The Urban Unit

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

Solid Waste Management Plan

Gujranwala Region

January 2021

DISCLAIMER

Urban Sector Planning and Management Sector Unit (Pvt.) Ltd. has prepared this report for development of regional landfill sites in Gujranwala Division. Maximum care and caution has 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 it requires a handling system to save environment and public health. In Punjab estimated 40,000 tons of solid waste is generated each day which needs collection, transport and safe disposal. Increased waste collection efficiencies imply more and more waste to be disposed at some selected place(s). The increased amounts of solid waste reaching the final disposal sites are putting huge pressure on natural and human environment. Waste disposal must be done in accordance with standards placed to protect nature and human health. Unfortunately, waste is dumped at any open space available in the country. It can be any open plot, land depressions, streams banks or simply the area along railway tracks and roads. Among the several methods used for waste disposal, landfilling is considered to be the most feasible especially if suitable land is economically available. Furthermore, it also provides an option of rehabilitation and reclamation of land once useful life of landfill facility expires. Owing to urban sprawl, lack of land and financial constraints, the construction of separate landfill site in every city is not possible and would involve huge investment and operational costs beyond our economic capability. The Urban Unit has brought the concept of establishing Regional Landfills in Punjab. Presence of smaller dumpsites and landfills pose greater environmental risks and difficulty to operate as compared to large size well designed and operated centralized regional landfills. This is an important line of action from the viewpoint of the protection of key environmental factors (land, water and air), landscape and most importantly public health. Population of Gujranwala Division is expected to rise from 16.12 Million (2017 Census Report) to 19.32 Million in next 10 years. The expected cost of providing the whole proposed system in the division is **Rs. 236/Person per year.**

In Gujranwala Division four regional landfills are being proposed in Gujranwala, Sialkot, Gujrat and Hafizabad Districts. In addition to these, 6 transfer stations have also been proposed in the Division. Human settlements have been connected to the regional landfills through these transfer stations. The projection has been done for next 10 years for the amount of waste to be catered by these landfills. The proposed system would handle a total of **20 Million tons** of waste in ten years. Average amount of solid waste production is expected to increase from 5,546 tons/day to 7,168 tons/day in 2030. Costing has been provided for different phases of waste management including secondary, tertiary waste collection, transport and safe disposal. Total cost of Capital Investment of proposed system is **Rs. 17.8 Billion** & Operational Cost of the system is **Rs. 8.3 Billion**. In addition to this, cost of closure and rehabilitation of these RLFs is estimated **Rs. 6.7 Billion.** Average estimated cost of the system that would provide efficient collection and safe disposal for total of 20 million tons of waste in next 10 years is calculated as **Rs. 1,700/ton**. This includes all capital and operational costs of the whole system with efficient waste transport and safe disposal from all human settlements comprising of urban as well rural areas in Gujranwala Division. This cost does not include cost of Primary collection, contractor's profit and other applicable taxes.

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List of Acronyms

CDG	City District Government
EPD	Environmental Protection Department
SWMC	Sialkot Waste Management Company
GWMC	Gujranwala Waste Management Company
FEL	Front End Loader
GoP	Government of Punjab
GPS	Global Positioning System
HR	Human Resource
LF	Landfill
MC	Municipal Corporation
MSW	Municipal Solid Waste
NOC	No Objection Certificate
PL	Project Life
PM	Prime Mover
RLF	Regional Landfill
SWM	Solid Waste Management
TS	Transfer Station
TPD	Ton per Day
WMC	Waste Management Company

Glossary

Capital Cost	Capital cost is fixed one time expense required to purchase an asset.
Geographical Information System (GIS)	A Geographical Information system is a system designed to store, analyse, capture, manage, and present spatial or geographical data.
Integrated Solid Waste Management (ISWM)	Integrated solid waste management refers to the strategic approach to sustainable management of solid wastes covering generation, segregation, transfer, sorting, treatment, recovery and disposal in an integrated manner.
Material Recovery Facility	A material recovery facility is a facility where solid waste or commingled materials are sorted manually or by automated method for the purpose of recovering valuable products.
Multi Criteria Analysis	Multi Criteria Analysis or Muti Criteria Decision Analysis (MCDA) is a valuable tool that we can apply to many complex decisions. It is most applicable to solving problems that are characterized as a choice among alternatives.
Municipal Solid Waste (MSW)	Municipal solid waste include all the waste generated from residential and commercial establishments. It covers waste from households, including bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, yard and garden, street sweepings, contents of litter containers, and market cleansing.
Primary Collection	Primary collection includes collection of solid waste from its point of generation. It normally refers to door to door collection.
Sanitary Landfill	Sanitary Landfill is a scientific and an engineered method of final disposal of solid waste, in a manner that protects the public health and the environment.
Secondary Collection	Transportation of waste from communal collection points to designated Transfer Station/Landfill site using Arm Roll Vehicles.
Tertiary Collection	Transportation of waste from Transfer station to respective Landfill Site using Prime Haulers.
Transfer Station	A facility used for transferring solid waste from collection vehicles to long-haul vehicles.

CHAPTER - 1
Introduction

1.1 Background

The management of municipal solid waste is a global concern and becoming a great challenge in rapidly growing towns and cities of developing countries. Pakistan, being the 6th largest country in the world in terms of population[1], is facing the problem at relatively higher scale with every passing day as the corresponding increase in waste generation is imminent.

The challenge is getting even greater 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, bottles, 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, industrial activity 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 that it is imperative to undertake substantial steps in MSW management for an improved civic life in the province.

There is a dire need to device and implement an integrated SWM system that can cater waste collection, transportation and safe disposal. Sanitary landfills are engineered facilities having systems to prevent pollution of ground water or other environmental problems. The waste is disposed through appropriate technological processes, compacted as densely as practicable to minimize its volume and covered with a layer of soil or some other material in a systematic and sanitary manner. Nevertheless, to locate, purchase, design and operate a separate landfill in every city is not possible and is very costly. Therefore the concept of Regional Landfills is so far the most feasible option to handle MSW problem in the province.

1.2 Problem Statement

Up-till now, solid waste collection system is somehow at better position, however waste disposal in the form of dumping is directly leading to irreversible pollution of the environment as well as social and aesthetic issues. Thus, an immediate action is needed to introduce an integrated approach, which encompasses well-designed waste disposal facility in line with efficient collection and transportation. Yet the realism is that owing to urban sprawl and financial constraints, the construction of separate landfill site in every city is not possible and would involve huge costs beyond our economic capability.

The Urban Unit has brought the concept of establishing regional landfills all over Punjab. The implementation or realization of this concept will be of vital importance for future of integrated solid waste management system.

Presence of smaller dumpsites and landfills pose greater environmental risk and difficulty to operate as compared with large size centralized regional landfills. This is an important line of action from the viewpoint of the protection of key environmental factors (land, water and air), landscape and most importantly public health.

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

This project will serve as a foundation to provide guidelines for the future planning and infrastructure investment related to the Regional Landfill Sites.

1.3 Objective of the Study

The purpose of this study is to make this fact evident that targets of Solid Waste Management Road Map can be achieved if waste collection and transportation initiatives conjoin with scientific disposal i.e. sanitary landfill sites, built under acceptable international standards. Furthermore, segregation or material recovery facility can also be incorporated in future once enough volumes of segregated waste are collected.

1.4 Scope of work

This report provides the data base supported by maps of potential regional landfill sites within the province and an assessment of each site, in terms of the environmental conditions, current and future capacity. The assessment took into account national and international practices and local needs. This report addresses the analysis for Gujranwala Division.

The scope of this report is to propose regional landfill sites on Divisional level. The aim is to connect populated areas through designated routes, which would be serving the municipal waste collection for various settlements. To facilitate this, waste transfer stations will be established which serve as a linkage between community's solid waste collection point and regional landfill sites. Depending upon the transfer distance and waste load, appropriate numbers of transfer stations are selected in every region. The waste, then, will be transported to regional landfill sites using vehicles of larger capacity

1.5 Methodology

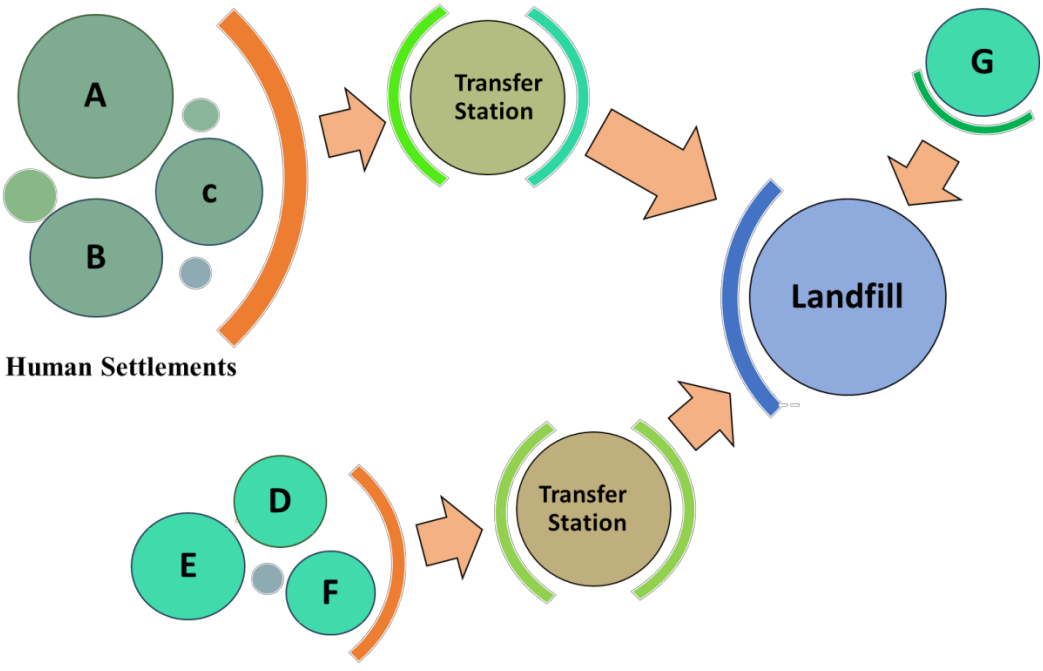


Figure 1: RLFs Model

In order to achieve the objectives of this study, a framework was developed and it broadly consisted of seven phases. Following methodology has been adopted for these seven phases of the project.

Phase 1: Complete division wise dataset has been collected and analyzed.

- UC wise population projections for next 10 years (2021-2030), on the basis of 2017 population census report.
- Approximation of urban & rural waste generation amount in each Tehsil.
- Computations of total waste generated per day at tehsil, district and divisional level.

Phase 2: Reckoning the geo-physical and geographical constraints of various sites, some potential locations were firstly identified with the help of GIS. The method of multi criteria analyses was used for the purpose. This approach was used in locating barren areas, their distance from residential areas, road access, presence of nearby water bodies etc. At this level, the sites selected through GIS application were evaluated on the basis of following criteria;

- Ecological or environmental aspects (type of land, Impact on eco system and presence of perennial stream within proximity)
- Socio-economic or socio spatial aspects (Land availability, Displacement of local inhabitants, Distances from nearest human settlements)
- Technical and operational aspects (Road connectivity, transportation distance for the waste, availability of cover material).

Phase 3: In order to visually observe the sites identified through GIS system, field visits were carried out by team of experts. In order to nominate the sites for regional landfills, following aspects were taken into account:

- Preliminary analyses i.e. distance from settlements to the potential landfill sites
- Consultations and recommendations given by local inhabitants & authorities
- Guidelines set by Environmental Protection Department
- Relevant ecological data and information from the existing documentation

Phase 4: Based upon the daily waste load and distance between selected landfill sites and human settlements (urban, peri-urban, rural); potential sites for appropriate number of transfer stations were identified with the help of GIS. The deliberations were made on the basis that each transfer station serves the settlements within proximity of 30-35 km, and arm roll vehicles will be used for transporting collected waste to the transfer stations.

In continuation, these transfer stations have been connected to regional landfill sites and heavy duty waste haulers will be used for the transportation of waste to regional landfills. This approach will minimize the collection & transportation cost and will increase the system efficiency.

Phase 5: Based upon the above described phases, further sections of this report has been developed comprising of specific division's solid waste data. Further chapters of this report cover the division specific information regarding regional landfills, requirements of resources and their cost estimations.

Phase 6: Estimations of costs would further assist in estimation of required financial resources and funds allocation over future time frame. Budget is sought through PC II for different technical studies like geotechnical investigations, topography surveys, Environmental Impact assessment and detailed engineering design of Landfill Sites. Based on these findings PC I will be developed. The approval of PC I will lead to the construction phase of regional landfill.

Phase 7: In this phase all the parameters for effective LF site operation would be monitored. Standard Operating Procedures (SOPs) for landfilling would be developed in order to achieve its maximum operating efficiency over whole project life. These operational parameters includes waste handling and placement, its compaction, daily soil cover, equipment & machinery maintenance, personnel & safety etc.

Phase 8: This phase includes Closure and Post-Closure plan to determine the end use of landfill site. Keeping in view the international standards for landfilling, its closure & monitoring plan would be developed in compliance with implementation. Once life period of Landfill site completes, it would be rehabilitated into most feasible option suited at that time.

FRAMEWORK OF PUNJAB REGIONAL LANDFILL SITES

Phase 1

Divisional Data Base

- Population Projection
- Waste Generation Calculation
- Estimated Total Waste Tonnage with locations

Phase 2

Site (s) Identification

- Selection of Tentattive Sites using GIS.
- Identification of suitable land with connecting roads.

Phase 3

Field Visits

- Sites Evaluation.
- Geographical Data i.e its location & other socio-economic factors.
- Finalization of potential suitable sites.

Phase 4

Identification of Transfer stations

- Connecting human settlements with nearest Transfer stations and conjoining these Transfer stations with Landfill sites.

Phase 5

Integrated Waste Collection Systesm of Municipalities with RLFS

- Development of Divisional Waste Management Report.

Phase 6

Division Wise Project Approval & Implementation

- Approval from LGCD & P&D Department/relevent authorities.
- Budget allocation in ADP.
- Submission & Approval PC-II & PC-I..

Phase 7

Landfill Operational Plan

- Development of SOPs for effective Landfill Operation over whole Project Life.
- Management & Monitoring of Resources required for Landfilling.

Phase 8

Closure & Rehabilitation Plan

- Development of Landfill Closure & Rehabilitation Plan
- Standard Operating Procedures for monitoring gas and leachate generation at Post Closure Stage.

CHAPTER - 2
Gujranwala Division Profile

2.1 Description:

Gujranwala Division is an administrative division of Punjab Province and is avowed as the largest division of the Punjab province, considering its area and population. The division covers an area of 17,207 Km^2. It is bound in the North by Jammu Kashmir, in the North-West by Rawalpindi Division, in the West by Sargodha Division, in the South-West by Faisalabad Division, in the South by Lahore Division and in the East by India. According to the census of 2017, the population of the division is 16,123,984. There are following six districts in the said Division:

- Gujranwala District
- Gujrat District
- Hafizabad District
- Mandi Bahauddin District
- Narowal District
- Sialkot District

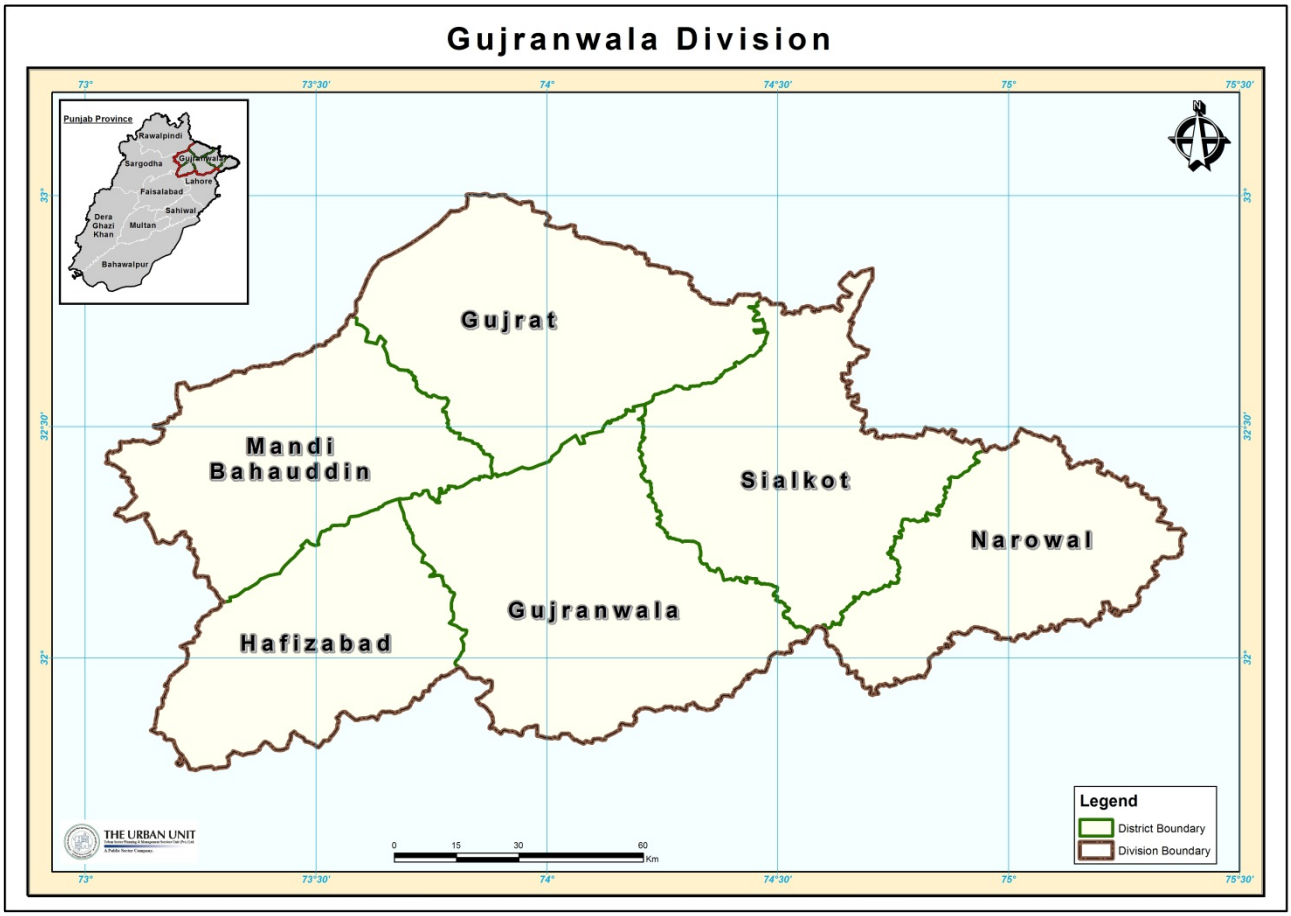


Figure 3: Gujranwala Division Map

2.2 Population:

Population is one of the most important characteristic for determining waste amount produced in a region. The population is further divided into two categories i.e. Urban and Rural. Waste generated per capita from Urban and rural population is different due to different lifestyle and consumption patterns.

Table 1: Tehsil Wise Population of Gujranwala Division

Division	District	Name of Tehsil	Rural Population (Millions)	Urban Population (Millions)	Total Population Tehsil (Millions)	Total Population District (Millions)
Gujranwala	Gujranwala	Gujranwala City	0.074	0.186	0.260	5.014
		Gujranwala Saddar	0.643	2.164	2.807	
		Kamoke	0.332	0.250	0.581	
		Nowshera Virkan	0.486	0.049	0.536	
		Wazirabad	0.531	0.300	0.830	
	Sialkot	Daska	0.643	0.204	0.847	3.893
		Pasrur	0.719	0.122	0.841	
		Sambrial	0.273	0.138	0.411	
		Sialkot	1.115	0.680	1.795	
	Gujrat	Gujrat	0.955	0.543	1.498	2.756
		Kharian	0.781	0.230	1.011	
		Sarai Alamgir	0.192	0.055	0.247	
	Hafizabad	Hafizabad	0.400	0.264	0.664	1.156
		Pindi Bhattian	0.354	0.139	0.493	
	Mandi Bahauddin	Malakwal	0.328	0.043	0.372	1.593
		Mandi Bahauddin	0.451	0.217	0.668	
		Phalia	0.488	0.066	0.553	
	Narowal	Shakargarh	0.592	0.082	0.674	1.709
		Zafarwal	0.400	0.039	0.439	
		Narowal	0.461	0.136	0.597	
	Total					**16.123**

2.3 Socio economic status of Gujranwala Division:

According to census 2017, 63% of the population of this division resides in to urban settlements whereas 37 % belongs to rural areas. Hence majority population of the area is associated with agriculture and the rest with industrial sector. Gujranwala has a literacy rate of 56.5% (Male 63.60 % whereas Female 48.80%) [3]

2.4 Administrative Structure of Gujranwala Division:

The whole Division is administrated by one Commissioner (government representative on Divisional level), further districts are handled by their respective Deputy Commissioners and Tehsils by each Assistant Commissioner.

Sialkot, Gujranwala and Gujrat are three major cities of Gujranwala Division and they hold the status of municipal corporation. Municipal Corporation consists of The Mayor, Deputy Mayor, Chief Officer, Municipal Officers and other officials of the Local Council Service. The other cities of this division are municipal committees. Municipal Committee is a body corporate and consists of the Chairman, Tehsil Municipal Officer, 4 Tehsil Officers and other officials of the Local Council Service. The existing solid waste management system in whole division is being managed by its respective municipality. However, in rural settlements, Chairmen and secretaries of each rural union council are responsible for provision of SWM services. In Gujranwala and Sialkot waste management companies are in place to manage solid waste related issues, named as Gujranwala Waste Management Company (GWMC) and Sialkot Waste Management Company (SWMC).

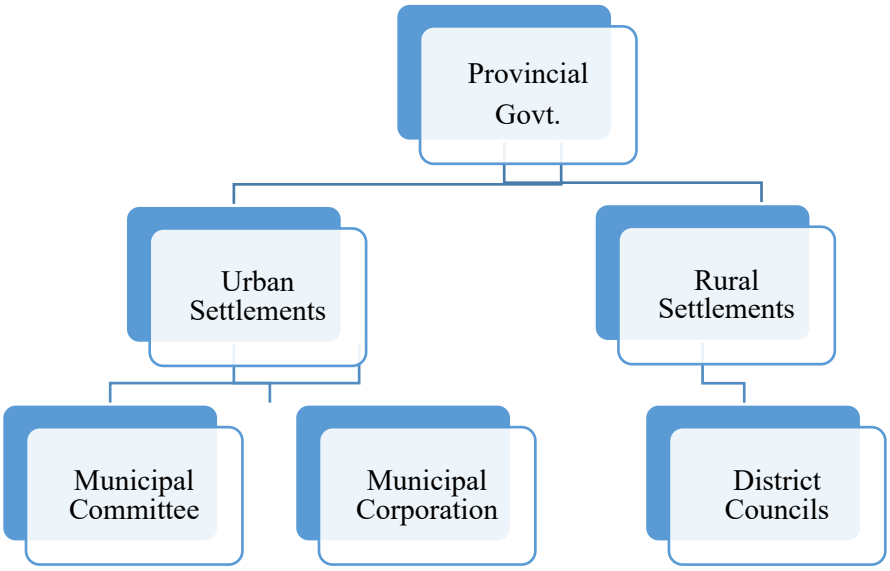


Figure 4: Administrative Structure of Gujranwala Division

2.5 Waste Generation Details:

Waste management is a complex process which implies a control of the entire waste management system (from waste generation, through collection and transportation of waste, to waste treatment and disposal). According to Department of Solid Waste Management, The Urban Unit, Lahore, Pakistan the waste generation per capita for rural areas is 0.3kg/capita per day while for urban it varies from 0.40 to 0.46kg/

[3] PAKISTAN BUREAU OF STATIC: REPORT ON GUJRANWALA DIVISION (2016).

capita per day[4] therefore the current waste generation of Gujranwala Division is calculated around **6200 TPD.** Details of waste generation in Urban and rural areas of Gujranwala Division is given in table below.

Table 2: Urban and Rural Areas Waste Generation of Gujranwala Division

Division	District	Name of Tehsil	Waste Rural (TPD)	Waste Urban (TPD)	Total Waste (TPD)
Gujranwala	Gujranwala	Gujranwala City	22	78	100
		Gujranwala Saddar	193	909	1,102
		Kamoke	100	105	204
		Nowshera Virkan	146	21	167
		Wazirabad	159	126	285
	Sialkot	Daska	193	86	279
		Pasrur	216	51	267
		Sambrial	82	58	140
		Sialkot	334	286	620
	Gujrat	Gujrat	287	228	514
		Kharian	234	97	331
		Sarai Alamgir	58	23	81
	Hafizabad	Hafizabad	120	111	231
		Pindi Bhattian	106	58	165
	Mandi Bahauddin	Malakwal	99	18	117
		Mandi Bahauddin	135	91	226
		Phalia	146	28	174
	Narowal	Shakargarh	178	35	212
		Zafarwal	120	16	136
		Narowal	138	57	195
	Total		**3,064**	**2,482**	**5,546**

Considering the above table, MSW generation of whole division is approximately 2.024 million Ton per year and is expected to reach 2.616 million Ton per year taking 1.5% average annual increase[5,6] waste generation rate for next ten years. The table showing the amount of waste generated annually in every tehsil in upcoming 10 years is given in annexure A.

[4] Waste Amount Survey and Physio-Chemical Analysis of Municipal Solid Waste Generated in Gujranwala-Pakistan Kashif Nadeem*, Kiran Farhan and Hassan Ilyas

[5] Municipal Solid Waste Management Manual for India – Part II, Ministry of Urban Development Report 2016.

[6] What a Waste: A Global Review of Solid Waste Management, The World Bank report, March 2012

2.6 Current Disposal Practices in Gujranwala Division:

Unfortunately there is no proper sanitary landfill in whole Gujranwala division. There is a dire need of sanitary landfill for safe disposal of waste. This task has not been achieved mainly due to lack of finances and non-availability of appropriate land.

In **Gujranwala District**, currently the collected waste is being openly disposed of at "Gondalanwala" dumpsite without any soil cover. This site is in use for years without proper sanitary conditions causing a great hazard to the environment and public. Disposed waste remain uncovered at this site and leachate (water that has percolated through solid waste containing both dissolved and suspended solid) generated from this waste seeps through the soil and contaminates ground water.

The **Gujrat District dump** its waste in "Sheikhsukha Dumpsite" whereas Kharian and Sarai Alamgir have their respective dump sites where waste is being dumped for years without adopting any engineered practice.

In **Gujranwala City** Waste is Managed by Gujranwala Waste Management Company. The collection and transportation of Waste is in good condition as GWMC collect 98% of generated waste. The company dispose of waste in Dumpsite near city entrance. Which has already achieved is carrying capacity. Gujranwala city is disposing the waste currently at "Chiyaan Wali" (32.036526, 74.210236) site along GT Road. However, GWMC has procured a land name "Bhakharay wali" for its future Landfill site.

In **Mandi Bahauddin District**, the collected waste is being disposed off in vacant plots. The situation is same for **Hafizabad District**. No soil cover or underground lining was deployed. The insanitary condition of waste dumping is a huge threat to the undergoing water resources, air, soil, living organisms and human health.

In **Sialkot District** the disposal of solid waste is also in the form of open dumping in the depressions at Gohidpur. This open dumping is creating total in-sanitary & unhygienic conditions, degrading the environment of the district, emitting obnoxious smells and providing breeding places for mosquitoes and flies. Citizens have reservations for such undesirable open dumping which escalates the demand of a sanitary landfill in the district to ensure the proper dumping of solid waste.

In **Narowal city,** Solid Waste is being managed by Municipal Corporation Narowal (MC NWL). The collection and transportation of Solid Waste is in somewhat satisfactory condition despite of limited resources. The major problem in management of solid waste is the absence of proper land for dumping of solid waste which results in dumping of solid waste in rented places all over the city. The disposal of solid waste is mainly done in the form of uncontrolled open dumping 6km away from city center at location named Klass Goraya (32.0658380, 74.8308380). This site is currently in use and about to reach its maximum capacity years and city is still deprived of a sanitary landfill or even a controlled dumpsite. This open dumping is creating total in-sanitary & unhygienic conditions, degrading the environment of the town, emitting obnoxious smells and providing breeding for mosquitoes, flies and other rodents. Disposed waste remain uncovered at this site and leachate (Percolated contaminated water from solid waste) generated from this waste seeps through the soil and may contaminate ground water. There is no transfer station existing in the city as well.

Following are the current SWM system in overall Gujranwala Division:

- In Gujranwala division, solid waste is being disposed off directly.
- No treatment of waste is carried out except for incidental recycling by scavengers
- No system exists for separate disposal of hazardous waste
- No measures are taken to negate adverse environmental effects caused by open dumping or throwing of waste into water streams

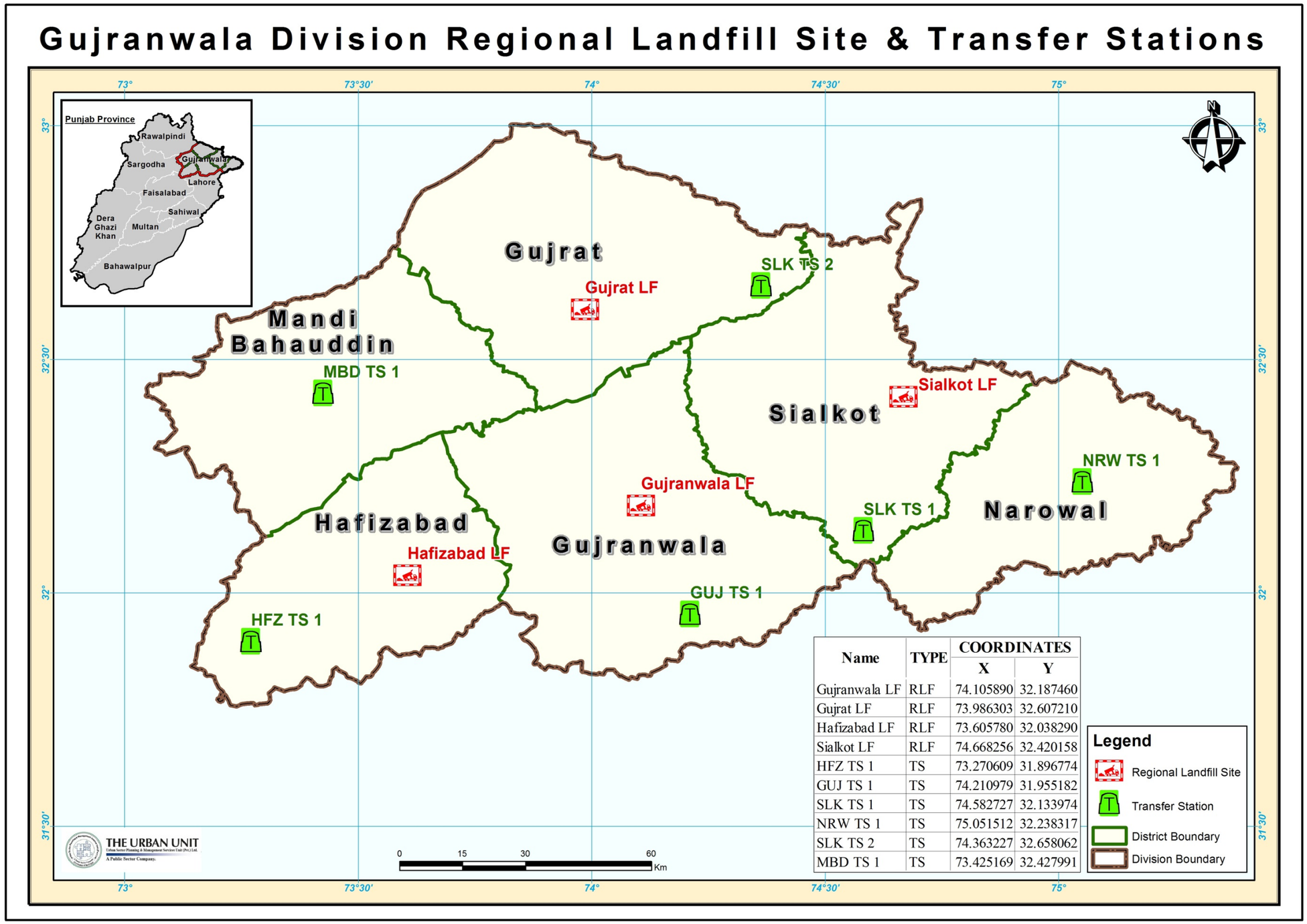
2.7 Proposed Landfill Sites in Gujranwala Division:

A total number of four potential landfill sites have been identified in Gujranwala Division named as

1. Gujranwala landfill site
2. Gujrat landfill site
3. Hafizabad landfill site
4. Sialkot landfill site

All these 4 sites have been identified according to site selection criteria given by EPA.[7] Following map shows locations of potential landfill sites and transfer stations planned for Gujranwala Division.

[7] JICA Solid Waste Management Guidelines report for Pakistan, June 2005.



Name	TYPE	COORDINATES	
		X	Y
Gujranwala LF	RLF	74.105890	32.187460
Gujrat LF	RLF	73.986303	32.607210
Hafizabad LF	RLF	73.605780	32.038290
Sialkot LF	RLF	74.668256	32.420158
HFZ TS 1	TS	73.270609	31.896774
GUJ TS 1	TS	74.210979	31.955182
SLK TS 1	TS	74.582727	32.133974
NRW TS 1	TS	75.051512	32.238317
SLK TS 2	TS	74.363227	32.658062
MBD TS 1	TS	73.425169	32.427991

Figure 5: Gujranwala Division Landfill Sites and Transfer Stations

Below is the brief about each potential site.

Gujranwala Landfill Site:

Table 3: Gujranwala Landfill Detail

Attributes	Description
Location	The identified site located at about 4.5 Km towards Bhakhraywali Village from Canal crossing at Alipur Chatta Road, this is about 3.5 Km off Gujranwala Pindi Bypass Road.
Coordinates	74.66821 32.18746
Status	Acquired
Area Available	65 Acres
Waste Load	2,031 tons/day
Connectivity	One-way single paved road is present
Feasibility	There is no residential area within premises of 500 metres. A Paved Canal is flowing next to the identified site. Land is partly used for agriculture and for borrowing the material for earth works leaving up to 6 m deep depressions
Other	The land area is of 65 acres, however to cater the need of Gujranwala District, almost 200 acres area is required in order to cater the waste for upcoming years. It is proposed that this site can be extend according to needs

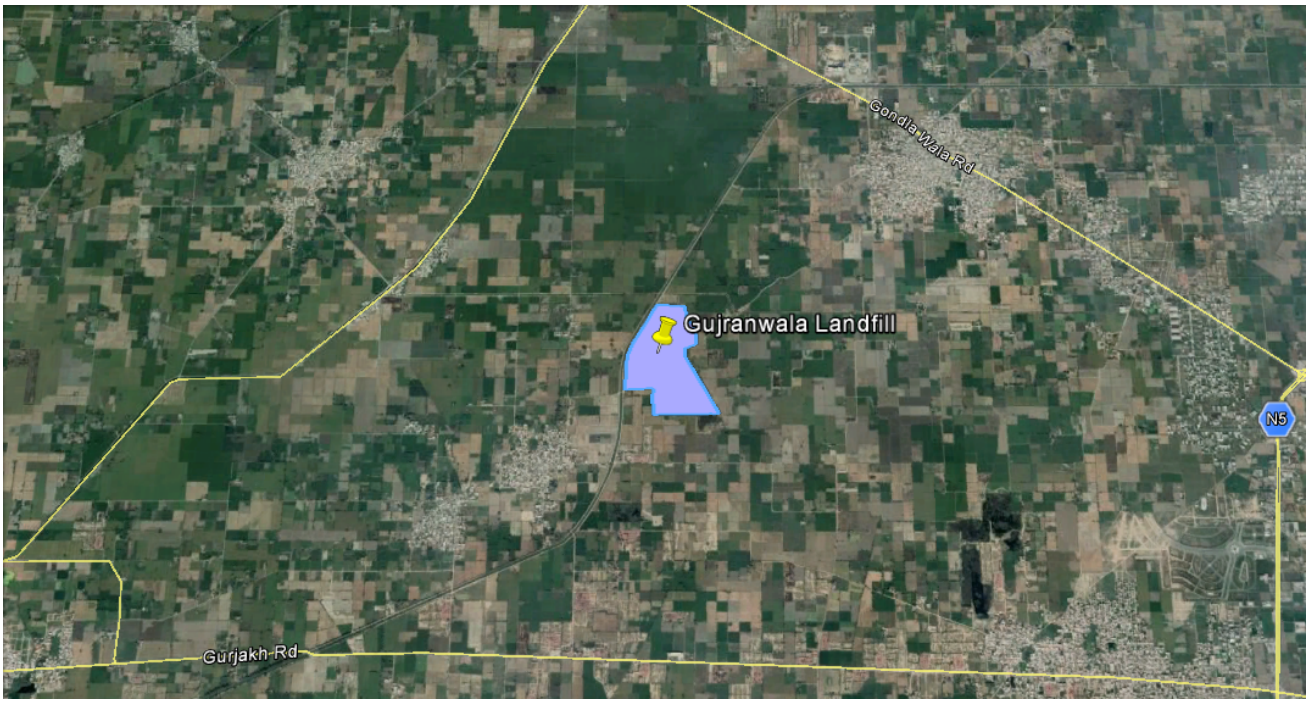


Figure 6: Gujranwala Landfill Site Satellite Imagery


Figure 7: On-site View of Gujranwala Landfill

Gujrat Landfill Site:

Table 4: Gujrat Landfill Details

Attributes	Description
Location	The Gujrat landfill site is located within the district Gujrat, 11 km away from Gujrat City centre on Dinga- Gujrat road.
Coordinates	73.986314 32.60723
Status	Site identified.
Area Available	78 Acres
Waste Load	1,437 tons/day
Connectivity Roads	Two-way single paved road is present
Feasibility	There is no residential area within 500 m proximity. No water bodies in nearby area. The land is partially cultivated.
Others	The area is approx. 78 acres which will not be enough to cater the waste of Gujrat District for coming years.

Figure 8: Gujrat Landfill Site Satellite Imagery

Figure 9: On-site View of Gujrat Landfill

Sialkot Landfill Site:

Table 5 Sialkot Landfill Detail

Attributes	Description
Location	The Sialkot Landfill site is located within Sialkot District, 18 km away from Sialkot City Centre situated on Sialkot-Sankhtara Road.
Coordinates	32.42009, 74.66821
Status	Site Identified.
Area Availability	64 Acres
Waste Load	1,662 tons/day
Connectivity Roads	Two-way single paved road is present
Feasibility	No water bodies present nearby. No human settlement within 500m of landfill area Land is barren
Others	The land area is of 65 acres, however to cater the need of Gujranwala District, almost 200 acres addition in area is required for upcoming years.

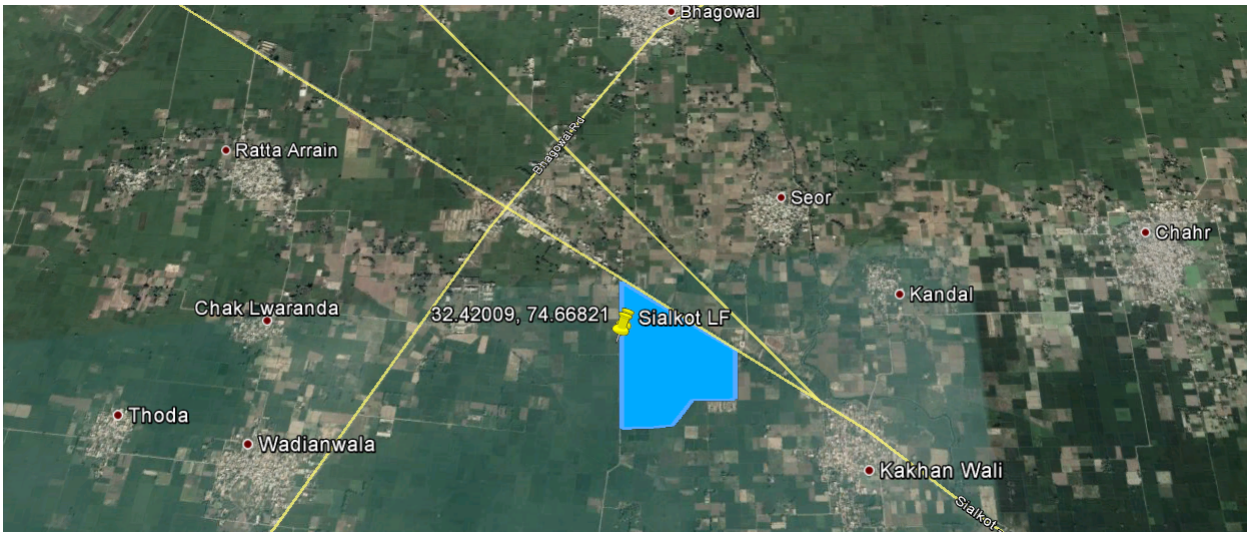


Figure 10: Sialkot Landfill Site Satellite Imagery

Figure 11: On-site View of Sialkot Landfill

Hafizabad Landfill Site:

Table 6 Hafizabad Landfill Detail

Attributes	Description
Location	The Hafizabad Landfill site is located within Hafizabad District, 10 km away from Hafizabad City Centre situated on Hafizabad-Kassesay Road.
Coordinates	32.03829, 73.60578
Status	Site Identified.
Area Availability	40 Acres
Waste Load	409 tons/day
Connectivity Roads	Two-way single paved road is present
Feasibility	No water bodies present nearby. No human settlement within 500m of landfill area Land is barren
Others	The land area is of 40 acres, this land is enough to cater the need of Hafizabad District for upcoming years.

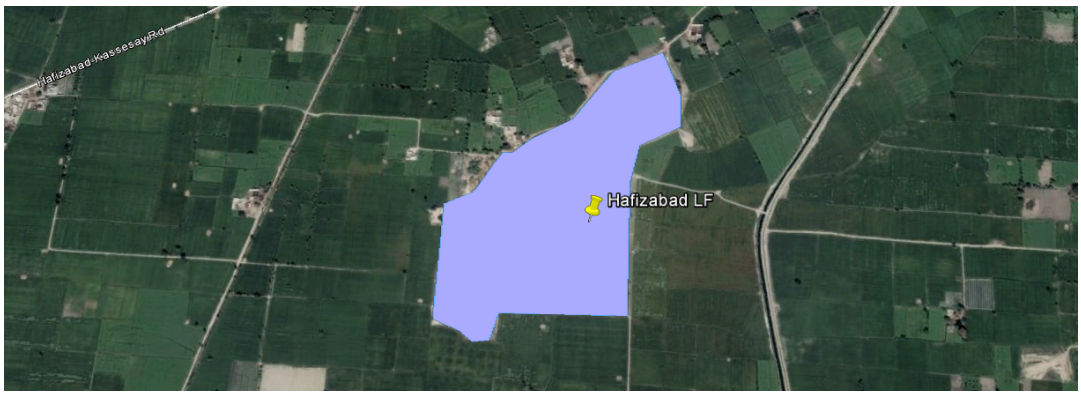


Figure 12: Hafizabad Landfill Site Satellite Imagery

CHAPTER - 3
Operational model & Requirements for Gujranwala RLFs.

Punjab Regional Landfill project (RLFs) is proposed to establish regional landfill sites for safe disposal of solid waste at centralized locations. These landfill sites would serve their respective allocated regions for disposing their waste properly in future.

However when regional landfill sites are established the hauling distances from the waste producing settlements to the sites increases. So it would be uneconomical to transport all waste to distant landfill sites without introduction of waste transfer stations. Therefore, a combination of regional landfills and waste transfer stations is recommended in each division depending upon the optimum hauling distances.

This combination of Transfer Stations and Landfill sites would cater all the waste coming from human settlements lying within the vicinity of Landfill/Transfer Station. For Gujranwala Division, a total number of **six transfer stations** along with **four landfill sites** have been proposed. These transfer stations would connect cities and villages all over the division with landfill sites. The figure showing proposed transfer stations and landfill sites in the Gujranwala division is given below:

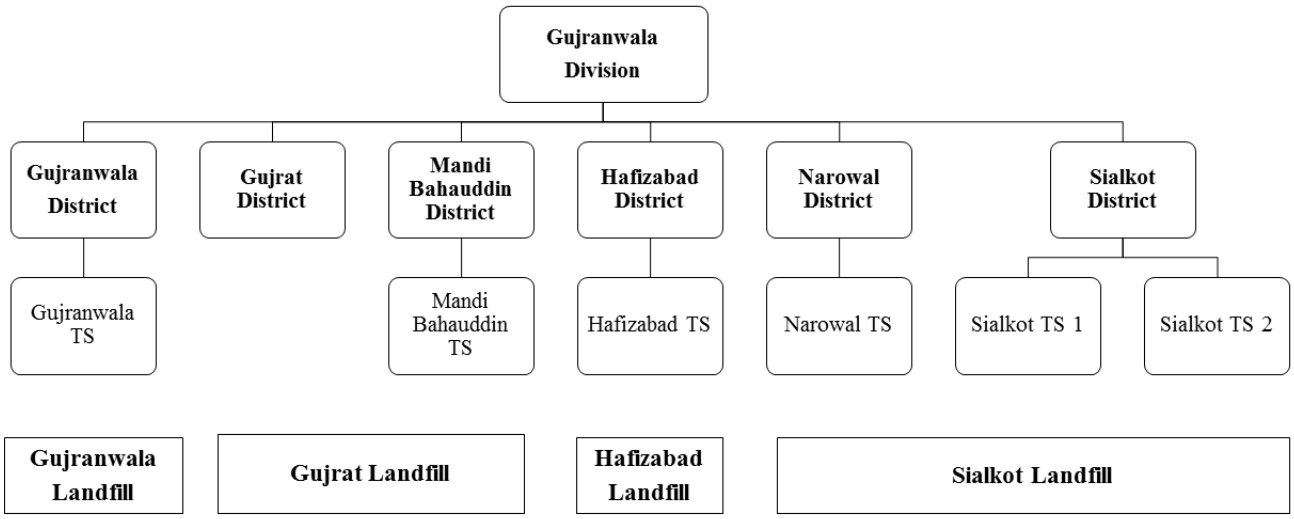


Figure 13: Gujranwala Division RLFs Structure

The municipalities/villages/areas, lying within the service zone of any transfer station/landfill i.e. 25 km, will transport their waste directly to that particular TS/LF. The waste from the transfer station will be transported to the Landfill lying within the service zone of 70 km.

Primary Waste Collection:
MCs or villages will perform primary waste collection according to their available resources. They will collect the waste from households, markets, open vacant plots through their resources and transfer the waste to nearest collection point or communal container. In this report it is proposed that Respective Municipality and Tehsil Councils will be responsible for Primary Collection of Waste, Hence the Expenditures and Resources required for Primary Collection are not the part of this report

Secondary Waste Collection:
Secondary waste collection implies that the waste collected from the community level would be taken to the designated Transfer Station using Arm Roll vehicles. Depending upon the optimum hauling distance from the community, suitable no. of TS would be identified. Then waste load on each TS will be estimated to determine the capacity of TS to be built in respective area. On the basis of waste load, requirements of arm rolls, containers ($10m^3$) and HR will be calculated on tehsil level.

Tertiary Waste Collection:
Tertiary waste collection includes transportation of waste from Transfer station to respective Landfill Site. Once the waste reaches the designated transfer stations, hauler truck would be used for transportation of the waste from these TS to final regional landfill site. Based on estimated waste load, requirement of waste haulers/PM and HR associated with it will be calculated.

Hence as shown in figure below RLF planning include;

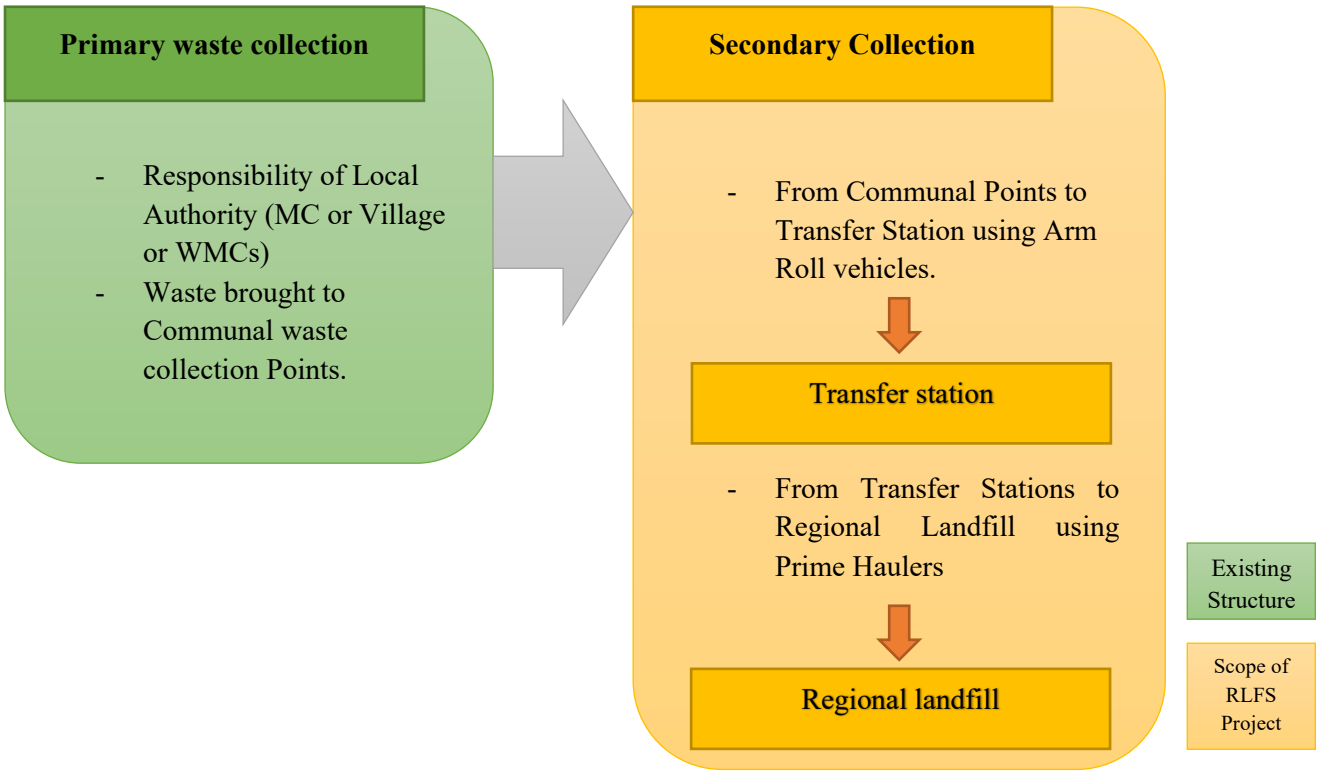


Figure 14: RLFs Project Plan

3.1 Sialkot Region (Sialkot Landfill):

The Current population of Sialkot District is 3.89 Million[8] whereas Narowal District has a population of 1.70 Million. Approximately 1849 Ton of MSW is generated by both districts every day (using waste generation rate of 0.42 kg/capita/day for urban settlements and 0.3 kg/capita/day for rural ones)[9]. Depending upon the optimum haulage distances, two transfer stations are being proposed for whole Sialkot District whereas Narowal will have one transfer station. Both Districts share one (01) Sanitary Landfill Site located near Moaza Seour Village (Sialkot). The network for effective solid waste management in both districts is given below.

[8] Pakistan Bureau of Statistics (PBS) Census Report 2017.
[9] Waste Amount and Characterization study by Urban Unit, October 2016.

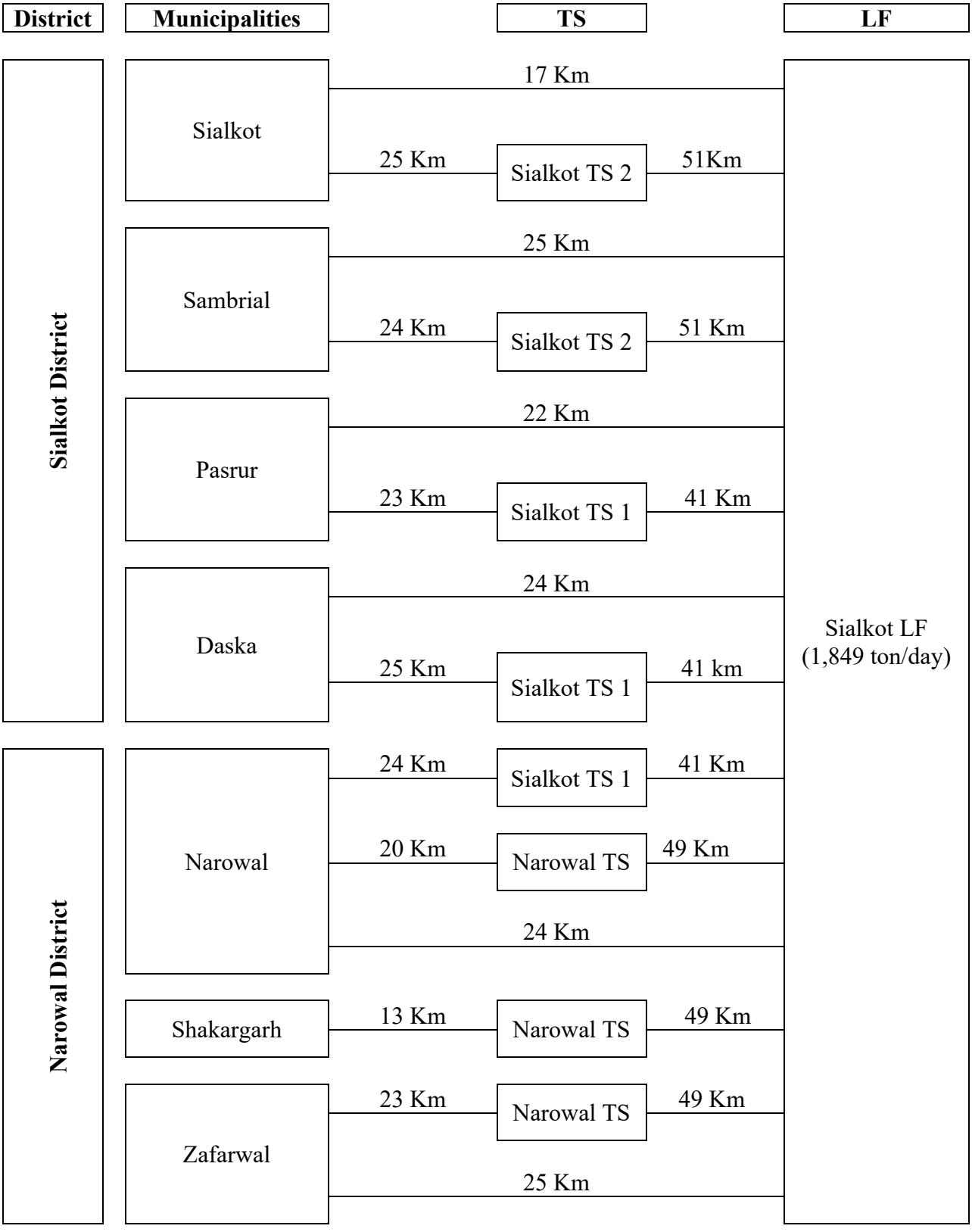


Figure 15: SWM Operational Plan for Sialkot and Narowal District

3.2 Gujrat Region (Gujrat Landfill):

According to 2017 census, the total population of Gujrat District is 2.75 Million and Mandi Bahauddin District is 1.59 Million. The current estimated everyday waste production is about 1500 Ton/day (using waste generation rate of 0.42 kg/capita/day for urban settlements and 0.3 kg/capita/day for rural one). Depending upon the optimum hauling distances, one landfill is being proposed for both District.

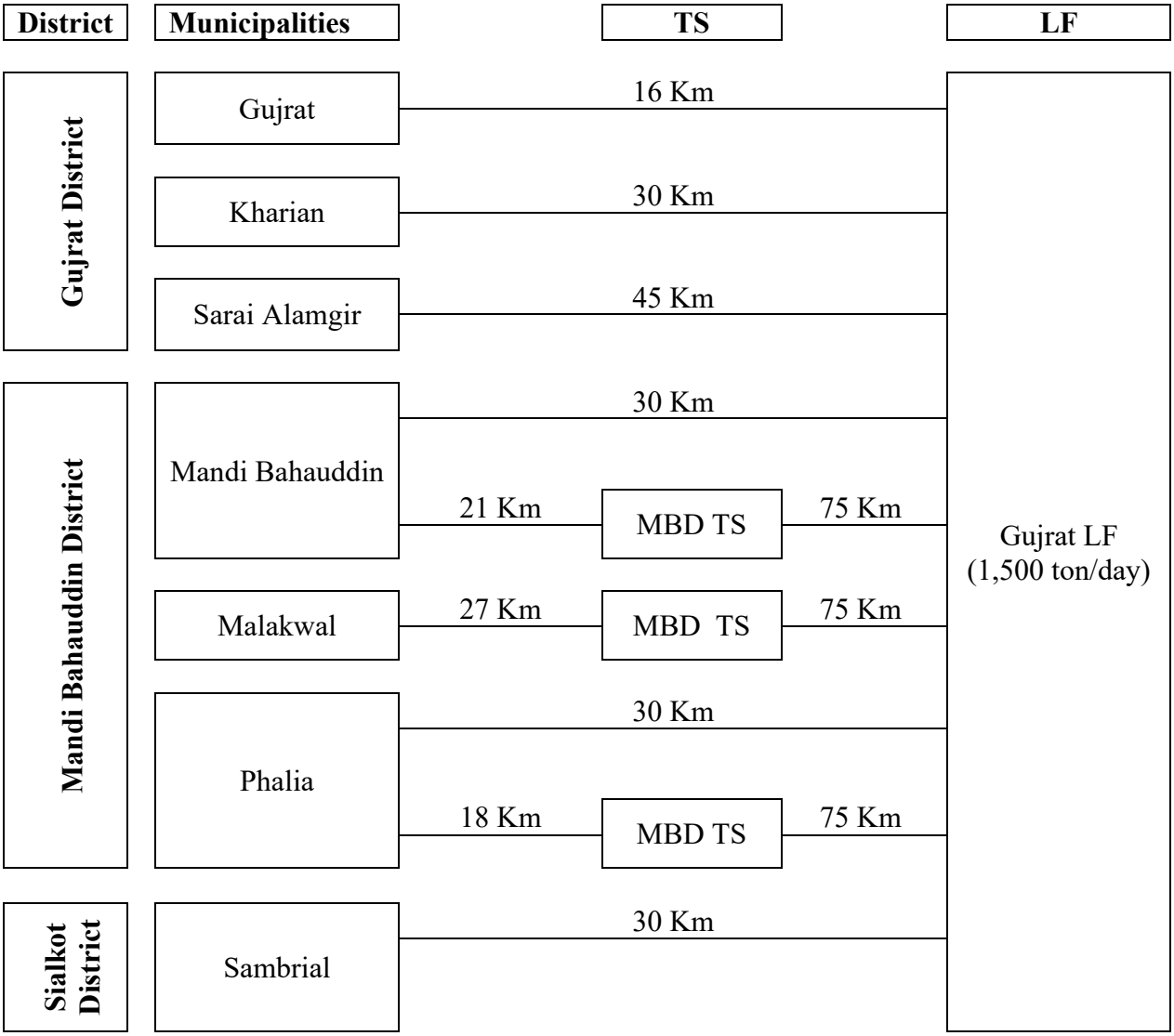


Figure 16: SWM Operational Plan for Gujrat and Mandi Bahauddin District

3.3 Hafizabad Region (Hafizabad Landfill):

According to 2017 census, the total population of Hafizabad District is 1.15 Million and it's estimated that existing everyday waste production is about 430 Ton/day (using waste generation rate of 0.42 kg/capita/day for urban settlements and 0.3 kg/capita/day for rural one). Depending upon the optimum hauling distances, one transfer station is being proposed for Hafizabad District. The waste from this transfer station will be transferred to Hafizabad landfill site.

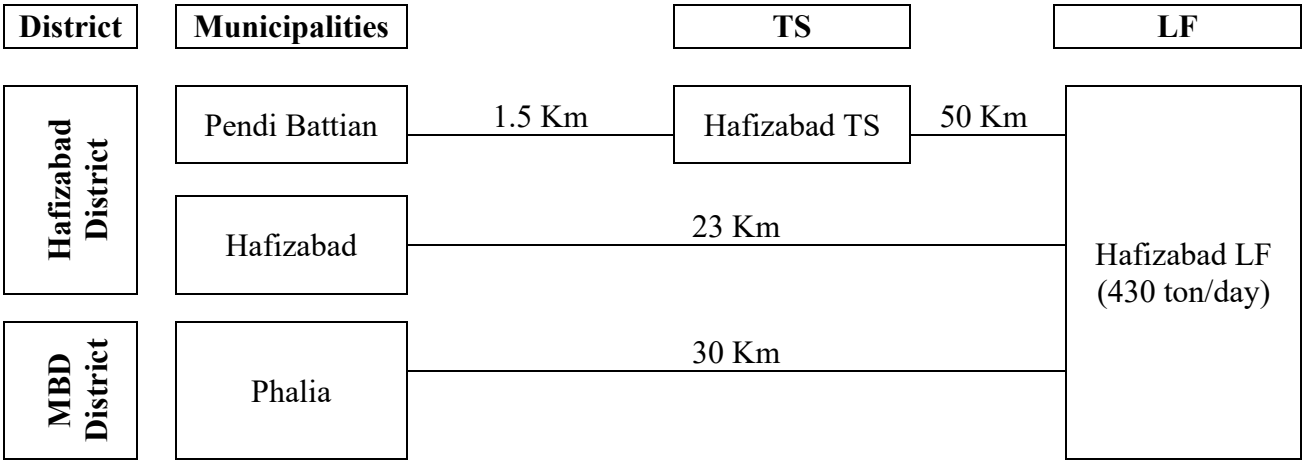


Figure 17: SWM Operational Plan for Hafizabad and Mandi Bahauddin District

3.4 Gujranwala Region (Gujranwala Landfill):

The Current population of Gujranwala District is 5.01 million. The waste generated by Gujranwala District and Daska Tehsil is approximately 2200 tons/day (using waste generation rate of 0.42 kg/capita/day for urban settlements and 0.3 kg/capita/day for rural one). Depending upon the optimum haulage distances, one transfer station is being proposed for whole Gujranwala District with one Sanitary Landfill Site located near Bhakhraywali Village (Gujranwala). The network for effective solid waste management in whole district of Gujranwala is given below.

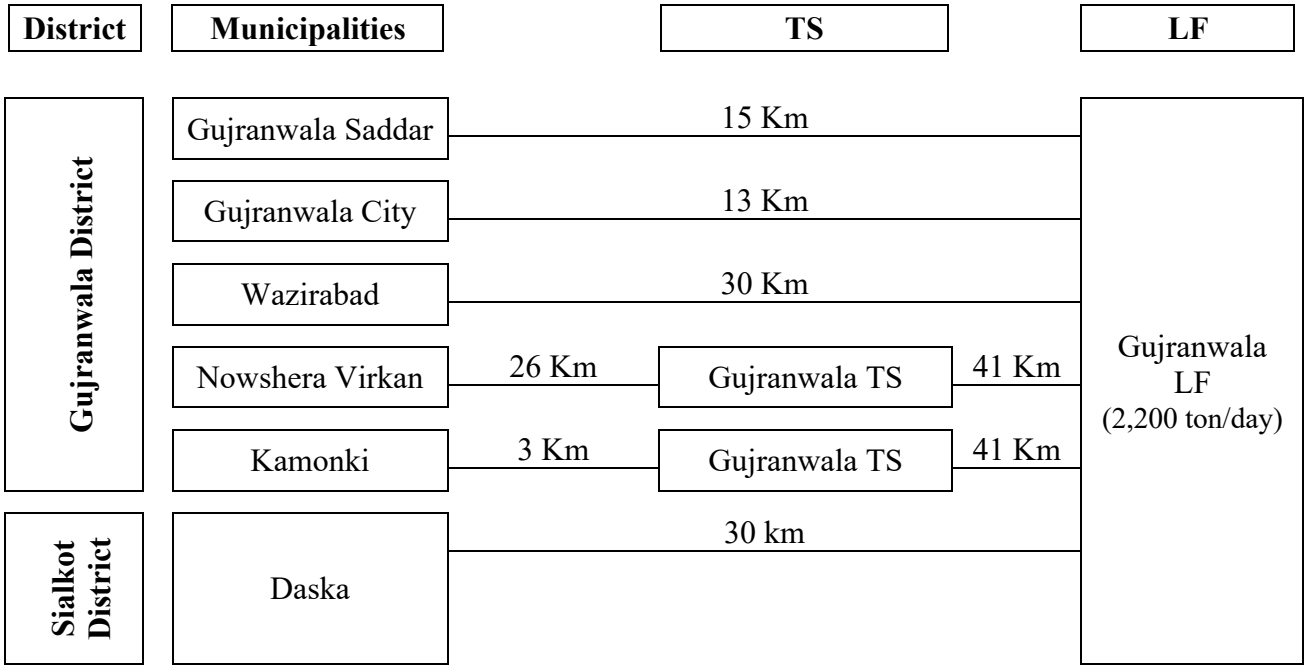


Figure 18: SWM Operational Plan for Gujranwala District

3.5 Baseline Design Criteria

As per waste produced per day, following standards are used to calculate the required resources i.e. equipment, machinery and HR

Table 7: Standards for Calculation of Resources

Equipment & Machinery	HR	
	Driver	Helper
	(/machinery/ shift)	
Container of 10 m^3 capacity to be placed in every Tehsil		
Arm Roll vehicles, for lifting of container/waste from collection point. Arm Roll vehicles will perform at least two trips per week but these trips can be adjusted depending upon the quantity of waste generated.	1	2
Front End Loader (FEL), for loading and unloading of waste at transfer station. At gravity transfer station the arm roll vehicle will be weighted before unloading of waste. At least one loader will be operational to manage the waste inside TS.	1	1
Prime Movers (PM) of 40 m^3 capacity (Approx. 25-30 Ton/trip) In gravity transfer station, these prime movers will be loaded with the help of FEL and waste will be transported to final Regional Landfill (RLF) for safe disposal. PM trips can be adjusted depending upon the waste load on respective transfer station.	1	1

Additional HR would be employed for the whole operation as a backup.

3.6 Resources (Equipment & Machinery):

According to above mentioned standards, following resources are calculated for whole division of Gujranwala for Secondary and Tertiary collection & Transport.

Table 8: Resources for Secondary & Tertiary Waste Collection and Transportation

District	Secondary Collection		Tertiary Collection		For Landfill	
	Item	Quantity	Item	Quantity	Item	Quantity
Gujranwala (1,900 tons/day)	Arm Roller	104	Prime Haulers	6	Compactors	2
	Container	1150	Front End Loader	2	Driver	3
	Monitoring Vehicle	5	Driver	5	Helpers	5
	Driver	131	Helpers	9		
	Helpers	251				
Gujrat	Arm Roller	52	Prime Haulers	0	Compactors	2

(950 tons/day)	Container	582	Front End Loader	0	Driver	3
	Monitoring Vehicle	5	Driver	0	Helpers	5
	Driver	69	Helpers	0		
	Helpers	126				
Hafizabad (400 tons/day)	Arm Roller	22	Prime Haulers	4	Compactors	2
	Container	252	Front End Loader	2	Driver	3
	Monitoring Vehicle	5	Driver	4	Helpers	5
	Driver	33	Helpers	6		
	Helpers	54				
Mandi Bahauddin (520 tons/day)	Arm Roller	28	Prime Haulers	14	Compactors	2
	Container	334	Front End Loader	2	Driver	3
	Monitoring Vehicle	5	Driver	10	Helpers	5
	Driver	40	Helpers	18		
	Helpers	69				
Narowal (570 tons/day)	Arm Roller	30	Prime Haulers	14	Compactors	2
	Container	352	Front End Loader	2	Driver	3
	Monitoring Vehicle	5	Driver	10	Helpers	5
	Driver	42	Helpers	18		
	Helpers	74				
Sialkot (1,305 tons/day)	Arm Roller	72	Prime Haulers	16	Compactors	2
	Container	806	Front End Loader	4	Driver	3
	Monitoring Vehicle	5	Driver	12	Helpers	5
	Driver	93	Helpers	22		
	Helpers	174				

3.7 Managerial Staff for Districts:

Table 9: Managerial Staff for Whole Division for Whole Project Life

	Gujranwala District	Gujrat District	Hafizabad District	Mandi Bahauddin District	Narowal District	Sialkot District	Total
Project Manager	1						**1**
District Manager	1	1	1	1	1	1	**4**
Assistant Manager	5	3	2	3	3	4	**17**
Office staff	4	4	4	4	4	4	**16**
							38

CHAPTER - 4
Financial Model

The total cost for Secondary and Tertiary waste collection & Transport at divisional level has been calculated using above mentioned standards and model. Taking the whole project life of ten years following parameters were considered costing

- Cost of Arm Roll vehicles, Prime Movers, Containers (10 m^3), Front End Loaders, Monitoring vehicles.
- Workshop construction and maintenance cost.
- Cost for land acquisition, construction & management of transfer stations.
- Weight bridges cost both for transfer stations & landfill sites.
- Landfill site construction and operational cost
- Project management cost
- Cost of HR for both Secondary and Tertiary waste collection system (drivers, helper, office staff)

These costs are shown in table below:

Table 10: Cost for Secondary Collection in Each District for Whole Project Life

District	Secondary Collection			
	Capital Cost	Operational Cost	HR	Total
	Millions (PKR)			
Gujranwala	1,119	2,057	605	3,782
Gujrat	573	1,327	317	2,219
Hafizabad	258	463	151	873
Mandi Bahauddin	325	793	184	1,304
Narowal	345	763	195	1,305
Sialkot	785	1,855	428	3,068
Total				**12,553**

Table 11: Cost for Tertiary Collection in Each District for Whole Project Life

District	Tertiary Collection			
	Capital Cost	Operational Cost	HR	Total
	Millions (PKR)			
Gujranwala	63	69	21	154
Gujrat	0	0	0	0
Hafizabad	42	24	15	82
Mandi Bahauddin	145	368	42	556
Narowal	145	251	42	439
Sialkot	167	271	51	491
Total				**1,724**

Table 12: Landfill Cost for Whole Project Life

District	Landfill Cost			
	Capital Cost	Operational Cost	HR	Total
	Millions (PKR)			
Gujranwala LF	4,895	19	12	4,927
Gujrat LF	3,402	19	12	3,434
Hafizabad LF	1,172	19	12	1,204
Sialkot LF	4,364	19	12	4,395
Total				**13,961**

Table 13: Managerial Cost for Whole Project Life

District	Management Cost
	Millions (PKR/10 Years)
Gujranwala	44.7
Gujrat	36.3
Hafizabad	32.1
Mandi Bahauddin	36.3
Narowal	36.3
Sialkot	40.5

For each mode of collection, final per ton cost is given in table below:

Table 14: Total RLFs Project Cost for Gujranwala Division

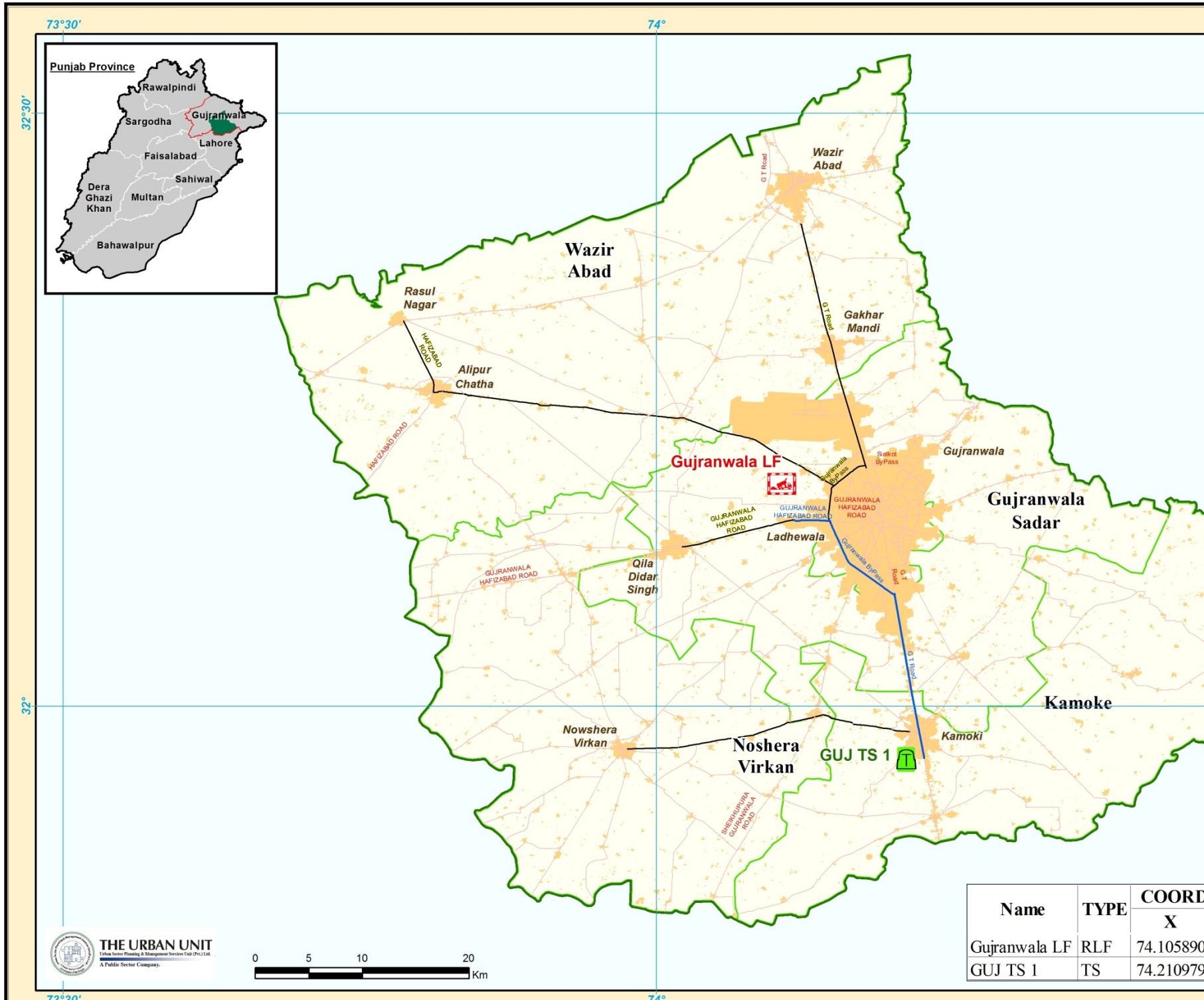
Total Cost		Cost
	Rupees/Project Life	Rs./Ton
Secondary Collection	12,723,552,000	586.32
Tertiary Collection	2,792,550,981	128.68
Landfill Capital & Construction Cost	6,898,565,166	317.89
Landfill Operational Cost	6,319,903,749	291.23
Closure Cost	5,631,218,041	259.49
Rehabilitation Cost	1,072,008,202	49.39
Leachate Treatment Cost	477,683,314	22.01
Management Cost	262,560,000	12.09
Total Project Cost	**36,178,041,453**	**1,667**

Annexures

Annexure A: Table of Yearly Projection of Waste for Gujranwala Division

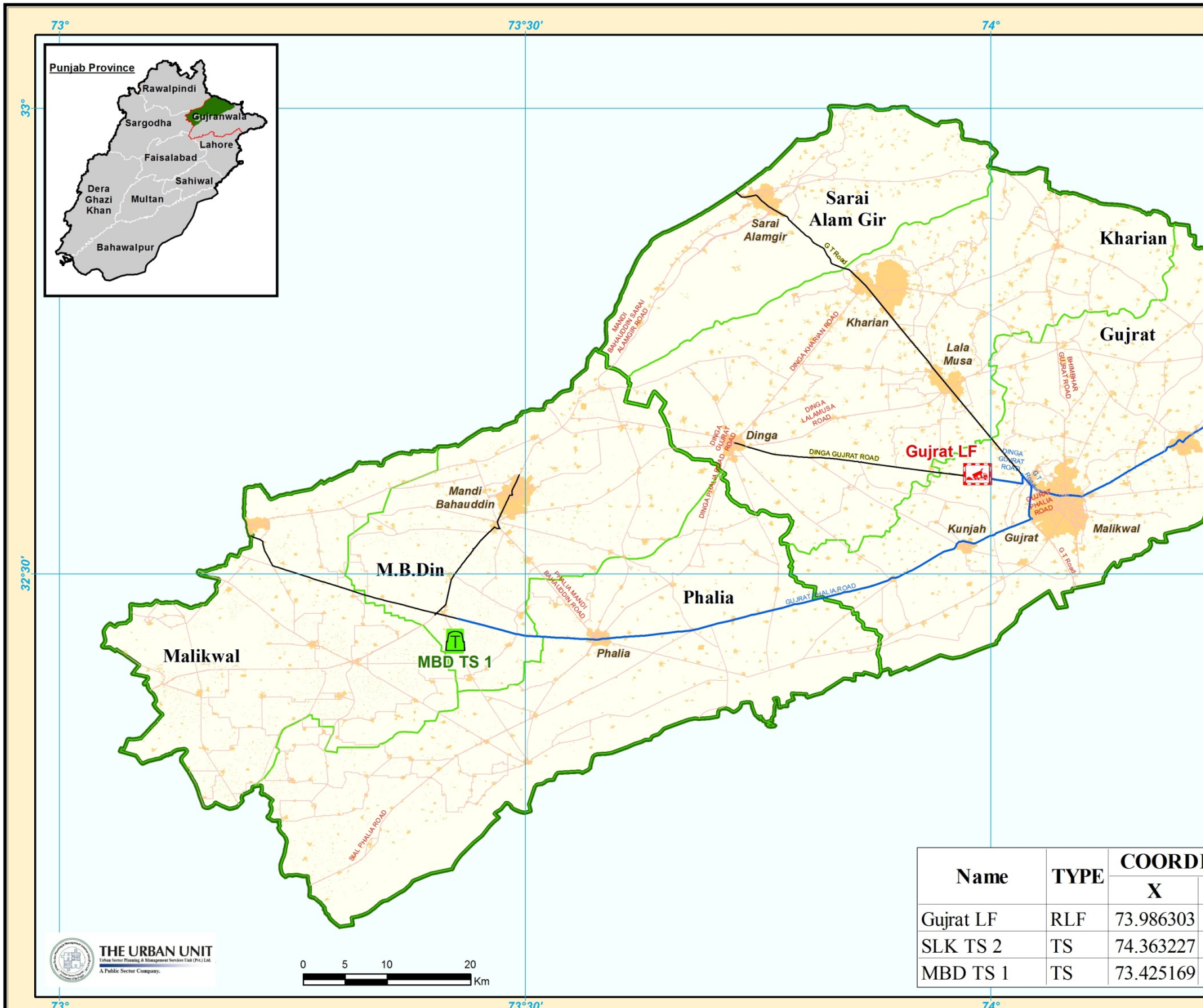
Tehsil	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Ton/year										
Daska	112,987	114,682	116,402	118,148	119,920	121,719	123,545	125,398	127,279	129,188	131,126
Gujranwala City	45,130	45,807	46,494	47,191	47,899	48,617	49,347	50,087	50,838	51,601	52,375
Gujranwala Saddar	453,737	460,543	467,451	474,463	481,580	488,804	496,136	503,578	511,132	518,799	526,581
Gujrat	206,401	209,497	212,639	215,829	219,066	222,352	225,687	229,073	232,509	235,996	239,536
Hafizabad	94,347	95,762	97,198	98,656	100,136	101,638	103,163	104,710	106,281	107,875	109,493
Kamoke	83,329	84,579	85,847	87,135	88,442	89,769	91,115	92,482	93,869	95,277	96,706
Kharian	132,498	134,485	136,503	138,550	140,628	142,738	144,879	147,052	149,258	151,497	153,769
Malakwal	46,920	47,624	48,338	49,064	49,799	50,546	51,305	52,074	52,855	53,648	54,453
MandBahauddin	91,559	92,932	94,326	95,741	97,177	98,635	100,114	101,616	103,140	104,687	106,258
Narowal	78,924	80,107	81,309	82,529	83,767	85,023	86,298	87,593	88,907	90,240	91,594
Nowshera Vikran	67,156	68,164	69,186	70,224	71,277	72,347	73,432	74,533	75,651	76,786	77,938
Pasrur	108,197	109,820	111,467	113,139	114,836	116,559	118,307	120,082	121,883	123,711	125,567
Phalia	69,888	70,936	72,000	73,080	74,176	75,289	76,418	77,565	78,728	79,909	81,108
Pindi Bhattian	66,658	67,658	68,673	69,703	70,749	71,810	72,887	73,980	75,090	76,216	77,360
Sambrial	56,800	57,652	58,517	59,395	60,286	61,190	62,108	63,039	63,985	64,945	65,919
Sarai Alamgir	32,357	32,842	33,335	33,835	34,342	34,857	35,380	35,911	36,450	36,996	37,551
Shakargarh	85,169	86,446	87,743	89,059	90,395	91,751	93,127	94,524	95,942	97,381	98,842
Sialkot	251,749	255,525	259,358	263,248	267,197	271,205	275,273	279,402	283,593	287,847	292,165
Wazirabad	116,004	117,744	119,510	121,303	123,122	124,969	126,844	128,746	130,677	132,638	134,627
Zafarwal	54,639	55,458	56,290	57,134	57,991	58,861	59,744	60,640	61,550	62,473	63,410
Total	**2,254,446**	**2,288,263**	**2,322,587**	**2,357,426**	**2,392,787**	**2,428,679**	**2,465,109**	**2,502,086**	**2,539,617**	**2,577,711**	**2,616,377**

Gujranwala District Regional Landfill Site & Transfe



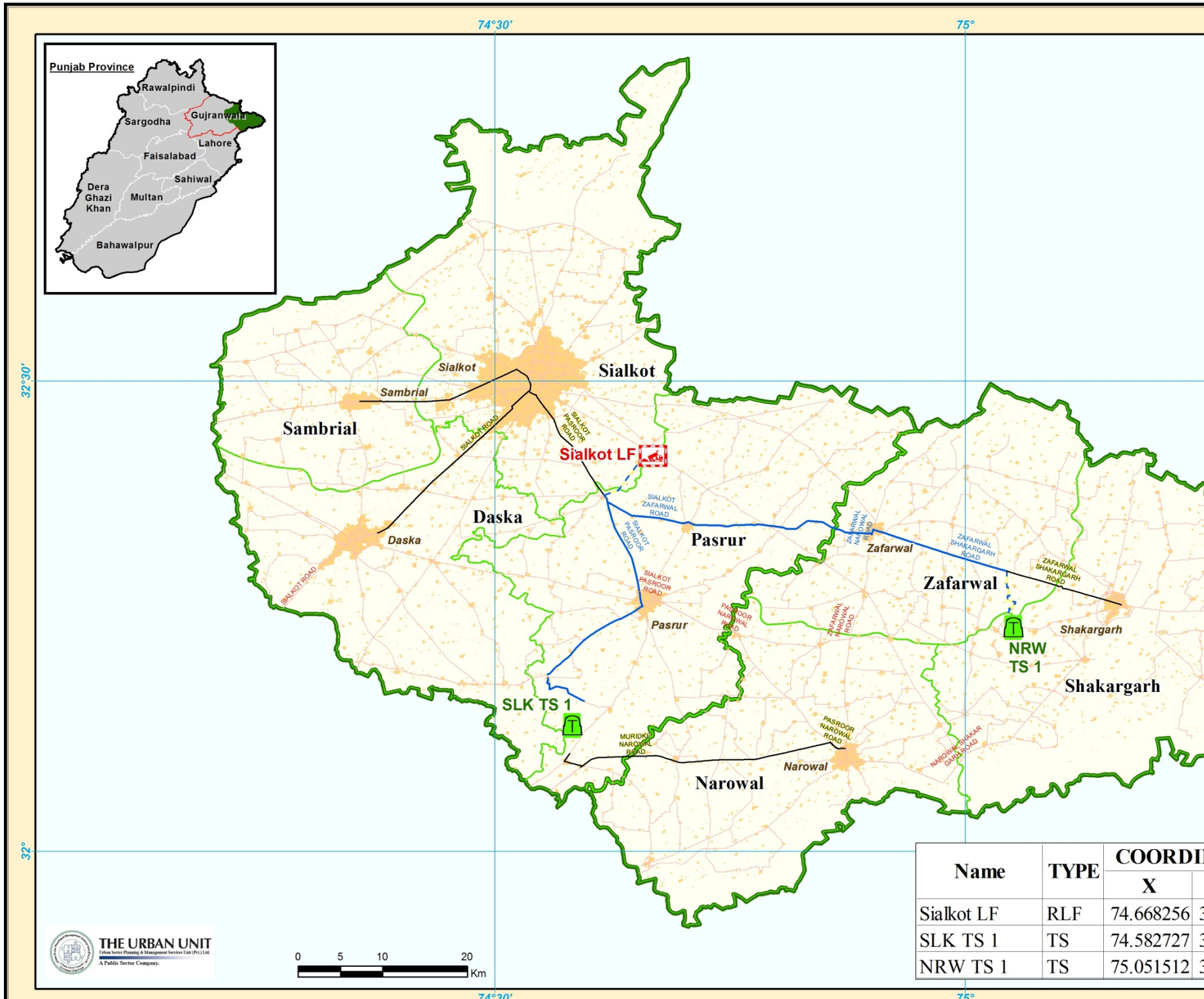
Name	TYPE	COORD
		X
Gujranwala LF	RLF	74.105890
GUJ TS 1	TS	74.210979

Gujrat & Mandi Baha Ud Din District Regional Landfill Site & T



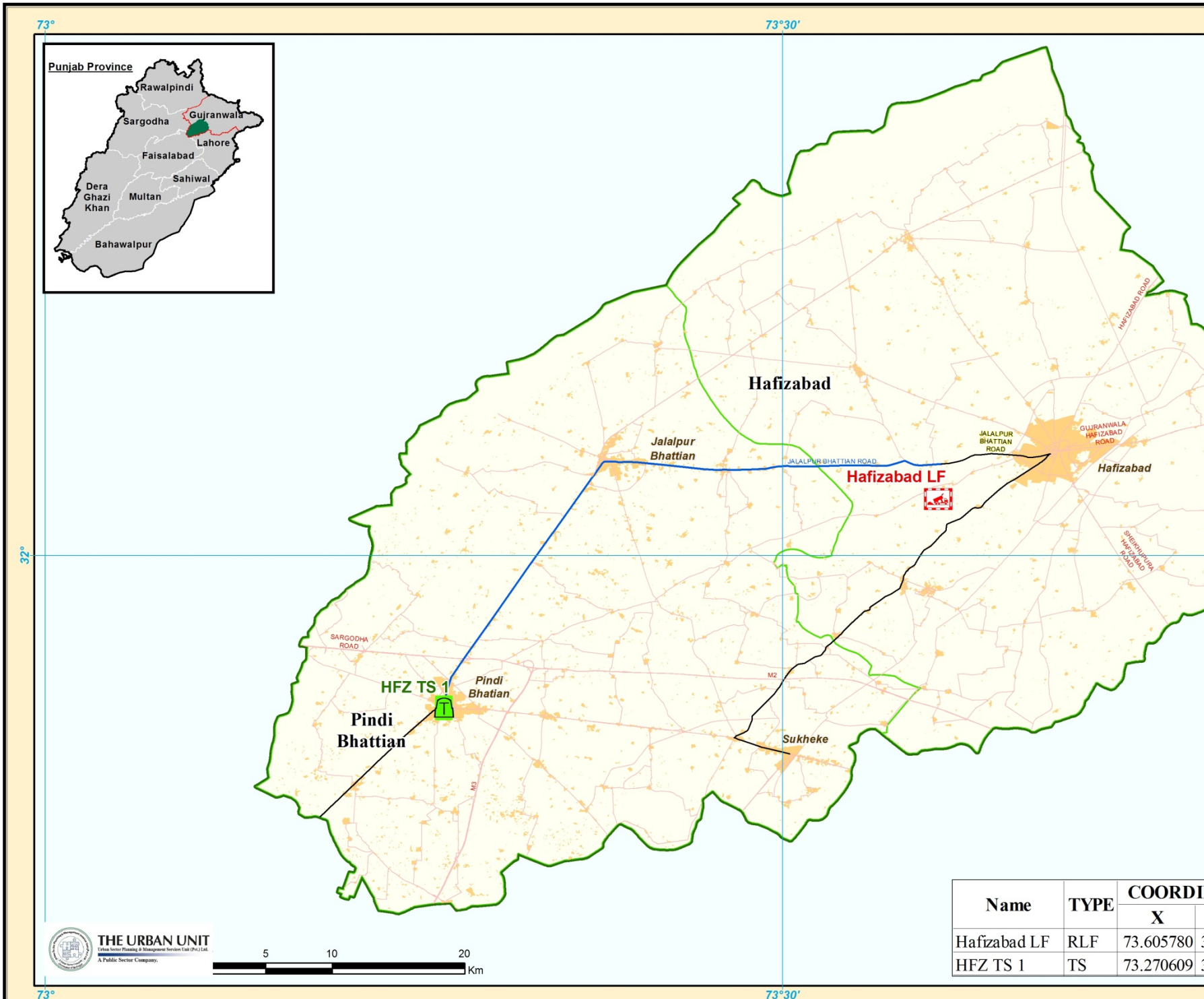
Name	TYPE	COORD
		X
Gujrat LF	RLF	73.986303
SLK TS 2	TS	74.363227
MBD TS 1	TS	73.425169

Sialkot & Narowal District Regional Landfill Site & Tran



Name	TYPE	COORDI	
		X	
Sialkot LF	RLF	74.668256	3
SLK TS 1	TS	74.582727	3
NRW TS 1	TS	75.051512	3

Hafizabad District Regional Landfill Site & Transfer



Name	TYPE	COORDI	
		X	
Hafizabad LF	RLF	73.605780	3
HFZ TS 1	TS	73.270609	3