,585
Monitoring Cost 4%	1,498,732	17,984,783
Total Annual Cost	38,967,031	467,604,369
Annual Tonnage	5,730	68,760
Cost per ton	6,801	6,801
Population	478,522	478,522
House Hold	77,431	73,281
Cost per Person	81	977
Cost per Household	503	6,381

Table 5:12: O & M Cost for Rural area of Jhang SWM

Particulars	Jhang		Shorkot		Ahmadpur Sial		18-Hazari		Total Cost	
	Per Month Cost (PKR)	Per Annum Cost (PKR)	Per Month Cost (PKR)	Per Annum Cost (PKR)	Per Month Cost (PKR)	Per Annum Cost (PKR)	Per Month Cost (PKR)	Per Annum Cost (PKR)	Per Month	Per year
Fuel Cost	1,141,292	13,695,500	619,558	7,434,700	423,908	5,086,900	293,475	3,521,700	15,792,521	189,510,256
Machinery Operational Cost	10,143,728	121,724,732	5,479,241	65,750,889	3,538,751	42,465,012	2,372,629	28,471,551	21,534,349	258,412,184
Total Operational Cost	22,253,223	267,038,679	12,061,655	144,739,863	8,002,428	96,029,141	5,385,762	64,629,137	47,703,068	572,436,820
Monitoring Cost 4%	890,129	10,681,547	482,466	5,789,595	320,097	3,841,165	215,430	2,585,166	1,908,123	22,897,473
Total Annual Cost	23,143,352	277,720,226	12,544,122	150,529,457	8,322,525	99,870,306	5,601,192	67,214,303	49,611,191	595,334,292
Annual Tonnage	7,604	91,251	4,138	49,654	2,814	33,765	1,891	22,691	16,447	197,361
Cost per ton	3,043	3,043	3,032	3,032	2,958	2,958	2,962	2,962	3,016	3,016

5.6.3 HR cost

Table 5:13: Total HR cost in Urban area of Jhang

Sr. No.	Name	Total Resources (HR)	Per month Cost	Per Annum Cost
1	Total Drivers HTV	33	1,120,068	13,440,815
2	Driver LTV	8.00	247,200	2,966,400
3	Total Helpers	42	1,227,692	14,732,307
4	Total Workers	479	13,829,291	165,951,488
Total			**16,424,251**	**197,091,010**

Table 5:14: HR cost for rural area of Jhang

Tehsil	Workers cost per month	Drivers LTV cost per month	Driver HTV cost per month	Helpers cost per month	Total Cost Per month	Total Cost Per Annum
Jhang	7,630,679	1,081,500	881,400	1,011,500	10,605,079	127,260,947
Shorkot	4,152,198	587,100	474,600	549,100	5,762,998	69,155,974
Ahmadpur Sial	2,823,511	401,700	305,100	375,700	3,906,011	46,872,129
18-Hazari	1,897,449	278,100	203,400	260,100	2,639,049	31,668,585
Total					**22,913,136**	**274,957,636**

CHAPTER 6. BUSINESS MODEL BY INTRODUCING WASTE RECOVERY FACILITY (MRF)

In Developed world least, preferred option for SWM is disposal of waste at dumping site or landfill to minimize its Harmful effects on the environment and sustainable use of land. So, we have proposed Material recovery facility for Faisalabad city.

The term **STD** is coined by the Urban Unit, referred to **Segregation**, **Treatment** & **Disposal** of the Municipal Solid Waste.

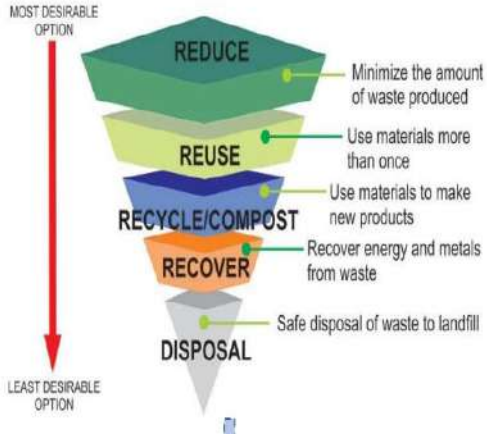


Figure 6.1: Waste Management Hierarchy

Segregation

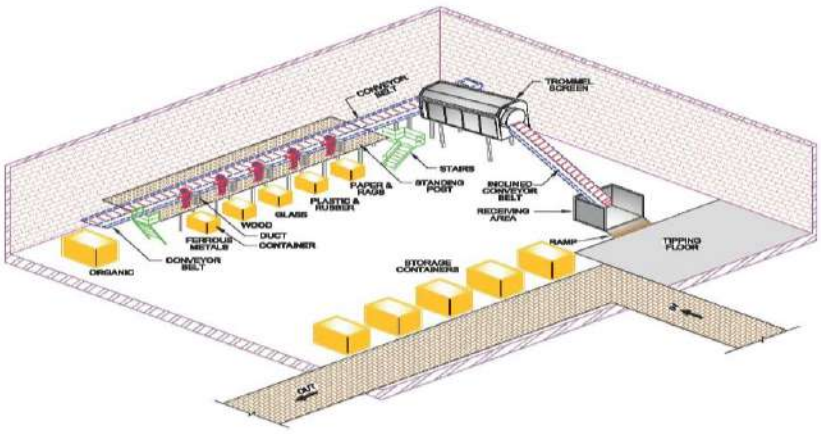
- Material Sorting Facility for recovering of the **Recyclables** (Plastic, Paper, Glass, ferrous Metals, Non-Ferrous Metals, Tetra Pack, cardboard etc.) and **combustibles** for production of Refused Derived Fuels (RDF)

Treatment

- Production of the compost from the **organic/ putrescible** waste.
- Production of RDF which can be used be used as fuel

Disposal

- Safe disposal of the residual **inert waste** on scientific basis



6.1 COMPONENTS OF STD

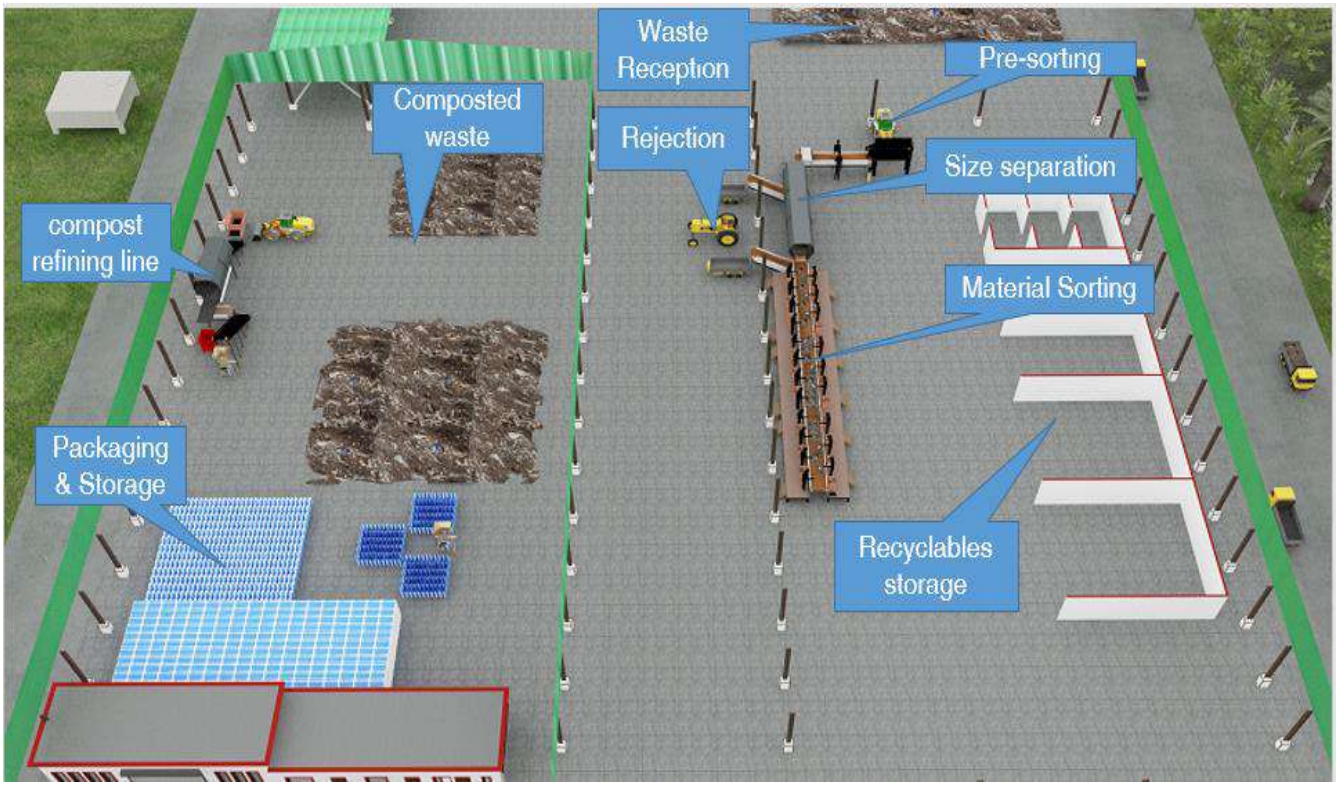


Figure 6.2: Components of STD Facility

6.2 BENEFITS OF THE FACILITY

- Convert Organic Waste to Compost.
- Segregation of Recyclable Material
- Segregation for Refuse-Derived Fuel (RDF) Material.

6.3 ENVIRONMENTAL BENEFITS

Improvement in Groundwater Quality

After sorting and treatment, organic material which cause leachate formation will be converted to Compost, thus preventing any further water pollution.

Improvement in Air Quality

Burning of waste produce many toxic compounds which cause air pollution and endanger human health. After processing through this facility most of waste will be utilized and thus preventing the air pollution.

Improvement in Soil Quality

Use of the compost in agriculture as a fertilizer will help soil to retain and absorb nutrients and water. Better water retention means less watering which ultimately help water conservation.

6.4 DETAILS OF ACTIVITIES OF STD FACILITY

The different activities performed in Segregation, Treatment and Disposal Facility (STD) Facility depend upon the functions of STD Facility i.e.

a) The role that the STD Facility is to serve in the waste management system
b) The types of material to be recovered
c) The form in which the materials to be recovered will be delivered to the STD Facility
d) The containerization and storage of processed materials for the buyer.

In view of the abovementioned functions, the following processing and recovery activities are being formulated for the STD Facility receiving mixed MSW of Faisalabad City:

- Material Handling (transport and transfer of solid waste)
- Manual Sorting (recovery of recyclable materials from solid waste)
- Size Separation (separation of contraries and organics from the solid waste)
- Size Reduction (removal of bulky items)
- Densification (compaction of recovered materials)

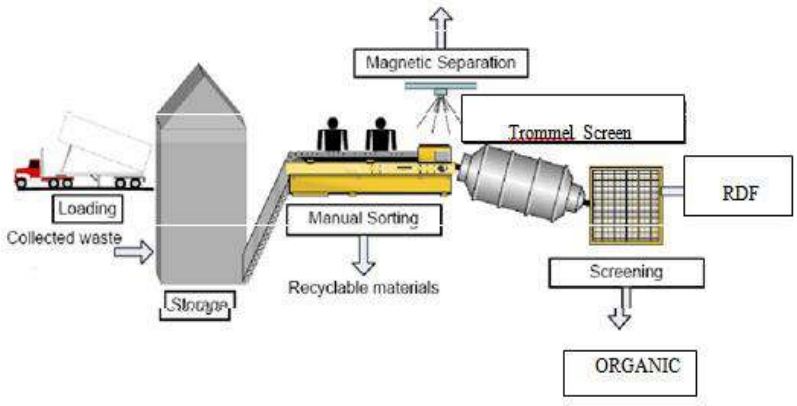


Figure 6.3: Processing and recovery activities at STD

Different operations to be carried out in STD Facility are best described with the help of following process flow diagram shown in fig 8.5.

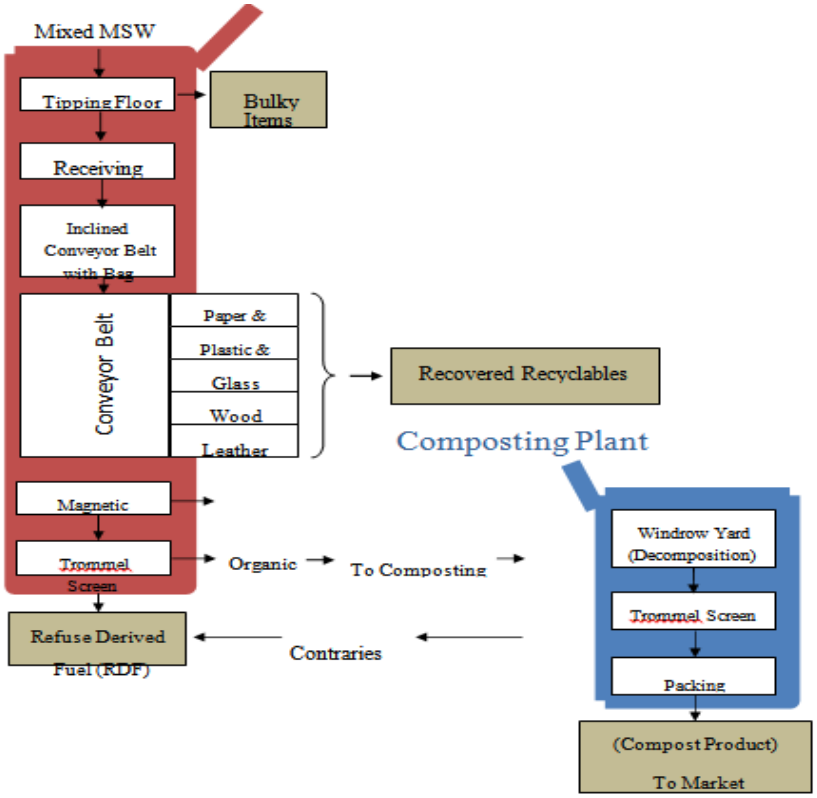


Figure 6.4: Process flow diagram of STD

6.5 PROCESS DESCRIPTION OF COMPOSTING

Composting is a biological process which utilizes microorganisms present in organic matter and soil naturally to decompose it into a stable organic material. The raw materials going into the compost are often referred to as "feedstock." The end product, compost, is a dark brown, humus-like material which can be easily and safely handled, stored, and applied to land as a valuable soil conditioner as shown in below figure 6-6.

Figure 6.5: Waste to compost

6.6 WINDROW COMPOSTING

When enough space is available, compost is formed into long, narrow conical piles as shown in figure 6-7. This method is used most often for on-farm composting. Width and height of windrows depends on the equipment used to turn and aerate the piles, and lengths are flexible increasing with the area availability. Windrows can be turned with a frontend loader or tractor. Specialized windrow turners that turn piles in place often require wider, lower piles ranging from 3 - 9 feet high and 9 - 20 feet wide.

Figure 6.6: Windrow composting

Once the degradation level is achieved, two or more windrows may then be combined to make room for new raw materials. Windrow composting activity spans over the whole year. In winter turning should be done during the days when temperature is relatively higher. In summers turning should be more frequent to avoid excessive leachate formation. Proper drainage for leachate collection and its disposal should be incorporated in the design for environment friendly activity.

Figure 6.7: Windrow turner

6.7 COSTING OF FACILITY (MRF) AND RELATED REVENUE FOR FWMC

6.8 MAINTENANCE COST OF FACILITY

Table 6:1: Maintenance Cost of MRF

Item	Monthly Cost (Rs.)
Repaire & Maintenance (or mode via service contract)	500,000
Fuel for Moving Machinery	300,000
Lubricants	30,000
Inventory	10,000
Electricity Bill	1,000,000
Material Transport (Rejection)	500,000
Admin & others expense (Mask, Gloves etc.)	100,000
Lab Equipment	10,000
Research & Experiment	50,000
Total	**2,500,000**

6.9 HR COST OF MRF FACILTIY

Table 6:2: HR Cost of MRF For Faisalabad city

Human Resource	Required	Salary (Rs.)/ Month
Plant Manager/Overall In charge	1	200,000
Mechanical Engineer & Chemical Engineer	1	200,000
Shift Supervisor	2	200,000
Electrical Engineer	1	200,000
Intake Helper	2	100,000
T Loader Operator/ Trolley Driver	4	200,000
Sorting Labour/ Workers	12	360,000
Windrow Labour	4	120,000
Fitter & Fabricator	2	100,000
Auto Mechanic	2	120,000
Electrician	2	130,000
HSE + Lab Coordinator	2	100,000
Inventory In-charge & Admin & Store	2	100,000
Gate Keeper (3 shifts) for Site	4	120,000
Peon	1	30,000
Gardener	2	60,000
Weighbridge Operator	2	90,000
Accountant	2	120,000
Total	**48**	**2,550,000**

Estimated benefit in term of revenue is calculated based on the assumptions explained below:

- Material recovery facility is proposed based on 500 ton/day waste processing capacity
- Based on physical waste composition of Faisalabad city; 312 ton/day organic waste is available for compost manufacturing.
- About 47 tons'/day compost will be manufactured from 312 tons' waste.

- About 97.5 ton/day recyclable waste with 90% recovery will be available for sale in the recycling industry.
- Revenue from compost will be PKR 21902 per ton.
- Sale of recyclables has potential average revenue of PKR 76,382 per ton.
- Total average revenue from sale of compost and recyclables will be PKR 98,284 per ton.
- Average Cost Benefit Analysis (CBA): Average/ ton revenue will be PKR 30,119.
- Economic potential value per day from the sale of recyclables and compost will be PKR 4345264.
- Per annum economic potential will be about 1.4 billion from the sale of recyclables and compost in perspective of Faisalabad city as depicted in Table below:

Table 6:3: Capital Cost Of Facility (MRF) for Faisalabad[4]

Description	Cost (PKR.) S-1	formulas
Facility installation cost (20 years life)	1,500,000,000	Cc
30% Residual value after 20 years	450,000,000	Rc
70% cost for 20 years - depreciation cost	1,050,000,000	
Days in 20 years	7,300	Pl(d)
Capital cost of facility per day	143,835.62	
Per tons capital cost	996.99	
Rent/ month	2,000,000	
Rent/day	64,516.13	Rc/d
Rent/ ton	447.19	
Capita + rent/ton	1,444.18	
Shadow cost per day	10,000	Sc/d
Maintenance cost/day	80,645	Mc/d
Maintenance cost/ton	558.99	
HR cost per day	82,258	HRc/d
HR cost per ton	570	
Eq.1 – Per Day MRF Operating Cost	381,255	P/d(Fc)
Eq.2 – Per ton Facility Operating Cost	2642	P/ton(Fc)
Eq.8 – Per ton Revenue from sales of Recyclables and Compost	98,284	Per ton(R&Oc)Rev
Eq.10 – Cost Benefit Analysis (average per ton)	30,119	CBA(avg/t)
Total Economic Potential per day	4,345,264	Sale of Compost & Recyclables
Total Economic Potential per day	**1,390,484,403**	Sale of Compost & Recyclables

[4] For eequations reference https://www.mdpi.com/2071-1050/14/23/16234