

Environmental Impact Assessment

Project Number: 51036-002
June 2021

Pakistan: Khyber Pakhtunkhwa Cities Improvement Project

Mardan Solid Waste Management Facility Development
Main Report

Prepared by Project Management Unit, Planning and Development Department, Government of Khyber Pakhtunkhwa for the Asian Development Bank.

This draft environmental impact assessment is a document of the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature. Your attention is directed to the "terms of use" section on ADB's website.

In preparing any country program or strategy, financing any project, or by making any designation of or reference to a particular territory or geographic area in this document, the Asian Development Bank does not intend to make any judgments as to the legal or other status of any territory or area.

Environmental Impact Assessment

Project Number: 51036-003
June 2021

PAK: Mardan Solid Waste Management Facility
(SWMF) Development

This Environmental Impact Assessment Report is a document of the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature. Your attention is directed to the "terms of use" section of the ADB website.

In preparing any country program or strategy, financing any project, or by making any designation of or reference to a particular territory or geographic area in this document, the Asian Development Bank does not intend to make any judgements as to the legal or other status of any territory or area.

CURRENCY EQUIVALENTSAs of 6th June, 2021

Currency Unit – Pak Rupees (Pak Rs.)

Pak Rs 1.00 = \$ 0.00657

US\$1.00 = Pak Rs. 152

CONVERSIONS

1 meter = 3.28 feet

1 hectare = 2.47 acre

1 kanal = 0.125 acre

Acronyms

ADB	Asian Development Bank
ADC	Alternate Daily Cover
AD	Anaerobic Digestion
AIIB	Asian Infrastructure Investment Bank
AIP	Access to Information Policy
AMSL	Above Mean Sea Level
BC	Before Construction
BOQ	Bill of Quantities
CORDEX	Coordinated Regional Downscaling Experiment
COVID	Corona Virus pandemic
CSC	Construction Supervision Consultant
DC	During Construction
DO	During Operation
DTRO	Disc Tube Reverse Osmosis
EA	Executing Agency
EDCM	Engineering Design Construction Management
EGL	Existing Ground Level
EHS	Environmental, Health, and Safety
EIA	Environment Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
GER	Gross Enrollment Rate
GFI	Ground Fault Interrupter
GoP	Government of Pakistan
GRM	Grievance Redress Mechanism
HDPE	High Density Polyethylene
IA	Implementing Agency
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IWMS	Integrated Waste Management System
KP	Khyber Pakhtunkhwa
KPCIP	Khyber Pakhtunkhwa Cities Improvement Project
KP-EPA	Khyber Pakhtunkhwa Environmental Protection Agency
KPI	Key Performance Indicator
LAA	Land Acquisition Act (of 1984)
LARP	Land Acquisition and Resettlement Plan
Leq	Equivalent sound pressure level
LFS	Landfill Site
LGE&RDD	Local Government, Elections and Rural Development Department
LHW	Lady Health Worker
LULC	Land use/Land cover
MBT	Mechanical & Biological treatment
MGD	Million Gallons per Day
MRF	Material Recovery Facility
MSF	Material Sorting Facility

MSWLF	Municipal Solid Waste Landfill
NCS	National Conservation Strategy
NEP	National Environmental Policy
NEQS	National Environmental Quality Standards
NER	Net Enrollment Rate
OHS	Occupational Health and Safety
O&M	Operation & Maintenance
PAP	Project Affected Persons
PC	Public consultation
PCC	Plain Cement Concrete
PCOs	Public Call Offices
PDD	Planning & Development Department
PDA	Mardan Development Authority
PEPAct	Pakistan Environment Protection Act 1997
PEPC	Pakistan Environmental Protection Council
PESCO	Mardan Electric Supply Company
PGA	Peak Ground Acceleration
PMU	Project Management Unit
PPE	Personal Protective Equipment
RCC	Reinforced Cement Concrete
RDF	Refuse Derived Fuel
REA	Rapid Environmental Assessment
RFP	Request for Proposal
RO	Reverse Osmosis
RP	Resettlement Plan
SOPs	Standard Operating Procedures
SS	Suspended Solids
SPS	Safeguard Policy Statement
SSEMP	Site Specific Environmental Management Plan
SWMF	Solid Waste Management Facility
TPD	Tonnes per day
TMA	Tehsil Municipal Administration
TMP	Traffic Management Plan
UC	Union Council
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
WSSC	Water and Sanitation Services Company
WSSM	Water and Sanitation Services Mardan

NOTE

In this report, “\$” refers to US dollars

Definition of Terms

“Carbon Monoxide” (also CO): A colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion.

“Carbon Dioxide” (also CO₂): A colorless, odorless, incombustible gas, CO₂, formed during respiration, combustion, and organic decomposition and used in food refrigeration, carbonated beverages, inert atmospheres, fire extinguishers, and aerosols. Also called carbonic acid gas.

“Ground Water”: The supply of fresh water found beneath the Earth's surface, usually in aquifers, which supply wells and springs. Because ground water is a major source of drinking water, there is growing concern over contamination from leaching agricultural or industrial pollutants or leaking underground storage tanks.

“Laws”: means state and local laws and all regulations, rules, orders, decrees, decisions, instructions, requirements, policies and guidance which are issued or made by any Relevant Authority and which are legally binding, as any of them may be amended from time to time.

“Leachate” Contaminated water that seeps out of landfills. Often contains high amounts of organic matter and toxic chemicals.

“Liner system” The technical term for the layers of materials (such as clay and geosynthetics) that protect landfills from erosion, and keep trash and leachate from escaping from landfills.

“Methane” (also CH₄): A colorless, nonpoisonous, flammable gas created by anaerobic decomposition of organic compounds. A major component of natural gas used in the home.

“Municipal Solid Waste” (MSW) is a waste type that includes predominantly household waste (domestic waste) with sometimes the addition of commercial wastes collected by a municipality within a given area. The term residual waste relates to waste left from household sources containing materials that have not been separated out or sent for reprocessing.

“Operator” means the SLF operator employed or contracted by the EA to operate, maintain and manage the facility.

“Particulates” (also PM₁₀): 1. Fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions. 2. Very small solids suspended in water; they can vary in size, shape, density and electrical charge and can be gathered together by coagulation and flocculation.

“Personal Protective Equipment” (also PPE): Clothing and equipment worn by pesticide mixers, loaders and applicators and re-entry workers, hazmat emergency responders, which is worn to reduce their exposure to potentially hazardous chemicals and other pollutants.

“Peak Ground Acceleration” (PGA) is a measure of earthquake acceleration on the ground and an important input parameter for earthquake engineering.

“Recyclables” Any materials that will be used or reused, or prepared for use or reuse, as an ingredient in an industrial process to make a product, or as an effective substitute for a commercial product. This includes, but is not limited to, paper, glass, plastic and metal.

“Recycling” means the process by which recovered materials are transformed into new products or feedstock for new products.

“Residual Waste” means all municipal solid wastes that are not processed and/or recycled.

“Risk Assessment”: Qualitative and quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence and/or use of specific pollutants.

“Solid Waste Management” means any activity involving the handling, treatment and disposal of Solid Waste. Also means any supervised handling of waste materials from their source through recovery processes to final disposal.

“Solid Waste Management System” The entire process of storage, collection, transportation, processing, and disposal of solid wastes by any entity engaging in such process as a business, or by any state agency, city, authority, county or any combination thereof.

“Sulfur Dioxide” (also SO₂): A pungent, colorless, gas formed primarily by the combustion of fossil fuels; becomes a pollutant when present in large amounts.

“Waste” means any movable articles or material for which their owner wishes to relinquish responsibility by Disposal or which must be removed from their holding place as waste to safeguard the common welfare and to protect the environment.

Content Details

S/No.	Version	Date	Summary of Revisions made
1	1	15-01-2021	First Draft of EIA report
2	2	28-02-2021	Second Draft of EIA report
3	3	06-06-2021	Third Draft of EIA report

Table of Contents

EXECUTIVE SUMMARY	i
1 Introduction	1
1.1 Overview	1
1.2 Project Location	2
1.3 Environmental Category of Project	2
1.4 Objectives of the EIA Study	2
1.5 EIA Team	3
1.6 Methodology of EIA Study	3
1.6.1 Understanding of the Proposed Operation	3
1.6.2 Review of Legislation and Guidelines	3
1.6.3 Secondary Data Collection	3
1.6.4 Field Data Collection (Baseline Survey)	4
1.6.5 Public Consultations	4
1.6.6 Impacts Identification and Assessment	4
1.6.7 Recommendations for Mitigation Measures	4
1.6.8 Development of Environmental Management Plan (EMP)	5
1.7 Proponent of Project	5
1.8 Structure of the Report	6
1.9 Further Additions & Updating of EIA Study	6
2 Policy and Legal Framework	9
2.1 General	9
2.2 National Policy and Legal Framework	9
2.3 Regulations for Environmental Assessment, Pakistan EPA	9
2.4 Regulatory Clearances, KP EPA	9
2.5 Guidelines for Environmental Assessment, Pakistan EPA	9
2.6 National Environmental Quality Standards (NEQS) 2000 & 2010	10
2.7 Other Environment Related Legislations	10
2.8 Implications of national policies and regulations on proposed project	12
2.9 ADB's Safeguard Policy Statement (SPS), 2009	14
2.10 ADB's Access to Information Policy (AIP) 2018	14
2.11 ADB's Accountability Mechanism Policy 2012	14
2.12 Implications of ADB's safeguard policies on proposed project	14
2.13 IFC Sector Specific Guidelines on Solid Waste Management	17
2.14 Comparison of International and Local Environmental Legislations	18
3 Project Description	22
3.1 Component 1: Waste Collection & Transport to SWMF	22
3.1.1 Existing and proposed waste collection system in Mardan	22
3.1.2 Procurement of SWM Equipment, Machinery and Vehicles	29

3.1.3	Waste Transport	30
3.1.4	Transfer Stations	30
3.2	Component 2: SWMF Development & Operation	31
3.2.1	Objective of SWMF Development	31
3.2.2	Capacity of SWMF	31
3.2.3	Scope of Works for SWMF development	32
3.2.4	Project Need	36
3.2.5	Rationale for Site Selection	36
3.2.6	Proposed Design Considerations for SWMF	38
3.2.7	Detailed Process Description	40
3.2.8	Construction of Landfill Facilities	45
3.2.9	Landfill Cell Development	45
3.2.10	Landfill Gas Management	48
3.2.11	Leachate Collection and Treatment System	52
3.2.12	Construction Phase Details for SWMF	58
3.2.13	Operation Phase Details for SWMF	62
3.2.14	Closure and Post Closure Plan for SWMF	63
3.3	Institutional Review and Capacity Building (IRCB) Contract	64
3.4	Climate Risks from Project	64
3.4.1	Climate Change Trends and Extremes in Mardan	64
3.4.2	Climate Change Considerations for Landfill Site	67
4	Description of Environment	70
4.1	General	70
4.2	Physical Resources	70
4.2.1	Topography	70
4.2.2	Soils	70
4.2.3	Climate	75
4.2.4	Seismology	80
4.2.5	Surface water	82
4.2.6	Groundwater	82
4.2.7	Noise	83
4.2.8	Air Quality	83
4.2.9	Land Use	83
4.3	Ecological Environment	88
4.3.1	Flora	89
4.3.2	Fauna	90
4.4	Socio-economic Environment	94
4.4.1	Administrative Setup	96
4.4.2	Demography and Population	96
4.4.3	Religion	96
4.4.4	Cultural and Archaeological sites	97
4.4.5	Ethnicities in Project Area	97
4.4.6	Languages	97
4.4.7	Dress/Clothing	97
4.4.8	Marriages/Deaths	97
4.4.9	Dwellings	98
4.4.10	Main Sources of Livelihood/Income	98
4.4.11	Education Facilities in project area	98

4.4.12 Social Amenities in project area	98
4.4.13 Major Source of Drinking Water	98
4.4.14 Distance to nearest airport from project site	98
4.4.15 Literacy Rate	98
4.4.16 Types of Dwellings	99
4.4.17 Archaeological and Cultural Heritage	99
4.4.18 Energy Supplies	99
4.4.19 Available Social Amenities in the project area	99
4.4.20 Gender Assessment	99
4.4.21 Existing Scavenging Practices	100
4.5 Sensitive Receptor Mapping	101
4.6 Sensitive Receptor Mapping to assess compliance with IFC EHS Clause	118
5 Analysis of Alternatives	120
5.1 Overview	120
5.2 Alternatives Types	120
5.3 'No Project' Option	120
5.4 Site Selection Alternatives	121
5.5 Landfill Type Alternatives	124
5.5.1 Sanitary Landfill	124
5.5.2 Bioreactor Landfill	124
5.5.3 Secured Landfill	124
5.6 Landfill Construction Alternatives	124
5.6.1 Lining	124
5.6.2 Leachate Collection and Treatment	124
5.6.3 Gas collection and Treatment	125
5.7 Technological Alternatives for Anaerobic Digestion System (AD System)	126
5.8 Technological Alternatives for Material Recovery Facility (MRF)	126
5.9 Waste Disposal Alternatives	126
5.9.1 Thermal/Direct Burn Technologies	127
5.9.2 Physical Processing Technologies	127
5.9.3 Biological Processing Technologies	127
5.9.4 Combined Treatment	127
5.9.5 Qualitative Assessment of Various Technologies	127
5.10 Proposed Solution for Mardan City	136
5.10.1 Scenario Analysis for all possible treatment options	136
5.11 Economic Aspect Analysis	146
6 Potential Environmental Impacts and Mitigation Measures	147
6.1 Methodology for impact screening	147
6.2 Design/Pre-Construction Phase	148
6.2.1 Improper landfill design leading to various impacts (leachate leakage causing groundwater contamination, landfill gas leakage etc.)	150
6.2.2 Improper selection of landfill site due to non-compliance with IFC Landfill guidelines	151

6.2.3	Lack of integration of EIA/EMP requirements into Construction bid documents	151
6.2.4	Material Haul Routes	152
6.2.5	Contractor's Environmental Safeguards Capacity	152
6.2.6	Identification of Locations for Labor camps and ancillary facilities	153
6.2.7	Cultural Heritage & Religious Sites, Social Infrastructure	153
6.2.8	Land Acquisition and Resettlement Impacts	153
6.2.9	Impacts due to Natural hazards	154
6.3	Construction Phase	155
6.3.1	Construction of landfill not in accordance with finalized design	156
6.3.2	Degradation of Ambient Air Quality	157
6.3.3	Community Health and Safety	160
6.3.4	Occupational Health and Safety (OHS)	161
6.3.5	High Noise Levels	168
6.3.6	Hazardous and Non-Hazardous Waste Management	171
6.3.7	Camp & Batching Plant Effluent	172
6.3.8	Soil Erosion and Sedimentation	173
6.3.9	Soil Contamination	173
6.3.10	Employment Conflicts	174
6.3.11	Communicable diseases incl. COVID-19	174
6.3.12	Vegetation and Wildlife Loss	178
6.3.13	Historical/Archaeological Sites	179
6.3.14	Construction of Administration Building and Other Infrastructure	180
6.3.15	Sexual Abuse, Exploitation and Harrasement (SEAH)	181
6.4	Impacts Associated with Operation of SWMF	182
6.4.1	Generation of Leachate	183
6.4.2	Possible Contamination of Soil and Groundwater	185
6.4.3	Impact on Surface Water Resources – Canal passing along Southern Boundary of Landfill Site	192
6.4.4	Generation of Landfill Gas	193
6.4.5	Generation of objectionable Odor and impact on air quality	197
6.4.6	Attraction of Vermin and disease vector generation	201
6.4.7	Occupational Health and Safety	202
6.4.8	Waste Collection and Hauling Impacts	203
6.4.9	Wind Blown Litter	205
6.4.10	Impacts on Scavengers/Waste Pickers	206
6.4.11	Improved management of solid waste & health and sanitation	207
6.4.12	Improvements in Public Health	207
6.4.13	Improvements in Aesthetic Aspects	208
6.5	Closure and Post Closure Impacts	208
6.6	Cumulative Impacts	209
6.7	Indirect and Induced Impacts	209
7	Environmental Management Plan & Institutional Requirements	210
7.1	Introduction	210
7.2	Environmental Management Plan (EMP)	210
7.3	Objectives of EMP	211
7.4	Environmental Management/Monitoring and Reporting	211
7.4.1	Inclusion of EMP in Contract documents	211

7.5	Institutional Arrangements	212
7.5.1	Role of PMU, KP LGE & RDD	212
7.5.2	Role of the ADB	212
7.5.3	Role of Construction Supervision Consultant (CSC)	212
7.5.4	Role of KP EPA	213
7.5.5	Role of Project Contractor	213
7.5.6	Role of WSSM	213
7.5.7	Role of Third-Party Monitor	214
7.6	Monitoring Parameters	214
7.7	Environmental Training	215
7.7.1	Capacity Building and Training	215
7.8	Environmental Staffing and Reporting Requirements	215
7.9	Environmental Management Costs	307
8	Public Consultation and Information Disclosure	311
8.1	Identification of Stakeholders	311
8.1.1	Primary Stakeholders	311
8.1.2	Secondary Stakeholders	311
8.1.3	Key stakeholders	312
8.2	Information Disclosure and Consultation	312
8.2.1	Scope of Consultations	312
8.2.2	Social Safeguard Focus Group Discussions	320
8.2.3	Findings of the Public Consultations/Focal Group Discussions	321
8.2.4	Response from Social Safeguards Team	322
8.2.5	Basic data of affected people	322
8.2.6	Consultations with Scavengers and Scrap Dealers	322
8.3	Consultation Plan for Construction and Operation Phase	338
9	Grievance Redressal Mechanism	339
9.1	General	339
10	Conclusion and Recommendations	342
11	References	343

Annexures

Annexure A	Rapid Environmental Assessment (REA) Checklist
Annexure B	Questionnaires for Conducting FGDs & Surveys
Annexure C	Details of Public Consultations
Annexure D	Ambient Laboratory Monitoring
Annexure E	Occupational Health and Safety Plan
Annexure F	Emergency Response Plan
Annexure G	Archaeological 'Chance Find' procedure
Annexure H	Dust Management Plan
Annexure I	Site Specific EMP (SSEMP) Guide & Template for Guidance to Contractor
Annexure J	ToRs of Third Party Monitor
Annexure K	Traffic Management Plan
Annexure L	NEQS Guidelines
Annexure M	WHO Guidance on Laboratory Biosafety
Annexure N	WHO advice on Use of Masks for the COVID-19 Virus
Annexure O	Solid Waste Management Framework
Annexure P	IBAT Model Results
Annexure Q	Estimation of Leachate Leaking Effect on Ground Water Quality
Annexure R	Letter from KPK Wildlife Department
Annexure S	Hydrogeological Report on Impact on Surface Water Resources

List of Figures

Figure 1-1: Key Map	7
Figure 2-1: EIA Review and Approval Process of Pakistan EPAs.....	13
Figure 3-1: Modes of waste collection in Mardan	25
Figure 3-2: Residential Waste Collection Process Flow	26
Figure 3-3: Commercial Waste Collection Process Flow	26
Figure 3-4: Proposed SWM Facility for Mardan.....	34
Figure 3-5: Key Plan of Mardan SWMF.....	35
Figure 3-6: Schematic Diagram of Weigh Bridge.....	41
Figure 3-7: General process flow diagram for AD System and Composting	42
Figure 3-8: Process flow of Material Sorting Facility	43
Figure 3-9: 3D View of proposed MRF for SWM Facility - Mardan	45
Figure 3-10: Bottom Liner of the Landfill Cells.....	46
Figure 3-11: Capping of Landfill	47
Figure 3-12: Design Specification of Gas Vent	49
Figure 3-13: Extension of Gas Vent in Landfill Operations	49
Figure 3-14: Gas Vent System of Mardan Landfill Site	51
Figure 3-15: Leachate Collection Network for Mardan Site	53
Figure 3-16: Process Flow Diagram within DTRO	54
Figure 3-17: Proposed AIO-DTRO Series for leachate treatment.....	55
Figure 3-18: Layout of administration building at Mardan SWMF	56
Figure 4-1: Geology of Project Area	74
Figure 4-2: Year round Temperature Profile of Mardan City	75
Figure 4-3: Temperature trend analysis of Mardan (1951-2016)	76
Figure 4-4: Humidity Profile of Mardan City	77
Figure 4-5: Wind Speed Profile of Mardan City	77
Figure 4-6: Windrose for Mardan	78
Figure 4-7: Average Rainfall Profile of Mardan City.....	79
Figure 4-8: Precipitation trend analysis of Mardan (1951-2016)	79
Figure 4-9: Seismic Zones of Pakistan.....	81
Figure 4-10: Sampling Locations for Environmental Monitoring.....	85
Figure 4-11: Landuse map of the project area.....	86
Figure 4-12: Flora and Fauna of the Project area.....	92
Figure 4-13: Location of Protected area from Mardan LFS.....	93
Figure 4-14: Scio-economic conditions of the project area	95
Figure 4-15: Illustrating young children engaged in scavenging as an essential means of their livelihood.....	101

Figure 4-16: Sensitive Receptors and Prominent Structures within radius of 2 km from the proposed Landfill Site.....	102
Figure 4-17: Sensitive receptor map of landfill site	119
Figure 5-1: Location map of site alternatives	122
Figure 5-2: Scenario-1-No Intermediate treatment	136
Figure 5-3: Scenario-2 (2 streams).....	137
Figure 5-4: Mass balance and %age waste treatment by different options with scenario-2	137
Figure 5-5: Scenario 3 – Composting, Recycling and landfilling (3 streams)	138
Figure 5-6: Mass balance and %age waste treatment by different options with scenario-3	138
Figure 5-7: Composting, RDF, Recycling and Landfill (4 streams)	139
Figure 5-8: Mass balance and %age waste treatment by different options with scenario-4	140
Figure 5-9: Digestion/Methanation, RDF, Recycling and Landfill (4 Streams)	141
Figure 5-10: Mass balance and %age waste treatment by different options with scenario-5	141
Figure 6-1: Location of Tube-wells and ground water level showing underground direction of flow	187
Figure 6-2: Contamination Concentration at target tubewell locations vs. time in days.....	190
Figure 6-3: Potential Emissions from Landfill Site	196
Figure 6-4: Corridor of Impact of AirBorne Impacts from Landfill Operation.....	200
Figure 8-1: Map of Public Consultation Locations	313
Figure 8-2: Consultations with Institutional Stakeholders	319
Figure 8-3: Focus Group Discussions (FGDs) for Mardan SWMF	320
Figure 8-4: Consultations with Scavangers/Waste Handlers	337
Figure 9-1: Grievance Redressal Mechanism	341

List of Tables

Table 1.1: Executing Agency Contact Details.....	6
Table 2.1: Environmental Guidelines and Regulations	10
Table 2.2: ADB Policy Principles	15
Table 2.3: ADB Environmental Assessment Requirements for Category 'A' projects	16
Table 2.4: IFC Work Environment Noise limits	19
Table 2.5: Comparison of International and local Air Quality Standards*	19
Table 2.6: Comparison of International and Local Noise Standards	20
Table 2.7: Comparison of International and Local Water Quality Standards.....	20
Table 3.1: Modes of Waste Collection.....	23
Table 3.2: Audit of Existing Facility and Required Corrective Actions.....	27
Table 3.3: Current Waste Carrying Machinery Procurement	29
Table 3.4: Current Non-waste Carrying Machinery Procurement	29
Table 3.5: Total SWM Fleet Required	30
Table 3.6: Criteria for Site Selection.....	36
Table 3.7: Waste Generation Estimation Criteria.....	39
Table 3.8: Size of Landfill Cells	46
Table 3.9: Estimated Contractor's Equipment and Machinery	61
Table 3.10: Source of Raw Material	62
Table 3.11: Operation Phase Activities	62
Table 3.12: List of Equipment and Machinery for operation phase of Landfill Site	63
Table 3.13: Climate Change and potential impacts for Mardan	66
Table 3.14: Sensitivity Considerations for Landfill Site	67
Table 3.15: Non-climate Stressors and Potential Impact on Landfill Site	68
Table 4.1: Summary of ground conditions across Project Site.....	71
Table 4.2: Ambient Noise Monitoring Results (24 hrs) in Project Area	87
Table 4.3: Comparison of ambient air quality results versus applicable Air Quality standards	88
Table 4.4: Existing Flora in Project Area	89
Table 4.5: Existing Fauna in Project Area	90
Table 4.6: IUCN Status of Fauna in Project Area	91
Table 4.7: Ethnicities in Project Area.....	97
Table 4.8: Sensitive Receptors and Prominent Structures within radius of 2 km from the proposed Landfill Site.....	103
Table 5.1: Comparison of Site Alternatives	122
Table 5.2: Qualitative Assessment criteria for waste treatment options	127
Table 5.3: Qualitative/Subjective assessment of various technologies for Mardan City	129
Table 5.4: Pros/Cons of Scenario-1	136

Table 5.5: Pros/Cons of Scenario-2	138
Table 5.6: Pros/Cons of Scenario-3	139
Table 5.7: Pros/Cons of Scenario-4	140
Table 5.8: Pros/Cons of Scenario-5	142
Table 5.9: Qualitative Evaluation of Possible Scenarios for Mardan City.....	143
Table 5.10: Economic aspect analysis of waste treatment methods (UNEP, 2015)	146
Table 6.1: 'Activity Wise' screening of possible Impacts during Design/Pre-Construction phase	149
Table 6.2: Screening of Possible Impacts during Construction Phase.....	155
Table 6.3: Control measures for Fugitive Dust emissions.....	159
Table 6.4: Construction Equipment Noise Ranges, dB(A)	169
Table 6.5: Screening of Possible Impacts during Operation Phase	182
Table 6.6: Data of existing water resources around LFS	186
Table 6.7: Input Data for Otaga and Banks Equation	188
Table 6.8: Travel time and Leachate concentration at tubewell locations around LFS.....	189
Table 6.6: Typical Landfill Gas Components	194
Table 7.1: Environmental Management Plan.....	216
Table 7.2: 'Pre-Construction' Environmental Monitoring Plan for Baseline Development ..	302
Table 7.3: Construction Phase Monitoring Requirements.....	303
Table 7.4: 'Operation Phase' Environmental Monitoring Plan.....	304
Table 7.5: Capacity Development and Training Programme	305
Table 7.6: Annual Cost Estimates for 'Pre-Construction Phase' Environmental Monitoring	307
Table 7.7: Annual Cost Estimates for 'Construction Phase' Environmental Monitoring.....	307
Table 7.8: Annual Cost Estimates for 'Operation Phase' Environmental Monitoring	308
Table 7.9: Estimated Costs for EMP Implementation	308
Table 7.10: Capacity Development and Training Programme for Project Contractor(s)....	310
Table 8.1: List of Stakeholder Consultation and Concerns	314
Table 8.2: Consultations with Government Stakeholders	316
Table 8.3: Consultations with Scavengers and Scrap Dealers	324
Table 8.4: Responses from Scavengers based on Survey Questions	327

EXECUTIVE SUMMARY

Project Overview

1. The Khyber Pakhtunkhwa Cities Improvement Projects (KPCIP) will improve the quality of life of the residents of five KP cities, including Abbottabad, Kohat, Mardan, Mingora, and Peshawar, directly benefitting about 6 million of urban population. KPCIP will help selected cities improve their access to quality urban services through three interlinked outputs: (i) Climate resilient and gender friendly urban infrastructure improve, (ii) Institutional capacities of urban service providers and governments strengthened, and (iii) Increased women's participation in urban governance and access to economic opportunities.
2. KPCIP will support the Government of Pakistan's development priorities, established in (i) the National Water Policy (2018), (ii) the Local Government Act (2019), and (iii) Pakistan Vision 2025. The project is also aligned with ADB's operational priorities of (i) addressing remaining poverty and reducing inequalities; (ii) accelerating progress in gender equality; (iii) tracking climate change, building climate and disaster readiness; (iv) making cities more livable; and (v) strengthening governance and institutional capacity, outlined in ADB's Strategy 2030, and is included in ADB's country operations business plan for Pakistan, 2021–2023.
3. The project readiness financing (approved in March 2019) has financed the preparation and engineering design of the KPCIP. The Department of Local Government, Elections and Rural Development Department (LGE&RDD), the Government of Khyber Pakhtunkhwa, will be the executing agency for the project and the city governments of the five target cities, including the respective Water and Sanitation Services Companies, will be the implementing agencies.
4. This report has been prepared based on detailed engineering designs, due diligence assessments, and studies conducted by the government and project readiness financing consultants. The Government of Pakistan, Asian Development Bank (ADB), and Asia Infrastructure Investment Bank (AIIB) are expected to approve KPCIP in Q3 2021.
5. The Project has the following four major components:
 - Improvement of water supply systems in five cities.
 - Development of sewage treatment plants (STPs) in two cities.
 - Provision of Integrated Solid Waste management (ISWM) system in four cities.
 - Development of Urban/Green Spaces in five cities.
6. The proposed Integrated Waste Management System (IWMS) has the following two main components:
 - **Component 1:** Improvement of existing waste collection & transport system in Mardan City
 - **Component 2:** Solid Waste Managemetn Faciltiy Development & Operation
7. The IWMS within Mardan city is crucial for successful operation of the SWMF as it provides strategic approach to sustainable management of solid waste covering all

sources and all aspects, including generation, segregation, transfer, sorting, treatment, recovery and disposal in an integrated manner, with an emphasis on maximizing resource use efficiency. The operational protocols and modalities of the IWMS have been established to improve environmentally sound practices with respect to waste management and attempting to close existing bottlenecks in the system.

8. The Component 1 is an existing activity that is proposed to be further enhanced and improved in turns of its operational efficacy through implementation of the IWMS. On the other hand, the proposed Component 2 is the environmentally sensitive intervention and thus this EIA report focuses on this particular component.
9. The proposed Component 2 consists of the development of a well engineered and designed solid waste management facility (SWMF) which will ensure the solid waste generated from Mardan city is managed in accordance with international good practices on solid waste management.
10. The proposed SWMF is located about 3 km away from Mardan Ring Road, about 6.9 km from Haryana via Nisata Road, about 9.9 km from Sheikh Maltoon Town via Mardan Ring Road and approximately 10.7 km from the city center.
11. The total area of the landfill is 27 acres. The site has silty soils strata with no rock formation, and mainly comprises of unconsolidated surficial deposits of silts, sands and gravel. The area has a boundary wall constructed around it several years ago and no agricultural activity is taking place on the site. The access road to the landfill from main road is in good condition, which can be used for waste carrying vehicles.

A map of the project area is provided as **Figure ES-1**.

Project Need

12. The estimated waste generation for Mardan city in Khyber Pakhtunkhawa (KP) province of Pakistan is around 191 tons per day in year 2021, assuming waste generation rate of 0.33 kg/cap/day for all waste streams i.e. residential, commercial and bulk waste. An additional allowance of waste i.e. 25% is accounted for in the above tonnage, which is bulk waste.
13. Considering the climatic conditions of Mardan City, where humidity is high and temperatures provides a conducive environment for the microbes to rapidly degrade, the organic fraction of the waste which produce smell and attract animals, thus contributing to spread of filth and disease. Furthermore, there is common practice of burning waste which poses an even greater risk to safety of neighboring households.
14. Throwing of waste into the running water body, such as stream or a canal, is a common practice and almost all water bodies flowing through the city have been turned into dumping sites. Water and Sanitation Services Mardan (WSSM) aims to counter these practices and has deployed containers and litter bins on main roads and streets. Sanitary workers, after sweeping the streets, collect waste in wheelbarrows to their designated waste storage points in the area, usually containers.
15. Proposed installation of primary and secondary Municipal Solid Waste (MSW) collection systems, and the development of an international standard MSW management facility has been designed to address SWM issues of Mardan city.

Study Methodology

16. Both secondary and primary data on ambient noise levels and air quality, water resources, flora, fauna and information from the detailed design conducted for this and other projects of similar nature were collected, reviewed, and analyzed. Extensive field visits to the project area were undertaken and key receptors and stakeholders within the project area were identified and consulted.
17. Detailed ambient air quality and noise monitoring at different key receptor points in the project area were conducted. Apart from exceedances in PM₁₀ at three locations, all other pollutants are within the applicable 'most stringent' standards/guidelines. The ambient noise levels were also assessed to be generally within the applicable standards/guidelines during the day time while exceedance at one location was observed during the night time. Furthermore, the ground water quality was also assessed to be within the applicable NEQS limits.
18. The significance of impacts from the proposed project were then assessed and for those impacts requiring mitigation, suitable measures were proposed to reduce impacts to within acceptable limits as per local and international applicable regulations. A detailed environmental management and monitoring plan was developed to ensure compliance to the proposed measures during the project development.

Public Consultation Process

19. A total of six comprehensive focus group discussions with stakeholders were organized with a total of over 55 different stakeholders consulted with 26 stakeholders (forty seven percent) being women. The first round of public consultations was conducted in the month of January–February, 2020, while the second round of public consultation was completed in the month of March–April, 2020. Information on positive and negative impacts associated with constructional and operational stage and proper mitigation of adverse impacts were shared at these consultations.

Analysis of Alternatives

20. If 'no project' option is triggered, it will result in loss of all positive impacts caused that project will pose on Mardan city; such as eradicating open dumping of solid waste, improving civic services in terms of integrated waste management, removing existing bottlenecks in the system and improving the aesthetic aspects of the city. If the project is not implemented, urban environmental quality will be further degraded. It also limits the urban development of the area in a sustainable manner.
21. On the other hand, if the project is implemented, it will result in improved SWM system services and improved urban environment quality. Furthermore, project implementation will also create job opportunities during construction, thereby improving the socioeconomic condition of the local people and help in improving their quality of life. Thus, the 'no project' option is not a viable option.
22. The four different sites considered were as follows:
 - **Nisatta Road site:** located outside the south western periphery of the Ring Road, 3 km from the Ring Road and 15 km from the city center.
 - **Faqirabad:** general area located 8-10 km south east of the city center, within the Ring Road.
 - **Shankar:** located on the northern periphery of the Ring Road, 11-12 km from the city center.

23. The proposed site was selected since it fulfilled the detailed site selection criteria that was developed and is already owned by WSSM, which minimizes land acquisition issues. The social acceptability of the project is enhanced by educating the nearby population on the merits of a sanitary landfill and the robustness of the resettlement plan.
24. Different types of Landfills were also considered such as Sanitary landfill, Bioreactor landfill and Secured landfill. Based on the comparison conducted, the project design consultant suggested to construct a sanitary landfill for Mardan as it is relatively low in cost and requires less technical and operational maintenance as compared to other options.
25. Different landfill construction alternatives were also considered such as Lining, Leachate collection and treatment and Gas collection and treatment with flaring proposed for landfill gas management.
26. Other types of alternatives that were considered were technological alternatives for Anaerobic Digestion System, technological alternatives for Material Recovery Facility, Waste Disposal Alternatives along with a comparison of possible treatment options as well as an Economic Aspect Analysis of the different types of landfilling technologies.

Baseline Conditions

27. **Physical Environment:** Topography of proposed SWMF consist of plains. The site has silty soils strata with no rock formation, and mainly comprises of unconsolidated surficial deposits of silts, sands and gravel. Project area is falling in Zone 2B with moderate seismicity risk. There are two small canals, with one lying in the south west and the other to the south east of the proposed site. Ground water is found at depth of about 2.5-4 feet and lab analysis shows that water quality is within NEQS. Ambient noise levels being within the most stringent guidelines during the daytime, however, exceedances were observed at the night time at two locations in the project area. Air shed seems to be of good quality with the ambient air quality within the acceptable NEQS standards with PM₁₀ being the only pollutant that is exceeding the guidelines at one of the monitored locations. Major Landuse of the project area is barren land followed by cropped area.
28. **Biological Environment:** Project is falling outside environmental sensitive areas (Wildlife Park, Wildlife sanctuary, Game Reserve or Protected/Reserved Forests) and critical habitats. The present flora of the irrigated areas is exotic. The common trees are mesquite, ber, different species of acacia and jand. The most common shrubs are tarmariax, articulata, spands, akk, small red poppy, spera, pueghambrigul, drab grass, spera, eamelthorl and pohli chaulai etc. No endangered species are available present in the project area. Red Fox, Golden Jackal, Indian Crested Porcupine and Wild Boar are important mammals of the area with IUCN least concern status. The commonly found avifauna of the project area are Shikra (*Accipiter badius*), Crow (*Corvus splendens*), Common kite (*Milbus migrans*), Sparrow (*Passer domesticus*), Pigeons (*Columba livia*), Dove (*Strato pielia SSP.*), Parrot (*Psittacula krameri*), Partridges. No migratory birds or their routes were found near the project site.
29. The project area was also screened for ecological sensitivities using the Integrated Biodiversity Assessment Tool (IBAT) with its outputs provided as **Annexure P**. The tool was run for three buffer zones (3, 5 and 10 km). The findings of IBAT were correlated with the primary and secondary data collected as part of the detailed scoping activities conducted during preparation of this study. It was observed that IBAT correctly stated that no protected areas and/or key biodiversity areas are present within

these three buffer zones. Furthermore, it stated that within a 50 km area of interest, there are possibly 25 species that are listed in the IUCN Red List, consisting of terrestrial, marine and freshwater species.

30. An official letter from the KPK Wildlife Conservator, confirming that 'Neither wildlife sensitive areas nor corridors for endangered species fall in and around the proposed landfill site' was obtained and is provided as **Annexure R** of this report.
31. **Social Environment:** The project area falls in the jurisdiction of Union Council (UC) Rustom, Mardan in Khyber Pakhtunkhwa Province, under the latest revision of Pakistan's administrative structure, promulgated in 2001. The district divided into two sub-divisions Mardan and Takht Bhai with headquarters at Mardan. The population of Mardan city in 2017 was 358,604. The city's annual growth rate is estimated at 2.58 % per year, and the population of Mardan district is 2,373,061 according to the 2017 census.
32. The names of the major settlements falling in the project area are Saeedabad, Shotal Banda, Khwaja Rashakai and Shamilaat. Most of the people are farmers in profession in the nearby villages. They are engaged in agriculture either directly or indirectly. The literacy rate for population 10 years and above (2010-2011) was 54 percent (Males: 68%, Females: 38%).35 which increased to 59% in 2013.

Potential Major Impacts

33. The screening matrices for the pre-construction, construction and operation phases of the SWMF are provided below as **Tables ES.1, ES.2 and ES.3**.
34. **Pre-construction/design phase:** The key potential impacts that have been assessed and for which necessary mitigation measures have also been proposed, as required, are as follows:
 - Improper designing of landfill site leading to various impacts
 - Improper selection of landfill site due to non-compliance with IFC guidelines
35. **Construction phase:** The key potential impacts that have been assessed and for which necessary mitigation measures have also been proposed, as required, are as follows:
 - Improper Construction of landfill not in accordance with finalized design
 - Community health and safety issues
 - Occupational health and safety issues
 - Improper handling and/or disposal of hazardous and non-hazardous waste
36. **Operation phase:** The key potential impacts that have been assessed and for which necessary mitigation measures have also been proposed, as required are as follows:
 - Generation of Leachate
 - Possible Contamination of Soil and Groundwater
 - Generation of Landfill Gas

- Generation of Objectionable Odor and impact on air quality
- Attraction of Vermin and disease vector generation
- Occupational Health and Safety
- Waste Collection and Hauling Impacts
- Wind blown litter
- Closure and Post Closure impacts

Mitigation Measures

37. Mitigation measures associated with pre-construction, design, operation, closure and post closure phases are detailed in the EIA report. Necessary design considerations has been included for leachate collection and treatment, landfill gas management, odor and vector controls. Mitigations associated with construction phase are detailed in the EIA report to avoid soil and ground/surface water contamination, OHS issues, social conflicts, vegetation loss and communicable diseases.
38. Mitigations for operation phase are provided to ensure that leachate and landfill gas is managed properly, there would be no waste hauling impacts, traffic issues, wind blown litter, vector spread and air quality problems. Daily cover will be applied to avoid odour and litter issues. Buffer zone through necessary plantation will be developed to improve aesthetic appeal of the area. Project will result in improved waste management services, improved public health and improved aesthetic appeal of the area.

Climate Change Exposure of Landfill Site

39. This includes identification of climate change hazards in the context of potential climate scenarios. For example, precipitation changes can degrade covers of landfill. Moreover, a number of anthropogenic stressors, socio-economic and land-use changes near and around the landfill site in the future may complicate and exacerbate the above-mentioned climate change events and increase exposure of the site. Temperature changes can impact the composting process and also can impact the decomposition process responsible for leachate production. For example, land-development can affect natural protective barriers.

Climate Change Sensitivity of Landfill Site

40. Likelihood of climate change related hazards are included in sensitivity assessment that could negatively affect the functioning of the landfill site including direct impacts (accessibility, physical damage, water damage) and indirect impacts (accidental fire, explosion or ecosystem damage). These direct and indirect impacts can affect the landfill site in terms of damage to liner or cover materials, washout of contaminated contents, leachate collection and removal, landfill gas management etc.

Cumulative Impacts

41. No other infrastructure works are planned to be conducted in the landfill project area while these project works shall be conducted. Thus, no cumulative impacts are expected.

Indirect and Induced Impacts

42. Potential impacts arising from each phase of the proposed Mardan SWM facility have been identified and assessed on the basis of field data, secondary data, expert opinion and examining previous similar projects in Pakistan. These include effects on physical, biological and socio-economic environment. Impacts on the environment from air emissions, traffic and community noise have also been assessed and have found to be acceptable and within the carrying capacities of the environmental media.
43. Thus, negative indirect and induced impacts from the proposed landfill works are not expected.

Institutional Arrangements

44. During the construction phase, the overall responsibility for the implementation and monitoring of the EMP rests with the Project Director (PD), Project Management Unit (PMU), KP Local Government Election and Rural Development Department (LGE&RDD). The PD through assistance from the Supervision Consultant's Environmental staff and the Environment team of PMU, will supervise the implementation of the proposed mitigation measures and monitor the implementation progress in the field. Monthly environmental monitoring data/reports will be incorporated in the project implementation progress reports to be shared with ADB and such monthly reports will be consolidated into bi-annual monitoring reports and submitted to ADB for review and clearance. Upon clearance, all such reports will be uploaded on the PMU and ADB websites.

Conclusion & Recommendations

45. An action plan with clear roles and responsibilities of stakeholders has been provided in the report. The PMU, Contractors and the Construction Supervision Consultant are the major stakeholders responsible for the action plan. The action plan must be implemented prior to commencement of construction work. In order to execute successful operation of SWMF facility, institutional review and capacity building (IRCB) component is included in the project design to enhance services delivery of WSSM.
46. Mitigation measures will be assured by a program of environmental monitoring conducted during construction and operation to ensure that all measures in the EMP are implemented and to determine whether the environment is protected as intended. This will include observations on and off-site, document checks, and interviews with workers and beneficiaries, and any requirements for remedial action will be reported.
47. The majority of the environmental impacts are associated with the operation phase of the project since these will be long term, such as generation of objectionable odor and impact on air quality, attraction of vermin and disease vector generation, Leachate generation, Possible contamination of soil and groundwater, Generation of Landfill Gas etc., to name a few. These shall be mitigated through necessary measures.
48. The potential adverse impacts that are associated with design, construction, and operation can be mitigated to standard levels without difficulty through proper engineering design and the incorporation or application of recommended mitigation measures and procedures. Based on the findings of this EIA study, the classification of the Project as Category 'A' is confirmed. It is concluded that the proposed project should proceed, with appropriate mitigation measures and monitoring programs identified in the EIA study.

Table ES-1: Screening of possible Impacts during Design/Pre-Construction phase

S/No.	Potential Issue	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact (Short Term, Long Term)
1	Improper designing of landfill site leading to various impacts (leachate leakage causing groundwater contamination, landfill gas leakage etc.)	Likely	Moderate	Medium	Long Term
2	Improper selection of landfill site due to non-compliance with IFC guidelines for Landfills	Likely	Moderate	Medium	Long Term
3	Lack of integration of EIA/EMP requirements into Construction bid documents	Likely	Moderate	Medium	Short Term
4	Material Hauling impacts	Likely	Moderate	Medium	Short Term
5	Contractor's environmental safeguards capacity	Likely	Moderate	Medium	Short Term
6	Improper location of worker camps leading to improper disposal of solid waste and sewage and privacy issues for residents in project area.	Likely	Moderate	Medium	Short Term
7	Land acquisition and resettlement impacts	Likely	Moderate	Medium	Short Term
8	Cultural heritage & Religious sites, Social Infrastructure	Unlikely	Moderate	Low	No residual Impact
9	Impacts due to natural hazards	Unlikely	Moderate	Low	No residual Impact

[Red Box] Critical Risk Level

[Yellow Box] Significant Risk Level

[Orange Box] Medium Risk Level

[Blue Box] Low Risk Level

Table ES-2: Screening of Possible Impacts during Construction Phase

S/No.	Potential Issue	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact (Short Term, Long Term)
1	Construction of landfill not in accordance with finalized design	Likely	Major	Medium	Long Term
2	Degradation of air quality due to construction works	Likely	Moderate	Medium	Short Term
3	Potential accidents and injuries to communities in project area during construction works	Likely	Moderate	Medium	Short Term
4	Injuries to workers from lack of necessary training and/or not using PPEs etc.	Likely	Moderate	Medium	Short Term
5	High noise levels from construction activities	Likely	Moderate	Medium	Short Term
6	Improper handling and/or disposal of hazardous and non-hazardous waste	Likely	Moderate	Medium	Short Term
7	Untreated disposal of effluent from worker camps and batching plant(s)	Likely	Moderate	Medium	Short Term
8	Soil Erosion and Sedimentation	Likely	Moderate	Medium	Short Term
9	Soil Contamination	Likely	Moderate	Medium	Short Term
10	Employment Conflicts	Likely	Moderate	Medium	Short Term
11	Communicable diseases incl. COVID-19	Likely	Moderate	Medium	Short Term
12	Vegetation and Wildlife Loss	Unlikely	Moderate	Low	No residual Impact
13	Historical/Archaeological Sites	Unlikely	Moderate	Low	No residual Impact
14	Construction of Administration Building and Other Infrastructure	Likely	Moderate	Medium	Short Term
15	Sexual Abuse, Exploitation and Harrassment (SEAH)	Unlikely	Moderate	Low	No residual Impact

 Critical Risk Level

 Significant Risk Level

 Medium Risk Level

 Low Risk Level

Table ES-3: Screening of Possible Impacts during Operation Phase

S/No.	Potential Issues	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact (Short Term, Long Term)
1	Generation of Leachate	Likely	Major	Medium	Long Term
2	Possible Contamination of Soil and Groundwater	Likely	Major	Significant	Long Term
3	Generation of Landfill Gas	Likely	Major	Medium	Long Term
4	Generation of objectionable Odor and impact on air quality	Likely	Major	Medium	Long Term
5	Attraction of Vermin and disease vector generation	Likely	Major	Medium	Long Term
6	Occupational Health and Safety	Likely	Major	Medium	Long Term
7	Waste Collection and Hauling Impacts	Likely	Major	Medium	Long Term
8	Wind Blown Litter	Likely	Major	Medium	Long Term
9	Impacts on Scavengers and Waste Pickers	Likely	Major	Medium	Long Term
10	Improved management of solid waste & health and sanitation	Positive impacts expected			Long Term Positive Impact
11	Improvements in Public Health	Positive impacts expected			Long Term Positive Impact
12	Improvements in Aesthetic Impacts	Positive impacts expected			Long Term Positive Impact

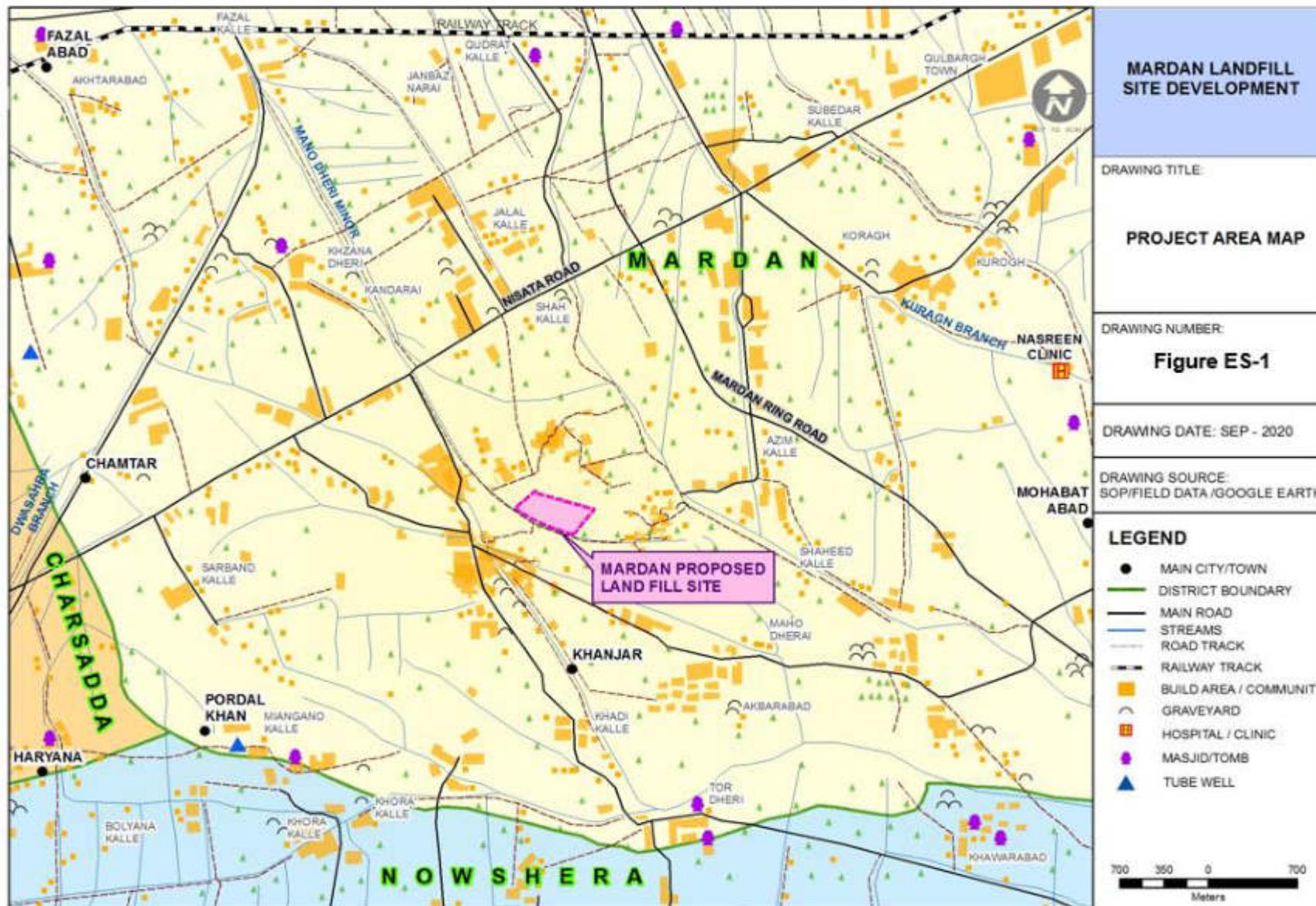
■ Critical Risk Level

■ Significant Risk Level

■ Medium Risk Level

■ Low Risk Level

■ Positive Impacts



1 Introduction

1.1 Overview

1. The Khyber Pakhtunkhwa Cities Improvement Projects (KPCIP) will improve the quality of life of the residents of five KP cities, including Abbottabad, Kohat, Mardan, Mingora, and Peshawar, directly benefitting about 6 million of urban population. KPCIP will help selected cities improve their access to quality urban services through three interlinked outputs: (i) Climate resilient and gender friendly urban infrastructure improve, (ii) Institutional capacities of urban service providers and governments strengthened, and (iii) Increased women's participation in urban governance and access to economic opportunities.
2. KPCIP will support the Government of Pakistan's development priorities, established in (i) the National Water Policy (2018), (ii) the Local Government Act (2019), and (iii) Pakistan Vision 2025. The project is also aligned with ADB's operational priorities of (i) addressing remaining poverty and reducing inequalities; (ii) accelerating progress in gender equality; (iii) tracking climate change, building climate and disaster readiness; (iv) making cities more livable; and (v) strengthening governance and institutional capacity, outlined in ADB's Strategy 2030, and is included in ADB's country operations business plan for Pakistan, 2021–2023.
3. The project readiness financing (approved in March 2019) has financed the preparation and engineering design of the KPCIP. The Department of Local Government, Elections and Rural Development Department (LGE&RDD), the Government of Khyber Pakhtunkhwa, will be the executing agency for the project and the city governments of the five target cities, including the respective Water and Sanitation Services Companies, will be the implementing agencies.
4. This report has been prepared based on detailed engineering designs, due diligence assessments, and studies conducted by the government and project readiness financing consultants. The Government of Pakistan, Asian Development Bank (ADB), and Asia Infrastructure Investment Bank (AIIB) are expected to approve KPCIP in Q3 2021.
5. The Khyber Pakhtunkhwa Cities Improvement Project (KPCIP) is being processed under the Project Readiness Finance (PRF) modality of the Asian Development Bank (ADB) under Loan 6016-PAK, being executed by KP LGE&RDD. The Project is focused on investments of subprojects related to water supply, sanitation and drainage, solid waste management, and urban/green spaces. The Project has following four major components:
 - Improvement of water supply systems in five cities.
 - Improvement of sewerage and drainage systems in five cities, including provision of sewage treatment plants (STPs)
 - Provision of Integrated Solid Waste Management (ISWM) System in five cities
 - Development of Urban/Green Spaces in all five cities.
6. The estimated waste generation for Mardan city in Khyber Pakhtunkhawa (KP) province of Pakistan is around 191 tons per day in year 2021, assuming waste generation rate of 0.33 kg/cap/day for all waste streams i.e. residential, commercial

and bulk waste. An additional allowance of waste i.e. 25% is accounted for in the above tonnage, which is bulk waste.

7. The current practice of material recovery and recycling often leads to additional littering in streets when rag pickers are rummaging the waste bags and bins. A denial to rag pickers in the streets forces them to collect recyclables from containers and open dumpsites sites as well. This practice leads to even higher health threats and environmental pollution. The development of a properly engineered and designed solid waste management facility (SWMF) will ensure that the solid waste generated from Mardan city is managed in accordance with international good practices on solid waste management.
8. This Environmental Impact Assessment (EIA) document focuses solely on the scope of works of the development of the SWMF and assesses any potentially significant impacts and proposes required mitigation measures, which shall be implemented by the Contractor and monitored by the Project Management Unit (PMU), KP Local Government, Elections and Rural Development Department (LGE&RDD) and ADB using the Environmental Management Plan (EMP).

1.2 Project Location

9. The proposed SWMF is located about 3 km away from Mardan Ring Road, about 6.9 km from Haryana via Nisata Road, about 9.9 km from Sheikh Maltoon Town via Mardan Ring Road and approximately 10.7 km from the city center.
10. The total area of the landfill is 27 acres. The site has silty soils strata with no rock formation, and mainly comprises of unconsolidated surficial deposits of silts, sands and gravel. The area has a boundary wall constructed around it several years ago and no agricultural activity is taking place on the site. The access road to the landfill from main road is in good condition, which can be used for waste carrying vehicles.
11. The key map and the project area map for the proposed SWMF are provided as **Figures 1.1 and 1.2** respectively.

1.3 Environmental Category of Project

12. According to ADB's Safeguard Policy Statement (SPS) 2009, a Rapid Environmental Assessment (REA) Checklist was prepared for the proposed SWMF works (**Annexure A**). The Pakistan Environmental Protection Agency's "Guidelines for the Preparation and Review of Environmental Reports (2000)" were also consulted. As per guidelines, the proposed project is falling in Schedule II (G) and requires an EIA to be prepared and submitted to KP EPA for review and necessary approval.
13. Based on the initial findings, it was ascertained that certain adverse environmental impacts are expected due to development of the proposed SWMF, and thus the subject project is considered environmentally "A" category as per ADB SPS, 2009. Therefore, an EIA has been conducted.

1.4 Objectives of the EIA Study

14. Following are the objectives of this EIA study:
 - Assess the existing environmental conditions of Mardan SWMF area, including the identification of environmental sensitive receptors and develop a baseline of its prevalent environmental and socioeconomic conditions;

- Identify and investigate all impacts of the proposed SWMF pre-construction/design, construction, operation, closure and post closure on the physical, biological and socioeconomic environment of the project area;
- To propose mitigation measures that would help KP LGE&RDD and WSSM in conducting the proposed project activities in an environmentally sustainable manner;
- To uncover the planning and operational phase impacts up to microenvironment levels in which project is proposed to be sited; and
- To develop an Environmental Management Plan (EMP) that would assist KP LGE&RDD and WSSM in the effective implementation of the recommendations of the EIA.

1.5 EIA Team

15. The EIA study team comprised of following experts.

- Environment Specialists by ADB, PMU KP LGE&RDD and EDCM
- Environmental associate
- SWM expert
- IWMS design experts
- Integrated Environmental Laboratory
- Climate change expert
- Social Safeguard Expert
- Social safeguard team of EDCM
- Gender Expert
- ADB and PMU technical team

1.6 Methodology of EIA Study

16. The following methodology was employed for this EIA study:

1.6.1 Understanding of the Proposed Operation

17. This involved collecting information from the ADB, PMU KP LGE&RDD and Engineering Design and Construction Management technical team on the proposed project activities and understanding the activities to identify potential impacts of implementing them.

1.6.2 Review of Legislation and Guidelines

18. National legislation, international agreements, environmental guidelines both of KP EPA, and ADB, and best industry practices have been reviewed to set environmental standards that KP LGREDD as the Implementing Agency will adhere to during implementation of the project.

1.6.3 Secondary Data Collection

19. Available published and unpublished information pertaining to the background environment has been obtained and reviewed. All data sources have been carefully reviewed to collect the following information:

- **Physical environment** – topography, geology, seismology, geomorphology, soils, surface and groundwater resources and climate;

- **Biological environment** – habitat types, flora and fauna (particularly rare or endangered species), critical habitats, vegetation and communities within the area;
- **Physical cultural resources** – sites, structures, groups of structures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance; and,
- **Socio-economic environment** – settlements, socio-economic conditions, infrastructure and land use.

1.6.4 Field Data Collection (Baseline Survey)

20. Field visits were undertaken consisting of preliminary scoping through survey and assessment activities to establish the potential impacts and categorization of activities and the Rapid Environmental Assessment (REA) Checklist was completed. The key receptors and stakeholders within the project area were identified.
21. Baseline surveys required to identify and establish physical and biological conditions and ecosystems in the project area has been carried out by EIA team and results has been incorporated in this report. The socio-economic environment in the project areas has been obtained through the socio-economic profiles and social impact assessment carried out by social safeguard team. Climate risk and vulnerability assessment findings have also been presented and discussed.
22. Primary data collection in a two kilometre area of influence, such as ambient noise levels, ambient air quality and ground water quality at the key receptor locations in the project area and particularly in close proximity to the project site was conducted.
23. Review of secondary information on the physical, biological and ecological aspects, physical cultural resources and infrastructure utilities in the Mardan SWMF area was conducted.

1.6.5 Public Consultations

24. Public consultations (PC) were carried out with all key stakeholders, particularly local communities residing in the project area, local businesses and government and local government bodies in line with ADB's "Safeguard Policy Statement (SPS) – June 2009"/ Environmental Assessment Guidelines. Under ADB requirements, the environmental assessment process must also include meaningful public consultations during the completion of the study. In this EIA study, the public consultation process was carried out including verbal disclosure regarding the project development with stakeholders to brief them about project and to seek their response/recommendation.

1.6.6 Impacts Identification and Assessment

25. Potential impacts arising from each phase of the proposed project have been identified and assessed on the basis of field data, secondary data, expert opinions and examining previous similar projects in Pakistan. These include effects on physical, biological and socio-economic environment.

1.6.7 Recommendations for Mitigation Measures

26. Mitigation measures to minimize, eliminate or compensate the potential environmental impacts has been recommended. The mitigation measures has been recommended

on the basis of past experiences, best industry practices, legislative requirements and professional judgement.

1.6.8 Development of Environmental Management Plan (EMP)

27. An Environmental Management Plan (EMP) has been developed for effective implementation of the recommended mitigation measures. The EMP includes controls to minimize the identified impacts and monitoring program to monitor effect of mitigation measures implemented and residual impacts, if any, during implementation. The EMP has identified roles and responsibilities of all concerned parties during the implementation of the project.

1.7 Proponent of Project

28. The LGE&RDD, GoKP is the Executing Agency (EA) for this SWMF development while the project will be implemented through WSSM with support from PMU.
29. Contact details of the EA are provided as **Table 1.1** below.

Table 1.1: Executing Agency Contact Details

Executing Agency Details	Information
Name of EA	Project Management Unit (PMU), Local Government, Elections and Rural Development Department (LGE&RDD), GoKP
Address	Ground Floor, Afzal Apartments, Jamrud Road, Phase-3 Chowk, Hyatabad, Peshawar
Telephone	0092-91-5854555
E-mail	pdkpcip@gmail.com , info@kpcip.gov.pk
Web	Kpcip.gov.pk

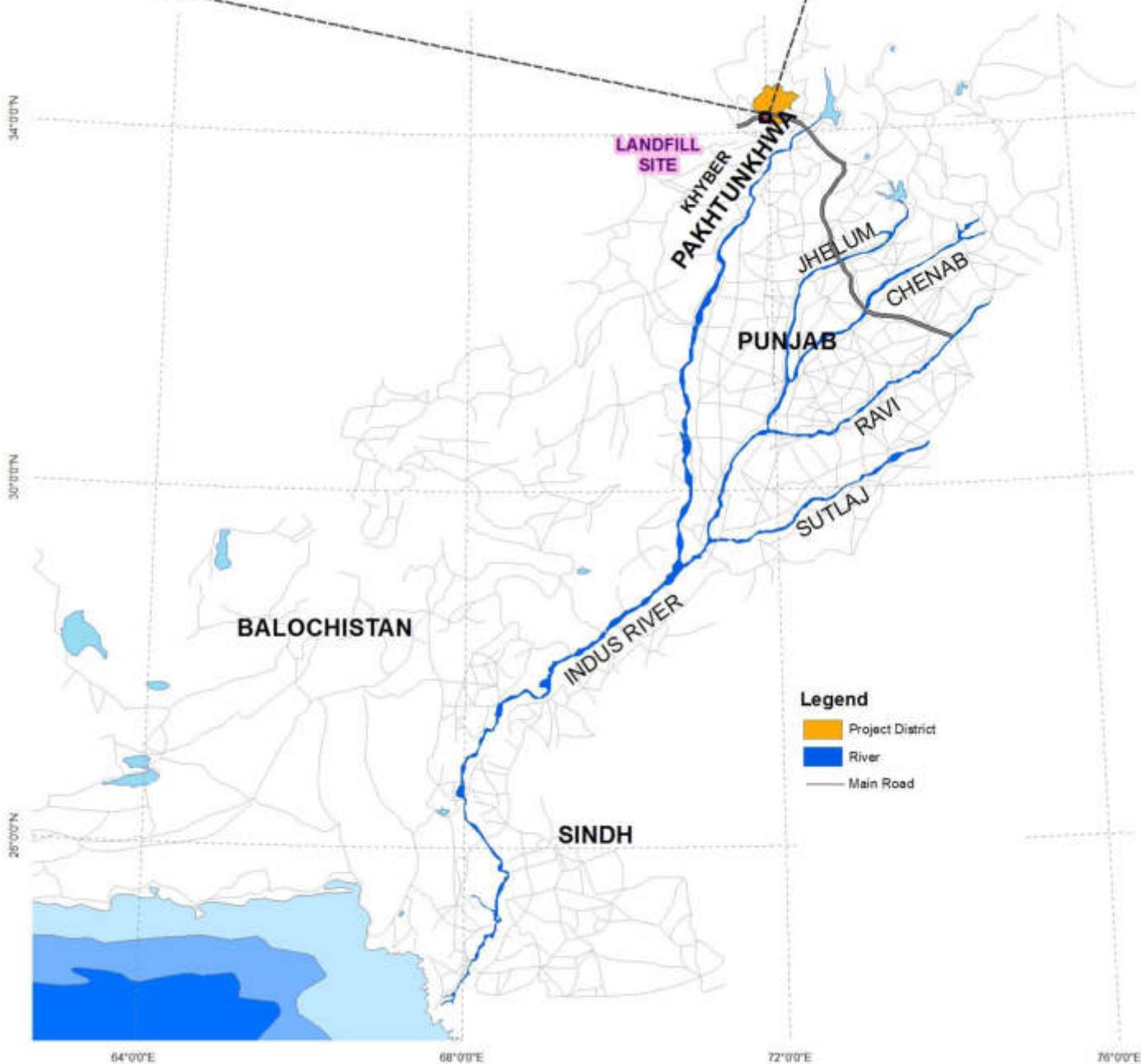
1.8 Structure of the Report

30. The EIA report contains eleven chapters as follows:

- Introduction
- Policy and Legal Framework
- Description of the Project
- Description of Environment
- Analysis of Alternatives
- Assessment of Environmental Impacts and Mitigation Measures
- Institutional Requirements Environmental Management Plan
- Public Consultation
- Grievance Redressal Mechanism
- Findings, Recommendations and Conclusions
- References

1.9 Further Additions & Updating of EIA Study

31. This version of the report will be further updated once the detailed design is completed and any other details of the proposed SWMF become available over the coming weeks and months. These revisions shall be incorporated into any subsequent updated versions of this EIA report.





2 Policy and Legal Framework

2.1 General

32. This section provides an overview of the policy framework and national legislation that applies to the proposed SWMF development in the outskirts of Mardan city, Pakistan. The project will comply with all national legislation relating to the environment in Pakistan and will obtain all the regulatory clearances required from the financing agency, ADB.

2.2 National Policy and Legal Framework

33. The Pakistan National Conservation Strategy (NCS) that was approved by the federal cabinet in March 1992 is the principal policy document on environmental issues in the country (EUAD/IUCN, 1992). The NCS outlines the country's primary approach towards encouraging sustainable development, conserving natural resources, and improving efficiency in the use and management of resources. The NCS has 68 specific programs in 14 core areas in which policy intervention is considered crucial for the preservation of Pakistan's natural and physical environment. The core areas that are relevant in the context of the proposed landfill development are pollution prevention and abatement and increasing energy efficiency while conserving biodiversity.
34. Prior to the adoption of the 18th Constitutional Amendment, the Pakistan Environmental Protection Act (PEPA) 1997 was the governing law for environmental conservation in the country. Under PEPA 1997, the Pakistan Environmental Protection Council (PEPC) and Pak EPA were primarily responsible for administering PEPA 1997. Post the adoption of the 18th Constitutional Amendment in 2011, the subject of environment was devolved, and the provinces have been empowered for environmental protection and conservation.

2.3 Regulations for Environmental Assessment, Pakistan EPA

35. Under Section 12 (and subsequent amendment) of the PEPA (1997), a project falling under any category specified in Schedule I of the IEE/EIA Regulations (SRO 339 (I0/2000), requires the proponent of the project to file an IEE with the concerned provincial EPA. Projects falling under any category specified in Schedule II require the proponent to file an EIA with the provincial agency, which is responsible for its review and accordance of approval or request any additional information deemed necessary.

2.4 Regulatory Clearances, KP EPA

36. In accordance with provincial regulatory requirements, an IEE/EIA satisfying the requirements of the KP Environmental Protection Act (2014) is to be submitted to KP environmental protection agency (KP-EPA) for review and approval, and subsequent issuance of NOC before the commencement of construction.
37. As per guidelines project is falling in Schedule II (G) of IEE/EIA regulation, 2000 and requires that an EIA shall be prepared and submitted to KP EPA for review and necessary approval.

2.5 Guidelines for Environmental Assessment, Pakistan EPA

38. The Pak-EPA has published a set of environmental guidelines for conducting environmental assessments and the environmental management of different types of

development projects. The guidelines that are relevant to the proposed sub-project are listed below:

- Guidelines for the Preparation and Review of Environmental Reports, Pakistan, EPA1997;
- Guidelines for Public Consultations; Pakistan EPA May 1997;

2.6 National Environmental Quality Standards (NEQS) 2000 & 2010

39. The National Environmental Quality Standards (NEQS), 2000 & 2010, specify the following standards:

- Maximum allowable concentration of pollutants (32 parameters) in municipal and liquid industrial effluents discharged to inland waters, sewage treatment facilities, and the sea (three separate sets of numbers);
- Maximum allowable concentration of pollutants (16 parameters) in gaseous emissions from industrial sources;
- Maximum allowable concentration of pollutants (two parameters) in gaseous emissions from vehicle exhaust and noise emission from vehicles;
- Maximum allowable noise levels from vehicles;
- Maximum allowable concentration of parameters in drinking water.

40. NEQS are provided as **Annexure L** of this EIA report.

2.7 Other Environment Related Legislations

41. The national laws and regulations are provided in **Table 2.1** below.

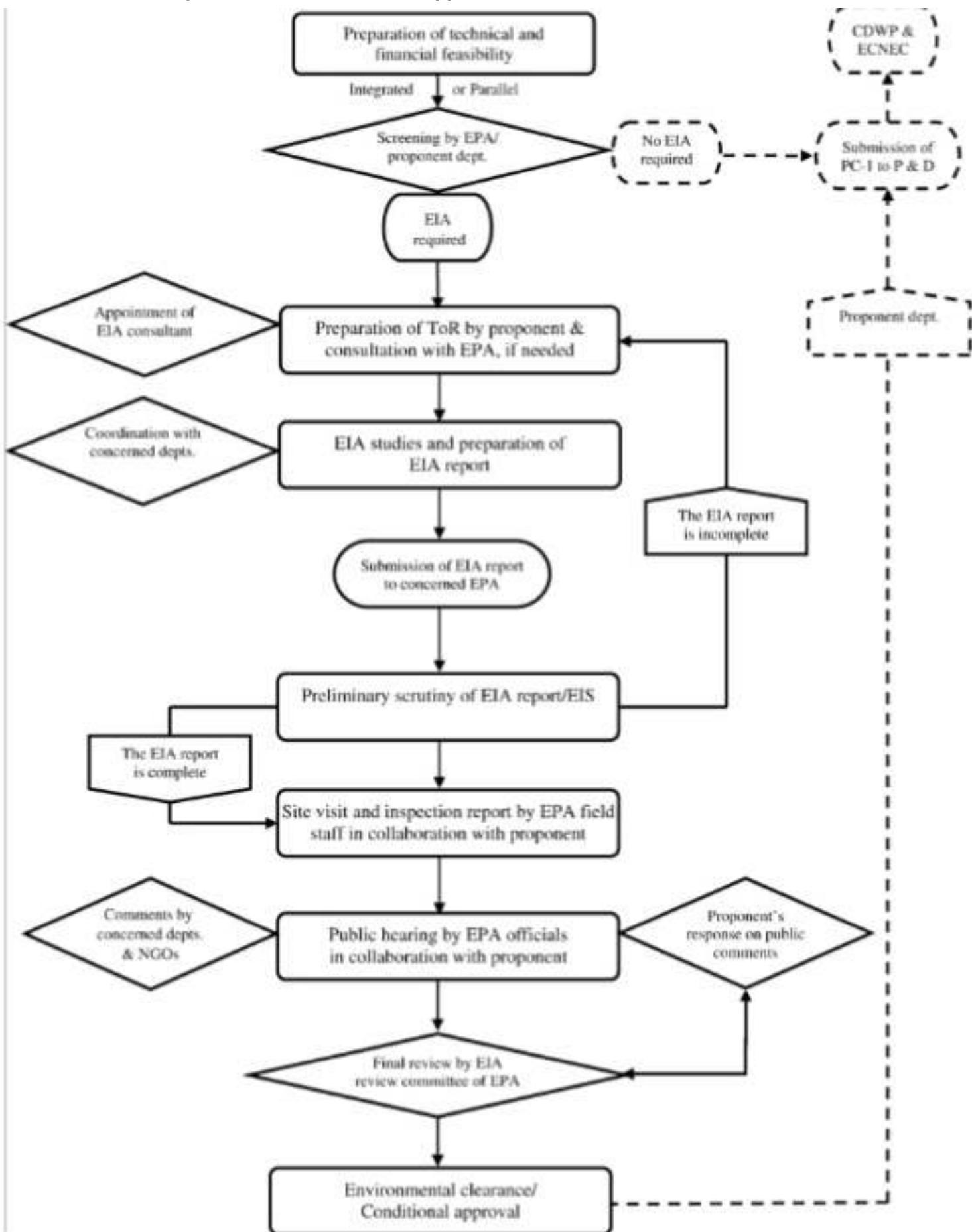
Table 2.1: Environmental Guidelines and Regulations

Legislation/Guideline	Description
National Environmental Policy (2005) (NEP)	NEP is the primary policy of Government of Pakistan addressing environmental issues. The broad Goal of NEP is, "to protect, conserve and restore Pakistan's environment in order to improve the quality of life of the citizens through sustainable development". The NEP identifies a set of sectoral and cross-sectoral guidelines to achieve its goal of sustainable development. It also suggests various policy instruments to overcome the environmental problems throughout the country.
The Forest Act (1927)	The Act empowers the provincial forest departments to declare any forest area as reserved or protected. It empowers the provincial forest departments to prohibit the clearing of forest for cultivation, grazing, hunting, removing forest produce, quarrying and felling, lopping and topping of trees, branches in reserved and protected forests. No protected forest is situated in the project area for the development of the SWMF.
Khyber Pakhtunkhwa Wildlife and Biodiversity Act, 2015	It empowers the government to declare certain areas reserved for the protection of wildlife and control activities within these areas. It also provides protection to endangered species of wildlife. As no activities

Legislation/Guideline	Description
	are planned in these areas, no provision of this law is applicable to the proposed project.
The KP Antiquities Act (2016)	It ensures the protection, preservation, development and maintenance of antiquities in the province of KP. The Act defines "antiquities" as ancient products of human activity, historical sites, or sites of anthropological or cultural interest, national monuments, etc. The Act is designed to protect these antiquities from destruction, theft, negligence, unlawful excavation, trade, and export. The law prohibits new construction in the proximity of a protected antiquity and empowers the GoKP to prohibit excavation in any area that may contain articles of archaeological significance. Under the Act, the subproject proponents are obligated to ensure that no activity is undertaken in the proximity of a protected antiquity, report to the Department of Archaeology, GoKP, any archaeological discovery made during the course of the project.
Pakistan Penal Code (1860)	It authorizes fines, imprisonment or both for voluntary corruption or fouling of public springs or reservoirs so as to make them less fit for ordinary use.
NATIONAL ENVIRONMENTAL AND CONSERVATION STRATEGIES	
National Conservation Strategy	Before the approval of NEP, the National Conservation Strategy (NCS) was considered as the Government's primary policy document on national environmental issues. At the moment, this strategy just exists as a national conservation program. The NCS identifies 14 core areas including conservation of biodiversity, pollution prevention and abatement, soil and water conservation and preservation of cultural heritage and recommends immediate attention to these core areas.
Biodiversity Action Plan	The plan recognizes IEE/EIA as an effective tool for identifying and assessing the effects of a proposed operation on biodiversity.
INTERNATIONAL CONVENTIONS	
The Convention on Conservation of Migratory Species of Wild Animals (1981.21)	The Convention requires countries to take action to avoid endangering migratory species. The term "migratory species" refers to the species of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries. The parties are also required to promote or cooperate with other countries in matters of research on migratory species. There are no endangered species of plant life or animal life in the vicinity of the proposed project areas for the landfill works.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973)	The convention requires Pakistan to impose strict regulation (including penalization, confiscation of the specimen) regarding trade of all species threatened with extinction or that may become so, in order not to endanger their survival further.
International Union for Conservation of Nature and Natural Resources Red List (2000)	Lists wildlife species experiencing various levels of threats internationally. Some of the species indicated in the IUCN red list are also present in the wetlands of Pakistan.

2.8 Implications of national policies and regulations on proposed project

42. The Pak-EPA formulated regulations in 2000 for 'Review of IEE and EIA' which categorise development projects under three schedules-Schedules I, II and III. Projects are classified on the basis of expected degree and magnitude of environmental impacts and the level of environmental assessment required is determined from the schedule under which the project is categorised.
43. The projects listed in Schedule-I include those where the range of environmental issues is comparatively narrow and the issues can be understood and managed through less extensive analysis. Schedule-I projects require an IEE to be conducted, rather than a full-fledged EIA, provided that the project is not located in an environmentally sensitive area.
44. The projects listed in Schedule-II are generally major projects and have the potential to affect a large number of people in addition to significant adverse environmental impacts. The impacts of projects included in Schedule-II may be irreversible and could lead to significant changes in land use and the social, physical and biological environments. The proposed SWMF development project has been categorized as Schedule II (G) and requires an EIA.
45. The LGE&RDD, GoKPK, being the Executing Agency for the Project is responsible for management of project impacts, and have to undertake the commitments and mitigation measures proposed in this environmental report and in the subsequent review and approval conditions.
46. According to the regulations, no construction, preliminary or otherwise, relating to the project shall be undertaken until and unless approval of the EIA report has been issued by the KP EPA.
47. The LGE&RDD will submit the EIA Report on a prescribed application along with the processing fee to KP EPA. After submission of the EIA report, a thirty (30) day period for public comments will be provided. The assessment will be completed within a period of one hundred and twenty (120) days from receipt of the complete documents, and earlier than this wherever practicable. Following the completion of public hearing, if required, and the provision of any further data from the proponent, the decision shall be made and conveyed after thirty days thereafter.
48. The EIA approval process as per environmental legislation applicable in Pakistan is summarized in **Figure 2.1** below.

Figure 2-1: EIA Review and Approval Process of Pakistan EPAs

2.9 ADB's Safeguard Policy Statement (SPS), 2009

49. The ADB's SPS 2009 requires that environmental considerations be incorporated into ADB funded projects to ensure that the project will have minimal environmental impacts and be environmentally sound. Occupational health & safety of the local population should also be addressed as well as the project workers as stated in SPS. A Grievance Redress Mechanism (GRM) to receive application and facilitate resolution of affected peoples' concerns, complaints, and grievances about the project's environmental performance is also established.
50. All loans and investments are subject to categorization to determine environmental assessment requirements. Categorization is to be undertaken using Rapid Environmental Assessment (REA) checklists, consisting of questions relating to (i) the sensitivity and vulnerability of environmental resources in project area, and (ii) the potential for the project to cause significant adverse environmental impacts. Projects are classified into one of the following environmental categories:
51. **Category A:** A proposed project is classified as category A if it is likely to have significant adverse environmental impacts that are irreversible, diverse or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works. An environmental impact assessment (EIA) is required.
52. **Category B:** A proposed project is classified as category B if its potential adverse environmental impacts are less adverse than those of category A projects. These impacts are site-specific, few if any of them are irreversible, and in most cases mitigation measures can be designed more readily than for category A projects. An initial environmental examination (IEE) is required.
53. **Category C:** A proposed project is classified as category C if it is likely to have minimal or no adverse environmental impacts. No environmental assessment is required although environmental implications need to be reviewed.
54. **Category FI:** A proposed project is classified as category FI if it involves investment of ADB funds to or through a financial intermediary (FI).

2.10 ADB's Access to Information Policy (AIP) 2018

55. ADB's new Access to Information Policy (AIP), reflects the ADB's ongoing commitment to transparency, accountability, and participation by stakeholders. The policy contains principles and exceptions to information sharing with external stakeholders, led by a new overarching principle of "clear, timely, and appropriate disclosure."

2.11 ADB's Accountability Mechanism Policy 2012

56. The objectives of the Accountability Mechanism is providing an independent and effective forum for people adversely affected by ADB-assisted projects to voice their concerns and seek solutions to their problems, and to request compliance review of the alleged noncompliance by ADB with its operational policies and procedures that may have caused, or is likely to cause, them direct and material harm. The Accountability Mechanism is a "last resort" mechanism.

2.12 Implications of ADB's safeguard policies on proposed project

57. The objectives of ADB's safeguards are to:

- avoid adverse impacts of projects on the environment and affected people, where possible;
 - minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible; and
 - help borrowers/clients to strengthen their safeguard systems.
58. ADB's SPS sets out the policy objectives, scope and triggers, and principles for three key safeguard areas:
- environmental safeguards,
 - involuntary resettlement safeguards, and
 - Indigenous Peoples safeguards.
59. The objective of the environmental safeguards is to ensure the environmental soundness and sustainability of projects and to support the integration of environmental considerations into the project decision-making process. ADB's policy principles are summarized in **Table 2.2** below.

Table 2.2: ADB Policy Principles

No.	Policy principle	Summary
1	Screening and categorization	Screening process initiated early to determine the appropriate extent and type of environmental assessment.
2	Environmental assessment	Conduct an environmental assessment to identify potential impacts and risks in the context of the project's area of influence.
3	Alternatives	Examine alternatives to the project's location, design, technology, and components and their potential environmental and social impacts, including no project alternative.
4	Impact mitigation	Avoid, and where avoidance is not possible, minimize, mitigate, and/or offset adverse impacts and enhance positive impacts. Prepare an environmental management plan (EMP).
5	Public consultations	Carry out meaningful consultation with affected people and facilitate their informed participation. Involve stakeholders early in the project preparation process and ensure that their views and concerns are made known to and understood by decision makers and taken into account. Continue consultations with stakeholders throughout project implementation. Establish a grievance redress mechanism.
6	Disclosure of environmental assessment	Disclose a draft environmental assessment in a timely manner, in an accessible place and in a form and language(s) understandable to stakeholders. Disclose the final environmental assessment to stakeholders.

No.	Policy principle	Summary
7	Environmental management plan	Implement the EMP and monitor its effectiveness. Document monitoring results and disclose monitoring reports.
8	Biodiversity	Do not implement project activities in areas of critical habitats.
9	Pollution prevention	Apply pollution prevention and control technologies and practices consistent with international good practices. Adopt cleaner production processes and good energy efficiency practices. Avoid pollution, or, when avoidance is not possible, minimize or control the intensity or load of pollutant emissions and discharges. Avoid the use of hazardous materials subject to international bans or phaseouts.
10	Occupational health and safety/Community safety.	Provide workers with safe and healthy working conditions and prevent accidents, injuries, and disease. Establish preventive and emergency preparedness and response measures to avoid, and where avoidance is not possible, to minimize, adverse impacts and risks to the health and safety of local communities
11	Physical cultural resources	Conserve physical cultural resources and avoid destroying or damaging them. Provide for the use of "chance find" procedures.

60. The basic environmental assessment requirements for Category 'A' projects are provided in **Table 2.3** below.

Table 2.3: ADB Environmental Assessment Requirements for Category 'A' projects

Aspect	Environmental Assessment & Management Requirements
Project processing	
Reporting	<ul style="list-style-type: none"> ▪ Prepare full-scale environmental impact assessment (EIA)
Public consultations	<ul style="list-style-type: none"> ▪ Conduct consultations at the early stage of EIA field work and when the draft EIA report is available during project preparation, and before project appraisal by ADB.
Disclosure of environmental assessment report	<ul style="list-style-type: none"> ▪ Disclose draft environmental impact assessment reports at least 120 days before Board consideration.
Project implementation	
Reporting	<ul style="list-style-type: none"> ▪ Submit semiannual reports during project construction, and annual reports during project operation to ADB for disclosure.

2.13 IFC Sector Specific Guidelines on Solid Waste Management¹

61. The IFC guidelines provide guidance with regards to development and operation of SWM sites. In terms of site selection of the landfill site, these guidelines require the location of the landfill to take into account potential impacts associated with releases of polluting substances, including the following:
- Proximity to residential, recreation, agricultural, natural protected areas, or wildlife habitat and areas prone to scavenging wildlife, as well as other potentially incompatible land uses:
 - Residential development should be typically further than 250 meters from the perimeter of the proposed landfill cell development to minimize the potential for migration of underground gaseous emissions;
 - Visual impacts should be minimized by evaluating locational alternatives;
 - Siting should be further than 3 km of a turbojet airport and 1.6 km of a piston-type airport or as permitted by the aviation authority fully considering potential threats to air safety due to attraction and presence of birds;
 - Proximity and use of groundwater and surface water resources:
 - Private or public drinking, irrigation, or livestock water supply wells located downgradient of the landfill boundaries should be further than 500 meters from the site perimeter, unless alternative water supply sources are readily and economically available and their development is acceptable to regulatory authorities and local communities;
 - Areas within the landfill boundaries should be located outside of the 10-year groundwater recharge area for existing or pending water supply development;
 - Perennial stream should not be located within 300 meters downgradient of the proposed landfill cell development, unless diversion, culverting or channeling is economically and environmentally feasible to protect the stream from potential contamination;
 - Site geology and hydrogeology:
 - Landfills should be located in gently sloped topography, amenable to development using the cell (bund) method, with slopes which minimize the need for earthmoving to obtain the correct leachate drainage slope of about 2%;
 - Groundwater's seasonally high table level (i.e. 10 year high) should be at least 1.5 meters below the proposed base of any excavation or site preparation to enable landfill cell development;
 - Suitable soil cover material should be available on-site to meet the needs for intermediate (minimum of 30 cm depth) and final cover (minimum of 60 cm depth), as well as bund construction (for the cell method of landfill operation).

¹ <https://www.ifc.org/wps/wcm/connect/5b05bf0e-1726-42b1-b7c9-33c7b46ddda8/Final%2B-%2BWaste%2BManagement%2BFacilities.pdf?MOD=AJPERES&CVID=jqeDbH3>

Preferably, the site would have adequate soil to also meet required cover needs (usually a minimum of 15 cm depth of soil)²

- Potential threats to landfill site integrity from natural hazards such as floods, landslides, and earthquakes:
 - Landfills should be sited outside of a floodplain subject to 10-year floods and, if within areas subject to a 100- year flood, amenable to an economic design which would eliminate the potential for washout;
 - There should be no significant seismic risk within the region of the landfill which could cause destruction of berms, drains or other civil works, or require unnecessarily costly engineering measures; otherwise, side slopes should be adjusted accordingly to prevent failure in the event of seismic activity;
 - No fault lines or significantly fractured geologic structure should be present within 500 meters of the perimeter of the proposed landfill cell development which would allow unpredictable movement of gas or leachate;
 - There should be no underlying limestone, carbonate, fissured or other porous rock formations which would be incompetent as barriers to leachate and gas migration, where the formations are more than 1.5 meter in thickness and present as the uppermost geologic unit above sensitive groundwaters.
62. All the guidelines mentioned above with regards to site selection for the landfill site have been taken into consideration during finalization of the site for the landfill development.
63. The IFC guidelines also provide guidance on the operational aspects of landfill sites, such as measures to prevent, minimize and control leachate generation, groundwater and leachate monitoring, measures for controlling of landfill gas emissions, controlling of dust and odor emissions from landfill site, measures for controlling dispersal of litter along with closure and post closure activities.

2.14 Comparison of International and Local Environmental Legislations

- 64. The ADB SPS requires application of pollution prevention and control technologies and practices consistent with international good practice, as reflected in internationally recognized standards. The SPS states that when host country regulations differ from these standards, the EA will achieve whichever is more stringent.
- 65. In order to select the most stringent standards applicable, a mix of local (NEQS) and international (IFC) regulations have been selected. The IFC Environmental, Health, and Safety (EHS) Guidelines, General EHS Guidelines and Environmental standards are also applicable. It shall be ensured that all necessary noise mitigation measures are implemented to minimize the noise levels in the project area.
- 66. The **Table 2.4** presents IFC workplace noise standards that are applicable to the construction workers. It should also be noted that IFC EHS guidelines advise that where existing ambient noise levels already exceed thresholds, the project should not

² Daily cover needs can be alternatively met by using removable tarps, other relatively inert materials (i.e., compost residuals), or by removing the previously laid daily soil cover at the start of each day for reuse at the end of the same day.

result in an increase of more than 3 dB over existing ambient noise levels at the nearest receptor location off-site.

67. A comparison of applicable local and international guidelines for ambient air quality has been provided in **Table 2.5** below. In the case of most pollutants, the Pak NEQS standards for ambient air quality are more stringent in comparison to USEPA and WHO/IFC standards. The applicable and most stringent parameters for each respective pollutant are highlighted in green.
68. Similar to the standards for air quality, the comparison of noise standards provided in **Table 2.6** clearly shows that the Pakistan NEQS standards for noise are more stringent in comparison to the IFC standards. The only exception is the daytime noise level standard for Industrial areas where the IFC standard is more stringent (70 dB(A)) in comparison to NEQS (75 dB(A)) and so for this particular parameter, the IFC standard will be used. Apart from this one exception, the NEQS standards have been used for the proposed landfill development project.
69. Comparison of international and local water quality standards is provided as **Table 2.7**.
70. As far as regulations regarding other environmental parameters are concerned such as acceptable effluent disposal parameters, the local regulations i.e. NEQS take precedence over any other international regulations such as IFC.

Table 2.4: IFC Work Environment Noise limits

Type of Work, workplace	IFC General EHS Guidelines	
Heavy Industry (no demand for oral communication)	85 Equivalent level L _{eq,8h}	
Light industry (decreasing demand for oral communication)	50-65 Equivalent level L _{eq,8h}	

Table 2.5: Comparison of International and local Air Quality Standards*

Pollutants	USEPA		WHO/IFC		Pak. NEQS	
	Avg. Time	Standard	Avg. Time	Standard	Avg. Time	Standard
SO ₂	3 hrs 1 hr	0.5 ppm 75 ppb	24 hr 10 min	20 ug/m ³ 500 ug/m ³	Annual Mean 24 hrs	80 ug/m ³ 120 ug/m ³
CO	8 hrs 1 hr	9 ppm (11 mg/m ³) 35 ppm (43 mg/m ³)	-	-	8 hrs 1 hr	5 mg/m ³ 10 mg/m ³
NO ₂	Annual Mean 1 hr	100 ug/m ³ (53 ppb) 100 ppb	1 yr 1 hr	40 ug/m ³ 200 ug/m ³	Annual Mean 24 hrs	40 ug/m ³ 80 ug/m ³
O ₃	8 hrs	0.07ppm (148 ug/m ³)	8 hrs	100 ug/m ³	1 hr	130 ug/m ³
TSP	-	-	-	-	Annual Mean 24 hrs	360 ug/m ³ 500 ug/m ³
PM ₁₀	24 hrs	150 ug/m ³	1 yr 24 hr	20 ug/m ³ 50 ug/m ³	Annual Mean 24 hrs	120 ug/m ³ 150 ug/m ³
PM _{2.5}	Annual Mean 24 hrs	15 ug/m ³ 35 ug/m ³	1 yr 24 hr	10 ug/m ³ 25 ug/m ³	Annual Average 24 hrs 1 hr	15 ug/m ³ 35 ug/m ³ 15 ug/m ³

*: The standards highlighted in green for each respective pollutant are the most stringent based on a comparison between local and international regulations and thus shall be applicable for the proposed project.

* In instances where the airshed is significantly degraded and the pollutant levels are already exceeding the ambient pollutant concentrations provided in the table above, it shall be ensured that the project activities cause as small an increase in pollution levels as feasible, and amounts to a fraction of the applicable short term and annual average air quality guidelines or standards as established in the project specific environmental assessment.

Table 2.6: Comparison of International and Local Noise Standards

Category of Area/Zone	Limit in dB(A) Leq			
	NEQS		WHO/IFC	
	Day Time 06:00 – 22:00	Night Time 22:00-06:00	Day Time 07:00 – 22:00	Night Time 22:00-07:00
Residential area (A)	55	45	55	45
Commercial area (B)	65	55	70	70
Industrial area (C)	75	65	70	70
Silence zone (D)	50	45	55	45

*: The standards highlighted in green for each respective Area/Zone are the most stringent based on a comparison between local and international regulations and thus shall be applicable for the proposed project.

* In instances where baseline noise levels are already exceeding the standards above, it will need to be ensured that the project activities do not cause an increment of more than 3 dB(A) from the baseline noise levels.

Table 2.7: Comparison of International and Local Water Quality Standards

Parameter	Unit	NEQS	WHO/IFC
Bacterial			
E-Coli	numbers/ml	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample
Total Coliform	numbers/ml	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample
Physical			
Color	TCU	≤ 15 TCU	-
Taste	No objectionable/Acceptable	-	-
Odor	No objectionable/Acceptable	-	-
Turbidity	NTU	< 5 NTU	
Total Hardness	mg/l	< 500 mg/l	
TDS	mg/l	< 1000	
pH		6.5-8.5	
Chemical			
Aluminum	mg/l	≤0.005 (P)	0.2
Antimony	mg/l	≤0.005 (P)	<0.005 (P)
Arsenic	mg/l	≤0.005 (P)	0.01

Barium	mg/l	0.7	0.3
Boron	mg/l	0.3	0.3
Cadmium	mg/l	0.01	0.0003
Chloride	mg/l	<250	250
Chromium	mg/l	≤0.05	0.05
Copper	mg/l	2	2
Cyanide	mg/l	≤0.05	0.07
Fluoride	mg/l	<1.5	1.5
Lead	mg/l	≤0.05	0.01
Manganese	mg/l	≤0.5	0.5
Mercury	mg/l	≤0.0001	0.0001
Nickel	mg/l	≤0.02	0.02
Nitrate	mg/l	≤50	50
Nitrite	mg/l	≤3	-
Selenium	mg/l	0.01	0.01
Residual Chlorine	mg/l	0.2-0.5 at consumer end	-
Zinc	mg/l	5	3

*: The standards highlighted in green for each respective Area/Zone are the most stringent based on a comparison between local and international regulations and thus shall be applicable for the proposed project.

3 Project Description

71. The proposed Integrated Waste Management System (IWMS) has the following two main components:
- **Component 1:** Improvement of existing waste collection & transport system in Mardan City
 - **Component 2:** SWMF Development & Operation
72. The IWMS within Mardan city is crucial for successful operation of the SWMF as it provides strategic approach to sustainable management of solid waste covering all sources and all aspects, including generation, segregation, transfer, sorting, treatment, recovery and disposal in an integrated manner, with an emphasis on maximizing resource use efficiency. The operational protocols and modalities of the IWMS have been established to improve environmentally sound practices with respect to waste management and attempting to close existing bottlenecks in the system.
73. The waste generated can be broadly categorized as residential, commercial, construction demolition, animal waste, institutional, or medical. The inorganic waste collected will be used as Refuse Derived Fuel (RDF), while organic component, plus the animal waste and organic kitchen waste will be used for preparing compost. This would significantly reduce the spatial requirements of the landfill and increase its useful life.
74. The development of the proposed SWMF is designed to support the WSSM and other involved agencies, so as to completely transform the SWM system in Mardan. Complete with institutional strengthening, recycling and other support initiatives, the project includes the installation of primary and secondary Municipal Solid Waste (MSW) collection systems and the development of an international standard MSW management facility that will accommodate Mardan's residual MSW for at least 20 years.
75. The Component 1 is an existing activity that is proposed to be further enhanced and improved in turns of its operational efficacy. On the other hand, the proposed Component 2 is the environmentally sensitive proposed intervention and thus this EIA report focuses on this particular Component.
76. The proposed Component 2 consists of the development of a well engineered and designed solid waste management facility (SWMF), which will ensure the solid waste generated from Mardan city is managed in accordance with international good practices on solid waste management.

3.1 Component 1: Waste Collection & Transport to SWMF

77. The operational modalities devised for successful implementation of this component are provided below.

3.1.1 Existing and proposed waste collection system in Mardan

78. The existing system of SWM by the Water and Sanitation Services Mardan (WSSM) is a continuation of the traditional system that was being managed by the Tehsil Municipal Administration (TMAs). Equipment used for waste collection includes the collection bins, containers, rickshaws, trucks, trolleys and compactors. The **Table 3.1**

below details the waste generation area and mode of waste collection and proposed improved practice for IWMS for Mardan city.

Table 3.1: Modes of Waste Collection

Waste Generation Area	Mode of Collection	Existing Practice	Proposed Improvements in existing practices
Residential Units	Door to door collection using compactors, mini dumper, motorcycle rickshaws or handcart depending on accessibility.	Information about timing of waste collection is provided to residents. WSSM complaint number and area supervisors' contact details are publically available.	Awareness among general public to encourage door to door collection of solid waste is proposed.
Commercial areas	Placing of communal bins or containers for large commercial area Door to door collection for business in residential area	Optimized timing of waste collection vis-a-vis commercial activities	Underground bins are proposed where containers cannot be placed due to congestion and less space. Waste segregation at source particularly in commercial areas and institutional buildings is proposed. Periodic awareness campaigns by WSSC Mardan with respect to waste segregation in commercial areas and institutional buildings are proposed. It is proposed that WSSC Mardan shall support/facilitate commercial markets committees and institutes in developing color coded waste collection system to promote segregation at the source.
Construction Demolition Waste	Construction waste is collected through use of special vehicles usually dump trucks along with loader	WSSM is collecting waste free of charge.	Protocols for builders to pay for debris removals are proposed.

Waste Generation Area	Mode of Collection	Existing Practice	Proposed Improvements in existing practices
Animal Waste	No organized mode of collection is available.	WSSM is collecting waste through use of special vehicle.	Organized waste collection system of animal waste is proposed as this waste can be used for composting.
Institutional Waste	Communal storage outside premises	WSSM is collecting waste from communal containers.	Placing of appropriate containers within premises of institutes by WSSC Mardan is proposed. Such container will be emptied by WSSC Mardan at regular interval.
Hospital Waste	Communal storage within premises	Non-hazardous municipal waste is being collected by WSSM. Infectious waste is being mixed with municipal waste by healthcare facilities.	Treatment of infectious waste within hospital premises is proposed to avoid its reach at landfill site.

Figure 3-1: Modes of waste collection in Mardan

79. The Residential and Commercial waste collection process flows are provided as **Figure 3.2** and **3.3** below.
80. The **Table 3.2** below provides the audit findings that was conducted to assess the existing activities being conducted from an environmental and social safeguards perspective and the required corrective measures that will be implemented.

Figure 3-2: Residential Waste Collection Process Flow



Figure 3-3: Commercial Waste Collection Process Flow



Table 3.2: Audit of Existing Facility and Required Corrective Actions

S/No.	Component	Existing Practice	Required Corrective Action
1	Storage of waste at source	<ul style="list-style-type: none"> ▪ Lack of public awareness, motivation, and education ▪ Lack of civic sense and bad habits of people to litter ▪ Lack of cooperation from households, trade, and commerce ▪ Lack of litter bins in the city ▪ Long distance between community bin ▪ Resistance to change the public attitude 	<ul style="list-style-type: none"> ▪ Door to Door collection will reduce littering in the streets ▪ Strong behavior change communication programs will improve citizen's behavior. ▪ Removal of roadside communal bins would have a major impact on the street environs.
2	Segregation of recyclables	<ul style="list-style-type: none"> ▪ Lack of wide publicity through electronic and print media ▪ Lack of public awareness and motivation, resulting in poor response from citizens ▪ Lack of citizens' understanding how to use separate bins for storage of recyclables ▪ Lack of sufficient knowledge of benefits of segregation ▪ Lack of cooperation and negative attitude of people ▪ Lack of finances to create awareness ▪ Difficulty of educating scavengers ▪ Absence of by-laws 	<ul style="list-style-type: none"> ▪ Segregation and materials recovery facilities will be developed at the transfer stations & /or at the LFS; ▪ Refuse Derived Fuel (RDF), facility will be made part of the MRF; ▪ Organic component of waste will be converted to organic compost; ▪ In the medium term (3rd year onwards), efforts will be made to encourage segregation at source, with a 2-bin system.
3	Collection	<ul style="list-style-type: none"> ▪ Citizens throw waste on streets instead of communal bins. ▪ Workers need to collect all scattered waste manually. ▪ Multiple transactions of waste till disposal site ▪ Lack of awareness and motivation ▪ Unavailability of adequate primary collection vehicles like mini tippers, handcarts etc. ▪ Insufficient response from citizens 	<ul style="list-style-type: none"> ▪ Improved citizens behavior throw communication programs will encourage better management of waste; ▪ Collection vehicles pool will be suited to door to door collection; ▪ All collection staff will have PEP, in order to safeguard their health and safety; ▪ Citizens will hold the key to accountability, to ensure that the daily door to door collection is performed.
4	Daily sweeping of streets	<ul style="list-style-type: none"> ▪ 100% manual sweeping system makes difficult for the sanitary workers to cover WSSM jurisdiction each day. ▪ Manual attendance management system is inefficient and leads to inefficiencies. 	<ul style="list-style-type: none"> ▪ With full Door to Door collection, the need for daily sweeping of all streets will be minimized to max twice a week;

		<ul style="list-style-type: none"> ▪ Unavailability of workers on Sundays and public holidays 	<ul style="list-style-type: none"> ▪ Focus will be on outcome-based indicators and not running after the workers attendance. ▪ No need to sweep on Sundays.
5	Communal Storage	<ul style="list-style-type: none"> ▪ Shortage of containers ▪ Lack of financial resources leading to broken and ill maintained bins; ▪ Lack of planning for waste storage depots or temporary storage locations; ▪ Inaccessible areas and narrow lanes that do not allow sufficient space for container 	<ul style="list-style-type: none"> ▪ All unnecessary communal storage points in residential areas will be removed. ▪ No containers, no throwing by households into the streets; ▪ Only commercial areas and institutions will have communal bins; ▪ User charges will be levied to induce financial sustainability.
6	Transportation	<ul style="list-style-type: none"> ▪ Many open vehicles for transport ▪ Old vehicles that are difficult to replace ▪ No route planning ▪ No scheduling for lifting of containers ▪ Lack of or no transfer stations 	<ul style="list-style-type: none"> ▪ Waste will be carried in fully covered vehicles, in order to avoid any littering and pollution. ▪ Number of vehicles will be minimized, with transfer stations and larger hauling containers. ▪ Environment friendly transfer facilities with dust & odor control.
7	Waste Treatment	<ul style="list-style-type: none"> ▪ Hardly any waste treatment in the formal sector - Lack of technical know-how for a scaled-up treatment facility ▪ Lack of institutional capacity - No success story in the country 	<ul style="list-style-type: none"> ▪ Materials Recovery Facility (MRF) will be an integral component of the treatment and disposal system. ▪ Options for Private sector participation will be explored in operations of the MRF centers. ▪ Specialized skilled workers will be operating the transfer stations, and MRF.
8	Disposal of Waste	<ul style="list-style-type: none"> ▪ Lack of financial resources for a scientifically designed land fill site; ▪ Lack of technical personnel for LFS management; ▪ Lack of technical know-how for scientific disposal of waste ▪ Unavailability of appropriate land - Lack of institutional capacity 	<ul style="list-style-type: none"> ▪ Landfill will be properly designed and operated. ▪ Segregation, MRF and Composting facilities will enhance the useful life of Landfill. ▪ LFs will have proper facilities like reception areas, weigh bridge, CCTV, RFID, access road, daily soil cover, security, lighting for 24 /7 usage and professionally trained workers to operate and supervise.

3.1.2 Procurement of SWM Equipment, Machinery and Vehicles

81. The project design consultant, Engineering Design Construction Management (EDCM), has analyzed the future waste generation of the city and identified SWM equipment, machinery and vehicle requirements for current year and for project life span. The procurement plan has been established based on the review of existing waste collection fleet of WSSM and taking into consideration the current total available volumetric capacity of WSSM. The total daily solid waste collection and disposal by WSSM is 120 tons, whereas the total daily waste generation in year 2021 will be 191 tons, resulting in a significant lapse of approximately 71 tons per day due to insufficient number and type of vehicles. PMU/WSSC Mardan will adopt energy conservation strategies through procurement of energy efficient equipment and vehicles. WSSM will consider optimization of such equipment/machinery during operation phase to adopt energy conservation.
82. Proposed procurement of SWM fleet for solid waste carrying machinery, non-waste carrying machinery and future machinery requirements for year 2030 are shown in **Tables 3.3, 3.4 and 3.5** below.

Table 3.3: Current Waste Carrying Machinery Procurement

Machinery	Vol. Cap m ³	Total Required	Current Procurement Quantity
Minitippers 1m³	11	11	13
Minitippers 2m³	41	20	23
Compactors 7m³	41	06	07
Compactors 13m³	192	15	17
Dumpers 10m³	94	09	11
Total	379	62	71

Table 3.4: Current Non-waste Carrying Machinery Procurement

S/N	Machinery	Qty	Working (Kms)/Machinery	Total daily Working (Kms)
1	Mechanical Sweeper – Vacuum	02	35	70
2	Mechanical Sweeper – Tractor	02	20	40
3	Mechanical Washer	02	15	30
4	Drainovator	03	10	20
5	Green Shredders	03	As Required	
6	Tractor Loaders	04	As Required	
Total		16		

Table 3.5: Total SWM Fleet Required

Source	Machinery	Year			
		2025		2030	
		No's	Vol. Cap m ³	No's	Vol. Cap m ³
Residential Waste Collection	Mini Tippers 1m ³	13	13	16	16
	Mini Tippers 2m ³	20	40	24	48
	Compactor 7m ³	7	49	9	63
	Hand Carts	212		260	
Commercial Waste Collection	Compactor 13m ³	4	54	5	65
	Mini Tippers 2m ³	4	8	7	14
	Hand Carts	133	-	163	-
Bulk Waste	Dumpers 10 m ³	11	111	14	140
Secondary Residential Waste	Compactor 13 m ³	13	172	16	208
Lifting Machinery	Tractor Loader	4	-	5	-
Total (Excl. Handcarts)		76	447	95	554

3.1.3 Waste Transport

83. In the case of residential areas, the handcarts, Minitippers and compactor (7m³) shall be deployed to collect the waste from each household on a defined schedule, whereas the compactor (13 m³) shall be used as mobile transfer stations, which shall receive waste from Minitippers and in some cases handcarts as well. Both the compactor types shall finally go to the landfill site for final disposal.
84. In the case of commercial areas, 13m³ compactors shall be used for two purposes, i.e. as a mobile TS and also to collect waste from bins. The waste collected via handcarts shall be transferred either directly to the mini tipper or compactor, which shall be parked at particular locations in commercial areas and upon receiving a full load of 8 tons, shall move towards the landfill site.

3.1.4 Transfer Stations

85. In order to improve the overall waste management system and urban environment, waste transfer stations would be developed and used to minimize the number of smaller vehicles commute to the Landfill site, thus reducing negative environmental impact. Depending upon the site, location and collection vehicles, we can have one of three types of transfer stations. Currently only Mini and Mobile transfer stations are proposed for SWMF of Mardan as the city is small and hauling routes are also short.

- **Mini Transfer Station** – Arm Roll vehicles containers of 15-20 m³ size, placed along a ramp in enclosures
- **Mobile Transfer Station for vehicle to vehicle transfer** – where space is constrained, large vehicles, like compactor trucks, could be used for emptying small collection vehicles.
- **Main Transfer Station** – for transport convergence into trailers. These transfer stations could be coupled with segregation or Material Recovery Facilities (MRFs), reducing load on the actual landfill site. Transfer stations will serve for transfer of waste from small capacity to large capacity vehicles to haul waste at SWMF. Waste management plan for transfer stations will be prepared prior to start of operations by the WSSCM. Main transfer stations in Mardan shall be constructed if required in future. Waste management plan will ensure that no waste is littered and mishandled during operations at transfer stations. Waste management plan will be prepared by WSSCM and will be submitted to PMU for review and approval before start of operations at transfer stations. It will be ensured that no public or neighbors grievances arise due to operations at waste transfer stations and if any received it will be timely and appropriately addressed by concerned authorities. SOPs will be established and implemented at waste transfer stations to avoid impacts of odour, land degradation, water pollution and public nuisance.

3.2 Component 2: SWMF Development & Operation

3.2.1 Objective of SWMF Development

86. The proposed SWMF is an urban development project with the objective of providing waste collection and disposal services for the residents of Mardan city. The project aims to benefit the current population of approximately 0.358 million that are estimated to increase to about 0.56 million by 2043 (i.e. an estimated project life of 20 years). The project is designed with the objective to cater to adverse environmental impacts from uncontrolled dumping and last of a proper solid waste management system:

- Haphazard waste spread in nearby agriculture lands
- Odor problems due to emission of CH₄, SO₂ and H₂S
- Risk of vector spread
- Risk of fire and explosion of dump site gas
- Uncontrolled leachate infiltration causing land degradation
- Surface water and groundwater pollution
- Aesthetic Impacts of the open dumpsite
- Economic loss due to disposal of recyclable materials
- Increased scavenging activity in the Mardan

3.2.2 Capacity of SWMF

87. The most suitable technological option for handling approximately 180 tons per day (tpd) generated in Mardan city is a combination of mechanical and biological treatment options. Around 95% of the organics, recyclables and combustibles will be disposed off through other means and this volume will not reach landfill, hence saving landfill handling capacity for a longer time, recovering the economic potential of the waste and improving environment through reducing the methane emissions from the landfill. This percentage varies in different cities keeping in view the life style and economic status of the residents. Furthermore, the estimates provided here are only benchmark figures used by the SWM experts during designing of the ISWM at the feasibility level and do not contradict the mass balance prepared by the design consultant, provided as **Figure 5.9** of this EIA study. Project design report has proposed a set of mechanical & biological treatment (MBT) options after detailed techno-economic assessment:

- Sorting line with capacity of 120-150 tpd consisting of bags opener, trommel screens, magnets, ballistic separator and baling units.
- 30 tpd of the green waste collected from the hotels, restaurants, fruits and vegetable markets will be used for the anaerobic digestion.
- After sorting and segregation, 100-120 tpd green waste will be subjected to Anaerobic Digestion and subsequent composting using aerated piles.
- Approximately 60 tpd of RDF will be produced which may be sold to the cement industries or brick kilns.
- Around 3-5 tpd recyclables will be sorted which may be sold to the recycling industry.
- Remaining 2-5 tpd of the inert waste will be landfilled.
- Landfill area would comprise of number of waste cells separated by access road for each cell, liner system at the bottom and provision of daily cover during the active phase of operation of each cell. Every cell will include gas and leachate collection piping network which will be transported on site for treatment and disposal. Other than the technical components of landfill, the site will house administration building, weighbridge for recording incoming waste data, wheel washing and parking yard.

88. The process flow of the proposed SWMF for Mardan is provided in **Figure 3-4** while the key plan for the proposed facility are provided as **Figure 3-5** below.

3.2.3 Scope of Works for SWMF development

89. In order to understand the impact of all the project phases to the receiving environment, it is necessary to provide details of the activities to be performed, its magnitude and duration.
90. The general step wise sequence of activities to be conducted for the SWMF development are described below. It shall be ensured that staging of activities takes place to manage any potential impacts, including traffic management issues.

Pre-Construction phase activities

91. The following activities have already been completed by PMU KPCIP and Engineering Design Construction Management (EDCM) consultant:

- PMU and EDCM consultant mobilization
- Situation analysis and condition assessment
- Geotechnical and topographic survey
- Detailed Engineering Design
- Social safeguard assessment
- Preparation of tender document, cost estimates and BOQs

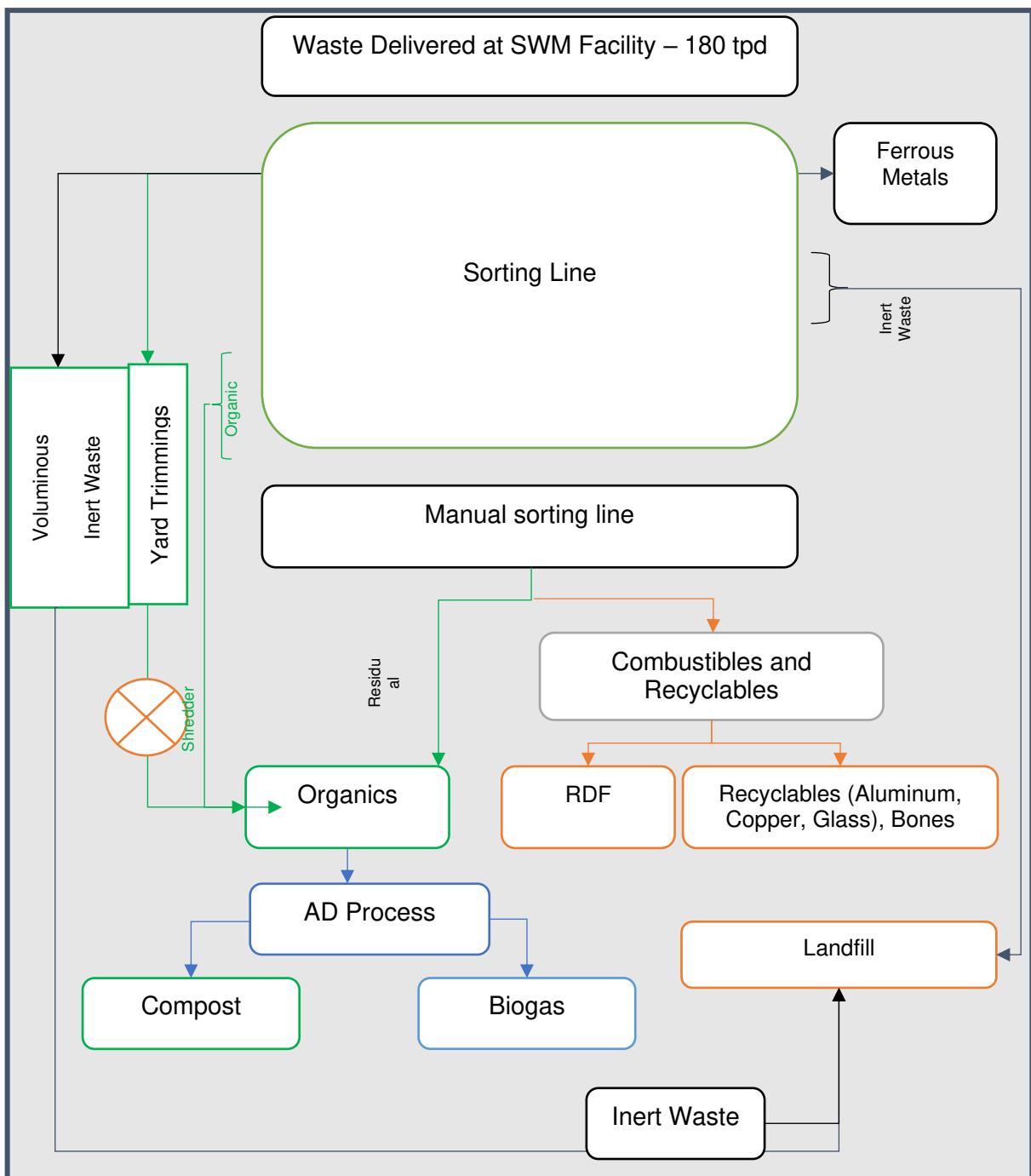
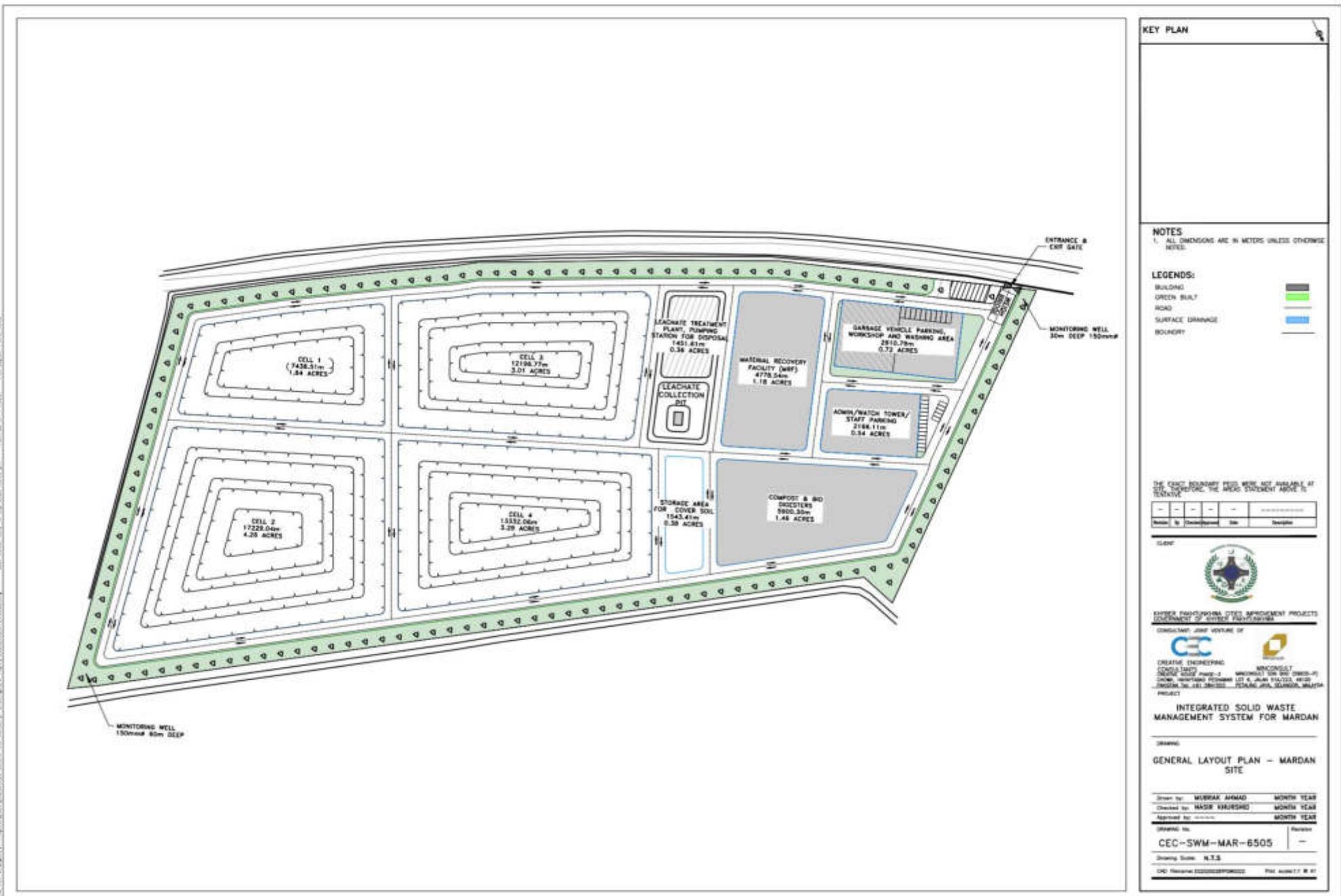
Figure 3-4: Proposed SWM Facility for Mardan

Figure 3-5: Key Plan of Mardan SWMF



3.2.4 Project Need

92. Out of the 191 tons of waste generated per day in Mardan city, an estimated 70% comes from households and the rest from other sources, including bulk waste. In terms of composition, almost 65% is organic, while about 10% is inorganic recyclables. 'At source storage of waste is yet not practiced in Mardan city as most households, shops, and establishments throw their waste just outside their premises, on streets, in drains, in open spaces, in water bodies, and in other inappropriate places.
93. Considering the climatic conditions of Mardan City, where humidity is high and temperatures provides a conducive environment for the microbes to rapidly degrade, the organic fraction of the waste which produce smell and attract animals, thus contributing to spread of filth and disease. Furthermore, there is common practice of burning waste which poses an even greater risk to safety of neighboring households.
94. Throwing of waste into the running water body, such as stream or a canal, is a common practice. WSSM aims to counter these practices and has deployed containers and litter bins on main roads and streets. Sanitary workers, after sweeping the streets, collect waste in wheelbarrows to their designated waste storage points in the area, usually containers.
95. Proposed installation of primary and secondary MSW collection systems, and the development of an international standard MSW management facility has been designed to address SWM issues of Mardan city.

3.2.5 Rationale for Site Selection

96. The proposed SWMF has been selected on the basis that it must comply with basic KP government regulations, IFC EHS guidelines for waste management facilities and the ADB SPS, 2009. Proposed selection of this SWMF must take into account impacts from leachate, litter, dust, vector and odor on surrounding environment. The various factors that have been kept in focus while selecting the proposed SWMF site are provided in **Table 3.6** below.

Table 3.6: Criteria for Site Selection

Factors considered for site selection	Rational for Site Selection
Landfill area and capacity to meet requirement of landfill site	There is adequate land area (approx. 27 acres) available at the proposed site which can be used for landfilling for next 20 years.
Accessibility of landfill site	Site is accessible through already developed road network in the project area. Transfer distance is about 3 km from Mardan ring road.

Factors considered for site selection	Rational for Site Selection
Site Stability	Site is located outside areas susceptible to natural or human-induced events or forces capable of impairing the integrity of landfill components. Examples of unstable areas are those with poor foundation conditions, areas susceptible to mass movements (landslides, rock falls, etc.) and areas with karst terrains (sinkholes). Geotechnical report has been carried out for the site and design is based on the findings of this report.
Land Use	The site is not presently in use for any specific purpose
Critical Habitat/Sensitive ecosystem	Site is falling outside of critical habitats of plants, wildlife and sensitive ecosystems.
Restricted Zone, Wildlife/Forest Protected areas	Site is falling outside of restricted zone/wildlife/forest protected areas.
Site should be located outside of the 10-year groundwater recharge area for existing or pending water supply development	Site is located outside of the 10-year groundwater recharge area for existing or pending water supply development. However, the area naturally causes the subsoil water recharge during the high rainy seasons.
Perennial stream	No perennial stream is present in the project area, however, two small canals are present on the south west and south east directions of the site. However, bottom lining of each landfill cell and leachate collection system will ensure that no contamination is entering these two canals. Surface drainage network has been provided in the detailed design to avoid risk of surface runoff and contamination.
Topography	Landfill site is located in mildly sloped topography.
Ground Water Table	<p>The groundwater table was encountered at the shallowest depth of 1.25 m below existing ground level in boreholes during geotechnical investigation in June 2020. However, one borehole revealed exceptionally shallow water table at 0.78 m possibly due to presence of a small rainwater pond.</p> <p>Considering the high-water table, it will be ensured that the landfill operation is conducted from the EGL upwards to ensure no groundwater contamination takes place.</p>
Flood plain & other climate risks	Site is located outside of flood plain, however, in case of high precipitation there are chances of urban flooding. Surface drainage network has been provided in detail design of landfill site to avoid risk of surface runoff and contamination.

Factors considered for site selection	Rational for Site Selection
	Please refer to Section 3.3 below for a detailed assessment of the climate risks facing the project.
Seismic Risk/Fault lines	Site is located outside of seismically active area as it falls in Zone 2B with peak ground acceleration (PGA) in range of 0.16g to 0.24g on seismic map of Pakistan. No fault lines or significantly fractured geologic structure is present within 500 meters of the perimeter of the proposed landfill cell development that may allow unpredictable movement of gas or leachate.
Private/ Public water supply wells	No private and/or public water supply wells are located in the project area.
Airports	Airport is located at a distance of about 52 km from the site, therefore no impacts of scavenging birds are anticipated on flight operations.
Sensitive Receptors	There are no sensitive receptors in the project area of the proposed landfill site Furthermore, no LARP is required for site as land has already been acquired.

3.2.6 Proposed Design Considerations for SWMF

97. The design selection has a major influence on the construction, operation and restoration of the facility. The design concept depends on the ground conditions, the geology and hydrogeology of the site, the potential environmental impacts and the location of the waste disposal site. In order to incorporate advancement in technology and changes, a periodic review of the design should be carried out, as the lifespan of a disposal site from commencement to completion is long compared to other construction projects. Aspects that have been considered in the design are briefly discussed below.

Nature and Quantity of the Waste

98. Nature of waste that will be landfilled at Mardan would be only MSW. It is regarded as waste generated by households and waste of similar nature generated by commercial and industrial premises, institutions such as schools, hospitals and other facilities inhabited by people, construction and demolition of buildings, and from public spaces such as streets, markets, slaughter houses, public toilets, bus stops, parks and gardens.
99. As per the estimates, Mardan city generates about 180 tons of waste per day in 2020. For the purpose of calculation of useful life of landfill, if 25% extra waste generated from all other sources is factored-in, total waste reaching the landfill is considered to be 221 tons in 2025. Main criteria used for estimation waste generation rate is given in **Table 3-7** below.

Table 3.7: Waste Generation Estimation Criteria

Criteria	Description
SWM Planning Horizon (2020-2030)	10 Years
Population	Projections based on 1998 Census
Population growth rate (%)	2.13%
Per Capita Waste Generation	0.33 Kg/ca/d
Per capita waste generation annual increment (%)	1.5%
Additional allowance (%)	25%
Loose waste density (kg/m ³)	305

100. For waste projection in the future, an annual growth rate of 1.5 % is applied to current waste generation of 0.33 kg/ca/d. Similarly, population projection is also made at the population growth rate as suggested by Pakistan Bureau of Statistics at 2.13% annually. Mardan has a total waste generation rate of 180 tons per day in 2020. For purposes of design for waste treatment, the calculation has been made at 221 tpd, considering the growth till 2025. Keeping in view the infrastructure investment required for landfill, 20 years useful life of landfill is considered for design.

Protection of Soil and Water

101. Bottom and cap lining system for each landfill cell has been designed for the protection of soil, groundwater and surface runoff. The liner system may consist of a natural or artificially established mineral layer combined with a geo-synthetic liner that must meet prescribed permeability and thickness requirements.

Leachate Control and Management

102. An efficient leachate collection system has been provided to ensure leachate accumulation at the base of the landfill and keep it to a minimum. The leachate system will consist of a leachate collection layer of either natural granular (sand, gravel) or synthetic drainage material (e.g. geonet or geo-composite) with pipe network to convey the leachate to treatment facility.

Gas Control

103. The accumulation and migration of gases from landfill facility must be controlled. Landfill gas will be collected through installation of perforated pipes within the cells. This gas transferred to gas recovery unit where it receives subsequent treatment and utilization, or disposal in a safe manner through flaring or venting.

Odor/Litter/Vector Control

104. Daily cover will be provided at end of each day to avoid risk of fire, wind littering, odor, vector breeding and dust hazards in the landfill. Working surface of waste will be covered with a soil layer called “daily cover” at the end of each working day. Amount of soil to be used in daily cover will be about 10% of the waste volume. Suitable quality of excavated material can be used as daily cover material.

Stability

105. Consideration has been given to the stability of the sub-grade, the base liner system, the waste mass and the capping system. The sub-grade and the base liner will be sufficiently stable to prevent excessive settlement or slippage.

Visual Appearance and Landscape

106. Consideration has been given to the visual appearance of the landfill site during operation and at termination of landfill site and its impact on the surrounding landforms. Necessary plantation will be carried out which will act as buffer zone from surrounding environment. Reasonable area has been allocated for plantation within and at boundary of facility to improve landscape of the area.

Operational and Restoration Requirements

107. Landfill will be operationalized in a phased manner. Site infrastructure has been included for the provision of; administration building, lookout tower, weighbridge, waste inspection area, wheel wash area, site services and security fencing to meet operational and restoration requirement.

Monitoring Requirements

108. One groundwater monitoring well was maintained out of the drills made for geotechnical investigation. However, more wells may be constructed, if required, once the landfill starts operation.

3.2.7 Detailed Process Description

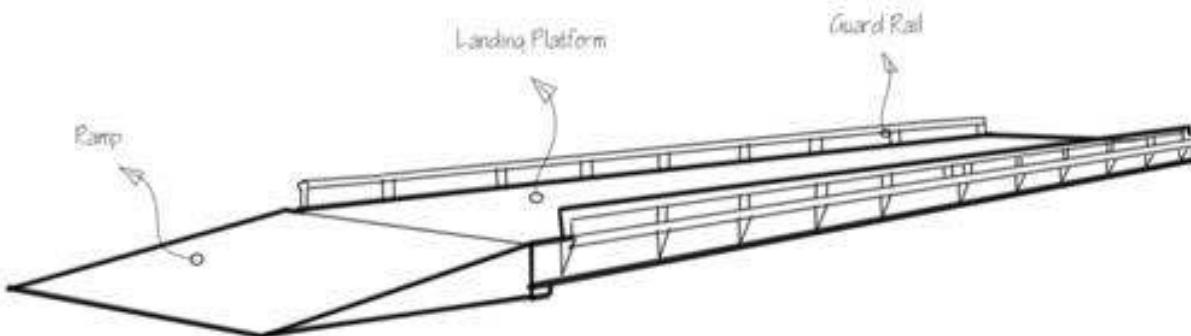
109. Following are the major operations that will be performed at the SWMF in Mardan:
- Reception of the incoming waste stream;
 - Placement and volume reduction of the waste through mobile compactors such as bulldozers;
 - Installation of material recovery facility, Aerobic Digestion (AD) system and composting; and
 - Installation of the landfill and environment control facilities
110. In a SWMF, waste is spread in thin layers, compacted to the smallest practical volume and covered with the soil or other suitable material at the end of each day. When the disposal site reaches its ultimate capacity, a final layer of cover material is applied.
111. The detailed process description for disposal of MSW at the proposed site is presented in the following sections.

Weigh Bridge and Unloading Bay

112. Prior to the unloading, the trucks will pass over a weight bridge to determine the exact amount of collected garbage from the city every day. In order to minimize the solid waste collection vehicle's circulation inside the landfill boundary and to reduce emissions and odours, an unloading bay has been incorporated in the design. To reduce the possibility of littering, incoming collection vehicles will empty the waste on the tipping floor outside the building to reduce the circulation at the site. Weighbridge

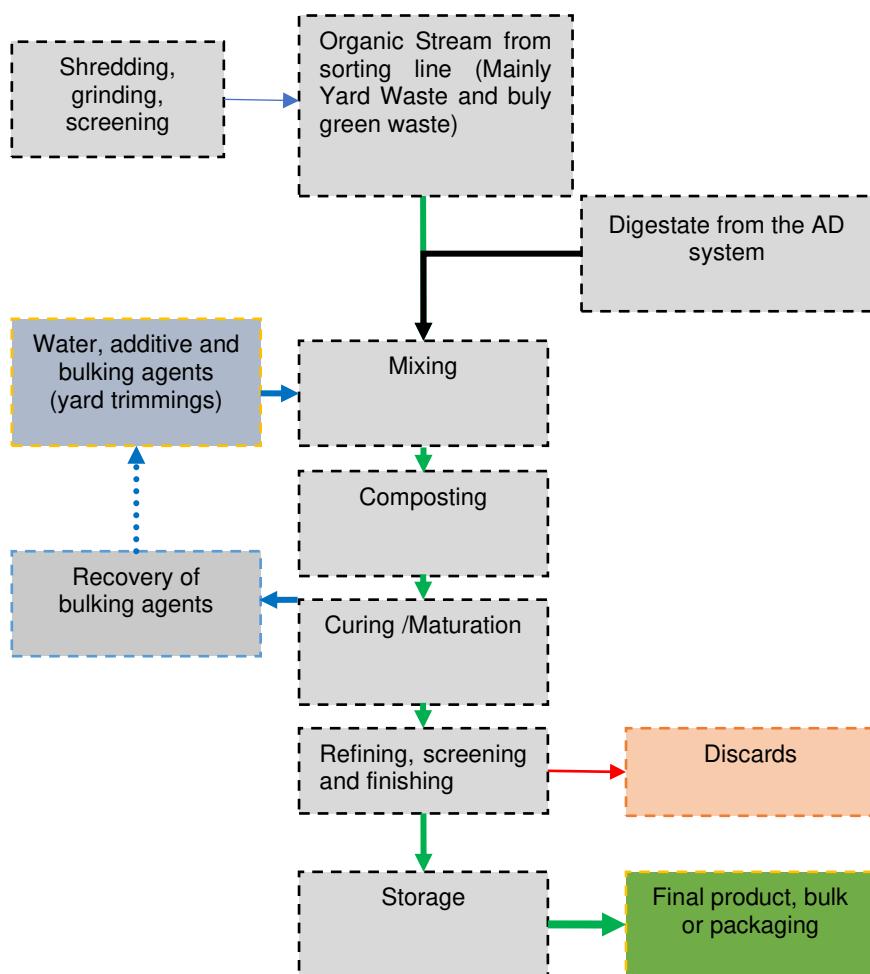
of 100 tons capacity will be installed at the entrance gate for Mardan landfill site. A pit type weigh bridge of size 20X5 m having modular cubical bolting assembly will be installed on steel platform which will be fixed on RCC raft. Schematic diagram of weighbridge is shown in **Figure 3-6** below.

Figure 3-6: Schematic Diagram of Weigh Bridge



Composting and Biogenerators

113. During the detail design phase, feasibility of choice of organic waste treatment has been discussed in detail, nonetheless, area for biological treatment of organic waste has been set aside. All the waste collected from the city will first reach MRF for sorting and segregation. From there, organic waste and residual waste will be transported to bio digester and composting area for final treatment and disposal. Compost pad of Plain Cement Concrete (PCC) will be constructed for windrow composting. After segregation and sorting, the yard waste will be sent to AD system where it will be dried and then sent to composting process.
114. The general process flow diagram for the AD system and composting facility is provided as **Figure 3-7** below.

Figure 3-7: General process flow diagram for AD System and Composting

115. Typical preparation steps include: (a) sorting of salvageable material (b) removal of non-putrescible (c) grinding (d) addition of wastewater sludge if necessary. Following conditions are essential for effective composting. For optimum results, the size of the waste should lie between 2 and 8 cm. Size reduction is accomplished through shredding. Sufficient number of microorganisms must be present to perform digestion and so sewage sludge is added for this purpose. The following conditions will be achieved for composting of MSW:

- C/N ratio should be 30 to 50;
- C/P ratio should be 100 or less;
- Moisture content should be 50 to 60%. Addition of water is done to raise moisture contents, if required;
- pH should vary between 5.5 to 8.5 throughout the process;
- Air should be thoroughly dispersed throughout the organic waste. This is done by frequently turning and mixing the wastes;
- Temperature should be maintained between 50 to 60°C for active composting period.

116. For Aerobic digestion system (AD system), the following options are proposed:

- Wet or dry AD;
- Single or two stage ADS;
- Thermophilic or mesophilic AD;
- Continuous, plug flow or batch AD.

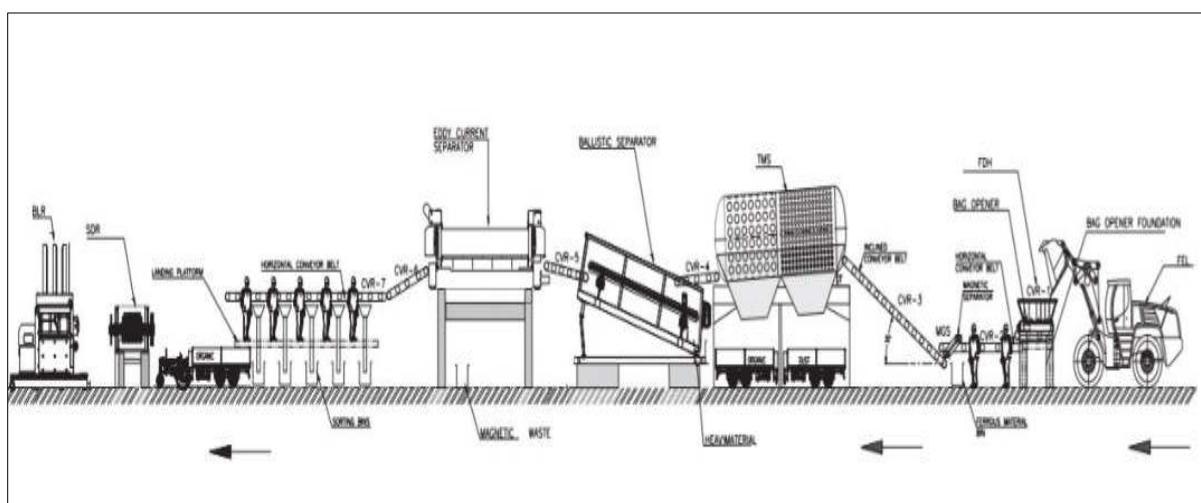
117. The design decisions would need to be combined with pre-treatment decisions to create an overall AD design which would best meet the needs of the project, depending upon the waste characterization. Project design report suggests that AD system should not be prescribed at this stage and KP government may invite AD vendors/EPC contractors to provide customized approaches to AD and pre-treatment options.

118. WSSM/GoKP may set out performance specifications that AD vendors/EPC Contractor will need to meet and vendors/EPC Contractor will pick the combination of technologies and approaches which they feel will work best for the feedstock to be treated. For example, a dry AD vendor could put a wet pre-processing system on the front end of their system. Understanding risks and benefits is important background, but this information should not be used in making a procurement decision (either by dictating requirements in an RFP and/or in the evaluation of proposals). Specifying the AD system design at this stage may limit the competition and thereby cost escalation of the proposed system.

Material Recovery Facility (MRF)

119. The MRF area is located adjacent to landfill facility. The sorting area will be constructed with steel structures for roof with a ceiling height reaching approximately two stories' high. Dedicated machinery will be provided for sorting and segregation area such as a front-end loader and fork lifter. Process flow description is provided in **Figure 3-8** below.

Figure 3-8: Process flow of Material Sorting Facility



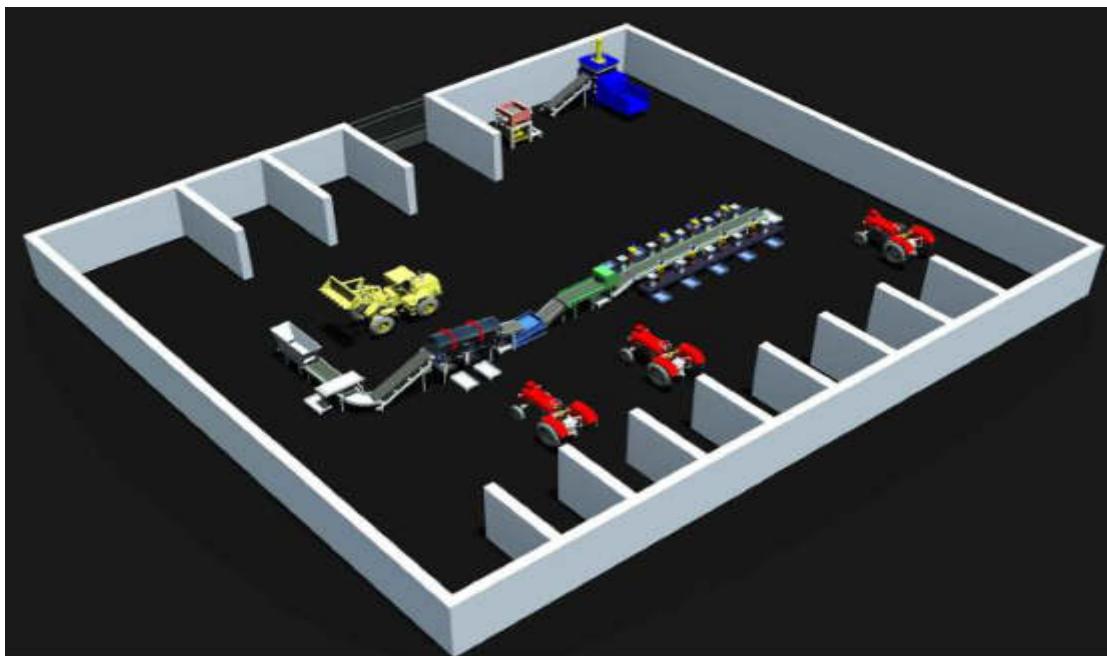
120. The operations involved in MSF are as follows:

- Waste will be off-loaded on a tipping floor at the MRF. The floor is divided into three chambers to ease the operations on first-in, first-out basis. The overall area can

cater for 'two days' offloads, keeping a safety cushion for routine maintenance shutdowns.

- From tipping floor, front end loader will carry waste in batches and load into hopper.
- A bag opener is installed at the beginning of the segregation process. It will be used to open the closed bags. It will also work as a metering input device to control the throughput.
- After passing the bag opener, the waste will pass through a small horizontal conveyor belt, where larger components of the waste will be removed manually before entering other sorting equipment. The removal of large items from sorting line will not only safeguard the facility against unnecessary loading of bulk waste, but it will also save the mechanical equipment from avoidable wear and tear.
- At the end of pre-sorting conveyor belt, a magnet will be installed to recover ferrous metals.
- A Trommel screen with two distinct opening sizes of <90 mm and <6 mm is incorporated afterwards. Material below 90 mm is mostly organic, which will be dropped into trolleys placed right underneath the trommel. Once filled, the trolleys will be transported by tractors for further processing. As for the material < 6 mm which is primarily inert or fines, it will also be collected in a trolley and taken to landfill cells. This reject from MRF can be used as cover soil in waste cells.
- Waste stream after the trommel screen will pass from a Ballistic Separator and separated into two main streams: a) 3D or rolling fraction where all PET, HDPE, PP and other heavy fractions tend to jump towards the lower end of the system and b) 2D or flat fraction where all film and flat material tends to move upwards. During this process, material is continuously shaken and consequently the dust and 'fines' are screened by the perforated surface of the blades.
- Another chamber separates non-ferrous metals with the help of Eddy-Current technique of aluminum sorting.
- Afterwards, the material is fed onto a manual sorting conveyor belt located inside the picking station where plastics, glass, paper, cloth and other materials are picked before non-ferrous metals. Waste sorting manually will be collected in containers placed beneath the chutes, which will be emptied in their designated areas within the sorting facility. These materials can then be consolidated with the help of baler for ease of transportation.
- Recyclables and RDF materials are fed onto a baler automatically to be packed in the shape of blocks. These are then stored for transportation to market.
- Industrial size shredder is proposed for reducing the size of larger waste components.
- The whole facility will have ventilation installed for creating a comfortable environment for the waste picking team. The installed ventilation will also reduce the spread of COVID-19.

A 3D view of a typical MRF is provided as **Figure 3-9** below.

Figure 3-9: 3D View of proposed MRF for SWM Facility - Mardan

3.2.8 Construction of Landfill Facilities

121. Following activities are involved in construction of sanitary landfill:
- Landfill Cell Development
 - Landfill Gas Management
 - Leachate collection and treatment system
 - Associated Infrastructure and Buildings

3.2.9 Landfill Cell Development

Landfill Cell Size

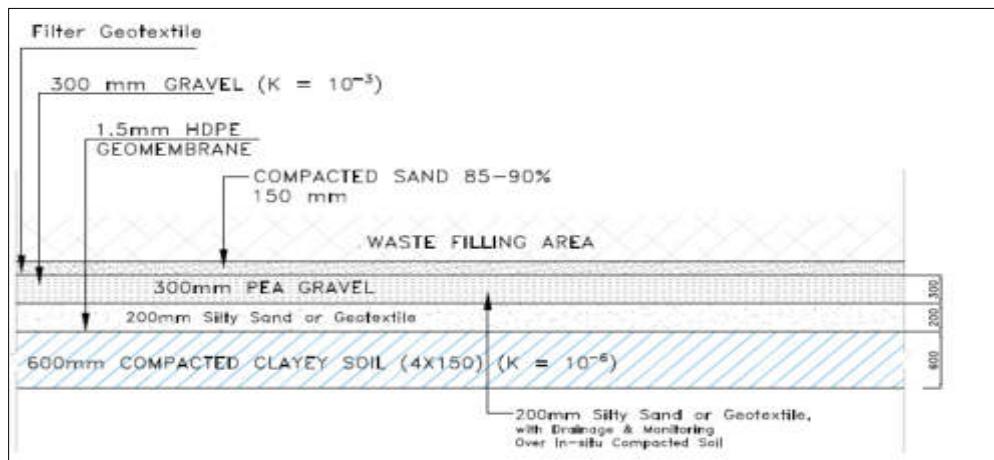
122. The landfill site is planned to contain 4 waste cells. The size of waste cell ranges between 1.8 to 4.2 acres. Cells will be excavated to a depth of 1 to 3 m below the natural ground level wherever shallow water permits excavation. The leachate collection pond is planned to be positioned towards the eastern side of the site. An area is reserved for the leachate treatment facility next to leachate collection pond, which is proposed to be designed as activated sludge treatment with advance level treatments for heavy metals and other pollutants potentially present in leachate.
123. Layers of composite barrier will be constructed to prevent any percolation of leachate into groundwater. Excavation slopes will be maintained at 1:3 with four landfill cells of different sizes proposed for the landfill site and the location of the landfill cells is provided in project key plan. The size of the proposed landfill cells are provided in **Table 3-8** below.

Table 3.8: Size of Landfill Cells

Landfill Cell ID	Size (Acres)
Landfill Cell-1	1.84
Landfill Cell-2	4.26
Landfill Cell-3	3.01
Landfill Cell-4	3.29

Bottom Lining of Landfill Cells

124. The liner system at the base of waste cells is aimed to protect the surrounding environment. It includes soil, groundwater and surface water protection through containment of leachate, controlling ingress of groundwater, and assisting in the control of the migration of landfill gas. The liner system must achieve consistent performance and has to be compatible with the expected leachate for the useful life of the facility. Bottom lining of the landfill cells will be carried out through provision of lining at subsoil comprising of plastic and clay material. Specifications of bottom liner designed for the proposed landfill are provided in **Figure 3-10** below.

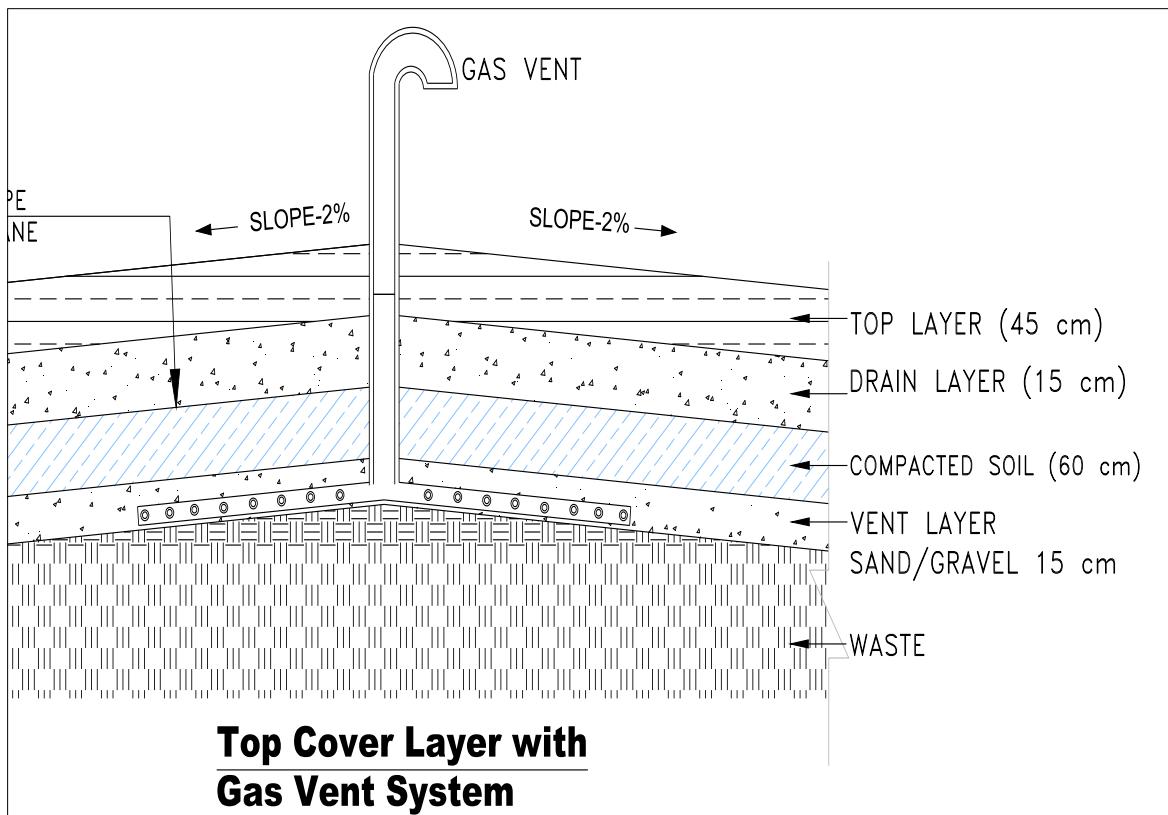
Figure 3-10: Bottom Liner of the Landfill Cells

125. As illustrated in the Figure above, the specification of bottom lining of the proposed landfill site are as follows:
- A total of 600 mm clay liner of permeability of 1×10^{-6} cm/sec will be compacted at the bottom in series of 150mm layers each compacted to 95% of compaction, followed by 150 mm base layer for drainage and monitoring. This layer will be topped by 1.5 mm HDPE geomembrane.
 - As soon as HDPE is placed, 200 mm silty sand or geotextile will be covered on top of HDPE for the protection of the HDPE on the side slopes. The main purpose of this sand layer on top of HDPE geomembrane serves as leakage detection layer.
 - Above this 300 mm PEA gravel layer will be placed followed by 150 mm compacted (85-90%) sand layer.

Final Capping Layer of Landfill Cell

126. Final capping of landfill cells will be carried out in order to limit and control the amount of precipitation that enter the waste and to limit wind and water erosion and burrowing animals' activity. Main objectives of the capping system are: minimizing infiltration into landfill, maximize surface drainage and run-off and gas control migration.
127. The **Figure 3-11** below illustrates the typical final cover layer designed for landfill cells.

Figure 3-11: Capping of Landfill



128. The top cover system will consist of the following arrangements:
- Thick top soil layer of 45 cm capable of supporting vegetation in order to protect the landfill surface from wind and water erosion.
 - Drain Layer of 15 cm at bottom to maximize runoff of precipitation while minimizing infiltration and preventing ponding of water on the landfill.
 - Compacted soil layer or barrier of 60 cm of low permeability to limit and control the amount of precipitation that enters the waste.
 - Vent layer of 15 cm thickness comprised of sand and gravel

Daily Cover

129. Daily cover is placed on working surface of waste in order to reduce the risk of fire, wind littering, odor, vector breeding and dust hazards in the landfill. It is a soil layer

and is placed on each working day. Generally, the amount of soil to be used in daily cover will be about 10% of the waste volume. Suitable amount of daily cover is usually stocked at the landfill sites during landfill cell excavation. However, any suitable excavated material from construction works can be used as daily cover.

3.2.10 Landfill Gas Management

130. Landfill gas is produced through decomposition of organic fraction present in the MSW deposited to the landfill site by microbial activity. Landfill gas is composed of roughly 50 percent methane (the primary component of natural gas), 50 percent carbon dioxide (CO_2) and a small amount of non-methane organic compounds. Methane is a potent greenhouse gas 28 to 36 times more effective than CO_2 at trapping heat in the atmosphere over a 100-year period, as per the latest Intergovernmental Panel on Climate Change (IPCC) assessment report (AR5)³. Methane possesses the combustible and explosive properties and also a Green House Gas responsible for global warming. In order to limit landfill gas entrance into environment and to avoid fire and explosive hazards, land fill gas collection system has been designed.
131. The average height of the waste body in waste cells is recommended at 30 meters. Therefore, vertical gas collection systems will be implemented in the facility. The gabion of the gas collection wells will be 1 m square filled with gravel, and these will be constructed with iron mesh. There will be a perforated HDPE pipe 150 mm in diameter and with pressure class of PN16 in the center of the gas collection wells. The gap between the iron mesh and the perforated pipe will be filled with 16/32 mm pebble stone. The proposed gas vent system designed for Mardan landfill site has been shown in **Figure 3.14** below.
132. At start of Landfill operation venting is proposed as small quantity of gas will be produced. The passive gas collection system is planned with simple venting of landfill gas to the atmosphere without any treatment before release. This is appropriate, considering that only a small quantity of gas is produced and no people live or work nearby. Common methods to treat landfill gas include combustion and non-combustion technologies, as well as odor control technologies. For KPCIP landfill operations after few years when significant quantity of gas is produced. open flame flare technology, consisting of a pipe through which the gas is pumped, a pilot light to spark the gas, and a means to regulate the gas flow is proposed. The simplicity of the design and operation of an open flame flare is an advantage of this technology.
133. With gas generation starting in 2023, a modeling software Land GEM is used to forecast the volumes of gas and accordingly, gas collection and venting system within landfill cells is designed as shown as **Figures 3-12 and 3-13** below.
134. Project design consultant EDCM has estimated the amount of emissions through US EPA Landfill Gas Emission Model (Land GEM). It is an automated tool for estimating emission rates for total landfill gas, methane, carbon dioxide, nonmethane organic compounds (NMOCs), and individual air pollutants from MSW landfills. Land GEM results for pollutant emissions resulting from the flaring operations at the site are presented in impact assessment section. Land GEM results shows that emissions of Sulphur dioxide (SO_2) and Methane (CH_4) are both minimal with only 4.9 kg/day (0.06 g/s) of SO_2 and 110.9 kg/day (1.2 g/s) of CH_4 being emitted. Also result shows very limited yearly volumes of emissions of NMOC and Hazardous Air Pollutants (HAPs) from landfill site. Keeping in view these limited volumes and after controlled flaring no deterioration to air quality is expected from the facility. Further the project area

³ <https://www.epa.gov/lmop/basic-information-about-landfill-gas>

consists of a rural and open setting with no built area located in close proximity to the site, thus any minimal pollutant emissions will be rapidly diluted upon release and thus will not result in any significant impact on the airshed of the project area. Keeping in view the amount of gas production after few years of landfill operation, feasibility for gas reuse will be carried out and accordingly design changes will be executed.

Figure 3-12: Design Specification of Gas Vent

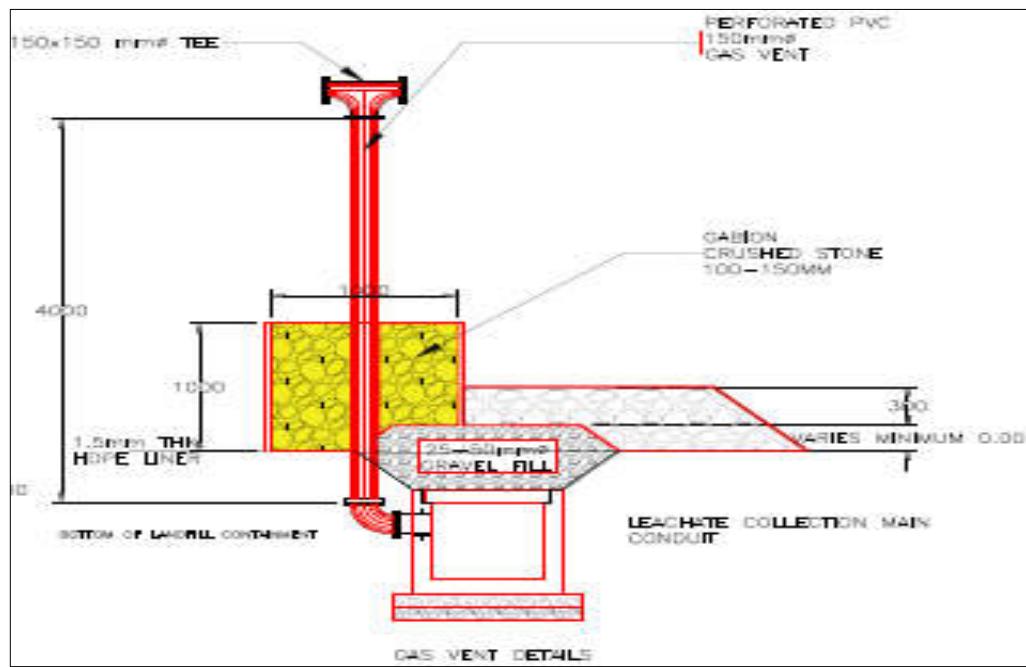


Figure 3-13: Extension of Gas Vent in Landfill Operations

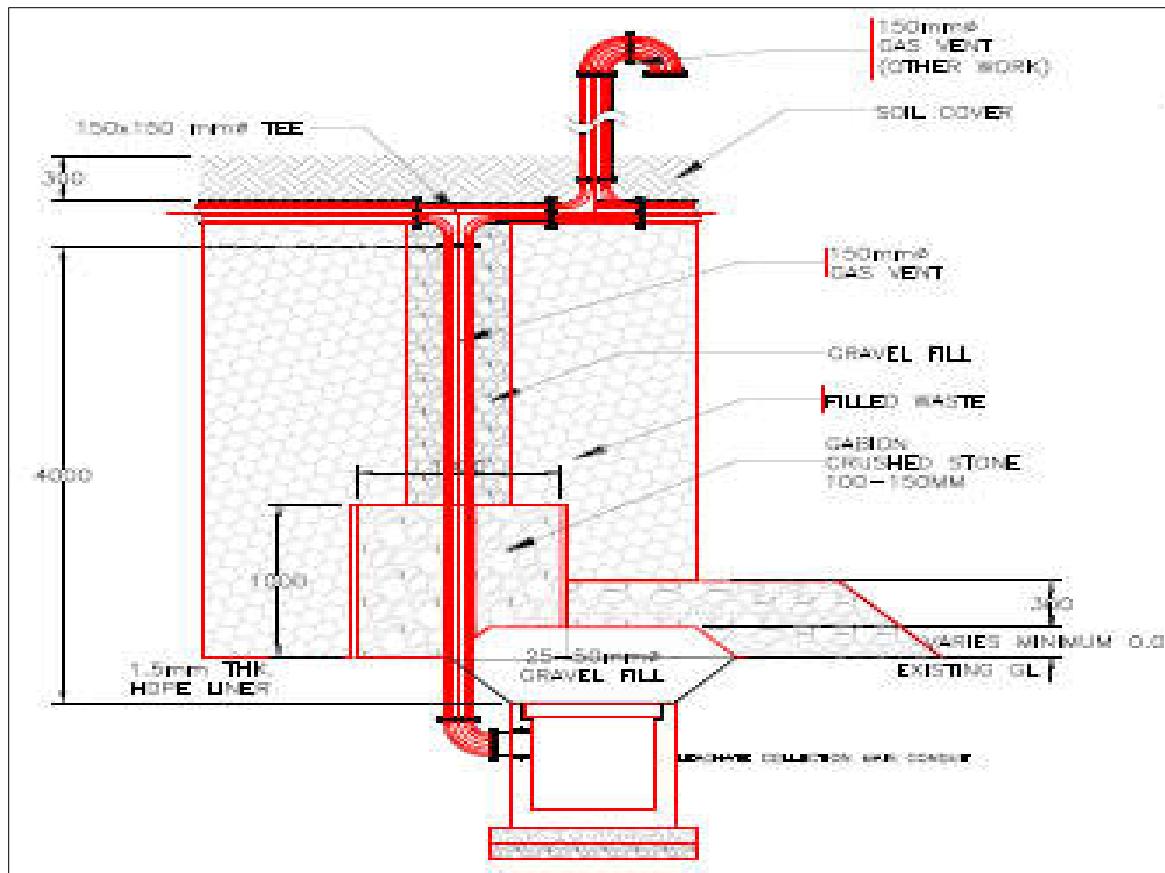
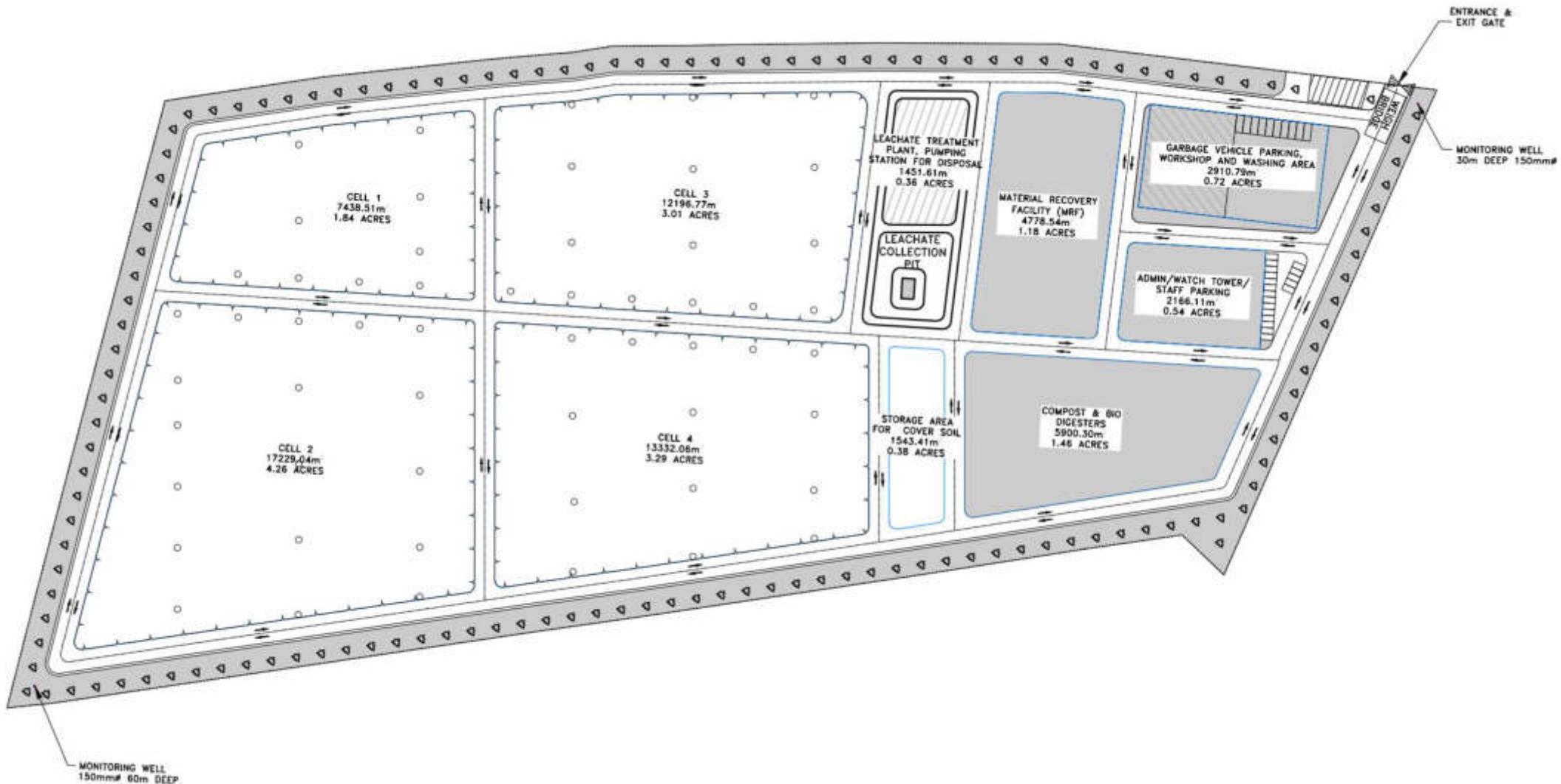
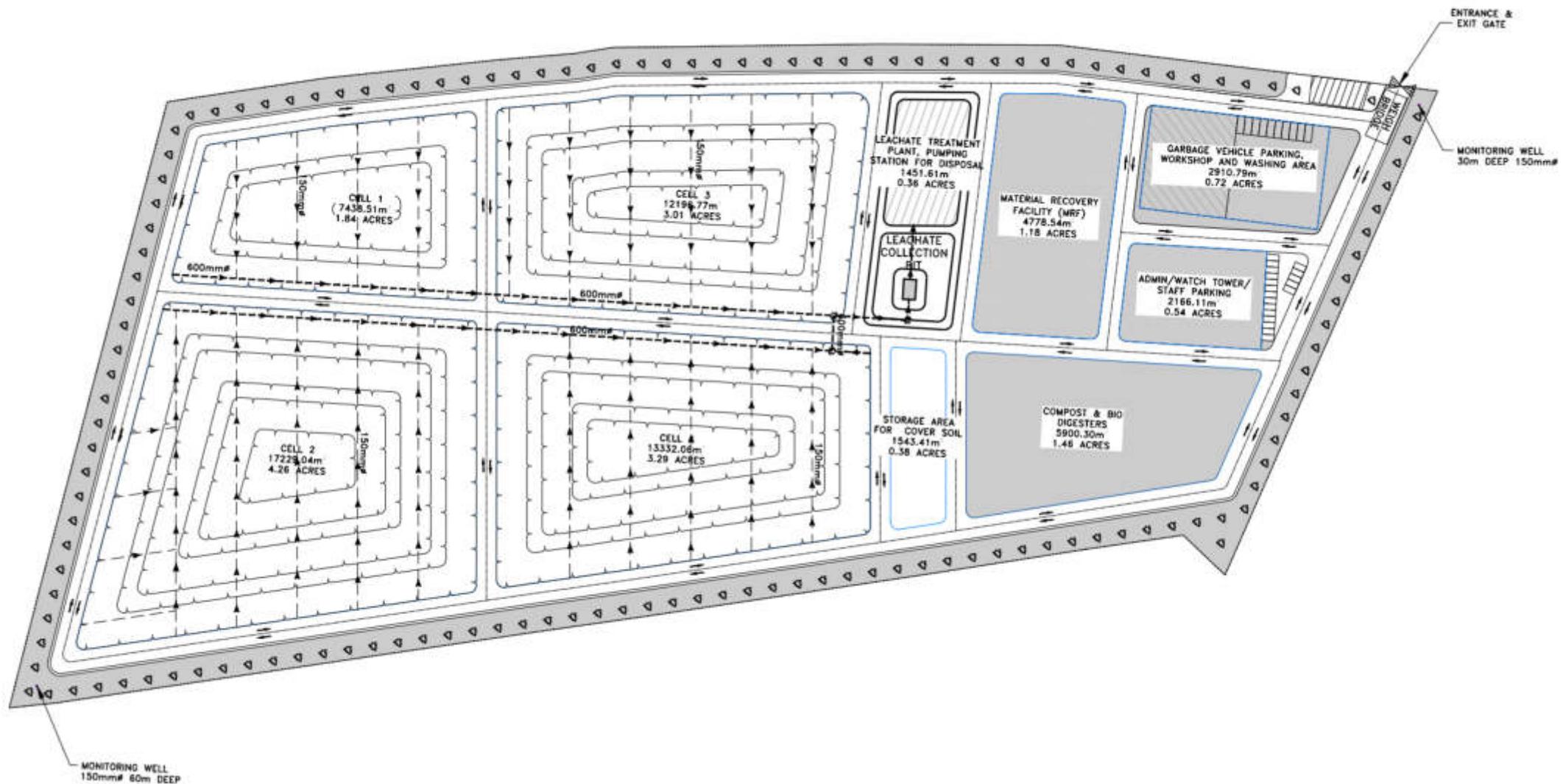


Figure 3-14: Gas Vent System of Mardan Landfill Site



3.2.11 Leachate Collection and Treatment System

135. Leachate produced in a landfill is a liquid which percolates through the waste carrying suspended and soluble materials that originate from or are products of the degradation of the waste. This liquid needs to be managed on site to avoid any seepages into the ground, any spill-over into ditches and drains, influence on gas collection system or effect on the stability of waste fill. For Mardan landfill site, leachate collection and treatment system has been designed which is explained below.
- **Leachate Collection System**
136. Leachate is a waste product produced as a result of decomposition of organic fraction of waste by microorganisms in the landfill site. The mass balance in the leachate generally depends on the biological decomposition in the garbage body, amount of precipitation, temperature changes, and treatment of the leachate and/or transfer rate of the leachate to the treatment facility. This balance will be controlled and arranged according to the conditions during the operation phase. The leachate is collected via main and auxiliary leachate pipes. The longitudinal elevation of the leachate collection pipes laid inside the pebble stone drainage bed at 1% minimum.
137. Auxiliary leachate collection pipelines are planned in each waste cell to be placed at 30 m distance apart. In addition to that, 2 main leachate collection pipes will be placed longitudinally across the 4 waste cells. The main leachate collection pipes shall be HDPE pipes 600 mm in diameter and in PN16 pressure class. The auxiliary leachate collection pipes shall be perforated uPVC pipes 300 mm in diameter and in PN16 pressure class. The main leachate collection pipes conjoin on a common line and connect to the leachate collection pond.
138. A leachate collection system comprising of a drainage layer of either natural granular (sand, gravel) or synthetic drainage material (e.g. geonet or geo-composite) will be considered. Synthetic drainage material may be used on sidewalls of the landfill cells, where the construction and operation of granular material may be difficult. Perforated leachate collection pipes and filter layer will complete the piping network for the waste cell. Leachate collection and treatment system proposed for the landfill site is illustrated in **Figure 3.15** below.

Figure 3-15: Leachate Collection Network for Mardan Site

▪ **Leachate Storage**

139. Leachate production is calculated based on previous climate data and leachate generation model. The leachate collection pit is planned to be positioned to the east of the cells. A leachate holding tank of 500 m³ (sufficient to store 15 days leachate production) will collect the leachate before it enters the treatment plant. Inside the plant, a second over-sized holding tank of 125 m³ will be provided for condensed liquid (membrane refuse) which will be reinjected into the landfill. The sludge from leachate treatment system will be dewatered to 60% water content by air drying followed by disposal in the landfill.

▪ **Leachate Treatment**

140. A leachate treatment plant and pumping station for disposal over an area of 0.36 acres will be developed as shown in **Figure 3-15** above.

Containerized Leachate Treatment solution AIO-DTRO Series

141. The Disk Tube Reverse Osmosis (DTRO) plant will be used for leachate treatment. These are commercially available as package unit which may be procured from the vendor directly and installed. DTRO is a kind of RO (Reverse Osmosis). It has the advantages compared with other processes, such as unaffected by biodegradability and C/N ratio, stable effluent quality, flexible system operation and fast start-up and better handling of the heavy metals which is the major concerns. It has been widely used for landfill leachate treatment as construction costs for leachate treatment have been gradually reduced by these systems over past 10 years.

142. The process flow diagram within DTRO and typical AIO-DTRO series proposed for Mardan facility are shown in **Figures 3-16** and **3-17** below.

Figure 3-16: Process Flow Diagram within DTRO

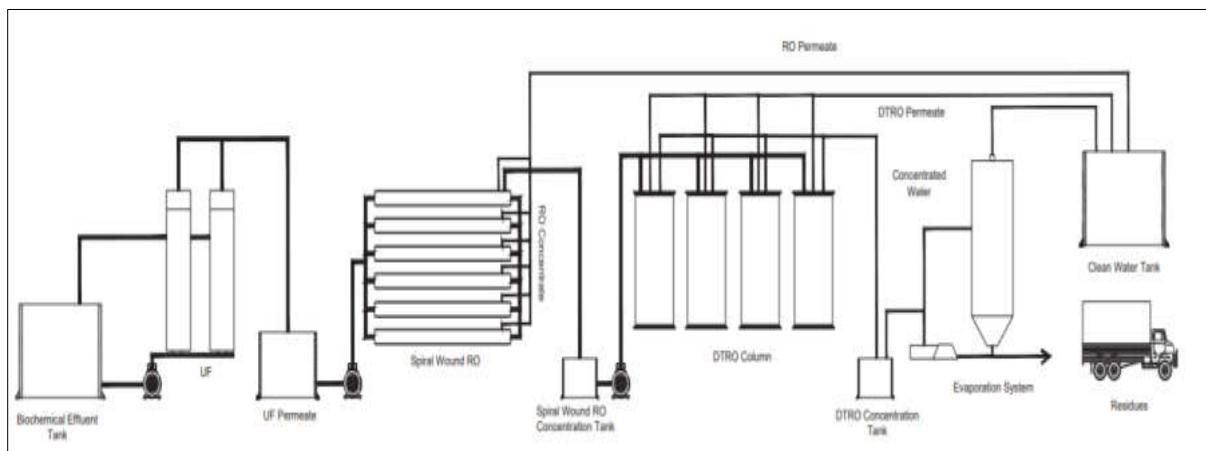


Figure 3-17: Proposed AIO-DTRO Series for leachate treatment***Concentration Basin***

143. An over-sized holding tank to handle 11m³/day will be provided for condensed liquid (membrane refuse) which will be re-injected into the landfill.

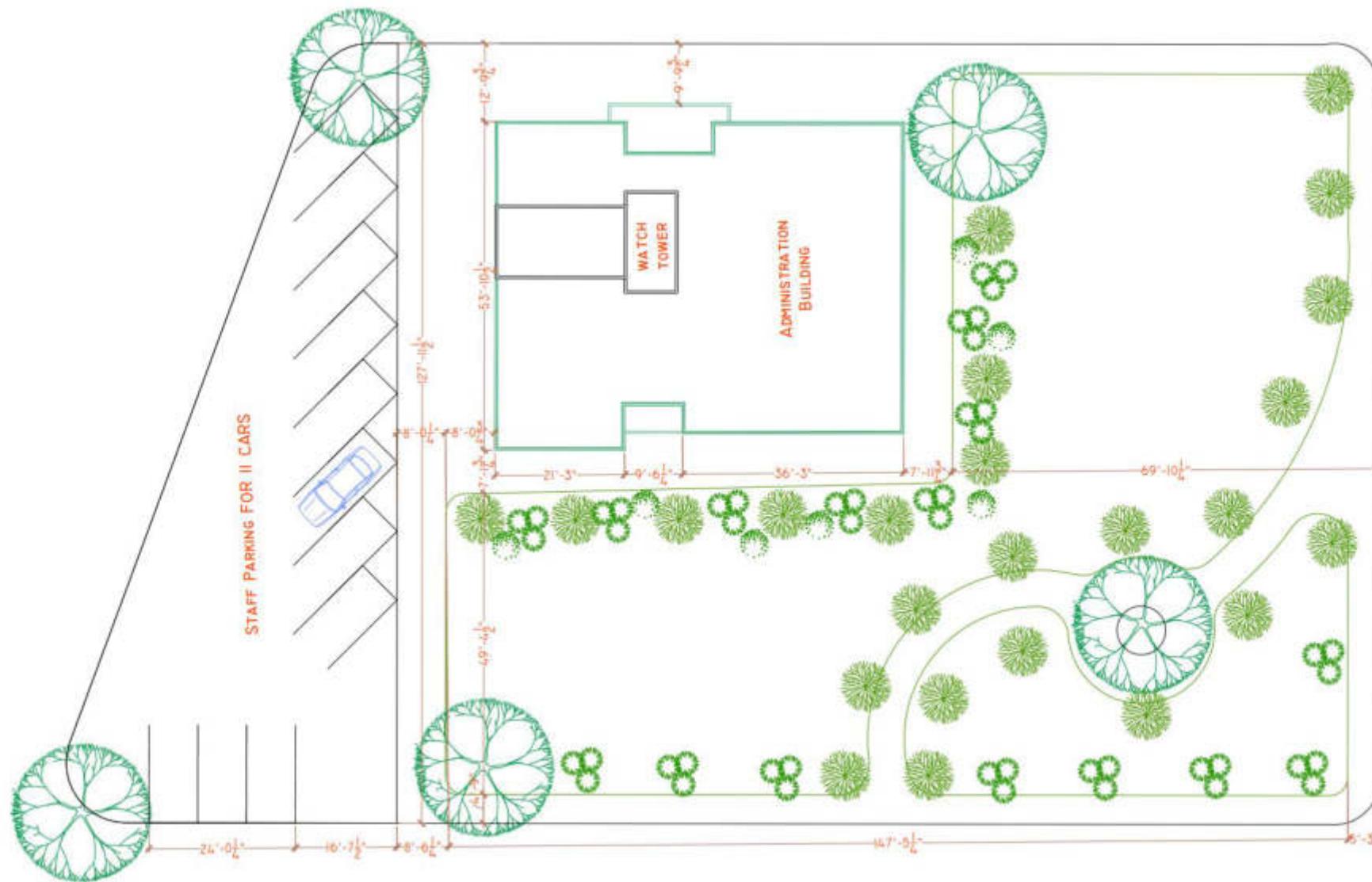
Degassing Unit

144. A degassing tower is provided to act as the stripper which eliminates surplus CO₂ by stripping with air in order to raise the pH of the permeate, which was sent to the top of the stripper and was rinsed downwards through the column counter currently with up flowing air sent by blowers. The stripper will remove 95% of inorganic carbon, and 68% of TOC.
145. Treated water will be stored for application like landscaping and sprinkling or it can be discharged to municipal drains after compliance with NEQS.

Infrastructure / Buildings

146. The proposed landfill will have proper facilities such as administration building, waste reception areas, weigh bridge, CCTV, RFID, access roads, daily soil cover, security, lighting for 24/7 usage and professionally trained workers to operate and supervise.
147. The following building infrastructure is proposed:
- **Administration building and Lookout Tower**
148. A 3-storey high administration building has been designed within the landfill premises. It is planned such that it will accommodate landfill operations team, has a laboratory for quality control and MIS monitoring room for data acquisition and transfer to head office. The building also contains a conference room for meetings at landfill, an inventory room for storing supplies for repair and maintenance of landfill machinery and vehicles. There are showers, prayer area, rest rooms and a kitchen in the building. A car park outside the building is also designed for personnel's' vehicles. The area of the administrative building is surrounded by landscaping and greenery. The building has a look-out tower on the fourth level for viewing operations at the facility. A Lookout tower of height 49'-6" will be constructed for visual surveillance of the landfill facility. The layout of admin building, including lookout tower, is presented in **Figure 3-18** below.

Figure 3-18: Layout of administration building at Mardan SWMF



Construction of roads

149. Roads inside the premises will cover all periphery. Road width will be 10 m wide with two lanes each 4 m for two-way traffic of waste carrying vehicles. Access roads within cells will be kept 8 meters wide while the longitudinal slope has been designed at 1:10. Vehicle parking shed for waste carrying vehicles has been designed along with a workshop for routine repair and maintenance work.

Surface Drainage Network

150. The runoff at landfill will be managed through the provision of surface water diversion channels and collection systems. Drainage for surface runoff along periphery is proposed through a network of RCC drainage channels.

Storage area for Soil Cover

151. Soil or similar inert material shall be used for the lifetime of the landfill site, to cover the waste on a regular basis. Extra thickness of "final cover" material shall also be required once the site has reached completion. The simple spreading of daily cover is a highly effective way to reduce the attraction of waste to birds, suppress odor, prevent fly infestations, discourage rats and other animals and to reduce exposure to atmospheric conditions and to reduce wind blown litter.
152. Ideally, cover material will be taken from within the site, increasing the available space for waste disposal and reducing the need to bring material from elsewhere. The material excavated from the site is estimated to be adequate for use as temporary and final cover material. Final confirmation will be made on remolded permeability of the representative samples taken from the borrow source, if adopted. At this time, we expect that the soil removed during excavation will be used. The soil will be compacted to at least 95 percent of the modified proctor density within a moisture content range of 0 to 3 percent wet of optimum.

Wheel Washing and Vehicle Parking

153. A vehicle parking shed for landfill vehicles and occasional parking of waste carrying vehicles has been designed along with a workshop for routine repair and maintenance work. There will be pumps and nozzles that spray pressurized water to clean the wheels. The wheel washing unit will comprise of a sedimentation tank. The dirt on the wheels of vehicles will settle and the water in the pool will be transferred to wastewater sedimentation tank while the stale water can be used for washing the vehicles.

Workshops

154. There will be two different sections for greasing and oil/filter change for the vehicles, and a waste oil storage tank for storing the waste oil while there will be separate units for welding and electrical repairs.

Tree Plantation/Buffer Zone

155. Inside the boundary wall, tree plantation will be conducted to create an environmental barrier between the external and internal environment. Indigenous tree plantation will be carried out which will serve as the buffer zone. Green belt provided for project is shown in project key plan. For the landfill to present a clean and aesthetically pleasing view, buffer zone with tree plantation and landscaped berms will be done. Plantation will start as one of the earliest activities of site development. Once the design of landfill

is approved and necessary funds mobilized, plantation activity can be started in collaboration with Mardan Development Authority or WSSM can outsource the activity separately.

Boundary Wall

156. The boundary around the landfill will be a wall constructed of brickwork of 9" thickness all around the premises.

3.2.12 Construction Phase Details for SWMF

Construction Schedule

157. The project construction phase is expected to last for a total of 2 years with the activity expected to commence in the second quarter of 2021 and completed by mid of 2023.

Construction phase activities

158. The activities to be conducted during construction phase of the project are provided below:

- **Development of Construction and Labor Camps**

159. One of the first activities to be completed by the Contractor shall be the establishment of the construction and labor camp. The Contractor will also establish construction yards and sites (including storage and batching plant), offices and a workshop.

160. The construction of the proposed landfill will be divided into construction work packages and these packages will be awarded to the selected project Contractors.

161. The construction activity has to span over approximately twenty-four months. There shall be a number of contracts for a variety of works. The selected Contractors shall have the option to select suitable site(s) located near the project sites to establish his labor camps. If private land is selected, the Contractor shall enter into contract with the private owner. During construction phase, an estimated 150-200 persons consisting of both semi-skilled and skilled human resource will be required.

162. Essential for the work bases is easy approach, availability of a suitable place for temporary storage of material and availability of water for construction in the vicinity. Presence of shade from trees close to the work bases can add to the comfort of the labor while taking rest during the hot season.

163. The location of storage materials and camps will be critical. Since the project contractor(s) will be responsible for identifying the suitable locations for storage and labor camps from the private sector, thus there will need to be clear guidelines for this process, which will need to be closely monitored by the implementing agency. As far as possible, the project design team shall be assigned the task to identify the suitable location(s) for storage of materials since inappropriate storage of materials may result disruption of the traffic movement.

164. The proposed site for the Contractor's camp shall include the following facilities:

- **Labor camp site**

- Accommodation

- Kitchen
- Dining area
- Sanitation facilities
- Septic tank
- Liquid and solid waste disposal facilities
- Generator(s), for operation when the power supply from the grid station was not available

- **Construction camp site**

- Uncovered material storage
- Covered material storage
- Parking for vehicles and plant
- Batching plant
- Generator(s)
- Site offices

- **Workshop site**

- Workshop
- Storage area
- Generator(s)

- **Site preparation**

165. There may be a need to carry out cutting and filling of the land in order to attain the designed ground elevation. During the process, areas above the design elevation shall be cut and spoils shall be used to fill areas below the designed elevation. The area is to be clean of any obstructions in areas where the general design elevation is already attained. Cut and fill activities will be carried out using mostly heavy mechanical equipment. Manual labor will be negligible.

166. The ground will be compacted until the desired ground bearing capacity is attained. This is to ensure that all structures, particularly the foundations to be erected are stable and will not be subject to subsidence, settlements and other earth pressures.

- **Development of Access Roads & Internal Roads, drainage facilities and other horizontal earth works**

167. Haul roads from the reception area to the entrance to each phase shall be designed to a standard adequate to allow trafficking of heavy vehicles. Haul roads may need to accommodate the passage of heavy construction vehicles e.g. steel wheel compactors and tracked bulldozers. Service roads to other facilities on site e.g. leachate treatment

plant, gas extraction system, should be to an adequate standard to allow access by service vehicles.⁴

168. Particular attention should be given to the access point to each cell. It is important that the access routes chosen do not put the liner at risk. Typical access ramps will be up to 6m in width and have slopes up to 10%.

- **Construction of building infrastructure**

169. Site building infrastructure must be designed, constructed and maintained to a high standard and should include the following facilities:

- Administration building consisting of an administration office, first aid area and general reception area;
- Sanitary facilities: showers and toilets;
- Staff facilities: lockers and mess room;
- Waste reception area;
- Monitoring equipment store;
- Equipment maintenance and fuel storage; and
- Parking area
- Properly installed ventilation to reduce the spread of COVID-19

170. Purpose built buildings will be constructed with on-site laboratory facilities provided as necessary. The administration building would include a working telephone, a facsimile machine and would be suitable for the storage of records.

- **Construction of the weighbridge system and Unloading Bay and its components**

171. The weighbridge should be located adjacent to the waste reception area and sufficiently far enough away from the public road to avoid queuing onto the road. Weighing facilities should be adequate to accommodate the weighing of both incoming and outgoing traffic if necessary.

- **Construction of MRF & Allied Machinery**

- **Landfill Site Construction**

172. The development of the landfill area will consist of the following activities:

- Excavation for landfill cell and bottom lining along with leachate collection and treatment pond & gas collection pipes;
- Construction of the access ramps, leachate collection and treatment pond;

⁴ https://www.epa.ie/pubs/advice/waste/waste/EPA_landfill_site_design_guide.pdf

- Run off and run on collection network;
- Final capping and arrangements for gas venting and flaring;

Construction Machinery Requirement

173. For storing materials, stocking equipment and parking machinery and vehicles, the Contractor(s) shall require open and accessible sites close to the labor camps. The Contractor(s), at his own expense, but keeping in view his contractual obligations to honor the applicable national and international guidelines regarding level of pollution, shall make the arrangements.
174. The **Table 3.9** below outlines the approximate number of major machinery and vehicles that are envisaged to be required for the project construction works.

Table 3.9: Estimated Contractor's Equipment and Machinery

Sr. No.	Machinery / Equipment	Quantity required*
1	Excavators	4
2	Dumpers	2
3	Batching Plants	1
4	Loaders	2
5	Power Generators	4
6	Rollers	2
7	Tractor Trolley	6
8	Transit Mixer	1
9	Compactor / Roller	2
10	Crane	1
11	Crush Plant	1
12	Concrete Pump	1
13	Vibro Hammer	1
14	Welding Generators	2
15	Watering Tanks (moveable)	3
16	Haulage Trucks	20
17	Cars/Pickups	8

* Number of machinery is indicative and can be changed subject to working schedule.

Construction Materials Requirement

175. During the construction phase, construction materials in considerable volumes will be required. Typical material required for landfill cell development include base mineral liner, cap barrier layer, leachate drainage blanket; other drainage layers e.g. capping

layer and groundwater/surface water, gas collection and venting system, road material and daily cover. The common source of the materials required for civil works are described in **Table 3.10** below.

Table 3.10: Source of Raw Material

Sr.#	Raw Material	Source
1	Earth Material	Available locally, borrowed from the lands acquired for the project.
2	Aggregate	Available at many sources within the vicinity of the site.
3	Rip-rap material	Available locally from nullah bed deposits and rock excavations.
4	Sand	Sand is available in near vicinity and river bed.
5	Water	Ground water is available at depth of 4-5 feet and it will be used for construction purpose.
6	Cement	Ordinary Portland Cement is suitable, which is available at various factories in Pakistan mainly from Mardan.
7	Reinforcement steel	Steel re-rolling mills in Mardan meeting the standards from the billet produced either by Pakistan steel or imported. These will serve the purpose of steel availability.
8	Energy	Electricity supplies are available at the site through WAPDA grid, located at a distance of 25 km.

3.2.13 Operation Phase Details for SWMF

Scope of Activities

176. The activities to be conducted during the operational phase of proposed project are provided in **Table 3.11** below.

Table 3.11: Operation Phase Activities

Landfill Development	Operation activities involved
Waste hauling to LFS	The compactor truck will transfer waste from Mardan city to the landfill site.
Weigh Bridge and Unloading Bay	<ul style="list-style-type: none"> ▪ Weighing operation ▪ Maintenance of mechanical and electrical equipment
Landfill site operations	<ul style="list-style-type: none"> ▪ Waste inventory management ▪ Material Recovery Facility ▪ AD and Composting Facility ▪ Daily cover ▪ Leachate management (i.e., collection, treatment and disposal) ▪ Landfill gas management (i.e., monitoring, collection, flaring) ▪ Environmental monitoring
General Operations	<ul style="list-style-type: none"> ▪ Admin block operations ▪ Maintenance of equipment and machinery ▪ Vehicle servicing ▪ Disposal of solid waste and waste water generated during operations ▪ Workers Health and Safety ▪ Site Security

Operation Equipment and Machinery

177. The equipment required during the operation phase of the landfill site can be divided into three functional categories: waste movement and compaction, earth cover transport and compaction, and support functions. The **Table 3.12** below provides the equipment expected to be required for operation phase of the landfill site.

Table 3.12: List of Equipment and Machinery for operation phase of Landfill Site

Sr. No.	Machinery / Equipment	Equipment use in landfill operations	Quantity required*
1	Bucket Loader	It is used to fill earth cover material into vehicles at landfill site.	1
2	Chain Dozer	It is used for leveling of waste or excavated soil at the landfill site.	1
3	Trash Compactor	It is used for compaction, propulsion and spreading of waste in a landfill.	1
4	Hydraulic Excavator	It is used for Excavation purposes.	1

* Number of machinery is indicative and can be changed subject to working schedule.

Manpower Requirement

178. It is expected that existing organizational capacity of WSSM may not be able to successfully run the future model, therefore, ISWM system along with human resource requirement will be proposed. The institutional design of the WSSM and its linkage with line reporting departments would be reviewed. The agreement will be reviewed and KPIs would need to be aligned with the design of the solid waste management system.
179. An institutional review and capacity building firm has been engaged under the project to successfully operationalize the project and improve the capacity of WSSM in terms of efficient SWM service delivery.
180. Estimated manpower requirements during construction phase of the project would be about 150-200 persons while during operation phase would be 50 persons.

3.2.14 Closure and Post Closure Plan for SWMF

181. Both the Closure and Post Closure plans will come into effect towards the end of the SWMF's useful life, usually 40 to 50 years from commencement of operation of the SWMF. In this time, there could be marked changes made to them depending on how environmental and socioeconomic conditions in and around the site and Mardan city have evolved.
182. The closure plan will include:
- Landfill cover and landscaping of the completed site;
 - Long term plans for the control of runoff, erosion, gas and leachate collection & treatment.
183. Post closure plan will include:

- Routine inspection of completed landfill;
 - Maintenance of surface water diversion facilities, landfill surface grades, the condition of liners;
 - Maintenance of landfill gas and leachate collection equipment;
 - Long term environmental monitoring plan so that no contaminants are released from the landfill site.
184. These plans have yet to be developed but will be customized to the proposed SWMF facility and will be prepared within first few years after commencement of the SWMF.

3.3 Institutional Review and Capacity Building (IRCB) Contract

185. In order to execute successful operation of SWMF facility at Mardan, institutional review and capacity building (IRCB) component is included in the project design to enhance services delivery of WSSM. PMU KPCIP has awarded IRCB contract to consortium of four firms in November, 2020. It is an integral part of the larger multi-year KPCIP. IRCB contract will facilitate improvements to the business model to ensure operational efficiency and sustainability. IRCB firm will conduct an applicable training needs assessment and training plans.
186. IRCB contract will facilitate performance benchmarking of KPCIP based on an understanding of current operations and developing an output-based monitoring system for impact of the planned sub-project investments. IRCB will evaluate business model by considering following options.
- Service delivery by the WSSP (or other government or quasi-government entity)
 - Service delivery by outsourcing to a private sector provider
 - Service delivery via a hybrid of the above two options
 - Service delivery by other, innovative means, such as community initiative, that may not have been initially identified
187. PMU KPCIP will design capacity building interventions using participatory approach through IRCB contract. PMU KPCIP will define monitoring of IRCB contract in project administration manual and will closely monitor the effectiveness of IRCB contract within WSSM.

3.4 Climate Risks from Project

3.4.1 Climate Change Trends and Extremes in Mardan

188. Increases in precipitation, urban flooding and possibly high temperature are considered as the key potential climate change impacts for Mardan city. These are expected to increasingly effect household and business assets, livelihoods and water supply. They are also expected to exacerbate the challenges associated with urban and transport infrastructure development, choking of drains, community health and energy supply (ADB 2017a). Union Councils (UCs) in Mardan face floods from main nullahs, rivers, streams together with urban flooding. Rivers and streams floods are mainly due to intense rainfalls events, while urban flooding is due to intense rainfall events as well as due to changes in land-use (converting bare soil to concrete surface during residential area growth) and due to inadequate sewage and drainage system.

189. Dominated by the monsoon seasonal patterns, Mardan's climate can be categorised as comprising winter (November to March) and summer (June to September) seasons, including western disturbances entering from Afghanistan and Iran. Based on Risalpur climate station data (1954-2015), monthly average temperature during winter ranges from 17.1°C to 9.7°C, where the highest monthly average temperature was 35.4°C, observed in June 1984. During summer, the monthly average temperature ranges from 28.5°C to 33°C. There are no statistically significant increasing trends in historic maximum temperature except for the month of May, where about 1.55°C rise occurred during last 62 years. Summer days (temperature > 25°C) are projected to be increased by 92.6 days during 2011-2100. These will eventually affect different infrastructure as well as will increase energy consumption, will decrease human work efficiency, and will adversely affect human health.
190. Average annual rainfall was 657 mm during the period 1954-2015 as recorded by the Pakistan Meteorological Department, (PMD), Risalpur climate station. The highest annual rainfall was recorded in 1959 (1,273mm), whilst the second highest annual precipitation (1,077mm) was recorded 2013. Annual precipitation of 2010 stands at fourth highest record (1,065mm). Historic precipitation data show an increase in overall annual precipitation together with an increase in local streams/nullahs flows. One of the major nullah in Mardan is Kalpani, where an increase in flows is statistically significant during 1980-2015. Future precipitation is also expected to rise, although extreme events are not statistically significant. Such increase in flow events and increase in precipitation may rise potential urban flooding together with seasonal flooding in Mardan. Increase in such events will also affect waste water and solid waste disposals.
191. Future climate projections based on GCM (CanESM214) show increase in summer days (> 25°C) under RCP15 8.5 scenario. Annual average temperature and annual precipitation also show rise under RCP 4.5 and RCP 8.5 during 2011-2040, 2041-2070 and 2071-2100 periods compared to 1976-2005 period. However, some of the future projection trends are not statistically significant.
192. Based on CSIRO-CCAM16 RCM, precipitation is expected to rise between 142 mm/yr to 174 mm/yr during 2011-2100, compared to 1976-2005 period, based on both scenarios. Maximum temperature is also expected to rise between -0.1°C to 5.45°C during 2011-2100 compared to 1976-2005. Similarly, minimum temperature is expected to rise between 0.94°C to 4.8°C during 2011-2100 compared to 1976-2005. There is no clear monthly precipitation pattern change during 2011-2100 compared to base period. However, maximum precipitation rise is expected during summer monsoon period. Overall precipitation may rise during the future whereas decadal precipitation does not show any linear rise. In contrast both maximum and minimum decadal temperature show linear rise.
193. Sudden rise and fall in terrestrial temperatures cause low air pressures, bringing whirling winds since during April and May days are relatively warmer and the nights are cooler in Mardan where frequency of wind storms is higher in these months as compared to other seasons according to a study⁵.
194. These climate change patterns and socio-economic changes including rapid urbanization can cause urban flooding events. Intense precipitation as well as infrastructure developments that have reduced urban surface interception, flash floods are increasing, which are likely to continue to become more severe in the future. Urban

⁵ Ata Hussain , Hazrat Mir & Muhammad Afzal (2005). Analysis of dust storms frequency over Pakistan during 1961-2000, Pakistan. Journal of Meteorology Vol. 2: Issue 3: (March 2005) 49 (quoted in ADB 2017a)

flooding is largely due to intense precipitation and changes in land use (especially increased concrete surfaces due to residential and commercial area growth) and due to inadequate sewerage and drainage systems while the main nullahs, rivers, streams are flooded due to intense rainfall.

195. Moreover, due to lack of open spaces, water storage ponds and a properly designed urban drainage system, increased surface water due to heavy rainfall has been transported through the existing sewerage systems. This lack of capacity to drain away surface water due to heavy precipitation is most likely the potential cause of increased urban and seasonal flooding in Mardan as well as disrupted waste water and solid waste disposal systems. The observed climatic changes and their potential impact is summarized in **Table 3.13** below.

Table 3.13: Climate Change and potential impacts for Mardan

Climate Trend	Description	Current/ Potential Impact
Temperature rise	<p>A temperature rise of 1.55°C observed in the month of May over last 62 years.</p> <p>Monsoon period shows a decline in maximum as well as minimum temperature</p> <p>Future climate projections show that during the period 2011– 2100, maximum temperature could further rise by 1.55°C to 5.5°C, while minimum temperature could rise by 1.96°C to 6.61°C</p>	<p>Risk of more frequent and intense heatwaves in Mardan, leading to increased mortality and morbidity in the region</p> <p>Increased per capita demand for water consumption due to warmer weather</p> <p>Decline in ground and surface water availability leading to drought like conditions</p> <p>Crop failure in surrounding peri-urban areas that could reduce regional food security</p> <p>Increased demand for electricity, and damages to power lines and infrastructure</p> <p>Increased damages to road surface and other communication infrastructure</p>
Increased summer days	<p>Summer days (temperature > 25°C) are projected to be increased by 92.6 days during 2011-2100.</p>	<p>Increased demand for water and Electricity</p> <p>Increased incidence of vector borne diseases including dengue, malaria and cholera</p>
Increased annual precipitation and changes to hydrological regime	<p>Historic precipitation data show an increase in overall annual precipitation together with an increase in local streams/nullahs flows. Shifting monsoonal patterns are also observed over the area</p> <p>Future level of annual precipitation is also projected to increase during 2011-2100 under RCP 4.5 and RCP8.5</p>	<p>Increased flooding from storms and heavy rainfall (especially flash and riverine flooding in Kalpani) in the area, resulting in damages to life and assets (infrastructure including communication, electricity, water supply etc.). Greater water runoff from storms, instead of normal rainfall retention in ground</p> <p>Increased demands on drainage and storm water management systems; sewer overflow</p> <p>Higher levels and period of humidity caused by high temperatures combining with</p>

	<p>scenarios. According to RCP 4.5 precipitation may reach to 972 mm/yr during 2071-2100 compared to base period (1976-2005).</p>	<p>increased precipitation, affecting human health and infrastructure.</p> <p>Increased water supply contamination and health effects.</p>
--	---	--

3.4.2 Climate Change Considerations for Landfill Site

- 196. Climate change can impact different aspects of the landfill site due to projected increased temperatures and intense floods from heavy rainfalls at the location of the landfill site. These climatic changes in the nearby areas can also have serious consequences at the landfill site due to flash flooding.
- 197. In addition to the impacts of changing climate, landfill sites can also be a source of greenhouse gas emissions which need to be considered for climate change mitigation options. These gases can also create a fire hazard due to a change the decomposition rates caused by increased temperatures.
- 198. Based on the Climate Risk and Vulnerability Assessment (CRVA) theoretical framework, it is important to assess the climate change exposure and sensitivity of the landfill site and suggest possible adaptation measures with respect to the identified elements. The suggested adaptation measures need to be monitored and re-evaluated as a continuous process during the operations for any required changes to ensure that the suggested measures are sustained over the life span of the landfill site. Three aspects of landfill sites are assessed for potential climate change impacts (temperature, precipitation, winds, fire hazard) in terms of exposure and sensitivity: 1) underground components, 2) over-ground components and 3) Site infrastructure and operations, provided as **Table 3.14** below.
- 199. **Climate Change Exposure of Landfill Site:** This includes identification of climate change hazards in the context of potential climate scenarios. For example, precipitation changes can degrade covers of landfill. Moreover, a number of anthropogenic stressors, socio-economic and land-use changes near and around the landfill site in the future may complicate and exacerbate the above-mentioned climate change events and increase exposure of the site. Temperature changes can impact the composting process and also can impact the decomposition process responsible for leachate production. For example, land-development can affect natural protective barriers. Some of these non-climatic stressors are provided in **Table 3.15** below.
- 200. **Climate Change Sensitivity of Landfill Site:** Likelihood of climate change related hazards are included in sensitivity assessment that could negatively affect the functioning of the landfill site including direct impacts (accessibility, physical damage, water damage) and indirect impacts (accidental fire, explosion or ecosystem damage). These direct and indirect impacts can affect the landfill site in terms of damage to liner or cover materials, washout of contaminated contents, leachate collection and removal, landfill gas management etc.

Table 3.14: Sensitivity Considerations for Landfill Site

System Components		Vulnerabilities		
		Physical Damage	Water Related Damage	Access
Landfill Components	Pipe systems for leachate treatment and disposal of landfill gas collection and transfer	X	X	X
	Transfer pumps for leachate and landfill gas	X	X	
	Treatment pond for leachate	X		X
	Pre-treatment of landfill gas (coolers, condensers, blowers)	X	X	
	Landfill gas flares	X	X	X
	Storage containers for chemicals	X	X	X
	Disposal system for treatment residuals	X	X	X
	Discharge system for treated leachate	X	X	
	Auxiliary and monitoring equipment	X	X	
	Synthetic materials (e.g. geomembrane in liners or cover system, geotextile for leachate filtration)	X	X	
	Bottom layer of unlined waste		X	
	Vegetative layer for an evapotranspiration cover	X	X	
Infrastructure and Landfill Site Operations	Groundwater or landfill gas monitoring wells	X		X
	Composting facility & AD system	X	X	
	Material Recovery Facility	X	X	
	Surface water drainage systems	X	X	X
	Fencing, boundary walls for access control and litter prevention	X		
	Unpaved road to landfill site			X
	Buildings, sheds etc.	X	X	X
	Natural gas and electricity connections/lines	X	X	X

Table 3.15: Non-climate Stressors and Potential Impact on Landfill Site

Non-climatic Events	Potential Impacts on Landfill Site
---------------------	------------------------------------

Land-use changes (e.g. new housing schemes, commercial buildings, small businesses and other built environment etc.)	<ul style="list-style-type: none"> Road leading to the site might be encroached or get congested in the future Wastewater generation and its disposal from the new commercial and domestic activities
Agriculture practices (changes in cropping patterns and water usage)	<ul style="list-style-type: none"> Seepage near the landfill site
Modification /construction of irrigation networks	<ul style="list-style-type: none"> Seepage near the landfill site, flooding due to increased water usage
Construction of new roads	<ul style="list-style-type: none"> Obstruction natural water ways might cause flooding
Groundwater contamination	<ul style="list-style-type: none"> Groundwater aquifers contamination due to leachate

201. The above-mentioned sensitivity and exposure analysis is based on available information in the concept designs, detailed design, other reports and information on general components of a landfill site.

4 Description of Environment

4.1 General

202. Mardan is a metropolitan city and is located at the north-west end of Pakistan, about 140 km west of federal capital Islamabad.
203. The proposed SWMF site is located in the outskirts of Mardan city at a distance of approximately 20.5 km from the city center.
204. The description of various features of the project area environment including the physical, ecological, cultural and socio-economic environmental aspects are presented in the following sub-sections.

4.2 Physical Resources

4.2.1 Topography

205. Mardan is situated near the eastern end of the Khyber Pass and sits mainly on the Iranian plateau along with the rest of the Khyber-Pakhtunkhwa.
206. Mardan district may broadly be divided into two parts, north eastern hilly area and south western plain. The entire northern side of the district is bounded by the hills. In the district, the highest points in these hills are Pajja or Sakra, 2056 meters high and Garo or Pato, 1816 meters high. The south western half of the district is mostly composed of fertile plain with low hills strewn across it. It is generally accepted that this plain once formed the bed of a lake which was gradually filled up by the load of the river flowing into from the surrounding hills. From the foothills the plain runs down at first with a steep slope which carried the rain water to the lower levels and ultimately to the Kabul river. Mardan is located in the south west of the district at 34° 12' 4.4" N 72° 0' 33" E and an altitude of 283 metres (928 ft).
207. Mardan is the district headquarter of Mardan district of Khyber Pakhtunkhwa. Risalpur is located to the south; Charsadda is located to the west, Yar Hussain to the east and Takht Bahi and Katlang to the north. It is the second largest city in Khyber Pakhtunkhwa, while 19th largest city of Pakistan.

4.2.2 Soils

208. The ground comprises of Very Soft to Soft to Firm to Stiff Lean Clay/Silty Clay/Silt/ up to a depth of 7.0 m underlain by Medium Dense to Very Dense Poorly Graded Sand with Silt/Silty Sand, with a sandwiched layer of Very Stiff to Hard Silty Clay/Lean Clay/Sandy Silt, up to a depth of 21.0 m underlain by Stiff to Very Stiff to Hard Lean Clay/Silty Clay/Silt up to maximum investigated depth of 25.0 m below EGL.
209. The average Net allowable bearing capacity for Isolated Foundation at a depth of 1.25 m (Width ranging from 1.0 m to 3.0 m) below EGL is 0.93 tsf, while average Net allowable bearing capacity for Strip Foundation at a depth of 1.25 m (Width ranging from 1.0 m to 3.0 m) below EGL is 0.8 tsf.
210. In addition, a summary of the ground soil conditions based on different boreholes conducted across the proposed project site are provided as **Table 4.1** below.

Table 4.1: Summary of ground conditions across Project Site

Borehole No.	Top Depth (m)	Bottom Depth (m)	Description
BH-01			
BH-01	0	7	Brown, Soft to Firm, Low Plastic, Low Dry Strength, Wet, Lean Clay.
BH-01	7	12	Grey, Medium Dense to Dense, Fine Grained, Dilatancy Quick, Wet, Silty Sand. Trace Mica.
BH-01	12	15	Grey, Medium Dense to Dense, Fine Grained, Dilatancy Quick, Wet, Poorly Graded Sand with Silt. Trace Mica.
BH-01	15	16.5	Brown, Hard, Non to Low Plastic, Low Dry Strength, Wet, Silty Clay. Little Fine Grained Sand.
BH-01	16.5	19.5	Grey, Dense to Very Dense, Fine Grained, Dilatancy Quick, Wet, Silty Sand. Trace Mica.
BH-01	19.5	23	Brown, Very Stiff to Hard, Non to Low Plastic, Low Dry Strength, Dry, Silty Clay.
BH-01	23	25.45	Brown, Very Stiff to Hard, Non Plastic, Moist, Silt.
BH-02			
BH-02	0	3	Brown, Firm to Stiff, Low Plastic, Low Dry Strength, Wet, Lean Clay.
BH-02	3	4	Brown, Soft, Non to Low Plastic, Low Dry Strength, Wet, Silty Clay
BH-02	4	5	Brown, Very Soft, Non Plastic, Wet, Silt.
BH-02	5	6	Brown, Soft, Non to Low Plastic, Low Dry Strength, Wet, Silty Clay.
BH-02	6	9	Grey, Medium Dense, Fine Grained, Dilatancy Quick, Wet, Silty Sand. Trace Mica
BH-02	9	10	Brown, Medium Dense, Non Plastic, Wet, Sandy Silt.
BH-02	10	17	Grey, Medium Dense to Dense, Fine Grained, Dilatancy Quick, Wet, Poorly Graded Sand with Silt. Trace Mica.
BH-02	17	18.5	Brown, Hard, Non to Low Plastic, Low Dry Strength, Moist, Silty Clay.
BH-02	18.5	20	Brown, Very Stiff, Non Plastic, Moist, Silt.
BH-02	20	23	Brown, Stiff to Very Stiff, Non to Low Plastic, Low Dry Strength, Moist, Silty Clay.
BH-02	23	25.45	Brown, Stiff to Hard, Non Plastic, Moist, Silt.
BH-03			
BH-03	0	4	Brown, Soft to Stiff, Low Plastic, Low Dry Strength, Wet, Lean Clay.
BH-03	4	5	Brown, Very Stiff to Hard, Non to Low Plastic, Low Dry Strength, Silty Clay. Trace Fine Grained Sand.
BH-03	5	6	Grey, Medium Dense to Dense, Fine to Medium Grained, Dilatancy Quick, Poorly Graded Sand with Silt
BH-03	6	7	Grey, Loose, Fine Grained, Wet, Clayey Sand
BH-03	7	8	Grey, Medium Dense, Fine Grained, Dilatancy Quick, Wet, Silty Sand.

Borehole No.	Top Depth (m)	Bottom Depth (m)	Description
BH-03	8	9	Brown, Hard, Non to Low Plastic, Low Dry Strength, Wet, Silty Clay.
BH-03	9	11	Brown, Firm, Non Plastic, Wet, Sandy Silt.
BH-03	11	19.5	Grey, Medium Dense to Dense, Fine Grained, Dilatancy Quick, Wet, Silty Sand. Sand is Very Dense at 18.00m.
BH-03	19.5	22.5	Brown, Stiff, Non to Low Plastic, Low Dry Strength, Wet, Silty Clay.
BH-03	22.5	24	Brown, Very Stiff, Low to Medium Plastic, Medium Dry Strength, Wet, Clay.
BH-03	24	25.45	Brown, Stiff to Very Stiff, Non to Low Plastic, Low Dry Strength, Wet, Silty Clay.
BH-04			
BH-04	0	7	Brown, Very Soft to Stiff, Low Plastic, Low Dry Strength, Wet, Lean Clay.
BH-04	7	9	Grey, Medium Dense, Fine Grained, Dilatancy Quick, Wet, Silty Sand. Trace Mica
BH-04	9	12	Brown, Very Stiff to Hard, Low Plastic, Low Dry Strength, Wet, Lean Clay.
BH-04	12	21	Grey, Medium Dense to Dense, Fine Grained, Dilatancy Quick, Wet, Silty Sand. Trace Mica.
BH-04	21	25.45	Brown, Very Stiff to Hard, Non to Low Plastic, Low Dry Strength, Moist, Silty Clay.
BH-05			
BH-05	0	1	Brown, Stiff, Non Plastic, Wet, Silt with Concretion.
BH-05	1	7	Brown, Soft to Firm, Low Plastic, Low Dry Strength, Wet, Lean Clay. Trace Concretion at places.
BH-05	7	21.5	Grey, Medium Dense to Very Dense, Fine Grained, Dilatancy Quick, Wet, Silty Sand. Trace Mica.
BH-05	21.5	25.45	Grey, Medium Dense to Very Dense, Fine Grained, Dilatancy Quick, Wet, Poorly Graded Sand with Silt. Trace Mica.

211. In addition, the recommendations of the geotechnical investigation of the project site are as follows:

Formation of Temporary and Final Cover

- Soil or similar inert material should be used for the lifetime of the landfill site, to cover the waste on a regular basis. Extra thickness of "final cover" material shall also be required once the site has reached completion.
- The simple spreading of daily cover is a very effective way to reduce the attraction of waste to birds, suppress odor, prevent fly infestations, discourage rats and other animals, to reduce exposure to atmosphere conditions and to reduce wind blow litter.

- Ideally, cover material should be taken from within the site, increasing the available space for waste disposal and reducing the need to bring material from elsewhere.
- The material excavated from the site should be adequate for use as a temporary and final cover material. Final confirmation should be made on remoulded permeability of the representative samples taken from the borrow source if adopted. At this time, it is expected that the soil removed during excavation will be used.
- The soil should be compacted to at least 95 percent of the modified proctor density within a moisture content range of 0 to 3 percent wet of optimum.

Excavation at Site

- The excavation required for the construction of foundation up to a shallow depth of about 1.0 m, can be made without provision of any supporting system. The provision of dewatering must be kept in the scope of work of construction due to possibility of rainy season, during construction.
- The excavation for the land fill area can be easily done with simple mechanical means. Since the adjacent areas are open therefore, no major stability issues are anticipated to result in property loss, however, it is recommended to excavate at a slope angle established by hit and trial method at site for an excavation of about 6 m, which is foreseen in the light of current ground conditions.
- As a broad guideline it is suggested to adopt a slope angle of 2H:1V, however, based on hit and trial method adopted at site, the angle can be further steepened.

Liquefaction Potential

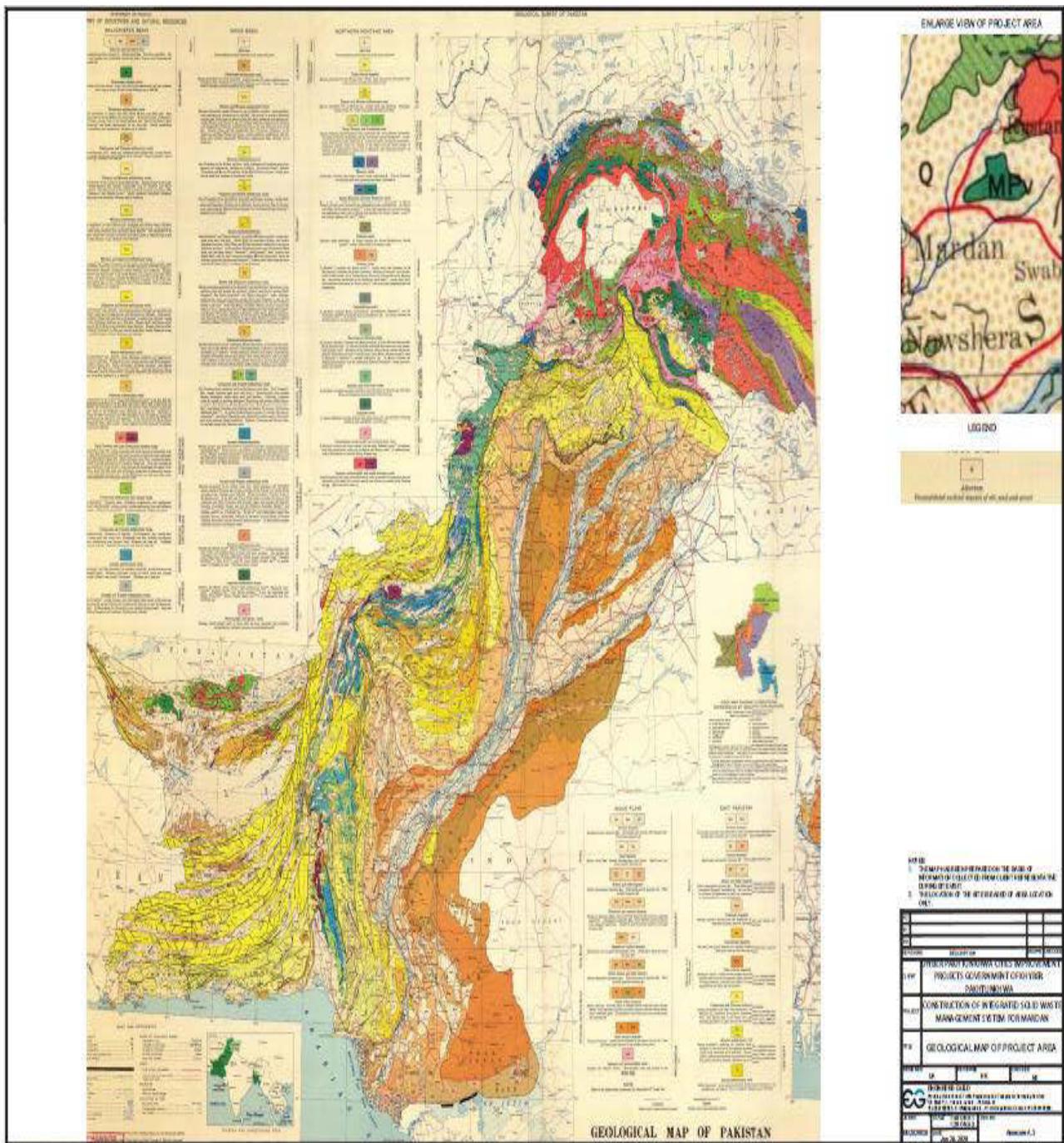
- Liquefaction is a loss of the shear strength of a soil that occurs when the ground experiences strong ground shaking. The phenomenon may result in large total and/or differential settlement beneath structures founded on the liquefying soils. In order for the potential effects of liquefaction to be manifested at the ground surface, the soils generally have to be granular, loose to moderately dense, saturated relatively near the ground surface, and must be subjected to a sufficient magnitude and duration of shaking.
- According to the grading plans for the proposed landfill site, surficial soils will be removed so that the proposed filling will be directly underlain by medium dense to dense sands. Due to the lack of a weak sandy soil, the relatively low design site acceleration being in zone 2B, and the competency of the sands, the potential for significant, large-scale liquefaction effects and associated dynamic settlement to cause damage to the composite liner system and other site facilities is very low.

212. In addition, the following additional recommendations have been made:

- Proper paving should be provided along the periphery of the Structure.
- All the backfilling of the foundation above concrete pad should be done with cohesive material to avoid seepage of water in the foundation base. Alternatively, the top 30 cm of any backfilling should be carried out with non-swelling cohesive soil.

- Adequate water proofing/damp proofing shall be provided for the structure. To avoid problem regarding moisture, it is recommended to adopt water-reducing admixtures in concrete.
- If any soft and loose material encountered, at foundation excavation level, during construction, then it should be further excavated and replaced with suitable granular material in proper compaction.
- Cement coatings should also be provided to avoid moisture movement through the concrete.

Figure 4-1: Geology of Project Area



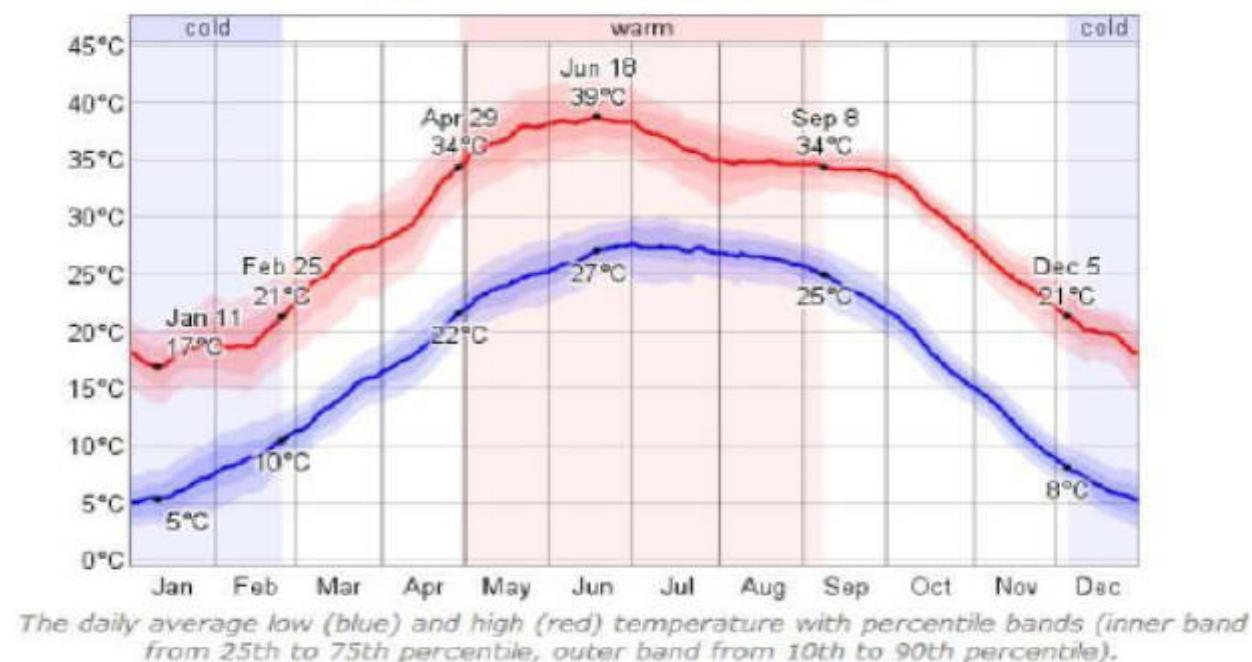
4.2.3 Climate

213. Mardan has a hot semi-arid steppe climate, which is very dry with little rainfall. It can rain at any time of the year but the rain does not last long. As well as being arid, the climate is extremely hot in the summer but slightly cooler in the winter months. There is no monsoon period. Throughout the year, temperatures fall dramatically at night, sometimes by as much as 20°C.

Temperature

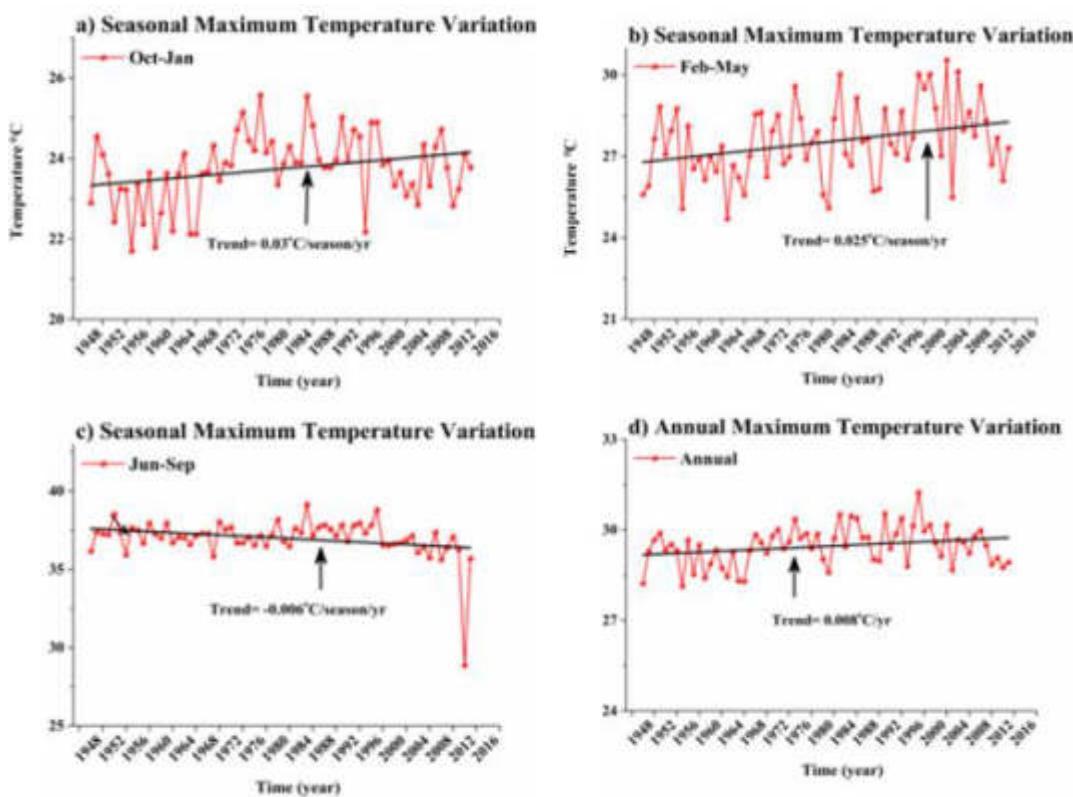
214. The warm season lasts from the April to September with an average daily high temperature of above 34°C. The cold season lasts from the December to February with an average daily high temperature below 21°C. The temperature profile for Mardan is shown as **Figure 4.2** below.

Figure 4-2: Year round Temperature Profile of Mardan City



215. Analysis of historical data for Mardan⁶ for 1950-2016 shows an overall increasing trend where the maximum temperature has increased by 0.57°C while minimum temperature has increased by 0.49°C. The mean annual maximum temperature was 28°C to 31°C while the mean minimum temperature ranged between 15°C to 17.7°C. Temperature trend analysis of Mardan is shown in **Figure 4.3** below.

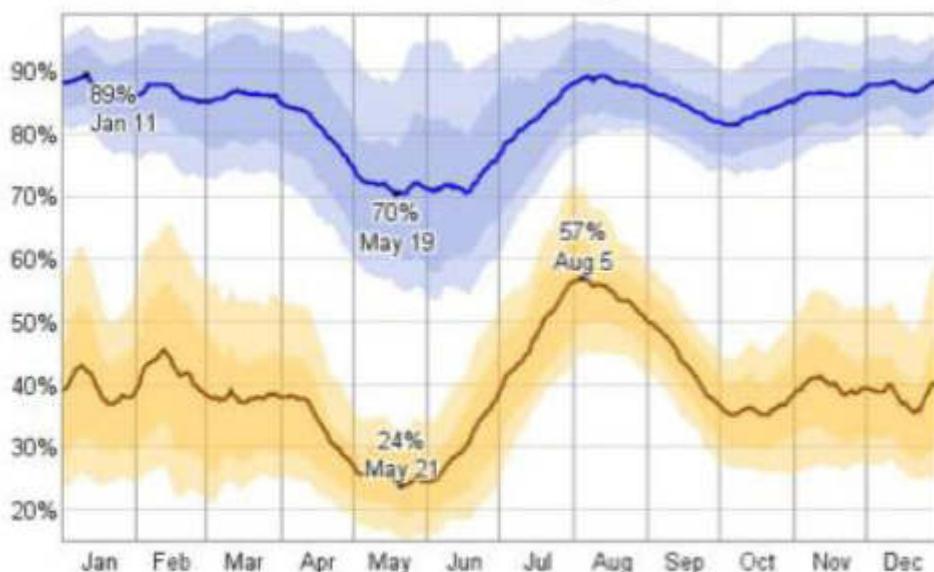
⁶ The weather data and information in this section is sourced from ADB (2017): UCCRTF TA-8913 PAK: Mainstreaming Climate Risk Management into Urban Infrastructure Investments through Urban Resilience Assessments (URAs), Mardan City, Khyber Pakhtunkhwa, Pakistan.

Figure 4-3: Temperature trend analysis of Mardan (1951-2016)

216. Except for February in most of the winter to early summer months (December to May), the temperature shows rising trends during 1950-2015 ranging from $0.015^{\circ}\text{C/month/yr}$ to $0.033^{\circ}\text{C/month/yr}$ for December and May respectively. This means a rise in maximum temperature between 1°C to 2.2°C during last 66 years. Seasonal temperature rise is ranging between 1.6°C to 2°C (for Feb-May and Oct-Jan respectively), whereas monsoon season shows a statistically insignificant decline in temperature. Overall, it shows a temperature increase of 0.53°C during 1950-2016 where annual maximum temperature raised at $0.008^{\circ}\text{C/year}$.
217. Except for January, the minimum temperature shows rise during September-May where trends are statistically significant. During 1950-2015, monthly rise in minimum temperature ranges between 0.72°C for September and 2.3°C for February, which means more rise in minimum temperature compared to maximum temperature, and suggests increase in warm nights compared to warm days. For the same period, minimum temperature for October to January shows a rise of 1.13°C while February to May shows a rise of 1.83°C . Statistically insignificant rise in minimum temperature is observed in monsoon. Overall, there is an increase of 1.06°C during 1950-2016 with annual minimum temperature rising at $0.016^{\circ}\text{C/year}$.

Relative Humidity

218. The relative humidity typically ranges from 24% (dry) to 89% (very humid) over the course of the year, rarely dropping below 15% (dry) and reaching as high as 99% (very humid) as can be seen in **Figure 4.4** below.
219. The air is driest around the 21st of May, at which time the relative humidity drops below 29% (dry) three days out of four; it is most humid around the 11th of January, exceeding 85% (humid) three days out of four.

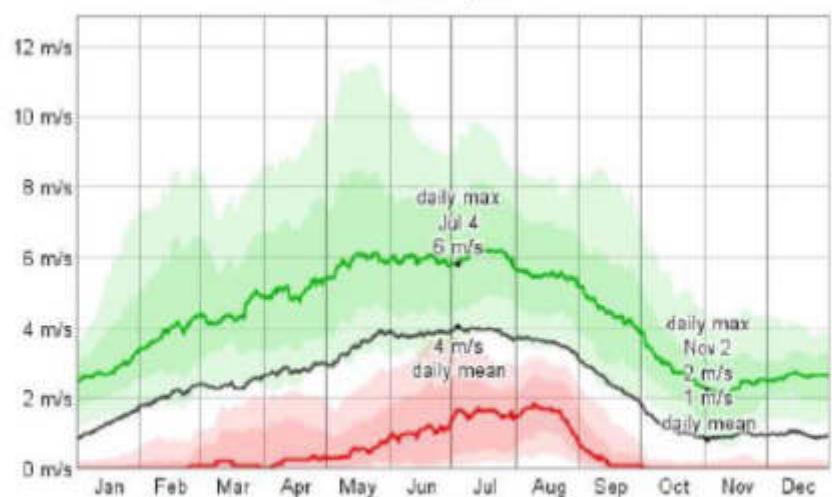
Figure 4-4: Humidity Profile of Mardan City

The average daily high (blue) and low (brown) relative humidity with percentile bands (inner bands from 25th to 75th percentile, outer bands from 10th to 90th percentile).

220. Although heatwaves⁷ do not have a statistically significant trend in Mardan, longer periods of rate of increase of maximum and minimum temperature together with heat waves and increased precipitation can cause increases in humidity and water consumption.

Wind Speed

221. Over the course of the year, the typical wind speed vary between 0 m/s and 6 m/s (calm to moderate breeze), rarely exceeding 12m/s (strong breeze) as can be seen in **Figure 4.5** below.

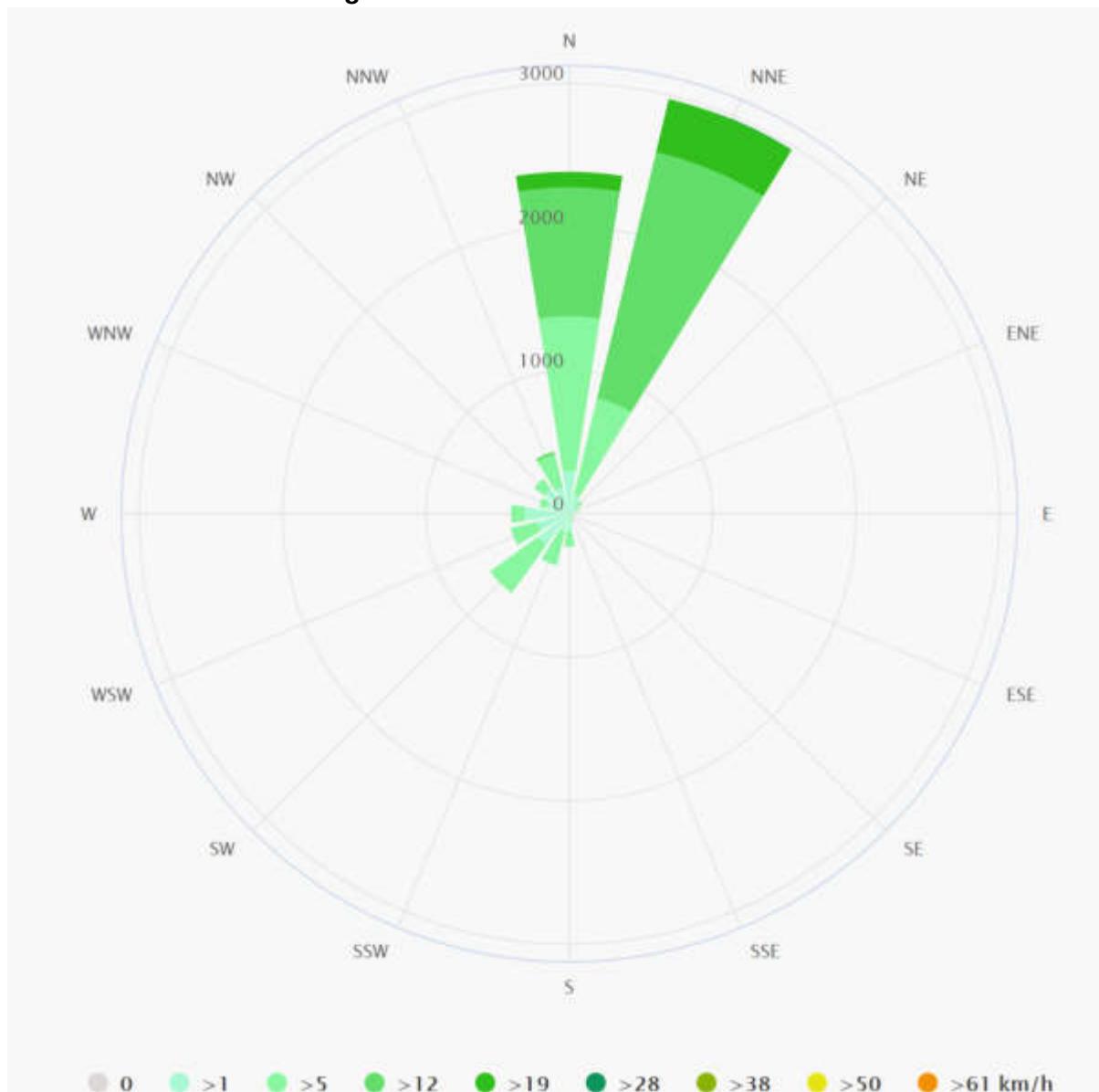
Figure 4-5: Wind Speed Profile of Mardan City

The average daily minimum (red), maximum (green), and average (black) wind speed with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile).

⁷ Heatwaves period can be defined as when consecutive 3-days temperature remains >45°C/day.

222. The Windrose profile for Mardan is provided as **Figure 4.6** below.

Figure 4-6: Windrose for Mardan⁸



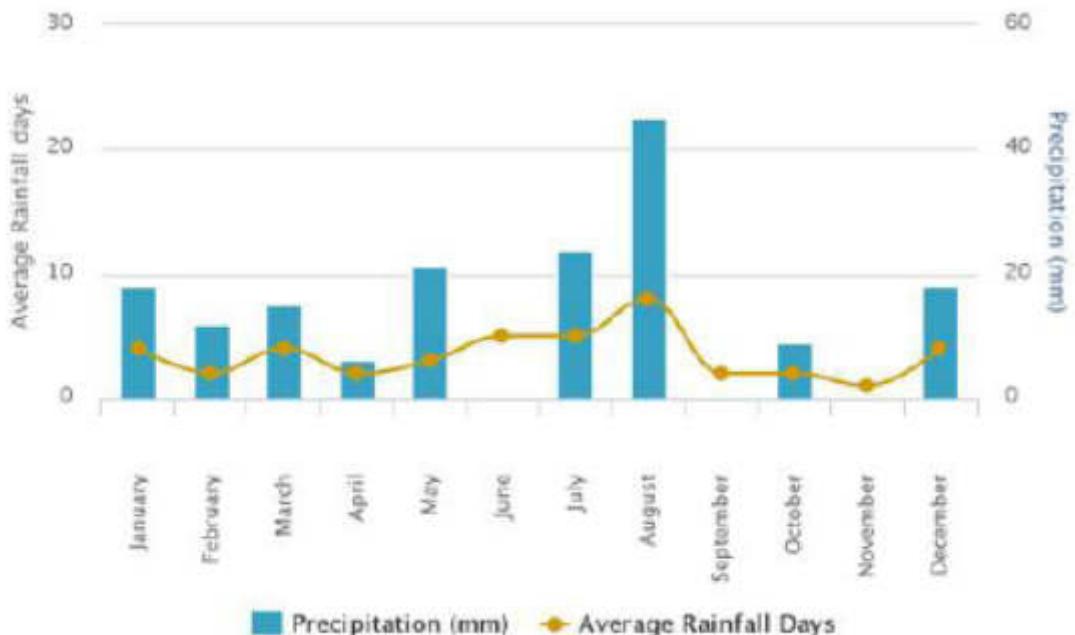
Precipitation

223. The city's average annual rainfall during 1961-2015 period was 474.4 mm with the highest annual rainfall of 904.5 mm recorded in 2003 while the highest daily precipitation (274 mm) was recorded on 29th July 2010. The lowest rainfall (190 mm) was recorded in 1974 based on Pakistan Meteorological Department, (PMD) Mardan climate station data. The annual precipitation together with an increase in extreme precipitation events in Mardan have increased according to the historic precipitation data. During the last 50 years, overall 212 mm increase in annual precipitation during last five decades have been observed according to the precipitation extreme indices. Likewise, heavy precipitation events (rainfall > 10mm) increased by 8.2 days, while

⁸ https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/Mardan_pakistan_1168197. The meteoblue climate diagrams are based on 30 years of hourly weather model simulations and available for every place on Earth at 30 Km spatial resolution.

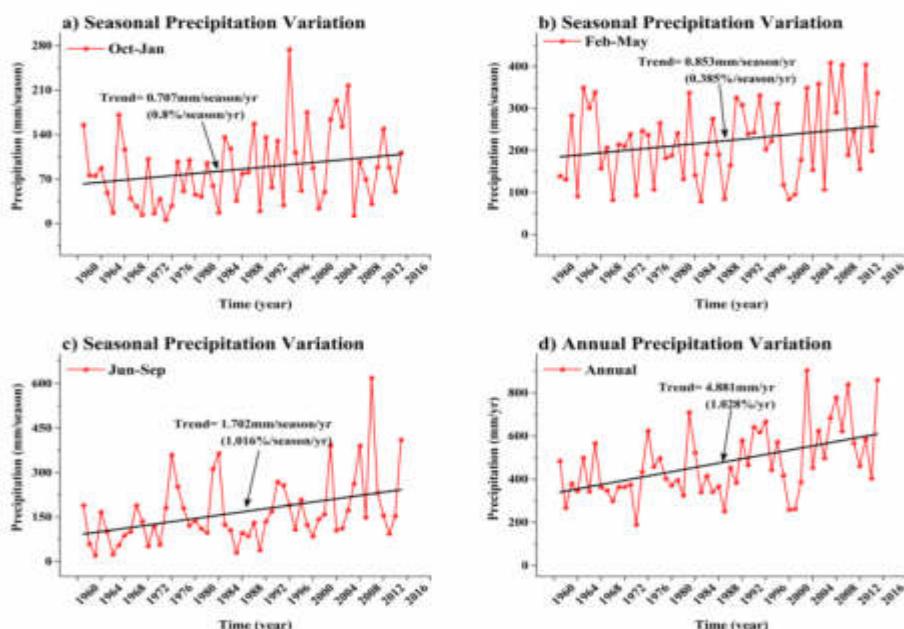
heavy precipitation events ($> 20\text{mm}$ and $> 25\text{ mm}$) increased by 5 and 4 days respectively.

Figure 4-7: Average Rainfall Profile of Mardan City



224. During the months of January, February, June, September and October statistically significant increase is observed in monthly precipitation data. Over the last 55 years, a total rise of about 18mm (maximum percentage increase of about 2.1% rise/month/yr) is observed in June precipitation data. During the same period (1961-2015), quantitatively maximum rise occurred during September, where a total of 23mm rise. Increasing trends are observed in seasonal precipitation during winter (October to January) and monsoon period (June to September). Spring to early summer period also shows rising trend but not statistically significant. Annual precipitation shows a statistically significant rising trend with a total of about 268.3 mm rise during 1961-2015 at a rate of 4.88mm/yr (about 1.02%/yr).

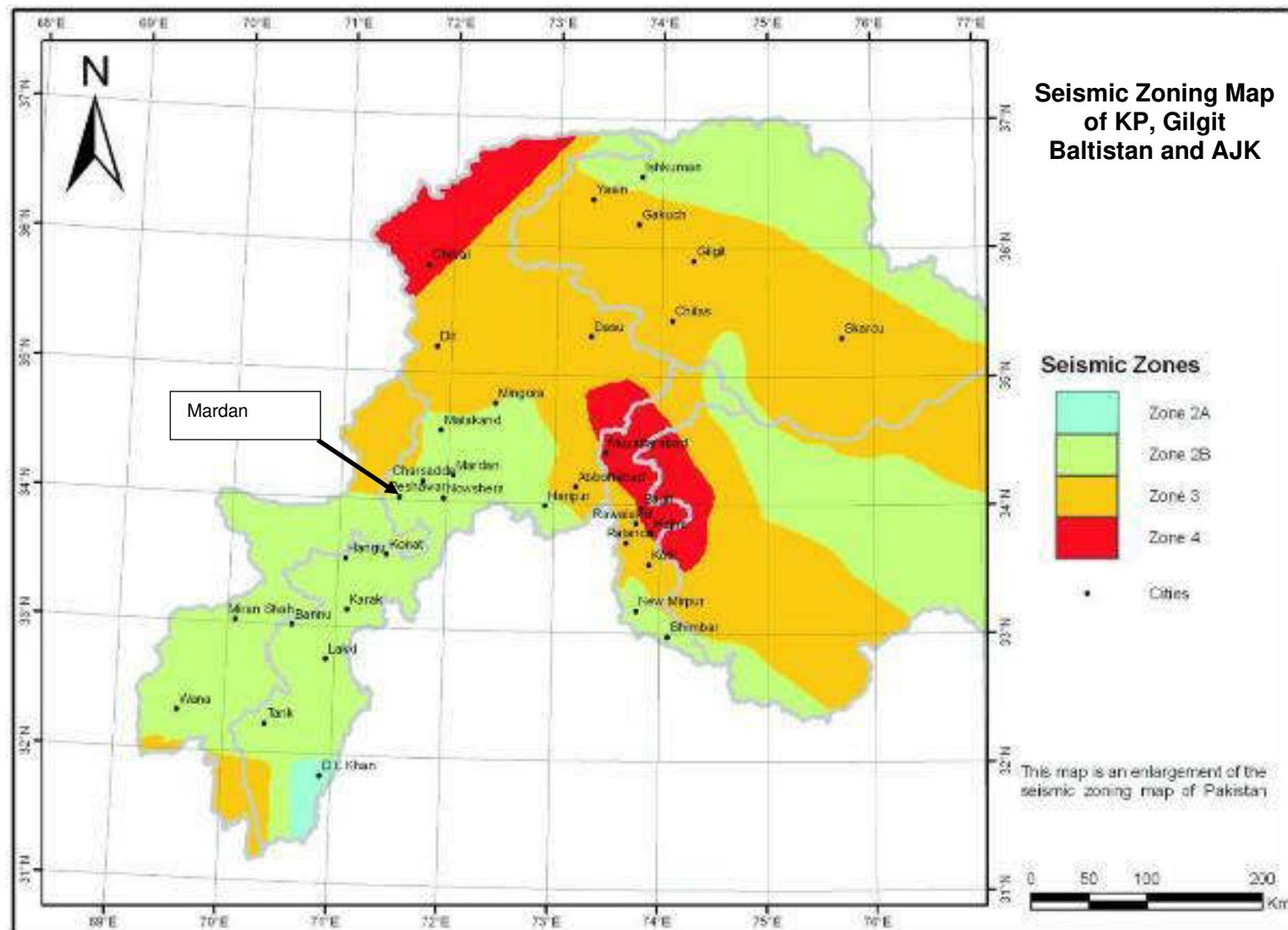
Figure 4-8: Precipitation trend analysis of Mardan (1951-2016)



4.2.4 Seismology

225. The seismic hazard in Mardan is aggravated by increasing vulnerability due to population growth and expansion in infrastructure due to its political and regional importance. It is located in the western Himalayan region characterized by high seismicity rates due to its vicinity to the active plate boundary between the Indian and Eurasian plates. The seismic zone map of Pakistan is shown in **Figure 4.9** below.
226. According to MOHW-PEC-NESPAK (2007), Mardan is placed in Zone 2B. The Zone 2B has Peak Ground Acceleration (PGA) in the range of 0.16g to 0.24g for a return period of 475 years and is considered to be at 'Moderate' risk of a major earthquake event.
227. It is therefore, recommended that the project structures should be designed to cater for the requirements of Zone 2B of Building Code of Pakistan (2007).

Figure 4-9: Seismic Zones of Pakistan



4.2.5 Surface water

228. Most of the streams in the project area drain into Kabul River. Kalpani, an important stream of the district rises in the Baizai and flowing southwards join Kabul River. Other important streams which join Kalpani are Baghiari Khawar on the west and Muqam Khawar, coming from Sudham valley and Naranji Khawar from the Narangi hills on the left.
229. Two small canals are flowing on the south western and south eastern sides of the proposed site. The entire gravity irrigation system of the valley is controlled by the three headworks Warsak, Munda and Amandara. The first two are located within the Mardan Valley whereas Amandara Headworks is located near Batkhela in Swat Valley. In addition to these headworks, Warsak weir, located 3 km downstream of the Warsak Dam, provides diversions for the Kabul River Canal system.
230. There is a minor 3.9 km long water channel along the southern boundary of the landfill site, originating from bifurcation of the main channel of lower swat canal in Fazalabad area. Distance of channel from landfill site is about 35 meters and this channel is running adjacent to the access road of the site. However, after a distance of approximately 375 meters, this channel reaches its tail end. Project hydrogeological study suggests that there are no surface water sources within a reasonable distance in the direction of ground water flow, which will be toward northern side from the landfill boundary. Irrigation channel is flowing on southern side and is NOT downgradient to the landfill cells, thus, the IFC criteria of 500-meter distance is not applicable to this channel. However, during landfill operation, periodic surface water quality monitoring will be carried out to ensure that surface water resources of the area are not impacted by the landfill operations.
231. There is heavy dependence on the Kabul, Bara and Swat rivers to obtain water for every day use for the residents of Mardan. The Government authorities are planning a Mardan Greater Water Supply Scheme, which will allow approximately 200 million gallons per day (MGD) to be pumped in from different rivers to meet the growing requirements of Mardan.
232. Agriculture in Mardan is largely dependent on Canals. Moreover, tube wells irrigation is also available in some places. The irrigated land in district Mardan constitutes a large percentage as compared to other districts of Khyber Pakhtunkhwa.

4.2.6 Groundwater

233. Groundwater is the major source of water in the study area, which is extracted with the help of pumps and motors. The groundwater extracted is used to fulfill various domestic, irrigation and industrial needs.
234. Underground water is plentifully available which is being harnessed by the local community of respective districts and will continue as the source of water even for the project. Under ground water from a depth of around 4 feet as the first aquifer is harnessed by the locals for human consumption and irrigation on a limited scale.
235. As part of EIA baseline, ground water samples were collected and analyzed from EPA certified lab. The results of the tests are presented as **Annexure D**, which indicates that all parameters of the ground water samples taken are within the applicable NEQS/WHO guidelines with no exceedances observed. Ground water sampling locations are provided in **Figure 4-10**.

236. Ground water table in the project area is at a depth of 2.5-4 ft and thus the dumping of waste will be conducted above ground on a concrete base with top soil cover being placed above ground on the waste and liner being installed below the concrete base. The likelihood of the liner bursting for a new landfill site is quite remote since high quality liner will be installed and in addition, it will be ensured that all countermeasures in terms of liner design are in place to prevent breakage of liner.
237. Furthermore, active life of landfill cell is about 4-5 years and after that, Final capping will be placed. After that, there are minimal chances of percolation of water in the landfill cell and hence limited leachate production. Possibility of a liner breakage is not expected to take place for at least 5 years or so from its time of installation. Keeping in view these design considerations, leachate percolation to ground water is not expected. Also, ground water quality monitoring wells are incorporated in the project design. Ground water quality will be monitored on frequent intervals to assess any leachate contamination. If required, ground water samples of surrounding areas will also be analysed to trace any leachate contamination.

4.2.7 Noise

238. The receptor map showing the selected ambient noise monitoring locations and their respective noise readings are provided as **Figure 4.10** below with the comparison of the results also presented in **Table 4.6** below. While the results indicate the ambient noise levels being within the most stringent guidelines during the daytime, however, exceedances were observed at the night time at one location (Village Saeedabad) in the project area. There are no sensitive receptors with regards to noise levels within close proximity from the proposed landfill site.
239. As already indicated in the footnote to **Table 4.6** below, these readings may not be considered representative due to the COVID-19 pandemic lockdown, leading to significantly reduced traffic volumes in the project area. Thus, ambient noise measurements will need to be repeated prior to commencement of the construction works.

4.2.8 Air Quality

240. The map showing the selected air quality monitoring locations and their respective ambient air quality readings are provided as **Figure 4.10** below with the comparison of the results presented as **Table 4.7** below. Ambient air quality has been carried out in all the directions of the landfill site and locations have been selected keeping in view the wind direction during the monitoring day.
241. As can be observed, in general the air shed seems to be of good quality with the ambient air quality within the acceptable NEQS standards with PM_{10} being the only pollutant that is exceeding the guidelines at three of the monitored locations (Primary School 1 & 2 and Shamilat village).
242. Similar to the ambient noise readings, these readings may not be considered representative due to the COVID-19 pandemic lockdown leading to significantly reduced traffic volumes in the project area with the pollutant concentration levels being considerably underestimated. However, the high particulate matter levels are generally aligned with historical data for this area. Thus, it is recommended to repeat ambient air quality measurements prior to commencement of the construction works.

4.2.9 Land Use

243. Current landuse of the project area (2 Km radius for landfill site) shows crop land (74%) followed by settlements (18.6%) and tree cover (6.9 %). Land use map of the project area is shown as **Figure 4-11**.

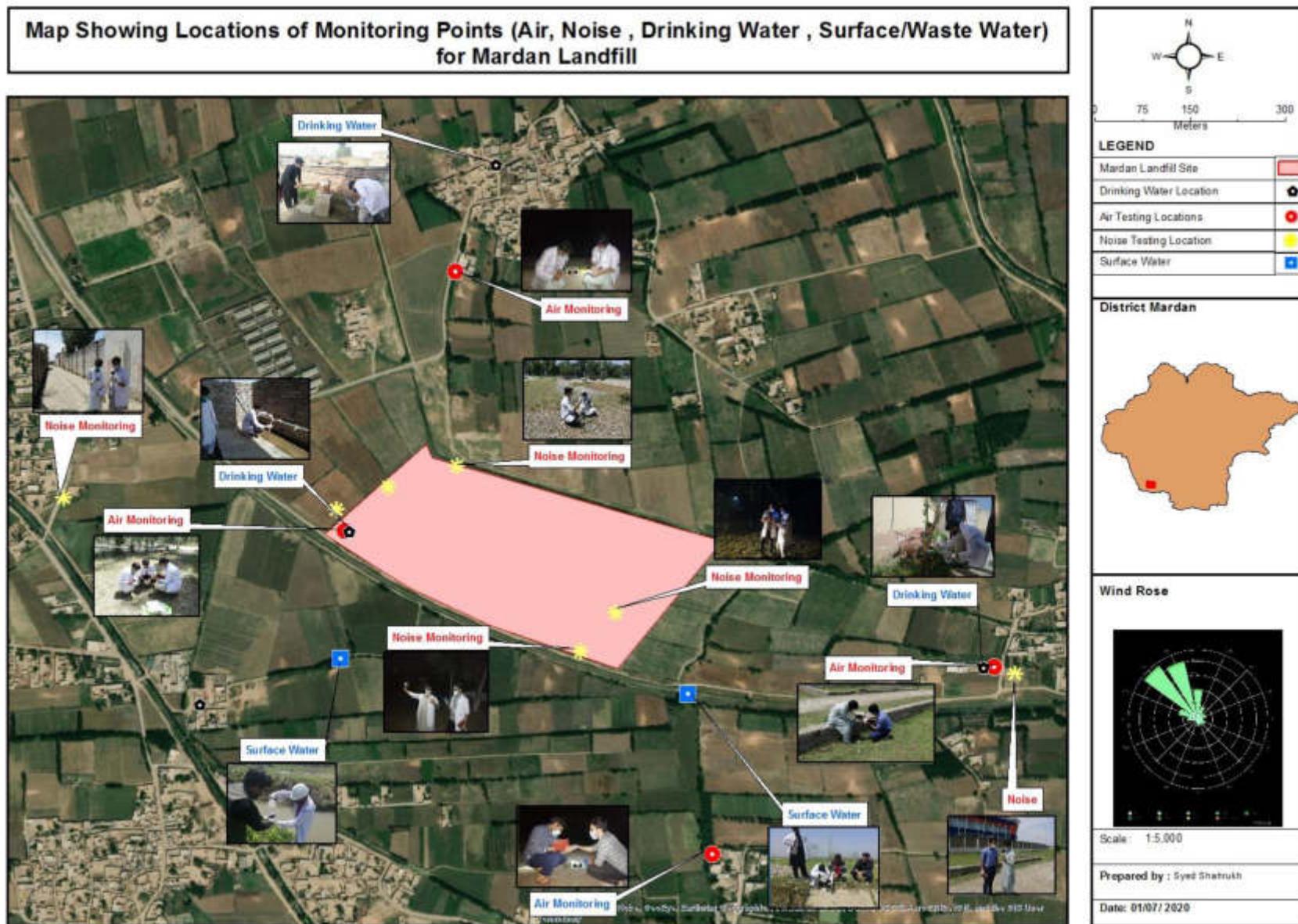
Figure 4-10: Sampling Locations for Environmental Monitoring

Figure 4-11: Landuse map of the project area

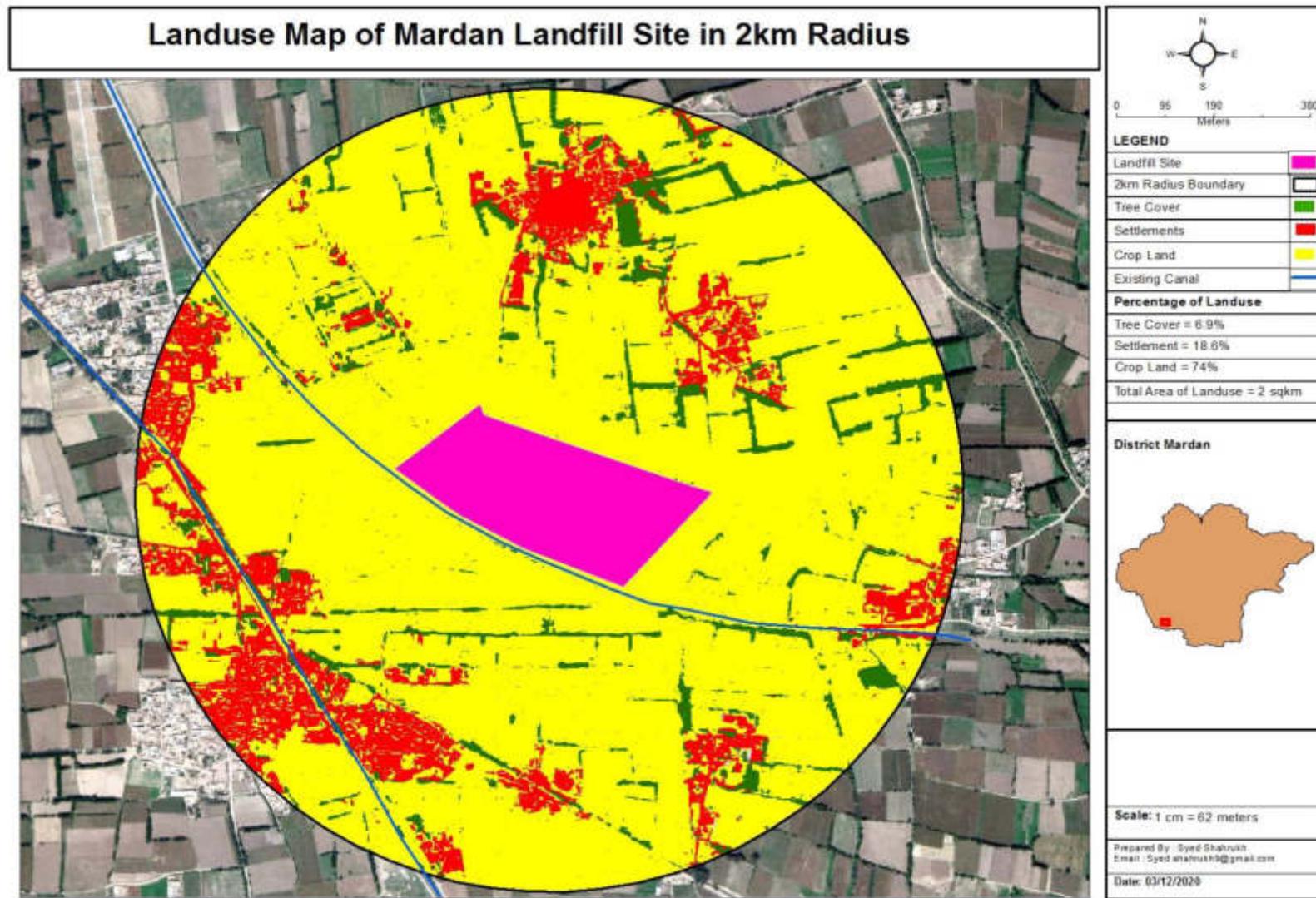


Table 4.2: Ambient Noise Monitoring Results (24 hrs) in Project Area

Monitoring Location	Parameter	Noise Reading Results	Noise Guideline (Commercial Area)	Compliance Status for Commercial Areas
Day Time Readings (0600 to 2200)			Day time	
Primary School No.1	dB(A) Leq	49.9	65	
Project Site (Center Plot)		49.9		
Village Shotal Banda		54.6		
Primary School No.2		50.0		
Village Saeedabad		58.1		
Night Time Readings (2200 to 0600)			Night time	
Primary School No.1	dB(A) Leq	49.0	55	
Project Site (Center Plot)		48.3		
Village Shotal Banda		53.3		
Primary School No.2		48.8		
Village Saeedabad		56.8		

█ Exceedance from applicable guidelines

█ 'Within' applicable guidelines

Note: It is recommended to repeat the ambient noise measurements at selected locations in project area since the readings presented above may not be representative due to the COVID-19 pandemic, there was a nationwide lockdown at the time of this monitoring activity, leading to considerably reduced traffic volumes.

Table 4.3: Comparison of ambient air quality results versus applicable Air Quality standards⁹

Monitoring Location	Parameter	NO (ug/m³)	NO₂ (ug/m³)	CO (ug/m³)	SO₂ (ug/m³)	PM_{2.5} (ug/m³)	PM₁₀ (ug/m³)
Applicable Guideline (ug/m³) for 24 hrs	Average	-	80	-	20	25	50
Landfill Site Main Gate	-	11.4	12.9	0.8	12.2	14.8	48.39
Primary School No.1	-	10.4	10.3	0.7	12.7	11.4	64.2
Primary School No.2	-	11.9	12.9	0.8	11.9	11.5	53.4
Shamilat Village	-	11.6	12.0	0.8	12.4	13.7	60.4

■ Exceedance from applicable guidelines

■ 'Within' applicable guidelines

Note: It is recommended to repeat the ambient air quality measurements at selected locations in project area since the readings presented above may not be representative due to the COVID-19 pandemic, there was a nationwide lockdown at the time of this monitoring activity, leading to considerably reduced traffic volumes.

4.3 Ecological Environment

- 244. In order to identify ecological resources, ecological baseline survey was carried out by EDCM team. Detailed surveys were conducted for project scoping during the start of March and mid of April 2020. The city of Mardan consists of an urban landscape with patches of plants and trees present across the city for the purpose of beautification and landscaping.
- 245. Integrated Biodiversity Assessment Tool (IBAT) screening was carried out to identify the biodiversity features and species that are located within the following buffers: 1 km, 5 km and 10 km. There were no protected and/or key biodiversity areas found within 10 km buffer from the landfill site. There are 25 threatened species that are potentially found within 50 km from area of interest consisting of a mix of terrestrial and freshwater species. Among these species 17 are Aves, 04 mammalian, 03 Actinopterygii, and 01 Magnoliopsida. As project area is located in urban sprawl of Mardan city and habitats have been converted into human settlements at large scale, therefore, no impact on such species is expected from project activities. IBAT screening report is attached as Annexure P.

⁹ The ambient air quality was monitored using the AQM 65, which is a fully integrated air monitoring station that delivers near reference levels of performance. The AQM 65 offers the optimal balance for measuring criteria pollutants to WHO air quality limits. With the AQM65 continuously measuring of common air pollutants was carried out and then results are produced on 24 hours average. AQM 65 ensures air quality data is reliable and robust in compliance to USEPA (40 CFR Part 53) and EU (2008/50/EC).

EDCM survey report listed species which are dominant and common in the project area. **Red fox, Golden Jackal, Indian crested porcupine and wild bore are the mammals found in the project area which have IUCN Least Concern Status.** Only *Lutra perspicillata* (Ludhar) is on IUCN Red List since 1996. Ludhar species is occurring in most of the Indian subcontinent and Southeast Asia, with a disjunct population in Iraq. As project is located in agriculture land with semi-urban/rural settlements and no key biodiversity area has been identified by IBAT study therefore no significant impact on flora and fauna of the area is anticipated from the project.

4.3.1 Flora

- 246. In the Mardan valley, subsistence agriculture is widely practiced with wheat, barley, millet, corn, cotton, pepper and sugarcane being the primary crops. The annual cycle is divided into two planting and harvesting periods, one for wheat and barley in winter and another for corn in summers. Planting and harvesting of sugarcane overlaps both the periods. These crops are supplemented with a variety of vegetables and with clover, which is used in conjunction with millet as a fodder.
- 247. In many villages in the Mardan, there are extensive pear, peach and apricot orchards and grape vineyards. Tobacco is also an important crop near the town of Nowshera. Wheat, cotton, pepper and particularly Tobacco and sugarcane are grown for the market as well as for local consumption.
- 248. The present flora of the irrigated areas is exotic. The common trees are mesquite, ber, different species of acacia and jand. The most common shrubs are tarmariax, articulata, spands, akk, small red poppy, spera, pueghambrigul, drab grass, spera, eamelthorl and pohli chaulai etc with the different flora in the project area shown in **Table 4.4** below.
- 249. Vegetation of the project area is dry deciduous scrub type. The stocking on the whole is poor. There are some species such as trees, grasses and shrubs are found near the project area. Good quality fodder grasses are also found at the moist places, where the incidence of grazing is less.

Table 4.4: Existing Flora in Project Area

Scientific Name		Common Name	IUCN Status
Tree	<i>Eucalyptus camaldulensis</i>	Safeda	Data Deficient (DD)
	<i>Olea Cuspidata</i>	wild olive	Data Deficient (DD)
	<i>Dodonaea Viscosa</i>	Broad leaf hopbush	Least Concern (LC)
	<i>Acacia Modesta</i>	Phulai	Data Deficient (DD)
Shrub	<i>Gymnosporia Royleana</i>	Royle's Spike Thorn	Data Deficient (DD)
	<i>Ziziphus nummularia</i>	Jujube	Data Deficient (DD)
	<i>Monotheeca Buxifolia</i>	-	Data Deficient (DD)
Grass	<i>Aristida Depressa</i>	Aristida	Data Deficient (DD)
	<i>Cymbopogon Jawarnica</i>	East Indian lemongrass	Data Deficient (DD)
	<i>Eleusine Flagellifera</i>	Goosegrass	Data Deficient (DD)

Scientific Name		Common Name	IUCN Status
Fodder Grass	Bothriochloa Pertusa	Indian bluegrass	Data Deficient (DD)
	Digitaria Bicornis	Crabgrass	Data Deficient (DD)

Source: EDCM Ecology Survey, April 2020

4.3.2 Fauna

250. The fauna present in the project area of the landfill site is provided in **Table 4.5** below.

Table 4.5: Existing Fauna in Project Area

Mammals			
Common Name	Scientific Name	Common Name	Scientific Name
Mongoose	<i>Herpestes anropunctatus</i>	Hare	<i>Lepus nigricolus</i>
Gheese/House Shrew	<i>Suncus marinus</i>	Ludhar	<i>Lutra perspiciliata</i>
Bat	<i>Pipistralius terwisi</i>	Jackal	<i>Canis auries</i>
Black Rat	<i>Ratus ratus</i>	Fox	<i>Vulpes bengalensis</i>
House Rat	<i>Mus musculus</i>	Hedge Hog	<i>Hemiechinus Sp.</i>
Mole Rat	<i>Bandicota bengalensis</i>	Porcupine/She	<i>Hystrice indirca</i>
Squirrel	<i>Fumbulus penanti</i>		
Birds			
Dove/Common Dove	<i>Streptophelia senegalensis</i>	Indian Sand Martuis	<i>Riparia paludicola</i>
Dove/Common Dove	<i>Streptophelia tranquebaria</i>	Indian River Term	<i>Sterna aurantia</i>
Larks	<i>Mirfa erythroptra</i>	Black Partridge	<i>Francolinus francolinus</i>
Larks	<i>Erimopterix grisea</i>	Common Babler/Bagla/Chakkira	<i>Turdoides candatus</i>
Larks	<i>Calaendrella cristata</i>	Neel Kanth	<i>Gracius garrulous</i>
Weaver Bird	<i>Ploceus philippinus</i>	Grey Partridge	<i>Pyeronotus xythopygos</i>

Jungle Pigeon	<i>Teron walia</i>	Shrieks/Lali/Myna	<i>Passeriformes Sp.</i>
Crow	<i>Corvus abyssinica</i>	Owl	<i>Bubo africanus</i>
Sparrow	<i>Passer Sp.</i>	Black Rock Pigeon	<i>Columba livia</i>
Reptiles			
Indian Cobra	<i>Naja naja</i>		

Source: EDCM Ecology Survey, April 2020

251. Important mammal species found in the vicinity of the project area are mentioned below in the **Table 4.6** with their respective IUCN status in the Red List. Similarly, to meet their requirements of milk, people keep domestic animals such as: cows, buffalos and goats. No endangered species are available in the project area.

Table 4.6: IUCN Status of Fauna in Project Area

Scientific Name		Common Name	IUCN Status
Mammals	<i>Vulpes Vulpes</i>	Red Fox	Least Concern (LC)
	<i>Canis Aureus</i>	Golden Jackal	Least Concern (LC)
	<i>Hystrix Indica</i>	Indian Crested Porcupine	Least Concern (LC)
	<i>Sus Scrofa</i>	Wild Boar	Least Concern (LC)

*IUCN Red List for species status of Pakistan. EDCM Ecology Survey April 2020

252. The commonly found avifauna of the project area are Shikra (*Accipiter badius*), Crow (*Corvus splendens*), Common kite (*Milbus migrans*), Sparrow (*Passer domesticus*), Pigeons (*Columba livia*), Dove (*Strato pielia SSP.*), Parrot (*Psittacula krameri*), Partridges. No migratory birds or their routes were found near the project site.
253. There is no protected area in the vicinity of the project area. Nearest protected area is Manglot National Park which is located in Nizampur, district Nowshera at a distance of about 45 km from the proposed Mardan SWMF and shown as Figure 4-13.

Figure 4-12: Flora and Fauna of the Project area

	
Typical view of project area	Cropland adjacent to the project area
	
Boundary line of Proposed Landfill site	Typical vegetation of project area
	
Yellow Footed Green Pigeon	Swallow

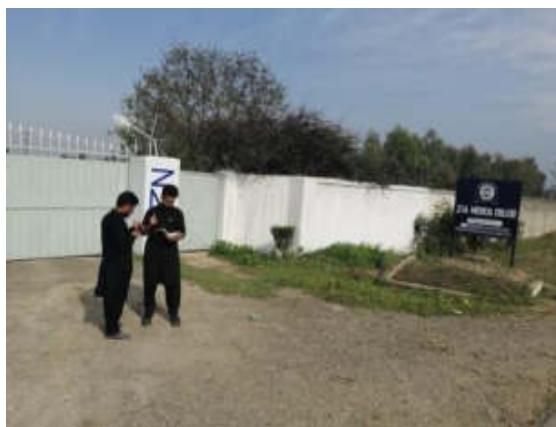
Figure 4-13: Location of Protected area from Mardan LFS



4.4 Socio-economic Environment

254. This section includes a summary of the prevailing socio-economic conditions in the project area and the population that will be potentially affected by the Project. To ascertain the socio-economic condition of the project area, primary and secondary data was collected including social and physical infrastructure in the project area.
255. To assess the socioeconomic conditions of the project area, 5 FGDs were carried out with 40 participants including 40% male and 60% female participation. Households (HH) have been studied during focus group discussions/ public consultations. These people belong to the nearest area of the project, FGDs were held with them to brief them about project and to seek their views. In addition, the secondary data, including Economic Survey of Pakistan (2018-19), Bureau of Statistics (2017-18), District Population Census 2017 of KPK, Crop Reporting Services KP (2017-18) and MICS of KP have been consulted. Survey questionarrie for conducting FGDs is provided as **Annexure B**.
256. Detailed surveys were conducted for project scoping during the mid of March and start of May 2020. For the purpose of the environmental and social assessment and sensitive receptor data collection, a two-kilometer-wide, corridor along the proposed project site has been considered as the study area or the project area. Most of the field data collection was carried out within this corridor though where relevant data was also collected from a wider area along the proposed project site. The reason for selecting this corridor is to cover those areas that have a potential to be affected by the project activities.
257. The names of the major settlements falling in the project area are Saeedabad, Shotal Banda, Khwaja Rashakai and Shamilaat. Photographs depicting socio-economic conditions in the project area are provided in **Figure 4-14**.

Figure 4-14: Socio-economic conditions of the project area



Photograph 4-1: Zia Medical College



Photograph 4-2: Govt. Primary School for boys



Photograph 4-3: Malik Medical and Children Rehydration Centre



Photograph 4-4: Govt. Primary School Khwaja Rashakai



Photograph 4-5: View of mosque alongside a water channel flowing across the route to the proposed landfill site



Photograph 4-6: A well maintained tube well situated along the route to the proposed landfill site



Photograph 4-7: A sight of veterinary hospital, Akbarabad



Photograph 4-8: View of a bridge situated along the route of the proposed landfill site. This bridge connects the locals to ring road. A stream of surface water also flows beneath this bridge.

4.4.1 Administrative Setup

258. The project area falls in the jurisdiction of Union Council (UC) Rustom, Mardan in Khyber Pakhtunkhwa Province. Under the latest revision of Pakistan's administrative structure, promulgated in 2001. The district divided into two sub-divisions Mardan and Takht Bhai with headquarters at Mardan. Like any other district in the country, district Mardan is headed by District Coordination Officer (DCO) assisting Zila Nazim and is accountable to him. DCO, appointed by provincial government from the federal or provincial civil service, coordinates with Executive District Officers (EDOs), who head each of the twelve district offices including health. District Mardan has two Tehsils i.e. Mardan & Takht Bhai. Each tehsil comprises of certain numbers of union councils. There are 75 union councils in district Mardan with 60 rural and 15 urban.

4.4.2 Demography and Population

259. The population of Mardan city in 2017 was 358,604¹⁰. The city's annual growth rate is estimated at 2.58 % per year, and the population of Mardan district is 2,373,061 according to the 2017 census.

Districts	Area (km ²)	Population (2017)	Density (people/km ²)
Mardan	1,632	2,373,061	1,454

*Source District wise population Census 2017 by Pakistan Bureau of Statistics: Government of Pakistan.

4.4.3 Religion

260. The population of the district is almost entirely Muslim, constituting 99.51 of the total population. The main minorities are Ahmadi and Christian who are 0.32 and 014 percent respectively. Other minority is Hindu who is 0.02 percent of the total population. The population of rural and urban area are mostly Muslim which is 99.69 and 98.81 percent respectively. The percentage of minorities i.e. Christian and Ahmadi

¹⁰ <https://en.wikipedia.org/wiki/Mardan>

is greater in urban area which is 0.62 and 0.46 as compared to rural area which is 0.29 and 0.02 percent.

4.4.4 Cultural and Archaeological sites

261. No archaeological and cultural site was observed in close proximity of Mardan landfill site. Archaeological Chance Find Procedure is attached as **Annexure G**.

4.4.5 Ethnicities in Project Area

262. The primary data collected by the EDCM team during EIA baseline survey and public consultation shows the following ethnic diversity in the project area. None of these castes may be considered as indigenous people (IP) based on ADB SPS definition. The ethnicities present in the project area are provided in **Table 4.7** below.

Table 4.7: Ethnicities in Project Area

Settlement	Caste/ Tribe	Decision Making Process in Settlements	Locally Used Language
Rashakai	Yousafzai	Court of Law, Within caste group	Pashto
Saeedabad	Maingan	Court of Law, within caste group	Pashto
Shamilaat	Yousafzai	Court of Law, within caste group	Pashto

4.4.6 Languages

263. The primary native language spoken in Mardan is Pashto as reported by 98.44 percent. Though English is used in the city's educational institutions, while Urdu is understood throughout the city. The district of Mardan is overwhelmingly Pashto-speaking; though the Hindko-speaking minority is concentrated in Mardan's old city, Hindko speakers in Mardan increasingly assimilate elements of Pashto and Urdu into their speech. Punjabi, Sindi, Balochi, Saraiki the other languages spoken as mother tongue are 0.33, 0.49, 0.02, 0.01, 0.03 percent of the population respectively.

4.4.7 Dress/Clothing

264. People wear the traditional pakhtoon Shalwar Kameez; a tunic (Kurta), loose trousers and sandals (Kheri). In winters, men wear waist coat in addition to Shalwar Kameez. Women comparatively wear colorful clothing but wear Burqa/Chaddar while travelling outside.

4.4.8 Marriages/Deaths

265. Marriages are arranged according to the traditions of Pakhtun society. The parents of the boys and girls usually arrange the majority of the marriages when they reach the age of 20/25 years. Parents prefer their close relations when choosing bride/groom for their children. Commonly most marriages are held with customs.

266. The death ceremony is performed in sorrowful but respectable manner. The neighbours jointly prepare the grave and men and women assemble in the house of the deceased for Taziat (mourning). Nemaz-e-Janaza (Funeral prayers) is offered at the time fixed by family of the deceased, and is attended by large number of men of the society. The men / women visit the hujra / house of the deceased for offering Fatiha

(prayers) up to three days. The family of the deceased gives food to the poor and relatives as Khairat (charity).

4.4.9 Dwellings

267. Housing conditions of the respondents have been analyzed according to the type of houses in which they were residing. The house or building constructed with concrete or burnt bricks fall in pacca category whereas house or building constructed with burnt bricks with mud comes under semi-pacca category while house constructed with mud bricks or temporary wooden logs etc. are categorized as kacha house. Project area most population is living in semi-pacca and pacca houses.

4.4.10 Main Sources of Livelihood/Income

268. Most of the people are farmers in profession in the nearby villages. They are engaged in agriculture either directly or indirectly. Industrial labor has increased after the establishment of factories in different places of the district. Some people are engaged in business and Government service also.

4.4.11 Education Facilities in project area

269. Education plays a pivotal role in changing social and economic condition of the individuals. Local community has access to educational facilities. Both primary and secondary schools for boys and girls are available in the project area (**Table 4.8**).

4.4.12 Social Amenities in project area

270. During the field survey, the access/availability of the social amenities/ basic infrastructure in the vicinity of the proposed landfill site was asked from the surveyed households as well as physically observed at site. It was noted that facilities such as Electricity, Sui Gas, Water Supply, Telephone, Sewerage Drainage, school are available in the settlement or in its vicinity.
271. For health care, BHU and a child care centre is present to facilitate the health of people in the project area and its near inhabitants.

4.4.13 Major Source of Drinking Water

272. The major sources of drinking water within the vicinity of the project area include community tube wells, individual and communal hand pumps. There are no proper water supply schemes available in the project area.

4.4.14 Distance to nearest airport from project site

273. The nearest airport to the proposed landfill site is the Bacha Khan International Airport, located at an 'aerial' distance of 51.8 km from the site.

4.4.15 Literacy Rate

274. The literacy rate for population 10 years and above (2010-2011) was 54 percent (Males: 68%, Females: 38%).³⁵ which increased to 59% in 2013. For the urban rural comparison, the urban literacy rate is higher than the rural, which is 62 percent. Among urban community, literacy ratio for male is 75 and for female it is 47; whereas the rural literacy ratio is 45 percent, and in rural community, literacy ratio for male is 61 and for female it is 29. Adult literacy rate (> 15 years) is 51 percent. Gross Enrollment Rate

(GER), at the primary level, is 93% (Male: 101%, Female: 85%). Net Enrollment Rate (NER), at the primary level, is 56% (Male: 59%, Female: 52%).

4.4.16 Types of Dwellings

275. Housing conditions of the respondents have been analyzed according to the type of houses in which they were residing. The house or building constructed with concrete or burnt bricks fall in pacca category whereas house or building constructed with burnt bricks with mud comes under semi-pacca category while house constructed with mud bricks or temporary wooden logs etc. are categorized as kacha house. Project area most population is living in semi-pacca and pacca houses.

4.4.17 Archaeological and Cultural Heritage

276. There are no sites of archaeological or cultural heritage located in the project area. Archaeological chance find procedure is provided as Annexure G.

4.4.18 Energy Supplies

277. The residents of project area are reliant on electricity available from the grid. Due to long duration of load-shedding particularly during summer, there is an increasing trend of using diesel generators and installing solar PV systems in both residences and businesses in order to ensure energy reliability.

4.4.19 Available Social Amenities in the project area

278. During the field survey, the access/availability of the social amenities/ basic infrastructure in the vicinity of the proposed landfill site was asked from the surveyed households as well as physically observed at site. It was noted that facilities such as Electricity, Sui Gas, Water Supply, Telephone, Sewerage Drainage, school are available in the settlement or in its vicinity.

4.4.20 Gender Assessment

279. The focus group discussions with females were made from the main settlements/villages located in the project area. Detailed gender assessment study will be planned to mainstream gender elements in the development of Mardan SWMF.

280. A Gender Action Plan (GAP) will be proposed to support the gender element of affected as well as the other households in the project. PMU Gender specialist will facilitate women specifically (elderly and single women without male support) in preparation of requisites for compensation, which may include the following:

- Opening of bank accounts of women in their name and ensure transparency of transferring compensation allowance
- Provide priority to vulnerable women/women headed families in compensation provision
- Maintain gender segregated database
- Ensure that women are aware about the amount of compensation provisions
- Include gender disaggregated data in the monitoring and evaluation system

- Ensure that women specific concerns and priorities are considered in resettlement process.

4.4.21 Existing Scavenging Practices

281. It is estimated that nearly 185 tons of waste is being generated and collected in Mardan, most of it is being dumped in open dumping sites. These open dumping sites are openly accessible to scavengers that search through and collect items of a recyclable nature i.e. paper, metals, plastic. These items they then either sell to scrap dealers or bring to their specific godowns to be sold onwards.
282. The process of consultation was planned to begin with contacting the workers collecting waste door-to-door every morning, and progressing step by step through scrap collection and sorting facilities of various capacities, possibly including the transporters associated along the way, up till the larger scrap recycling or management facilities.
283. The visits conducted by the environmental team, covering most of the aforementioned groups, yielded some useful data which projects a picture of the current operations within the informal waste management system structure. Studies on a limited scale have tried to assess their socioeconomic conditions, from their mean monthly income figures, to their motivation for this line of work and their working conditions (Alam et al, 2011). Generally, a scavenger on average makes between PKR 2000 and 3000 per month (Dawn, 2017). In most cases, this income supports the primary income source in the household, but there are cases where the scavenger's income is the primary or even sole income of the household (Alam et al, 2011). The major concern observed within this line of work is the overall health and safety risk that scavengers are under, as they constantly have to deal with sharp or dangerous objects with usually no protective measures or gear. Scavenging activities are observed to be mostly concentrated in commercial market areas of the city, with not as much outreach into residential neighborhoods.
284. The Integrated Solid Waste Management (ISWM) system will certainly influence these scavenging practices which is effectively almost an industry in itself. There is a considerable potential to positively channelize the work that these scavengers put in towards waste reduction and recycling, possible immediately after door-to-door collection takes place as well as at a Material Recovery Facility (MRF). The informal networks of scavengers can be brought on board by the WSSM operations by subcontracting them these waste sorting activities. This is likely to significantly secure both their livelihoods and their working conditions. Some level of vocational training will be required to ensure a uniform basic skill level, however, it is expected that these workers will bring to the job considerable experience from having performed it in an informal and unregulated sector.
285. The images provided below as **Figure 4-15** depict how much of tendency there is in the scavenging industry to employ young children. Once under a formalized umbrella, care will be taken to ensure that Child Labour Laws and best practices are fulfilled. Examples of global brands like Levi's and Nike (Dawn, 2017) retaining their underage workforce in Bangladesh, investing in their education and bringing them to work once they were of legal age, is a good precedent to look up to, determined ultimately by financial feasibility in addition to ethical considerations.
286. A study places the present rate of recovering recyclables from Mardan's total waste at 35%, which is predominantly done by these scavengers. Making use of their service in

a formal, regulated system of operation which emphasizes can improve this rate to as high as 90% (Hussain, 2013).

287. Considering all these factors, it is clear that an overall positive effect is anticipated from the ISWM system on scavenging and recycling. In addition, detailed consultations with scavengers, scrap dealers and personnel involved in the waste management business were conducted and the details are provided in **Chapter 8 (Stakeholder Consultations)**.

Figure 4-15: Illustrating young children engaged in scavenging as an essential means of their livelihood



4.5 Sensitive Receptor Mapping

288. The proposed landfill site location with the sensitive receptors i.e. residential settlements in the form of clusters and individual settlements are shown in **Figure 4.16**. The respective distances of these sensitive receptors from the proposed site are provided in **Tables 4.8**. It can be observed that project area in general consists of settlements, which adds to the sensitivity of this project considering the scale of the project and potential impacts to be expected during both the construction and operation phases of the project.

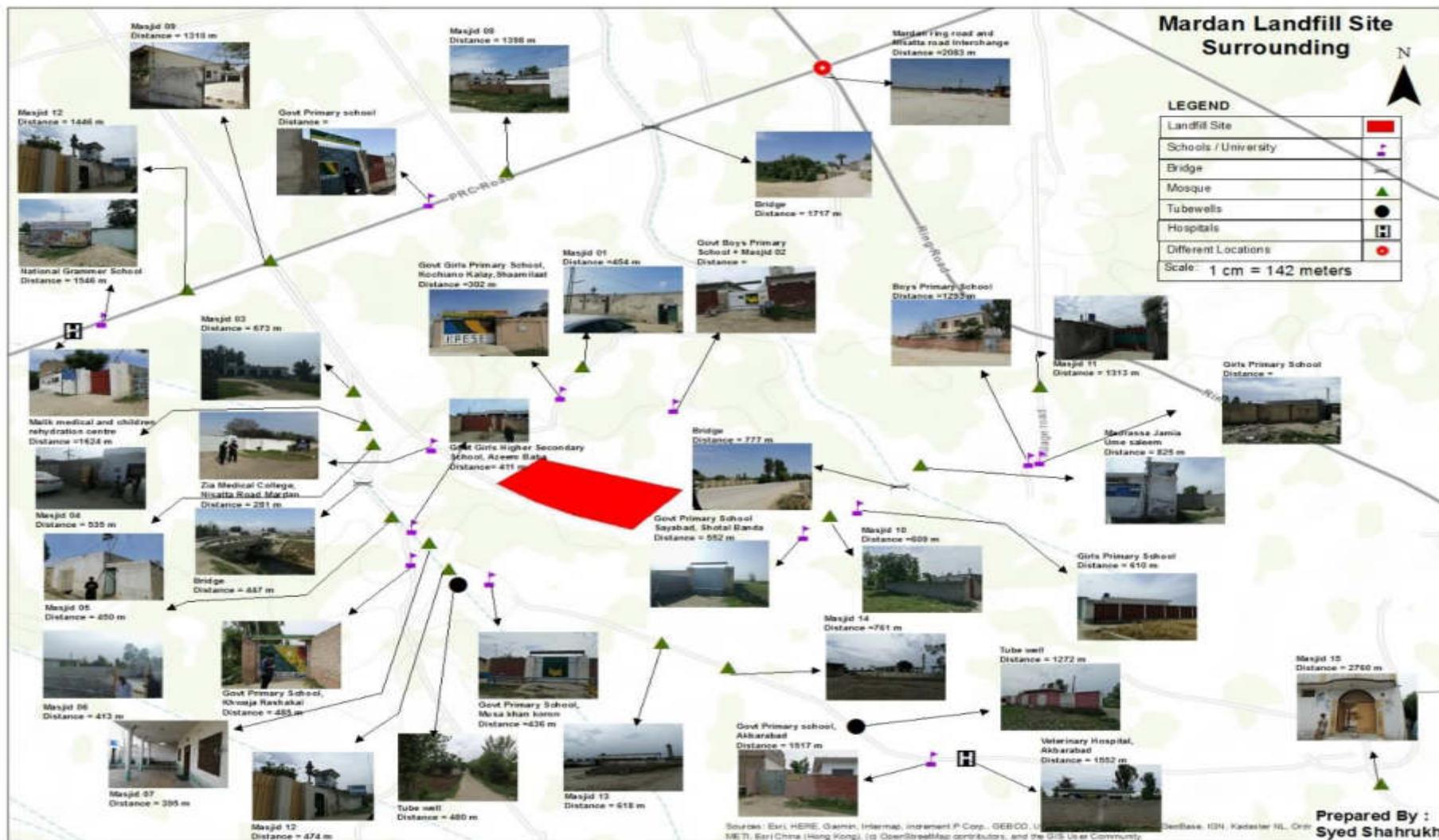
Figure 4-16: Sensitive Receptors and Prominent Structures within radius of 2 km from the proposed Landfill Site

Table 4.8: Sensitive Receptors and Prominent Structures within radius of 2 km from the proposed Landfill Site

	Pictorial View	Coordinates	Distance from site	Description
1.		71.97656 34.15198	500 m	<p>Govt Primary School Sayabad, Shotal Banda</p> <p>This is a new school to be inaugurated soon for the local kids of the village for educational purpose.</p>
2.		71.96774 34.15811	350 m	<p>Govt Girls Primary School, Kochiano Kalay, Shaamilaat</p> <p>This school is situated on the roadside of the route following the proposed landfill site.</p> <p>Student strength: 250</p>
3.		71.96848 34.15933	500 m	<p>Masjid 01</p> <p>This masjid is located in a nearby village to the proposed landfill site.</p> <p>Capacity: 100-130 people</p>

	Pictorial View	Coordinates	Distance from site	Description
4.		71.97186 34.15757	400 m	<p>Govt Boys Primary School Student strength: 120</p> <p>Masjid 02 Capacity: 70-100 people</p> <p>The mosque and school, located on the same property in a village near the proposed landfill site</p>
5.		71.96306 34.15584	300 m	<p>Zia Medical College, Nisatta Road Mardan</p> <p>This medical college is located along the roadside while following the route map to proposed landfill site</p>

	Pictorial View	Coordinates	Distance from site	Description
6.		71.96019 34.15825	670 m	Masjid 03 This is another masjid that has a madrassa as well as an Islamic education center
7.		71.96059 34.15673	540 m	Masjid 04 This masjid is located in a nearby village to the proposed landfill site. Capacity: 100-120 people
8.		71.96089 34.15590	450 m	Masjid 05 This masjid is located in a nearby village to the proposed landfill site. Capacity: 50-60 people

	Pictorial View	Coordinates	Distance from site	Description
9.		71.96053 34.15416	450 m	<p>Bridge</p> <p>A stream of water flows beneath this bridge. It's mostly sewerage water because a lot of sewers have been drawn open to these open drains.</p>
10.		71.96159 34.15271	390 m	<p>Masjid 06 (Hazrat Bilal Mosque)</p> <p>This masjid is located in a nearby village to the proposed landfill site.</p> <p>Capacity: 100-110 people</p>
11.		71.96235 34.15225	350 m	<p>Govt Girls Higher Secondary School, Azeem Baba</p> <p>This girl's educational centre is still under construction and is located near to the proposed landfill site.</p>

	Pictorial View	Coordinates	Distance from site	Description
12.		71.96293 34.15155	390 m	Masjid 07 This masjid is located in a nearby village to the proposed landfill site. Capacity: 80-100 people
13.		71.97721 34.17246	2083 m	Mardan Ring Road and Nisatta Road Intersection This is the intersection where exiting the Ring Road leads to the landfill site
14.		71.97100 34.16985	777 m	Bridge This bridge is situated on the route following the proposed landfill site. This bridge connects the local residents to bazar and ring road. A stream of surface water flows beneath this bridge.

	Pictorial View	Coordinates	Distance from site	Description
15.		71.96575 34.16788	1398 m	Masjid 08 This Masjid is located near to the proposed landfill site. Capacity: 80-120 persons
16.		71.96297 34.16661	1305 m	Govt Primary School This school is situated on the roadside along the route following the proposed landfill site. Strength of students: 200
17.		71.95717 34.16398	1310 m	Masjid 09 This masjid is located in a nearby village to the proposed landfill site. Capacity: 120-140 persons

	Pictorial View	Coordinates	Distance from site	Description
18.		71.97745 34.15275	609 m	Masjid 10 This masjid is located in a nearby village to the proposed landfill site. Capacity: 70-100 persons
19.		71.97852 34.15307	612 m	Girls Primary School
20.		71.97999 34.15405	1717 m	Bridge This bridge is situated on the route following the proposed landfill site

	Pictorial View	Coordinates	Distance from site	Description
21.		71.98075 34.15498	825 m	<p>Madrassa Jamia Ume Saleem</p> <p>This masjid is located in a nearby village to the proposed landfill site.</p> <p>Capacity: 150-180 persons</p>
22.		71.98470 34.15520	1293 m	<p>Boys Primary School</p> <p>Student strength: 170</p>

	Pictorial View	Coordinates	Distance from site	Description
23.		71.98512 34.15525	1293 m	Girls Primary School Adjacent to Boys School Student strength: 150
24.		71.98507 34.15844	1313 m	Masjid 11 This masjid is located in a nearby village to the proposed landfill site. Capacity: 100-130 persons
25.		71.95415 34.16269	1446 m	Masjid 12 This masjid is located in a nearby village to the proposed landfill site. Capacity: 150-180 persons

	Pictorial View	Coordinates	Distance from site	Description
26.		71.95112 34.16134	1546 m	National Grammar School Student Strength: 100
27.		71.95003 34.16086	1624 m	Malik Medical and Children Rehydration Centre

	Pictorial View	Coordinates	Distance from site	Description
28.		71.96234 34.15078	1485 m	Govt Primary School, Khwaja Rashakai Student Strength: 220
29.		71.96365 34.15040	1446 m	Masjid 12 This masjid is located in a nearby village to the proposed landfill site. Capacity: 100-120 persons
30.		71.96399 34.14969	1272 m	Tube well

	Pictorial View	Coordinates	Distance from site	Description
31.		71.96518 34.14995	436 m	Govt Primary School, Musa Khan Korona Student Strength: 300
32.		71.97137 34.14716	618 m	Masjid 13 This masjid is located in a nearby village to the proposed landfill site. Capacity: 100-120 persons
33.		71.97379 34.14609	761 m	Masjid 14 This masjid is located in a nearby village to the proposed landfill site. Capacity: 160-200 persons

	Pictorial View	Coordinates	Distance from site	Description
34.		71.97840 34.14347	480 m	Tube well
35.		71.98120 34.14204	1517 m	Govt Primary School, Akbarabad Student Strength: 130
36.		71.98241 34.14208	1552 m	Veterinary Hospital, Akbarabad

	Pictorial View	Coordinates	Distance from site	Description
37.		71.99745 34.14096	2760 m	Masjid 15 (Madina Masjid) This masjid is located in a nearby village to the proposed landfill site. Capacity: 160-200 persons
38.		72.00196 34.13843	2778 m	Masjid 16 This masjid is located in a nearby village to the proposed landfill site. Capacity: 100-120 persons
39.		72.00223 34.13917	2785 m	Govt Girls Middle School, Sherpur Student Strength: 250

	Pictorial View	Coordinates	Distance from site	Description
40.		72.00484 34.14008	2795 m	<p>Masjid 17</p> <p>This masjid is located in a nearby village to the proposed landfill site.</p> <p>Capacity: 110-130 persons</p>

4.6 Sensitive Receptor Mapping to assess compliance with IFC EHS Clause¹¹

289. The IFC EHS clause specific to Landfill Siting states the following:

"The location of the landfill should take into account potential impacts associated with releases of polluting substances including the following:

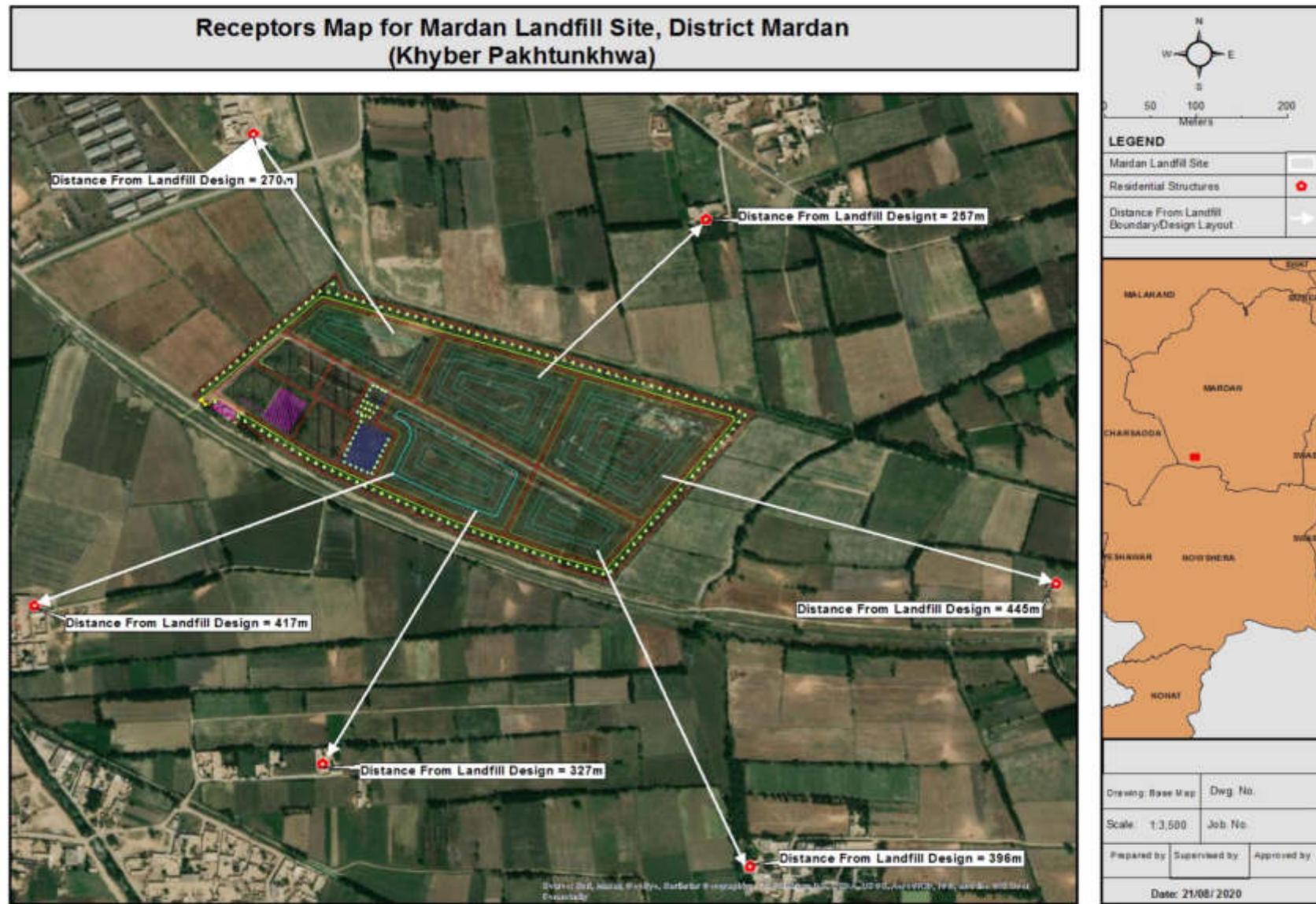
- *Proximity to residential, recreation, agricultural, natural protected areas, or wildlife habitat and areas prone to scavenging wildlife, as well as other potentially incompatible land uses:*

- ***Residential development should be typically further than 250 meters from the perimeter of the proposed landfill cell development to minimize the potential for migration of underground gaseous emissions.***

290. The field visits for social safeguard assessment by PMU and EDCM team has been carried out in September'20 to identify any sensitive receptors falling within 250 m distance from landfill cells. Assessment findings shows that none of the receptors are considered as sensitive as all are falling outside of 250 meters perimeter from landfill cells.

291. The details of these survey findings are provided in the **Figure 4.17** below.

¹¹ <https://www.ifc.org/wps/wcm/connect/5b05bf0e-1726-42b1-b7c9-33c7b46ddda8/Final%2B-%2BWaste%2BManagement%2BFacilities.pdf?MOD=AJPERES&CVID=jqeDbH3&id=1323162538174>

Figure 4-17: Sensitive receptor map of landfill site

5 Analysis of Alternatives

5.1 Overview

292. Project alternatives have been studied as a part of this EIA process. Alternatives analysis has been conducted in detail to foresee environment, economic and social impact of each alternative. This chapter also provides an overview of the various commercially available technologies for the treatment and processing of waste in an environmentally sound manner and are successfully running in developed countries in particular and recommend the most suitable set of options for Mardan city keeping in view its waste generation and composition.
293. Project alternatives has been studied keeping in view number of parameters including; waste quantum, physio-chemical properties of waste, suitability for mixed waste handling, land requirements, technical complexities, social acceptability, environmental and legal compliance, and OPEX & CAPEX requirements.
294. The development of the proposed SWMF is based on detailed feasibility assessments focusing on assessing the city requirements with regards to SWM and then determining the most suitable and effective technology and location for development of the required infrastructure.
295. This process of analysis of the different alternatives for development of the landfill site ensures that a well-informed decision is taken regarding the selection of the most optimal option amongst the possible options that are brought into consideration.

5.2 Alternatives Types

296. Types of alternatives considered for detailed analysis for Mardan SWM facility are given below;
- No Project Option
 - Site Selection Alternatives
 - Landfill Type Alternatives
 - Landfill Construction Alternatives
 - Waste Disposal Alternatives
 - Technological Alternatives for AD
 - Material Recovery Facility
 - Scenario Analysis for all possible treatment options for Mardan
 - Economic Analysis
 - Closure/Post Closure Plan

5.3 'No Project' Option

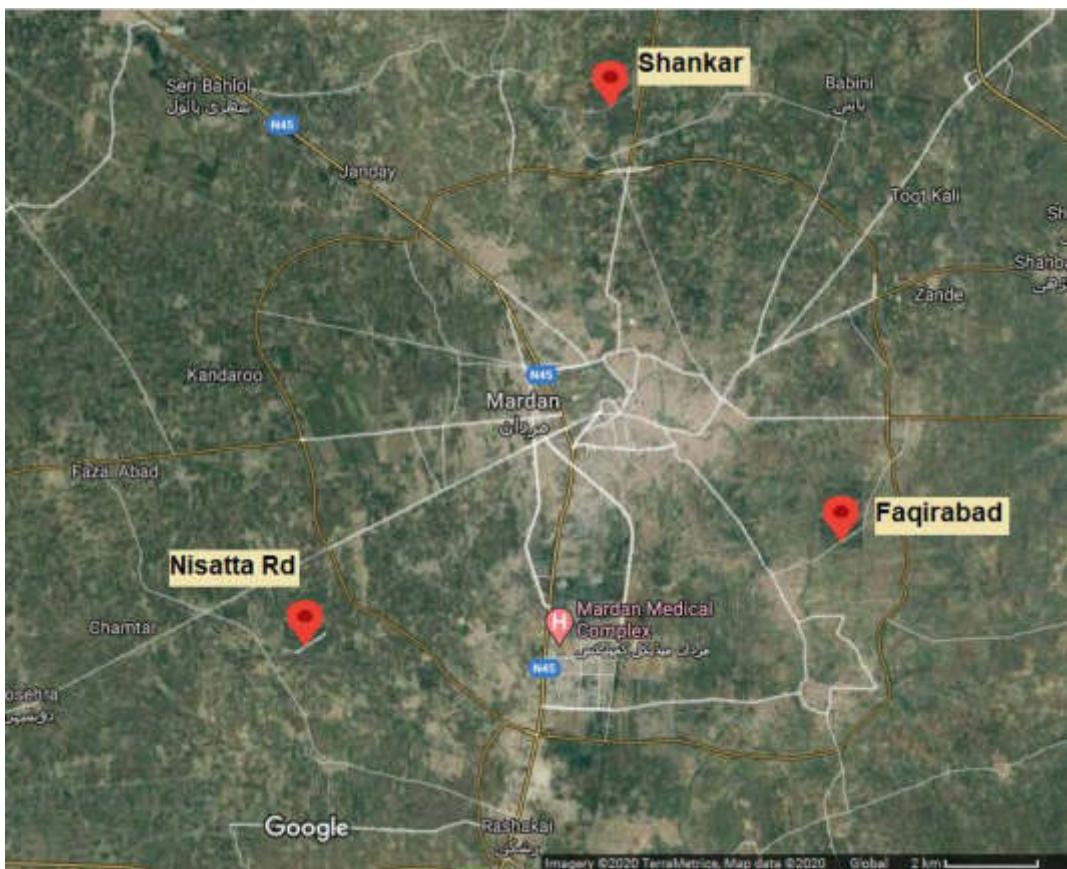
297. If 'no project' option is triggered, it will result in loss of all positive impacts caused that project will pose on Mardan city; such as eradicating open dumping of solid waste,

improving civic services in terms of integrated waste management, removing existing bottlenecks in the system and improving the aesthetic aspects of the city. If the project is not implemented, urban environmental quality will be further degraded. It also limits the urban development of the area in a sustainable manner.

298. On the other hand, if the project is implemented, it will result in improved SWM system services and improved urban environment quality. Furthermore, project implementation will also create job opportunities during construction, thereby improving the socioeconomic condition of the local people and help in improving their quality of life. Thus, the 'no project' option is not a viable option.

5.4 Site Selection Alternatives

299. In most official plans for a solid waste management facility, the site considered was identified on Nisatta Road a few kilometers outside the Ring Road in the south west of the city. Initially, no other site had been considered prior to designating this particular area for the proposed landfill site, following which even the pertinent land acquisition protocols had been initiated. However, the current project consultants and environmental experts proactively decided to explore other alternative site options in order eliminate any bias in favour of the original site to identify a site most feasible from a sustainability standpoint. Considerations in line with the criteria detailed above were kept in view when comparing the different sites and it was determined that availability of infrastructure, existing utilities, land availability in terms of acquisition and ownership, and the particular working modalities of the project would be the factors most influential in determining which site would eventually be deemed most feasible.
300. The sites analysed in this exercise thus included:
- **Nisatta Road site:** located outside the south western periphery of the Ring Road, 3 km from the Ring Road and 15 km from the city center.
 - **Faqirabad:** general area located 8-10 km south east of the city center, within the Ring Road.
 - **Shankar:** located on the northern periphery of the Ring Road, 11-12 km from the city center.
301. These sites are shown in the **Figure 5.1** below and the comparison of these different site alternatives is provided in **Table 5.1** below.

Figure 5-1: Location map of site alternatives**Table 5.1: Comparison of Site Alternatives**

Parameters	Site Alternatives		
	Nisatta Road Site	Faqirabad	Shankar
Environmental Sensitivity	Moderate to high as the surrounding area is predominantly agricultural.	High due to agricultural land use and closer proximity to nearby Kalpani River.	Fairly high because of surrounding agricultural and residential land use.
Infrastructure	Easy access through existing road network.	Some rural roads in the area.	Easier road access, though busier and crowded route from city.
Site capacity	80 acres already owned by WSSC, area can accommodate landfill operations.	Specific site location and size was not finalized. Ample area available.	Specific site location and size was not finalized. Area availability likely to be spatially constrained.
Land Acquisition	Land is already owned by WSSC over the past several years, and	New land acquisition will trigger social safeguard and cause financial burden. Land prices on	Land acquisition will trigger social safeguard and cause financial burden. Current denser

	boundary wall has been constructed.	the higher side due to development of residential housing societies.	residential settlements likely to be affected.
Social Acceptability	Relatively easily achievable since much of the surrounding population is quite aware of the area's planned use as a landfill	Likely to be difficult as currently the area is intensively agricultural and future residential developments are anticipated.	Difficult as the potential site would lie on or near high traffic route with relatively higher current population and property value
Distance from City Centre (km)	15	8	11

302. The sites considered are located some distance away from the densely populated urban center of the city. Population density in the immediate vicinity of all these sites is generally very low, but still varies from one site to next. The road infrastructure serving the areas varies too. The environmental sensitivity of all the areas is generally on the higher side, which will be catered for by adopting comprehensive and technically sound design, construction and operation plans.
303. The site at Nisatta Road has easy access through a road network which is usually not congested with traffic. The site itself is located a fair distance away from most of the population clusters in the area. The land on the site had been previously acquired by WSSCM, which has minimized the requirement for further land acquisition at this site. Regarding the social acceptability of the project at this site, members of the surrounding population, especially the elders, have been gradually made aware of the basic concepts of the intended landfill and have shown a relatively positive inclination towards the idea given its overall public benefits.
304. The area of Faqirabad, which features some fairly vast amount of open space flanked by residential settlements, emerged as one possible option where a landfill could be planned. This population in the vicinity is not dense yet but the open space is effectively being utilized for agricultural purposes. The road network does service the area but through narrow streets which may not be able to easily accommodate larger vehicles unless expanded. Although no specific site within this open space has been identified, it is understood that land acquisition will be a cumbersome and complicated process as the local landowners and the city's developers do have some sort of plans for the future development of this part of the city. Much of the space in this area is in close proximity to the Kalpani River.
305. The area near the village of Shankar on the northern periphery of the Mardan Ring Road was one more alternate location studied. There is some open space which could be utilized however the surrounding villages including Shankar are more densely populated than the other two sites discussed above. The road network is well established but since traffic is heavier, congestion becomes a frequent issue and is likely to be a drawback in the construction and operation phases. Because of this comparative convenience in location, the property prices are expected to be high, combined with the anticipated difficulty in social acceptability, land acquisition and resettlement will likely be a very complex issue.

5.5 Landfill Type Alternatives

306. There are various types of landfills that are designed and constructed worldwide to manage MSW, such as sanitary landfill, bio-reactor landfill and secured landfill. The safe and effective operation of landfill depends on sound planning, administration, and management of the entire MSW management system and selection of appropriate landfill type.

5.5.1 Sanitary Landfill

307. An engineered disposal location fully equipped and operation with leachate and landfill gas collection and treatment system. A disposal technique resulting in burial of waste using an engineered method intended to protect the environment, typically employing plastic liner and drains in the bottom to collect the liquids and cover on the top to keep rain water out and to keep methane and other gases to escaping.

5.5.2 Bioreactor Landfill

308. A bioreactor landfill is a municipal solid waste landfill (MSWLF) in which liquids are added to help bacteria break down the waste. The increase in waste degradation and stabilization is accomplished through the addition of liquid and air to enhance microbial processes.

5.5.3 Secured Landfill

309. Secured landfill is a carefully engineered depression in the ground (or built on top of the ground) into which wastes are dumped to avoid pollution to the surrounding environment. Secured MSW landfill should be restricted to non-biodegradable, inert waste and other waste not suitable for recycling or for biological processing.
310. Based on above information, the project design consultant suggested to construct a sanitary landfill for Mardan as it is relatively low in cost and requires less technical and operational maintenance as compared to other options.

5.6 Landfill Construction Alternatives

5.6.1 Lining

311. The purpose of the liner system is to prevent migration of leachate generated inside a landfill from reaching the soil and ground water beneath the landfill. Thus, the function of leachate collection facility is to remove leachate contained within the landfill by the liner system for treatment and disposal, control and minimize leachate heads within the landfill, and avoid damage to the liner system. The drainage layer comprises of granular soil having an appropriate permeability. The geo-membrane and layer of compacted clay barrier below must also have an appropriate thickness to protect the soil and water.
312. The alternative of concrete lining is not as favorable as the HDPE (high density polyethylene) geo-membrane due to its higher erosion factor, indirectly amounting to a higher maintenance cost and greater harm to the environment.

5.6.2 Leachate Collection and Treatment

313. The most suitable option is to spray the daily leachate back on the surface of the solid waste dumped at the landfill site. This is an economical and environmentally friendly

leachate handling method. If the volume of the leachate production goes beyond the spraying capacity, leachate treatment will be required.

314. The alternatives regarding leachate management itself are:

- Discharge to lined drains
- Discharge to waste water treatment system
- Recirculation
- Evaporation of leachate
- Treatment of leachate

315. There are various pros and cons to each option being studied and experimented with, including one in particular where the practice of recirculation functions as a catalyst to increased gas production (Kumar et al. 2011) to assist in energy recovery.

316. For Mardan, a combination of leachate management options has been selected, which include leachate spraying and leachate treatment. Leachate will be primarily used for spraying on the waste and remaining leachate will be collected and sent to preliminary treatment and then sent to DTRO plant for final treatment.

317. Incorporating additional technology in the form of remote monitoring equipment to the leachate management system, as well as to the gas management system can include having remote sensor on pumps and storage tanks to transmit real time data and alerts to an online system, that will reduce the requirement for round the clock surveillance to only when required in emergency scenarios.

318. The use of control technologies within these systems will allow facility operators and supervisors to be able to remotely address routine or emergency issues, whenever notified, without physically being present at the site.

5.6.3 Gas collection and Treatment

319. Landfill gas can migrate laterally and potentially cause explosions. Landfills are therefore provided with gas collection and processing facilities. The rate of gas production varies depending on the operating procedure. The rate and quantity of gas generation with time, is difficult to predict. Typical generation rates reported in literature vary from 1.0 to 8.0 litres/kg/year. Gas production rates of 60 m³ per hour have been reported from landfill sites in India having an area of 8 hectares and a depth of 5 to 8 m (Dutta et al. 2012). The decision to use horizontal or vertical gas recovery wells depends on the design and capacity of the landfill. The decision to flare or to recover energy from the landfill gas is determined by the capacity of the landfill site and the opportunity to sell power produced.

320. Gas outputs of 10 to 20 m³ per hour (corresponding to 50 to 100 KW of energy) have been recorded in wells of 15 to 20 cm diameter drilled 10 m into waste at spacing of 30 to 70 m. For 1 MW output from a landfill site, 15 to 20 such wells are required.

321. Alternative plans for gas management can be one of the following:

- Uncontrolled release

- Controlled passive venting
 - Controlled collection and treatment/reuse
322. The selection among these alternatives has to take into account not just the monetary cost incurred to apply the plan but also the environmental impact associated with it. In the case that using the gas for energy is feasible than even the more expensive management plan can produce financial paybacks.
323. For Mardan, flaring has been proposed for landfill gas management. Keeping in view the amount of gas production after few years of landfill operation, feasibility for gas reuse will be carried out and accordingly design changes will be executed.

5.7 Technological Alternatives for Anaerobic Digestion System (AD System)

324. The Anaerobic Digestion System (AD system) is controlled biological conversion and treatment of organic material by bacteria and other microbes in the absence of oxygen. Oxygen is toxic to anaerobic bacteria and other micro-organisms (anaerobes). The AD process produces biogas (about 50-60% methane or natural gas, 40-45% carbon dioxide and traces of other gases), liquid effluent and a solid, partially stabilized organic material known as digestate which is generally sent for further aerobic composting to yield a stabilized product (compost).
325. Many AD system designs are available in the marketplace. AD system vendors/EPC contractors will choose between:
- Wet or dry AD
 - Single or two stage ADS
 - Thermophilic or mesophilic AD
 - Continuous, plug flow or batch AD
326. The design decisions would need to be combined with pre-treatment decisions to create an overall AD design which would best meet the needs of the Mardan SWMF depending upon the waste characterization. Project design consultant advised not to prescribe or limit the design options at the pre-feasibility stage of the assessment. AD vendors/EPC contractors may provide customized approaches to AD and pre-treatment options.

5.8 Technological Alternatives for Material Recovery Facility (MRF)

327. Having already discussed their site selection criteria above, the analysis of technological specifications within MRF or composting facilities within the ISWMS will also determine how effectively they operate from both a financial as well an environmental point of view. The facilities for the proposed landfill can range from labour-intensive, lower initial costs but lower efficiencies, to machine-intensive, higher initial costs but greater efficiencies.

5.9 Waste Disposal Alternatives

328. Broadly, four technologies including i) direct burn technologies, ii) physical processing technologies, iii) biological processing technologies and iv) combined treatment have been considered and assessed for their suitability for the proposed landfill site.

5.9.1 Thermal/Direct Burn Technologies

329. Technologies involve the thermal decomposition of waste into gaseous, liquid and solid conversion products with release of heat energy. The main thermal processing technologies adopted internationally for the treatment of municipal waste are incineration, gasification (pyrolysis) and plasma gasification. However, keeping in view the costs and regional scenarios, only incineration would be taken into account for the purpose of technological assessment of direct burning in the Mardan case.

5.9.2 Physical Processing Technologies

330. Physical technologies involve altering the physical characteristics of the MSW feedstock. The MSW may be separated, shredded, and/or dried in a processing facility. The resulting material is referred to as refuse-derived fuel (RDF) and if the quality of the RDF is improved to meet the minimum criteria for required BTU. It may be densified or pelletized into homogeneous fuel pellets and transported and combusted as a supplementary fuel for industrial boilers, cement manufacturing facilities, brick kilns or even waste to energy incineration plants.

5.9.3 Biological Processing Technologies

331. Biological treatment involves micro-organisms to decompose the biodegradable fraction of the waste. The biological process can be aerobic or anaerobic, and the main biological technologies adopted internationally for the treatment of municipal solid waste are composting and methanation (anaerobic digestion).

5.9.4 Combined Treatment

332. These include technologies like Mechanical Biological Treatment (MBT), which is a combination of technologies including material recovery facilities, refuse derived fuels and aerobic/anaerobic digestion. All the aforesaid technologies have been reviewed in the following section and their suitability for Mardan city has been assessed.

5.9.5 Qualitative Assessment of Various Technologies

333. In order to qualitatively assess the suitability of the technology for Mardan city, technology assessment criteria/ filters used are provided as **Table 5.2** below.

Table 5.2: Qualitative Assessment criteria for waste treatment options

Criteria	Description
Scale of Application (tpa) and with respect to population	Minimum quantum of waste for financial viability
Waste Suitability, moisture and organic fractions	Technologies that are suitable for MSW characteristics of Mardan city Technology must be capable of handling high organic waste & high moisture content – Waste Assessment and Composition (WAC) Study conducted under this project in May 2020 show high organic (53.6%) and moisture content (72.5%)
Suitability of technology for mixed waste and segregated waste and specific waste avoidance	Though there is no regulatory binding for the segregation of waste, putting segregation into practice requires a lot of efforts from WSSM side and is a time-consuming process to make resident adhere to waste segregation practices. In addition, it

Criteria	Description
	requires additional infrastructure for segregated collection and transportation and has high operation cost due to increase in transportation cost and deployment of additional manpower
Volume reduction %	Effectiveness of the technologies for reducing the volume of the waste
Land requirements	Area per tons of the waste required
Technology Reliability	Technologies that are proven internationally and have successful application in the region and could be considered without reservations for Mardan
Operational Complexity	Least complex technology is mostly suitable for the developing counties owing to the fact that the little or no expertise are available to operate and maintain the system
State of Art and Clean Technology	Technologies with low emission & low negative environmental impacts (Low carbon footprint)
Waste technology value chain assessment	<p>Technologies that require value addition of the MSW chain for sustainability against following parameters:</p> <ul style="list-style-type: none"> ▪ Technology that can process mixed waste ▪ Technology that requires pre-processing of waste to make it compatible ▪ Technology that requires source-segregated waste and a higher degree of pre-processing
Compliance with the regulatory requirement	The technology is in compliance with the regulatory requirements
Reject Diversion to the Landfill	Technologies with low diversion of rejects to the landfill are more acceptable
Social acceptability	Technology should be socially acceptable
Market sounding	Market for products and by products
Flexible	Modular and flexible plant to address the increasing waste supply in future
Lock-in Effect	Generally, refers to as a dedicated investment in a WtE project, and the requirement of a fixed amount of waste for incineration over the plant's life. The lock-in effect could lead to undermining waste prevention, reuse and recycling policies and programmes due to lack of funds to develop those systems, or "put or pay" contracts that mandate municipalities provide a fixed/minimum guaranteed amount of waste to the incinerator or pay a fine.
3Rs Trade-off	Technology be selected that is not impacted by the future recycling programs
Sustainability	Although it would be difficult to have a fully sustainable model. However, the CAPEX and OPEX of the system have to be looked in comparison with the cost per m ³ available airspace for landfill (with landfill infrastructure and maintenance and operational costs)

334. All the prevalent waste processing technologies discussed were assessed in comparison with landfill as per the above-mentioned criteria and details are presented in **Table 5.3** below.

Table 5.3: Qualitative/Subjective assessment of various technologies for Mardan City

Sr#	Criteria	Windrow Composting	Direct Incineration	RDF Incineration	Bio-Methanation	Mechanical Biological Treatment	Landfilling
1	Scale of Application (tpd)	Minimum waste tonnage should be 25 TPD and above. For Mardan the waste tonnage is 118 TPD and thus a suitable option	500 tpd and above (smaller plants are not technoeconomically viable, given the cost of required environmental control equipment & boiler technology. For Mardan, due to less waste availability (118tpd) direct incineration is not feasible	500tpd and above (smaller plants are not technoeconomically viable, given the cost of required environmental control equipment & boiler technology. For Mardan, due to less waste availability (118tpd) direct incineration is not feasible	Centralized up to 500 tpd plant as well as decentralized plants are operational in the region. Therefore, scale of application may vary from 1-500 TPD. Suitable for Mardan	Centralized up to 500tp plant as well as decentralized plants are operational in the region and globally. Therefore, scale of application may vary from 1-500 TPD. Suitable for Mardan.	Applicable for small to large scales and there is no minimum waste tonnage required
	Applicable with Population Size	Suitable for cities with population more than 0.1 Million while Mardan is city with population less than 0.2 Million.	Suitable for cities with population more than 1 Million while Mardan is city with population less than 0.2 Million.	Suitable for cities with population more than 1 Million while Mardan is city with population less than 0.2 Million.	Suitable for cities with population more than 0.5 Million while Mardan is city with population less than 0.2 Million.	Suitable for cities with population more than 0.5 Million while Mardan is city with population less than 0.2 Million.	Suitable for city of any size
2	Waste Suitability/acceptability	Food waste (including wastes	High moisture and organic content make it unsuitable.	High moisture content makes it unsuitable Calorific value	Food waste (including wastes from households,	Most suitable technology to handle	Municipal solid waste, construction

Sr#	Criteria	Windrow Composting	Direct Incineration	RDF Incineration	Bio-Methanation	Mechanical Biological Treatment	Landfilling
		from households, restaurants and markets), fats/ oils/ grease, paper and cardboard, landscaping and garden waste (e.g. hedge-clippings, leaves)	Requires waste with calorific value > 3000 BTU/lb Calorific value of the waste is higher than 6000 BTU but due to high moisture content, it would be unsuitable without pre-drying of the waste.	requirement is 3000-6000 BTU/lb for RDF with moisture less than 20% which is difficult to achieve without preprocessing/predrying of the waste and that would add additional costs	restaurants and markets), fats/ oils/grease, slaughterhouse waste> Mardan's waste contains high organic content (approximately 54%), Moisture content (72.5%) – suitable	heterogeneous waste with no initial requirement of segregation at source	and demolition waste, wastewater sludge, nonhazardous industrial wastes
3	Organic waste composition threshold or moisture content	Higher fraction of organic content is required. Mardan's waste contains high organic content (approximately 54%) and Moisture content (72.5%) – suitable	<50% moisture content Moisture content in Mardan's Waste is (72.5%) which makes it unsuitable for incineration	<12% moisture content Moisture content RDF (e.g. from DG Khan cement plant is above (20%) which makes it unsuitable for incineration or direct combustion	>50% of the MSW Mardan's waste contains high organic content (approximately 54%) and Moisture content (72.5%) – suitable	Low as possible to make the sorting process easier.	Low as possible to keep the leachate production lower. However, with leachate collection system in place moisture content does not impact the process of the landfilling and its operations

Sr#	Criteria	Windrow Composting	Direct Incineration	RDF Incineration	Bio-Methanation	Mechanical Biological Treatment	Landfilling
4	Waste to Avoid	Non-biodegradable wastes (plastic, glass, metal, inserts) Mixed waste in Mardan	Yard leaves or source separated food waste	C&D waste and sludge from the desilting of the drains	Non-biodegradable wastes (plastic, glass, metal, inserts), tree clippings	Medical infectious waste	Medical infectious waste
5	Suitability of technology for mixed waste and segregated waste	High – Feed stock should be free from non-biodegradable and debris and low on moisture	High – Feed stock should be free from inert and debris and low on moisture Content. In Mardan, due to mixed waste/sludge collection and higher moisture content, it's unsuitable	High – Feed stock should be free from inert and debris and low on moisture content. In Mardan, due to mixed waste/sludge collection and higher moisture content, it's unsuitable	Unsuitable for mixed waste Pre-sorting/segregation is required for Mardan	Most suitable technology to handle heterogeneous waste with no initial requirement of segregation at source	Ultimate treatment for the mixed waste
6	Pre-Processing	High Required for mixed waste	Low Required for mixed waste	High Required for mixed waste	High Required for mixed waste	Not required	Not required
7	Volume reduction %	50-70%	80-85%	80-85%	50%	80-85%	Nil

Sr#	Criteria	Windrow Composting	Direct Incineration	RDF Incineration	Bio-Methanation	Mechanical Biological Treatment	Landfilling
8	Land requirements	High (For 500 tpd of MSW, 6 ha of land is required)	Low land requirements 16-40 Sq.m per tons of the waste ¹²	Low land requirements 16-40 Sq.m per tons of the waste ¹³	Low to Moderate For small units: 500 sq. m for 5MT unit For large scale: 300 TPD of MSW: 2 ha of land is required)	High (For 500 tpd of MSW: 6-8 ha of land is required)	Generally large
9	Labor Requirements	Labor intensive and Requires considerable technical capacity	Not labor intensive but Requires considerable technical capacity	Not labor intensive but Requires considerable technical capacity,	Labor intensive (based on current practice)	Labor intensive (based on current practice)	Not labor intensive but Requires considerable technical capacity
10	Energy Requirements	Moderate	High	High	Moderate	High	Low
11	Reject	30-50%	Up to 15%	Up to 15%	Up to 50%	Up to 15%	100%
12	Reliability - proven internationally for large scale	Proven technology	Internationally proven Developed countries	Proven technology	Internationally proven and many plants under	Highly sensitive	Proven technology

¹² Incineration of Municipal Solid Waste February 2013, DEFRA UK¹³ Incineration of Municipal Solid Waste February 2013, DEFRA UK

Sr#	Criteria	Windrow Composting	Direct Incineration	RDF Incineration	Bio-Methanation	Mechanical Biological Treatment	Landfilling
			moving away from mass burn technology to cleaner technologies		operation	process and plant performance is impacted by slight contamination	
13	Operational Complexity	Least technically complex	Technically complex, requires highly skilled training and careful maintenance	Technically complex, requires highly skilled training and careful maintenance	Technically complex, requires highly skilled training and careful maintenance	Technically complex, requires highly skilled training and careful maintenance	Requires specialized training, careful maintenance, and post-closure care
14	State of Art and Clean Technology	High percentage of rejects i.e. 30-50% requires more space for disposal of the reject and have higher emissions.	High emission from waste incineration (SOx, NOx, heavy metals, Dioxins, Furans) Emission control system has high capital and operating cost	High emission from waste incineration (SOx, NOx, heavy metals, Dioxins, Furans) Emission control	No harmful emissions	No harmful emissions	Methane Emissions

Sr#	Criteria	Windrow Composting	Direct Incineration	RDF Incineration	Bio-Methanation	Mechanical Biological Treatment	Landfilling
				system has high capital and operating cost			
15	Leachate Pollution	High	Low	Low	High to slurry production. However, with the composting process, can be managed easily at site.	High	High
16	Carbon Foot Print	Low	Least	Moderate	Low	Low	High
17	Predominant skills for Operation and Management	Skilled & Semiskilled labour	Highly Skilled Labor required	Highly Skilled Labor required	Skilled & Semiskilled labor	Skilled & Semiskilled labor	Skilled & Semiskilled labor
18	Compliance with the regulatory requirement	Low environmental pollution	High environmental pollution if not the air purification system is substandard and temperature is maintained below 850 °C	High environmental pollution if not the air purification system is substandard and temperature is maintained below 850 °C	Low environmental pollution	Low environmental pollution	High environmental Pollution if leachate and gas collection system is inadequate
19	Social acceptability	Odour issues in case of improper aeration	Negative public perception & low acceptability	Negative public perception & low acceptability	High public acceptance	High public acceptance	Negative public perception

Sr#	Criteria	Windrow Composting	Direct Incineration	RDF Incineration	Bio-Methanation	Mechanical Biological Treatment	Landfilling
		Public acceptance higher than waste to energy technologies					& low acceptability
20	Market sounding	Market for Products and byproducts. In Pakistan compost market is very low	Readily available market for energy form waste	Readily available market for energy form waste	High demand for energy and Bio-CNG	High demand for recyclables while low to moderate demand for RDF and compost	None
21	Flexible/Modular and capable to adjust for lock-in effect	Highly flexible and capable to adjust according to the quantum and composition of the waste as well the possible future intervention for source separation intervention.	Not flexible and prone to lock in effect	Not flexible and prone to lock in effect	Flexible and capable to adjust according to the quantum and composition of the waste as well the possible future intervention for source separation intervention.	Flexible and capable to adjust according to the quantum and composition of the waste as well the possible future intervention for source separation intervention.	None

Green – Highly favorable, Light Blue – Moderately favorable, Brick red – Least favorable

5.10 Proposed Solution for Mardan City

335. Comparison of the prevalent technologies and waste characterization results for Mardan city indicates that incineration may not be suitable considering the high moisture content and organic fraction; and composting, bio-methanation and MBT are relatively more suitable technologies.
336. Bio-methanation as a technology is highly sensitive and requires highly segregated waste or pre-processing of waste to make it successful. Hence, Bio-methanation is suggested as a technology for processing the entire organic waste of Mardan (can be used only for segregated waste from hotels and market places that can be up to 30 tons/day and reject of the MRF facility making a total of around 100 tpd).
337. Composting technology is also a proven technology, but it failed badly with respect to the amount of rejects it transfers to the landfill (40-50%) and in terms of acceptability of the compost from the mixed waste. Mechanical Biological Processing Technology is found relatively more suitable, adaptable and flexible technology for the type of waste generated in Mardan.

5.10.1 Scenario Analysis for all possible treatment options

338. Based on the quantum of waste and composition, there are five possible scenarios which could be further ruled out through alternate technological comparative analysis. Landfill cannot be replaced because it would be needed in any case for the disposal of the reject and/or disposal of unsaleable compost and no single technology would be suitable for mixed waste.
339. **Scenario-1** can be without any intermediate treatment and 100% waste collected is landfilled as shown in **Figure 5.2** below.

Figure 5-2: Scenario-1-No Intermediate treatment

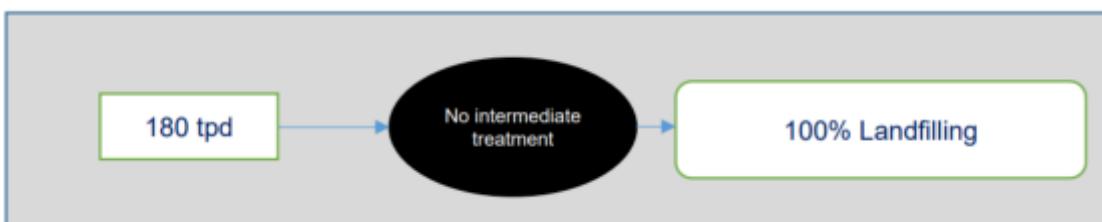


Table 5.4: Pros/Cons of Scenario-1

Pros	Cons
<ul style="list-style-type: none"> ▪ Most common method for ultimate treatment of the mixed waste in Asian countries. ▪ Less technicalities involved as compared to advanced treatment options. ▪ Lower risk of technology failures. 	<ul style="list-style-type: none"> ▪ Higher methane emissions in case of non-LFG capturing project. ▪ No remedy in case of landfill liner failure ▪ Higher O&M and life cycle cost ▪ 100% landfilling would require more landfill

- | | |
|--|--|
| <ul style="list-style-type: none"> ▪ Easy to operate and maintain, however, institutional competencies must be gauged for O&M of the landfills. ▪ Less capital investment required as compared to other technologies | <ul style="list-style-type: none"> ▪ 100% landfilling of the MSW is not in line with the SDGs and National Action plan ▪ Limited opportunities for harnessing economic potential of the waste. |
|--|--|

340. **Scenario-2** is to look for options considering the highest volume reduction and energy production and landfilling only debris and ash produced in combustion process as shown in **Figure 5.3** below.

Figure 5-3: Scenario-2 (2 streams)

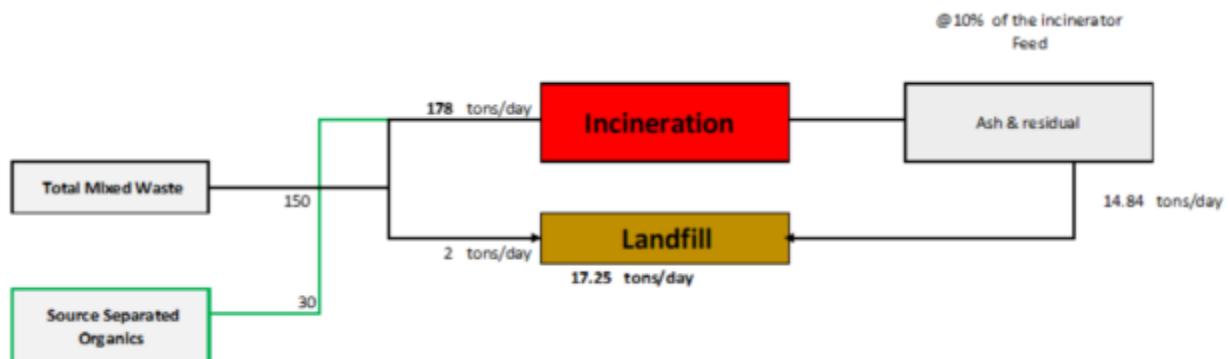


Figure 5-4: Mass balance and %age waste treatment by different options with scenario-2

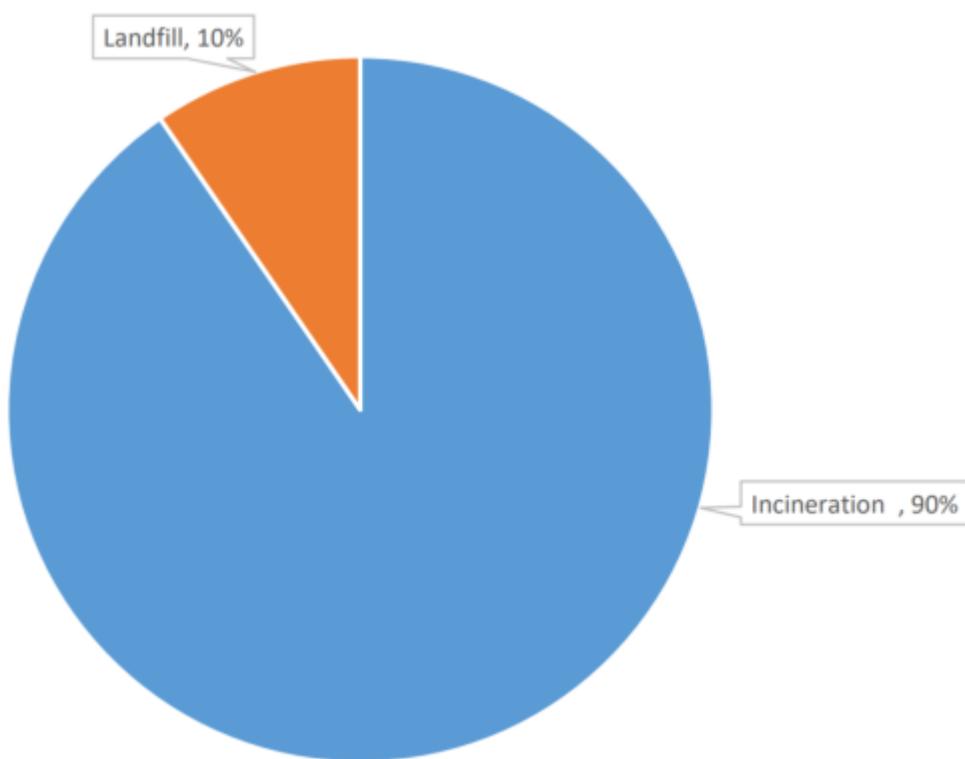


Table 5.5: Pros/Cons of Scenario-2

Pros	Cons
<ul style="list-style-type: none"> ▪ Suitable option for mixed MSW ▪ Less land requirements ▪ Can handle infectious and industrial wastes too ▪ Energy recovery 	<ul style="list-style-type: none"> ▪ Highly expensive and not financially viable due to low quantum of waste. ▪ Not suitable because of higher moisture and lower calorific values ▪ Low energy tariff

341. **Scenario-3** considers the recovery of the recyclables through sorting the mixed waste through mechanical means on conveyor belt after fine and coarse screening using trommels. Sorting may be done though magnetic separator and manual processes. Remainder organic fraction can be used for biological treatment using windrow composting (with sales of 50% of compost produced while using 50% as soil cover for landfill).

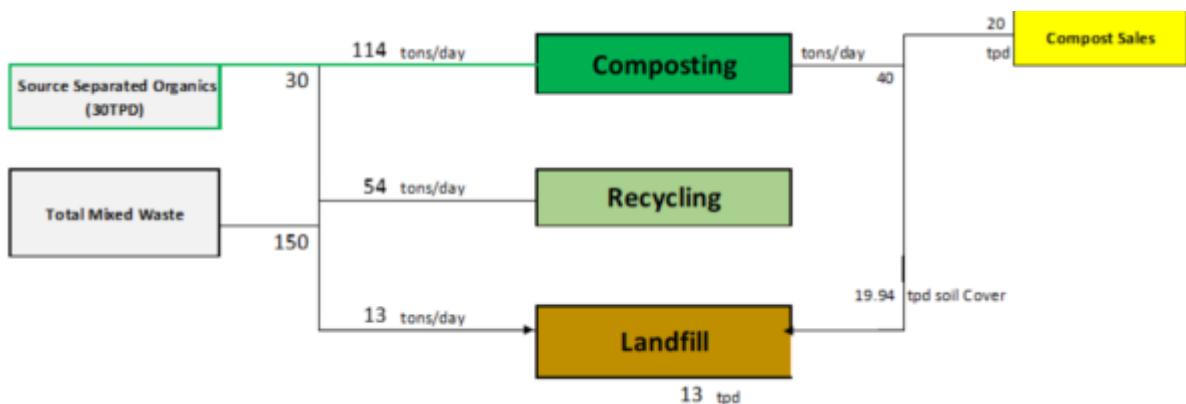
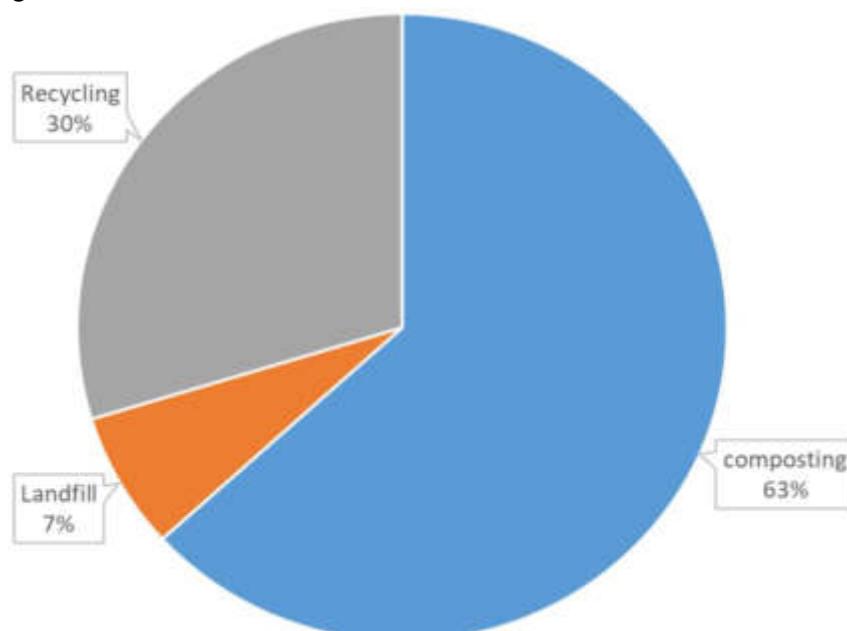
Figure 5-5: Scenario 3 – Composting, Recycling and landfilling (3 streams)**Figure 5-6: Mass balance and %age waste treatment by different options with scenario-3**

Table 5.6: Pros/Cons of Scenario-3

Pros	Cons
<ul style="list-style-type: none"> ▪ Suitable for mixed municipal waste with higher organic fractions ▪ Can recover recyclables ▪ Organic stream can be converted to compost which can be solid as soil enrichment material or can be used as soil cover for the landfill. Composting helps to reduce the mass of the organic waste by 60-75% by volume. Even if there are limited compost sales, it's still economically and environmentally beneficial to convert the organic waste to the compost saving environmental emissions, landfill air space (improving the life of the landfill) and reducing the O&M cost of the landfill. ▪ Least expensive Option ▪ Easy to operate and maintain the facility ▪ Sorting facilities are available for manual to-semi-automatic to fully automatic. 	<ul style="list-style-type: none"> ▪ Without removal of the combustible fraction, the impurities (particularly plastic) may deteriorate the quality of the compost, Therefore, furthermore removal of combustible to prepare RDF will be beneficial but this would be a trade-off between the recyclables and combustible for a better calorific value RDF. ▪ Recyclables entering the mixed waste stream and collected by the compactors are low quality and therefore would have limited sales and revenue potential. ▪ Composting process does not recovery the energy potential of the organic waste. It means, CO₂ produced during the aerobic composting process is emitted in the air, though CO₂ is 21 times less harmful than CH₄ ▪ Feedstock management for composting might be challenging especially maintain the required CN ratio, moisture content an organic matter %age for better sales

342. **Scenario-4** is to employ mechanical and biological treatment process for recovery of recyclables and compostable and conversion of the organic waste to the compost using biological process of windrow composting. Although, recovery of the recyclable would be low when targeting for high quality RDF however it is necessary for removing the impurities from the organic waste stream.

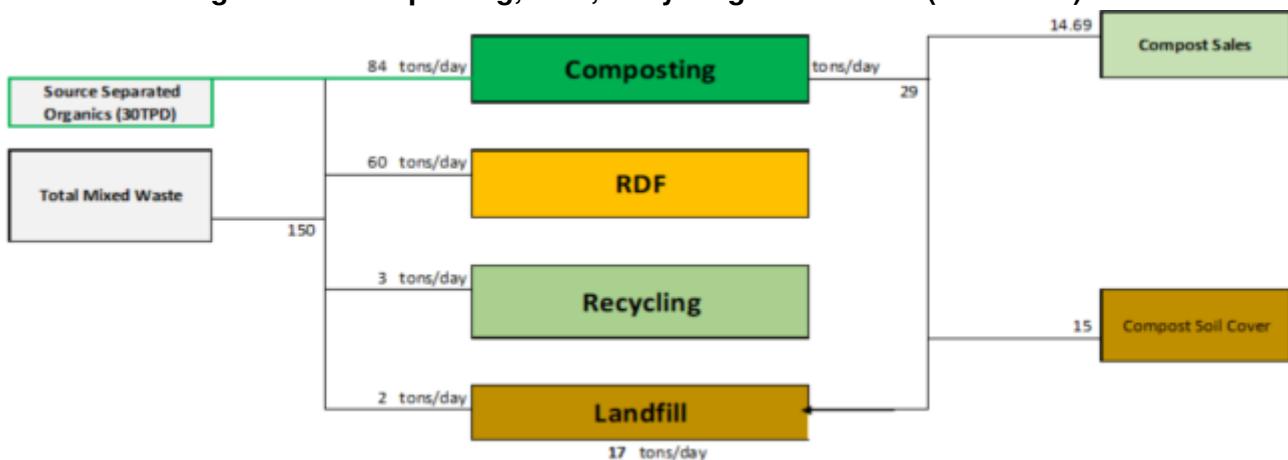
Figure 5-7: Composting, RDF, Recycling and Landfill (4 streams)

Figure 5-8: Mass balance and %age waste treatment by different options with scenario-4

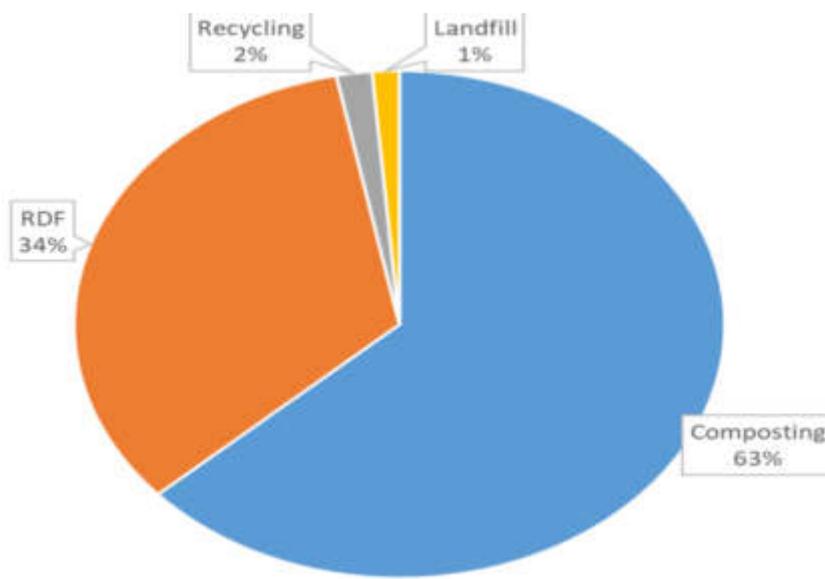


Table 5.7: Pros/Cons of Scenario-4

Pros	Cons
<ul style="list-style-type: none"> ▪ Suitable for mixed municipal waste with higher organic fractions ▪ Can recover recyclables ▪ Organic stream can be converted to compost which can be sold as soil enrichment material or can be used as soil cover for the landfill. Composting helps to reduce the mass of the organic waste by 60-75% by volume. Even if there are limited compost sales, it's still economically and environmentally beneficial to convert the organic waste to the compost saving environmental emissions, landfill air space (improving the life of the landfill) and reducing the O&M cost of the landfill. ▪ Least expensive Option ▪ Easy to operate and maintain the facility ▪ Sorting facilities are available for manual to-semi-automatic to fully automatic. 	<ul style="list-style-type: none"> ▪ Recyclables entering the mixed waste stream and collected by the compactors are low quality and therefore would have limited sales and revenue potential. ▪ Composting process does not recover the energy potential of the organic waste. It means, CO₂ produced during the aerobic composting process is emitted in the air, though CO₂ is 21 times less harmful than CH₄ ▪ Feedstock management for composting might be challenging especially maintain the required CN ratio, moisture content an organic matter %age for better sales ▪ No or limited market for the compost sales ▪ NO or limited market for the RDF sales. ▪ Environmental emission due to direct burning of the RDF by the Cement factories and brick kilns are not monitored.

343. **Scenario-5** is again based on MBT technologies employing sorting of the recyclables and combustibles and diverting the organic waste toward dry anaerobic digestion process for biogas/energy production and then treating digestate with aerobic composting process used aerated piles. Benefits and risks associated with this scenario are summarized in **Table 5-8** below.

344. Scenarios 4 and 5 are suitable options for Mardan keeping in view the analysis done. However, it's recommended to adopt and implement the option-5 for sustainable solid waste management. Institutional arrangement, operational plan business model would be key factors for the success of the proposed system. It is therefore necessary to review and develop an enabling environment for the implementation and success of the advanced treatment option.

Figure 5-9: Digestion/Methanation, RDF, Recycling and Landfill (4 Streams)

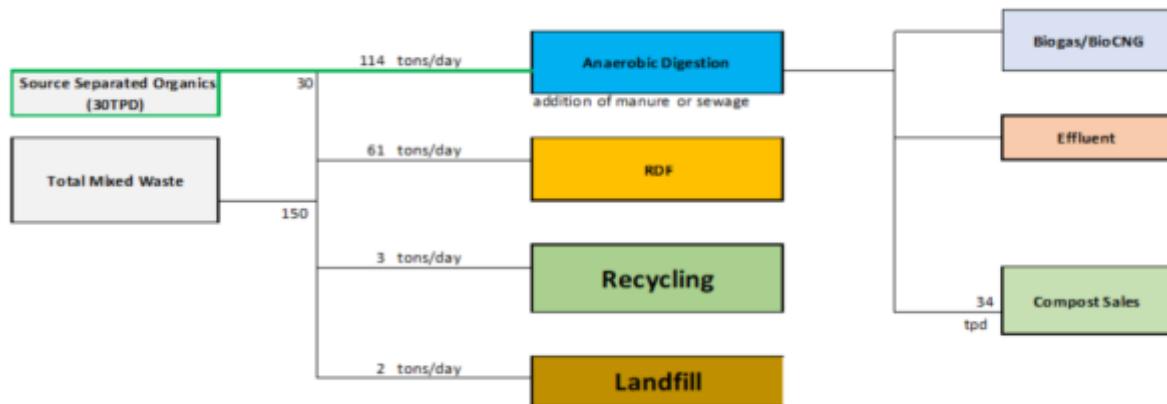


Figure 5-10: Mass balance and %age waste treatment by different options with scenario-5

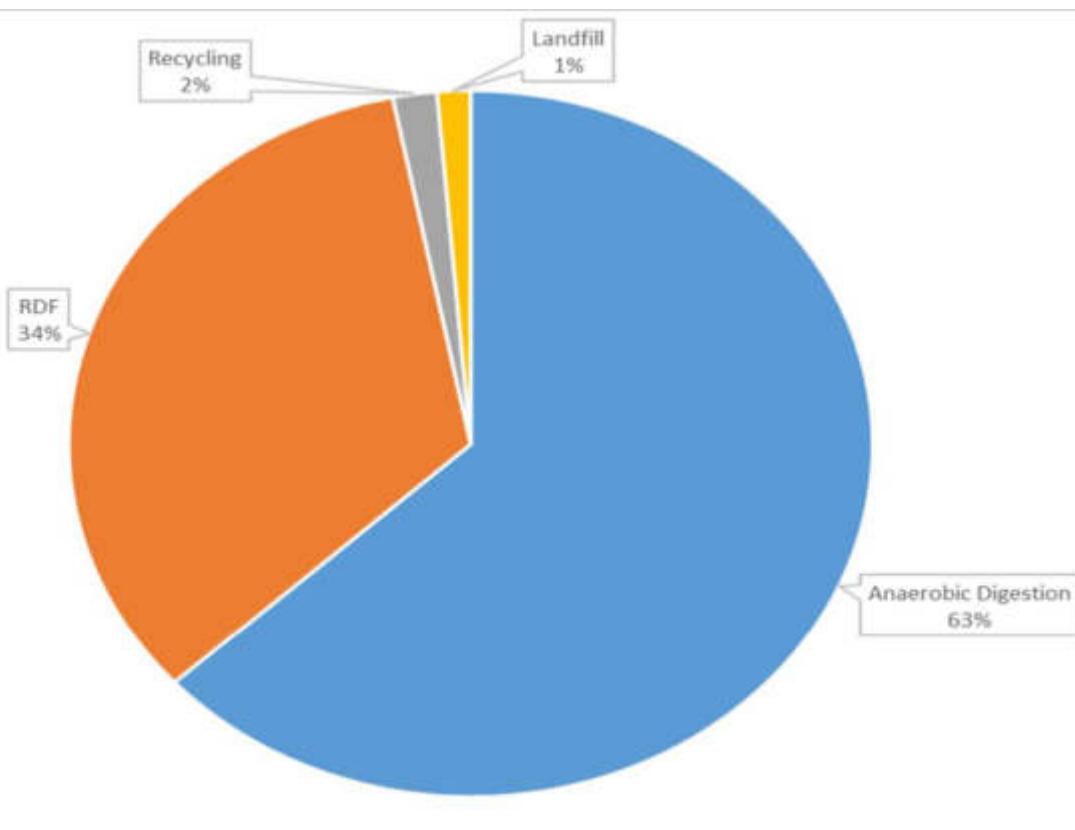


Table 5.8: Pros/Cons of Scenario-5

Pros	Cons
<ul style="list-style-type: none"> ▪ Suitable for mixed municipal waste with higher organic fractions ▪ Can recover recyclables ▪ Easy to operate and maintain the facility ▪ Sorting facilities are available for manual to-semi-automatic to fully automatic. ▪ Recovery of the Biogas and thus further reducing the environmental emissions ▪ Digestate from the AD process can be converted to compost which can be sold as soil enrichment material or can be used as soil cover for the landfill. Composting helps to reduce the mass of the organic waste by 60-75% by volume and combined by AD process can go up to 85-95%. Even if there are limited compost sales, it's still economically and environmentally beneficial to convert the organic waste to biogas and the compost saving environmental emissions, landfill air space (improving the life of the landfill) and reducing the O&M cost of the landfill. ▪ Can handle the animal and sludge from the wastewater treatment plants. ▪ Less land footprint. ▪ Several success stories from region (India) as well as from the Europe and USA 	<ul style="list-style-type: none"> ▪ Recyclables entering the mixed waste stream and collected by the compactors are of low quality and therefore would have limited sales and revenue potential. ▪ No or limited market for the compost sales ▪ No or limited market for the RDF sales. ▪ Environmental emission due to direct burning of the RDF by the Cement factories and brick kilns are not monitored. ▪ Comparatively expensive Option ▪ AD process is highly sensitive toward feedstock. maintain the required feedstock quality might be a challenging task

345. Summary analysis of all possible scenarios for Mardan city is provided below as **Table 5.9.**

Table 5.9: Qualitative Evaluation of Possible Scenarios for Mardan City

Scenario	Discussion	Recommendation
Scenario-1: No treatment	<ul style="list-style-type: none"> ▪ Landfilling of the waste is not in line with the SGDs and National Action plan. ▪ 100% disposal of the waste to the landfill will require large landfill infrastructure. Furthermore, the approach is not in align with the sustainable development goals and national vision 2025. ▪ Several landfills were developed under different initiatives, particularly in Punjab and majority of these are failures due to technical in competencies of the concerned waste management companies. 	Not recommended
Scenario-2: Incineration & landfilling	<ul style="list-style-type: none"> ▪ Given the fact that waste produced in Mardan is less than minimum threshold of 275 tpd for financially viable WtE intervention. Furthermore, as discussed earlier incineration is not suitable for WtE due high organic fraction (54%) and moisture content (72.5%) ▪ It is highly expensive options ▪ There is not a single MSW incitation facility in Pakistan. Though there are several very small-scale incineration units available with the healthcare facilities and that too are poorly managed and are non-compliant to the environmental emission standard (NEQS). 	Not possible
Scenario-3: Composting, Recycling and Landfilling	<ul style="list-style-type: none"> ▪ Semi-Automatic sorting line to segregate the recyclables & combustibles from organic stream is possible that would result in improving of the compost quality as well. ▪ In addition to recyclables, there is fraction of combustible waste too. If it's not separated from the reminder organic stream it might impact the compost quality. 	Not recommended

Scenario	Discussion	Recommendation
	<ul style="list-style-type: none"> ▪ As discussed in the previous sections, there are several small -large scale composting initiatives by the private as well as on PPP basis. Small scale initiatives by the private sector are successfully running while the large-scale intervention in Lahore (1000tpd) failed due to the mixed waste processing and unable to meet the required quality. 	
Scenario-4: Composting, RDF, Recycling and Landfilling	<ul style="list-style-type: none"> ▪ With manual sorting of the recyclables it would be possible to segregate the combustible fraction as well leaving only pure organic stream that would have high C:N ratio, moisture content and further additives like animal manure, fecal sludge from WWTP bulking agents like rice husk could be added to improve the quality of the waste. ▪ Mardan is not purely agricultural city and therefore, marketability of the compost is questionable. The marketability of compost and RDF in Mardan region must be explored via consultations with the possible buyers. ▪ Furthermore, keeping in view the failure of LCL, composting process may be replaced with other technology like AD process to produces end product having economic value higher than compost and have strong market potential. 	Recommended
Scenario-5: RDF, Recycling, Dry Anaerobic Digestion followed by composting and Landfilling	<ul style="list-style-type: none"> ▪ After sorting of the MSW using the semi-automatic sorting line to segregate the recyclables and the combustible fractions, the remaining fractions could be subjected to Anaerobic Digestion. ▪ Sorting line will help in improving the quality of the organic waste. ▪ Supply of source segregated organics and sludge from the wastewater treatment units can improve the biogas production. 	Highly Recommended

Scenario	Discussion	Recommendation
	<ul style="list-style-type: none"> ▪ Anaerobic digestion process is highly sensitive process, a slight change in the feedstock might disrupt the entire process. Therefore, high quality feedstock would be required. ▪ Anaerobic digestion would require highly technical skills to manage the process which are currently not available with the WSSM nor with the local private operators of biogas plants. An international expertise may be acquired through engaging European or similar technology provider. 	

5.11 Economic Aspect Analysis

346. Economic aspect analysis of different waste treatment methods has been carried out which also shows that for low-income countries such as Pakistan, sanitary landfilling is the most economically viable option. The **Table 5-10** shows the estimated total cost of waste per ton for different waste treatment methods.

Table 5.10: Economic aspect analysis of waste treatment methods¹⁴ (UNEP, 2015)

World Bank Project Data	Low Income Countries	Lower Middle Income	Upper Middle Income	High Income Countries
Total Cost in US\$/ton				
Sanitary landfilling	10-30	15-40	25-65	40-100
Composting	5-30	10-40	20-75	35-90
Waste-to-energy incineration	NA	40-100	60-150	70-200
Anaerobic digestion	NA	20-80	50-100	65-150

Disclaimer: All estimates are for comparative purposes only and are not indicative of actual costs at any particular local site. Costs for reduction, reuse and recycling are not captured in this table.

¹⁴ Incineration of Municipal Solid Waste February 2013, DEFRA UK

6 Potential Environmental Impacts and Mitigation Measures

347. Potential impacts arising from design, construction and operation phase of Mardan SWMF have been identified and assessed on the basis of field data, secondary data, expert opinion and examining previous similar projects in Pakistan. These include effects on physical, biological and socio-economic environments. Impacts associated with design, construction, operation and closure/post closure phases of SWMF components such as landfill cells, leachate collection network, landfill gas collection and venting system, AD and composting plant, material recovery facility and admin building have been detailed in the section. The impact assessment of Mardan SWMF has been carried in accordance with the requirements of KP EPA, 2014, Pak EPA-1997 and ADB SPS, 2009.
348. Impact-screening matrices during each of the SWMF development phases i.e. project design, construction, operation and closure/post closure are presented below.

6.1 Methodology for impact screening

349. The methodology for assessing the risk level associated with each potential impact is presented below.
350. Risk is assessed as the likelihood that the activity will have an effect on the environment as well as the consequence of the effect occurring. It is often described like this:

$$\text{Risk} = \text{Likelihood} \times \text{Consequence}$$

Likelihood Scale

Likelihood	Definition	Scale
Certain	Will certainly occur during the activity at a frequency greater than every week if preventative measures are not applied	5
Likely	Will occur more than once or twice during the activity but less than weekly if preventive measures are not applied	3
Unlikely	May occur once or twice during the activity if preventive measures are not applied	2
Rare	Unlikely to occur during the project	1

Consequence Scale

Consequence	Definition	Score
Catastrophic	The action will cause unprecedented damage or impacts on the environment or surrounding communities	5
Major	The action will cause major adverse damage on the environment or surrounding communities	3
Moderate	No or minimal adverse environmental or social impacts	2
Minor	No or minimal adverse environmental or social impacts	1

Risk Score Table

Likelihood	Consequence				
		Catastrophic	Major	Moderate	Minor
Certain	25	15	10	5	
Likely	15	9	6	3	
Unlikely	10	6	4	2	
Rare	5	3	2	1	

Risk: Significant: 15-25

Medium: 6-10

Low 1-5

351. Any 'Medium' to 'Significant' risk requires an environmental management measure to manage the potential environmental risk. Judgement will be required concerning the application of an environmental management measure to mitigate low risk situations.

6.2 Design/Pre-Construction Phase

Impact Screening Matrix

352. The 'activity wise' screening of potential impacts during the design/pre-construction phase is provided in **Table 6.1** below.

Table 6.1: 'Activity Wise' screening of possible Impacts during Design/Pre-Construction phase

S/No.	Potential Issue	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact (Short term, Long term)
1	Improper designing of landfill site leading to various impacts (leachate leakage causing groundwater contamination, landfill gas leakage etc.)	Likely	Moderate	Medium	Long Term
2	Improper selection of landfill site due to non-compliance with IFC guidelines for Landfills	Likely	Moderate	Medium	Long Term
3	Lack of integration of EIA/EMP requirements into Construction bid documents	Likely	Moderate	Medium	Short Term
4	Material Haul Routes	Likely	Moderate	Medium	Short Term
5	Contractor's Environmental Safeguards Capacity	Likely	Moderate	Medium	Short Term
6	Improper location of worker camps leading to improper disposal of solid waste and sewage and privacy issues for residents in project area.	Likely	Moderate	Medium	Short Term
7	Land acquisition and resettlement impacts	Likely	Moderate	Medium	Short Term
8	Cultural Heritage & Religious Sites, Social Infrastructure	Unlikely	Moderate	Low	No residual impact
9	Impacts due to natural hazards	Unlikely	Moderate	Low	No residual impact

 Critical Risk Level

 Significant Risk Level

 Medium Risk Level

 Low Risk Level

6.2.1 Improper landfill design leading to various impacts (leachate leakage causing groundwater contamination, landfill gas leakage etc.)

Impacts

353. The possibility exists that in case the landfill is not designed in accordance with international standards and guidelines for landfill development, particularly with regards to EHS aspects, such as the IFC Guidelines on Waste Management Facilities for Landfills¹⁵, it could result in multiple potential impacts that could adversely affect the project area and all receptors located in it, with the most notable being the residential settlements.
354. If Project design shall not take into account the consideration related to ground conditions, the geology and hydrogeology of the site, long term potential environmental impacts may arise.
355. Consideration like the nature and quantity of waste that will be landfilled is crucial for landfill operations, any change in waste stream may result in possible contamination to soil and water and other operational complexities.
356. If Project design shall not take into account visual aspects, environmental and social receptors it will result in public grievances and environmental nuisance in the project area.

Mitigation Measures

357. The following design related measures will be implemented to ensure the landfill operation does not result in unanticipated, long term and potentially irreversible impacts:
- Landfill will be designed in accordance with international standards and guidelines for landfill development, including but not limited to the IFC Guidelines on Waste Management Facilities for Landfills.
 - Consideration shall be given to the stability of the sub-grade, the base liner system, the waste mass and the capping system. The sub-grade and the base liner will be sufficiently stable and thick as per international standards to prevent excessive settlement or slippage.
 - Bottom and cap lining system for each landfill cell must be designed for the protection of soil, groundwater and surface runoff.
 - An efficient leachate collection system must be provided to ensure leachate accumulation at the base of the landfill and keep it to a minimum.
 - The accumulation and migration of gases from landfill facility must be controlled. Landfill gas will be collected through installation of perforated pipes within the cells.
 - Consideration will be given to the visual appearance of the landfill site during operation and at termination of landfill site and its impact on the surrounding landforms. Necessary plantation will be carried out which will act as buffer zone

¹⁵ <https://www.ifc.org/wps/wcm/connect/5b05bf0e-1726-42b1-b7c9-33c7b46ddda8/Final%2B-%2BWaste%2BManagement%2BFacilities.pdf?MOD=AJPERES&CVID=jqeDbH3&id=13231625381>

from surrounding environment. Reasonable area has been allocated for plantation within and at boundary of facility to improve landscape of the area.

- Daily cover will be provided at end of each day to avoid risk of fire, wind littering, odor, vector breeding and dust hazards in the landfill.
- One groundwater monitoring well will be maintained out of the drills made for geotechnical investigation. However, more wells may be constructed if required once the landfill starts operations.
- In order to incorporate advancement in technology and changes, a periodic review of the design will be carried out, as the lifespan of a disposal site from commencement to completion is long compared to other construction projects.

6.2.2 Improper selection of landfill site due to non-compliance with IFC Landfill guidelines

Impacts

- The IFC Guidelines contain specific criteria related to site selection for landfill sites that have been developed to ensure any potential Impacts resulting from landfill operation are minimized as far as possible. In case these Guidelines are not strictly implemented for the development of the proposed landfill, it could result in considerable irreversible, diverse or unprecedented impacts.
- Proposed landfill site should be selected on the basis that it must comply basic KP government regulations, IFC EHS guidelines for waste management facilities, ADB SPS 2009.
- Proposed selection of landfill site must take into accounts impacts from leachate, litter, dust, vector and odors on surrounding environment.

Mitigation Measures

358. The following mitigation measures will be implemented:

- Site selection for the proposed landfill site has been conducted in accordance with international standards and guidelines for landfill development, including but not limited to the IFC Guidelines on Waste Management Facilities for Landfills.
- Factors such as site capacity, accessibility, acceptability, stability, environmental sensitivity, land use, socio-economic receptors and climate hazards have been studied and site has been selected accordingly.
- Site for Mardan Landfill has been selected keeping in view environmental and social sensitive receptors and necessary design considerations have been provided to manage impacts relate to leachate, litter, dust, vector and odors on surrounding environment.

6.2.3 Lack of integration of EIA/EMP requirements into Construction bid documents

Impacts

359. The bidding documents must reflect the requirement to select a qualified and experienced Contractor from the perspective of ensuring implementation of required safeguards during project development.

Mitigation Measures

360. The proposed ‘Safeguards unit’ that will be developed at the PMU will be assigned the task to check that design and bid documents are responsive to key environmental, social and safety considerations, and that the proposed method of work reflects the boundaries defined in the EMP. The bid documents must include the EMP and its implementation cost must be reflected in the BoQ.
361. EIA/EMP implementation and monitoring requirements must be part of bidding documents and necessary contractual binding must be agreed by project contractors before award of contract.
362. Project contractors shall have qualified and experienced environmental staff to plan, arrange, implement, monitor and report EIA/EMP requirements.

6.2.4 Material Haul Routes

Impacts

363. Hauling of material can have significant impacts on the community, public safety, traffic congestion, air quality and lifespan of the Mardan city road ways.

Mitigation Measures

364. The construction vehicles hauling materials along the Mardan city roads and anywhere where there are sensitive receptors such as hospitals, schools and/or roadside residences will be limited and the PMU in collaboration with the focal agencies will establish a route plan to minimize this disruption which shall be appended to the EMP.

6.2.5 Contractor’s Environmental Safeguards Capacity

Impacts

365. Lack of contractor’s environmental safeguard capacity or selection of environment non-responsive contractors may result in failure of EMP implementation and may be a source of number of non-compliances.
366. The responsibility of the PMU KP LGE&RDD in collaboration with the focal agencies is to review and finalize the bidding documents relating to environmental issues.
367. Contractors that do not possess the required capacity for safeguards management must not be pre-qualified and selected.

Mitigation Measures

368. PMU KP LGE&RDD shall review the contractor capacity with respect to safeguard management and contracts shall be awarded accordingly.
369. The Contractor will be required to define an Occupational and Environmental Health and Safety procedure for all work, including work camp operation, management of cement dust, and use of Personal Safety Equipment. These procedures should be

developed and approved by the PMU in collaboration with the focal agencies before the Contractor commences any physical works on ground.

370. PMU KP LGE&RDD shall ensure the project contractors are selected on merit and necessary funds has been allocated in the contract documents for EMP implementation and monitoring.

6.2.6 Identification of Locations for Labor camps and ancillary facilities

Impacts

371. The duration of the construction activity for the landfill development is expected to be 24 months and a considerable amount of work force will be engaged. As a result, worker camps will need to be developed and ancillary facilities will need to be provided such as electricity, washrooms for labor with suitable effluent and sewage disposal facilities as well as water for their everyday use for drinking and bathing etc.

Mitigation measures

372. In order to prevent a nuisance, specific locations shall be designated for development of the labor camps. All necessary facilities and amenities shall be provided in these camps such as electricity, sufficient supply of water, solid and liquid effluent waste disposal facilities etc.
373. The use of proper planning while identifying locations for the labor camps will ensure there is minimal disturbance to all key receptors and the traffic is not disrupted by labor camps being set up roadside next to the construction sites.

6.2.7 Cultural Heritage & Religious Sites, Social Infrastructure

Impacts

374. No temples or religious sites are located in proximity of Mardan landfill site.
375. The nearest sensitive receptors already identified in the project areas have been mapped and a minimum buffer distance of 250 meters from all boundaries of the landfill site will be maintained, as required by the IFC EHS Guidelines on Waste Management Guidelines for landfilling. As a result, no major significant impact would be expected from the works on any social infrastructure. However, consideration will be made not to construct at night, from 7 pm onwards till 6 am in the morning, to avoid nuisances.

Mitigation Measures

376. No mitigation measures are required.

6.2.8 Land Acquisition and Resettlement Impacts

Impacts

377. Land acquisition process of the project has been completed in 2018 by KP government through notification and therefore, no Land Acquisition and Resettlement Plan (LARP) is required.
378. The field visits for social safeguard assessment by PMU and EDCM team has been carried out in September'20 to identify any sensitive receptors falling within 250 meters distance from landfill cells. Assessment findings indicate that none of these receptors

are considered as sensitive as all are falling outside of 250 meters perimeter from landfill cells.

Mitigation Measures

379. The PMU KP LGE&RDD shall ensure the following:

- Pending payment to all land owners must be paid before mobilization of construction contractors.
- Social safeguard unit shall ensure that project affected people has been paid following appropriate procedures and there are no grievances about land acquisition process.
- Accelerating the pending resettlement process in collaboration with DC Mardan and WSSM.

6.2.9 Impacts due to Natural hazards

Impacts

380. Site is located outside of seismically active area as it falls in Zone 2B with peak ground acceleration (PGA) in range of 0.16g to 0.24g on seismic map of Pakistan. No fault lines or significantly fractured geologic structure is present within 500 meters of the perimeter of the proposed landfill cell development that may allow unpredictable movement of gas or leachate.

381. Site is located outside of flood plain, however, in case of high precipitation, there are chances of urban flooding. Surface drainage network has been provided in detailed design of landfill site to avoid risk of surface runoff and contamination.

382. Furthermore, extreme rainfall events in Mardan do not show changing trends and also surface water drainage/diversion work is included in the project design to avoid percolation of rain water into the landfill cells.

Mitigation Measures

383. The PMU KP LGE&RDD shall ensure the following:

- Mardan SWMF infrastructure shall be designed keeping in view the seismic zone 2 B building considerations.
- Surface water diversion shall be included in the design to protect landfill from urban/flash flooding.
- Extreme precipitation events analysis shall be performed for landfill life i.e. 25 years, to predict and manage impacts of flash flooding.
- On site waste storage at loading bay shall be kept to minimum during high precipitation events.
- Emergency response plan shall be prepared by construction and operation phase contractors and will be submitted to PMU for approval to manage impacts of natural

hazards such as earth quakes and floods.

6.3 Construction Phase

Impact Screening Matrix

384. The screening of potential impacts during the construction phase is provided in **Table 6.2** below.

Table 6.2: Screening of Possible Impacts during Construction Phase

S/No.	Potential Issue	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact (Short term, Long Term)
1	Construction of landfill not in accordance with finalized design	Likely	Major	Medium	Long Term
2	Degradation of air quality due to construction works	Likely	Moderate	Medium	Short Term
3	Potential accidents and injuries to communities in project area during construction works	Likely	Moderate	Medium	Short Term
4	Injuries to workers from lack of necessary training and/or not using PPEs etc.	Likely	Moderate	Medium	Short Term
5	High noise levels from construction activities	Likely	Moderate	Medium	Short Term
6	Improper handling and/or disposal of hazardous and non-hazardous waste	Likely	Moderate	Medium	Short Term
7	Untreated disposal of effluent from worker camps and batching plant(s) and construction sites	Likely	Moderate	Medium	Short Term
8	Soil Erosion and Sedimentation	Likely	Moderate	Medium	Short Term
9	Soil Contamination	Likely	Moderate	Medium	Short Term

S/No.	Potential Issue	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact (Short term, Long Term)
10	Employment Conflicts	Likely	Moderate	Medium	Short Term
11	Communicable diseases incl. COVID-19	Likely	Moderate	Medium	Short Term
12	Vegetation and Wildlife Loss	Unlikely	Moderate	Low	No Residual Impact
13	Historical/Archaeological Sites	Unlikely	Moderate	Low	No Residual Impact
14	Construction of Administration Building and Other Infrastructure	Likely	Moderate	Medium	Short Term
15	Sexual Abuse, Exploitation and Harrassment (SEAH)	Unlikely	Moderate	Low	No residual Impact

 Critical Risk Level

 Significant Risk Level

 Medium Risk Level

 Low Risk Level

6.3.1 Construction of landfill not in accordance with finalized design

Impacts

385. If the proposed landfill is not developed in accordance with the finalized design and its corresponding design parameters, it could lead to a number of unanticipated impacts such as groundwater contamination due to inadequate liner installation etc.

Mitigation measures

386. The following mitigation measures will be implemented:

- Method statements must be prepared by the Contractor and approved by the Construction Supervision Consultant (CSC) prior to commencement of construction works.
- The CSC must closely monitor the construction works being conducted by the Contractor to ensure the finalized design is implemented in full and the landfill design is developed completely in compliance of the approved finalized designs.
- Any deviation by the Contractor from following the finalized design must be immediately highlighted and corrective measures must be implemented to ensure full compliance with the finalized design of the landfill.

- PMU KP LGE&RDD shall ensure that construction activities are being carried out in compliance to project design following best international practices. It will closely review and monitor the activities of CSC and contractors involved in construction activities.

6.3.2 Degradation of Ambient Air Quality

Impacts

387. The proposed landfill development will involve large scale earth works and transporting and dumping large quantities of dry material. This will likely lead to an increase in SPM (Suspended Particulate Matter) in and around the construction zones.
388. Potential sources of particulate matter emission during construction activities include earthworks (dirt or debris pushing and grading), exposed surfaces, exposed storage piles, truck dumping, hauling, vehicle movement on unpaved roads, combustion of liquid fuel in equipment and vehicles, land excavation, and concrete mixing and batching.
389. Vehicles carrying construction material are expected to result in increased Suspended Particulate Matter (SPM) levels near the haul roads. This can be of potential importance if the vehicles pass through the areas with a high concentration of sensitive receptors, such as residential areas, in this particular case.
390. At the construction yard, the dust levels are also expected to increase due to unloading of construction materials. It shall be ensured that most of the excavated material will be used within the project, with minimal cut and fill material to come from outside the site.
391. Poor air quality due to the release of contaminants into the workplace can result in possible respiratory irritation, discomfort, or illness to workers. Employers should take appropriate measures to maintain air quality in the work area.
392. The quantity of dust that will be generated on a particular day will depend on the magnitude and nature of activity and the atmospheric conditions prevailing on the day. Due to the uncertainty in values of these parameters, it is not possible to calculate the quantity from a 'bottom-up' approach, that is, from adding PM₁₀ emissions from every activity on the construction site separately. Typical and worst-case PM₁₀ emissions from construction sites have been estimated¹⁶ as 0.27 megagram per hectare per month of activity (Mg/ha-month) and 1.04 Mg/ha-month, respectively.
393. Dust management plan for the project is prepared and provided as **Annexure H.**

Mitigation Measures

394. The following mitigation measures will be adopted for preservation of the environment:
 - At the landfill site and the immediately adjoining areas, water will be sprinkled every three hours and at a higher frequency if felt necessary, at all construction sites to suppress dust emissions.

¹⁶ Gaffney, G. and Shimp, D. 1997. *Improving PM₁₀ Fugitive Dust Emission Inventories*. Sacramento, CA. California Air Resource Board. <www.arb.ca.gov/emisinv/pubs/pm10tmp.pdf>

- All heavy equipment and machinery shall be fitted in full compliance with the national and local regulations.
- Stockpiled soil and sand shall be slightly wetted before loading, particularly in windy conditions.
- Fuel-efficient and well-maintained haulage trucks shall be employed to minimize exhaust emissions.
- Vehicles transporting soil, sand and other construction materials shall be covered with tarpaulin.
- Limitations to speeds of such vehicles as felt necessary. Transport through densely populated area should be avoided.
- Concrete plants to be controlled in line with statutory requirements and shall not be close to sensitive receptors.
- Stack height of generators will be at least 3 meters above the ground.
- Project traffic will maintain maximum speed limit of 20 km/hr on all unsealed roads within project area.
- A minimum distance of 300 meters will be ensured between batching plant(s) and the nearest community.
- The need for large stockpiles shall be minimized by careful planning of the supply of materials from controlled sources. Stockpiles should not be located within 50 m of schools, hospitals or other public amenities and shall be covered with tarpaulin when not in use and at the end of the working day to enclose dust. If large stockpiles ($>25m^3$) of crushed materials are necessary, they should be enclosed with side barriers and also covered when not in use.
- Dust emissions due to road travel shall be minimized through good construction practices (such as keeping stock piles down wind and away from communities) and sprinkling water over the access road.
- Maintaining levels of contaminant dusts, vapors and gases in the work environment at concentrations below those recommended as TWA-TLV's (threshold limit value)—concentrations to which most workers can be exposed repeatedly (8 hours/day, 40 hrs/week, week-after week), without sustaining adverse health effects. .
- Developing and implementing work practices to minimize release of contaminants into the work environment including:
 - Direct piping of liquid and gaseous materials
 - Minimized handling of dry powdered materials; Enclosed operations
 - Local exhaust ventilation at emission/release points
 - Vacuum transfer of dry material rather than mechanical or pneumatic conveyance
 - Indoor secure storage, and sealed containers rather than loose storage

- Where ambient air contains several materials that have similar effects on the same body organs (additive effects).

Fugitive Dust Control

395. The source wise fugitive control measures are provided in **Table 6.3** below.

Table 6.3: Control measures for Fugitive Dust emissions

Source	Control Measures
Earth Moving	For any earth moving that is to take place in the immediate vicinity from the site boundary, watering must be conducted as required to prevent visible dust emissions
Disturbed Surface Areas	Apply dust suppression measures (clear vegetation only from areas where work is to commence, plant or mulch areas that will not receive traffic, construct artificial wind breaks or wind screens) frequently to maintain a stabilized surface. Areas that cannot be stabilized, such as wind driven dust, must have an application of water at least twice a day
Inactive Disturbed Surface Areas	Apply dust suppressants (clear vegetation only from areas where work is to commence, plant or mulch areas that will not receive traffic, construct artificial wind breaks or wind screens) in sufficient quantity and frequency to maintain a stabilized surface
Unpaved Roads	Periodic sprinkling on all roads used for any vehicular traffic at least twice per day during active operations and restrict vehicle speed to 20 kmph.
Open Storage Piles	Apply water to at least 80 percent of the surface areas of all open storage piles on a daily basis when there is evidence of wind driven fugitive dust or install an enclosure all along the storage piles Tarpaulin sheet should be provided on the storage piles to avoid dust emisisons.
Track-out Control	Wash down of construction vehicles (particularly tyres) prior to departure from site.

Vehicular & Equipment Emissions

396. It shall be ensured that the following measures are taken to control emissions from vehicles being used in the construction activity:

- Periodically check and conduct maintenance of the construction machinery and haul vehicles. Generators, compressors and vehicles used during construction works will be maintained in a good condition to ensure that emissions are kept to a minimum level.
- Regularly change the engine oil and use new engines/machinery/equipment having good efficiency and fuel burning characteristics.
- Controlled technology generator and batching plants will be used to avoid excessive emissions.
- Burning of wastes at any site will not be allowed.

- The stack height of generators will be at least 3 meters above the ground.
- Training of the technicians and operators of the construction machinery and drivers of the vehicles.
- All type of machinery and generator must comply with the NEQS. Vehicles, which are not in compliance with NEQS are not allowed to use.
- Periodic emission monitoring of vehicles, generator and batching plants is proposed.
- Project activities should be planned to avoid harsh weather conditions.

6.3.3 Community Health and Safety

Impacts

397. The landfill development will involve the use of considerable heavy machinery at the project site along with posing the risk of community members falling into trenches. In addition, the risk to commuters on the road during the construction works will be significant and thus a number of precautionary measures will be necessary to minimize the risk of possible accidents. Community Health & Safety may be compromised during road travel particularly in night hours if adequate barriers and lighting is not provided at construction sites.

Mitigation Measures

398. The following mitigation measures will be implemented:

- Work areas outside the project site, especially where machinery is involved, will be barricaded and will be constantly monitored to ensure that local residents, particularly children stay away while excavated areas being prepared for landfill related infrastructure will also be cordoned off. Also, no machinery will be left unattended, particularly in running condition.
- Local communities in the project area will be briefed on traffic safety, especially women who are the main care providers to children.
- Speed limit of 20 km/hr will be maintained by all project related vehicles and nighttime driving of project vehicles will be limited where possible.
- Educate drivers on safe driving practices to minimize accidents and to prevent spill of hazardous substances and other construction materials during transport.
- Contractor must take proper safety measures (placing warning tapes around excavations) to avoid people, especially children, accidentally falling into excavations.
- All the working platforms must be cordon off with special care by well-trained skilled workers.
- Contractor will prepare construction management plan which will include the hazard prevention and safety plan, which will address health and safety of the people in the project area.
- PMU KP LGE&RDD should ensure the contractor staff working in the the project

are well trained and educated in the Health, Safety and Environment (HSE) hazards associated with their duties, and that of the public, in the project area.

6.3.4 Occupational Health and Safety (OHS)

Impacts

399. There is invariably an OHS risk when construction works for the landfill are conducted, and precautions will be needed to ensure the safety of the workers.
400. The major OHS hazards expected during the proposed activities are as follows:¹⁷

Accident Hazards

- Falls from height, especially when standing/working on ladders;
- Slips, trips and falls, especially while carrying heavy or bulky loads;
- Cuts and injuries caused by sharp instruments and tools;
- Hazard of suffocation from asphyxiant gases released or from oxygen deficiency, during maintenance and cleaning operations;
- Burns caused by hot parts of equipment, steam lines etc, by release of hot water or steam;
- Electric traumas, caused by defective installations and equipment, especially portable;
- Musculoskeletal injury (especially of back), resulting from lifting and moving of heavy loads;

Physical Hazards

- Exposure to cold and/or heat stress, as a result of rapid movement between cold and hot areas;
- Exposure to UV radiation during welding operations;

Chemical Hazards

- Exposure to various chemicals, such as: adhesives, caulking compounds, fluxes (solder), hydrochloric acid, zinc chloride, tar and solvents, various greases and inorganic lead;

Biological Hazards

- Exposure to parasites, such as hookworm, ascaris, and various mites, chiggers and ticks;

Ergonomic, psychosocial and organizational factors

¹⁷ https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_192256.pdf

- Psychological stress due to dissatisfaction at work due to issues with peers, superiors etc.;
- General ill feeling as a result of work in confined spaces and development of 'sick building syndrome';

Mitigation Measures

General

401. The Contractor will be required to prepare and implement an effective OHS Plan that is supported by trained OHS personnel and emergency response facilities. Construction contracts will include standard OHS measures and contractors will be bound to implement these fully.
402. Monitoring will be required to ensure that the health and safety plan based on contract specifications is followed.
- Cement feed hopper areas will be inspected daily to ensure compliance with the requirement of dust masks.
 - Surfaces (including flooring and work surfaces) in camps, kitchens, dining areas and workshops should be solid and easy to clean. Flooring for work camps must be float finished concrete or better.
 - All drivers engaged by Contractors must hold a valid license for the vehicle they are operating.
 - Work in confined space shall be executed with available safety standards. Adequate monitoring and equipment shall be available to detect deficient oxygen levels.
 - The Contractor shall submit to the Engineer for approval an emergency evacuation plan and practice the procedure annually.
 - The Contractor shall submit to the Engineer for approval a site layout plan, identifying work areas, accommodation, kitchen, dining area, sanitary facilities, location of generators, plant and vehicle parking, transport routes through the camp, pedestrian routes through the camp, evacuation routes, emergency exits, batching plants, storage areas, waste facilities etc.
 - Fire extinguishers should be provided throughout camps and work sites. Fire extinguishers should be inspected monthly and maintained as necessary.
 - An adequate and reliable supply of safe drinking water shall be made available at readily accessible and suitable places including at all camps.
 - The Contractor shall take samples from each supply of drinking water and arrange for analysis of these samples at EPA certified laboratory prior to its use by the Contractor's staff. The results of these tests for each supply must be submitted to the Engineer and must demonstrate that each water supply meets national and World Health Organisation standards for drinking water.
 - The Contractor shall provide and maintain adequate hygienic kitchens which are sheltered and separated from the living quarters. Kitchens shall include raised and

washable surfaces suitable for food preparation.

- The Contractor shall provide and maintain adequate hygienic dining areas for staff. Work places and camps should be provided with both natural& artificial light. Artificial lighting should be powered by generator in the event of power cuts.
- Public sensitization training should be provided to workers to avoid social conflicts between residents and the construction contractor, Occurrence of any such impacts can be avoided by community sensitive project planning and implementation and through effective involvement of local administration.
- All OHS protocols should be implemented in true letter and spirit.
- Contractor must appoint an OHS resource to implement, monitor and report the HSE management plan to concerned authorities.
- Contractor must ensure the provision of first aid facility at construction site and camps through hiring medics and establishing a dispensary at the campsite.
- Reasonable number of first aid kits should be available on construction sites and within contractor camps.
- Site personnel will be provided appropriate type of personal protective equipment (PPEs). Contractor will ensure consistent use of PPEs.
- Emergency response plan to provide measures and guidance for the establishment and implementation of emergency preparedness plans during project execution is provided as **Annexure F**.

403. Based on the type of hazard applicable during the proposed works at site, the following mitigation measures as per IFC guidelines for Occupational Health and Safety (OH&S) must be implemented:¹⁸

Mitigation Measures for Physical Hazards

Rotating and Moving Equipment

404. Injury or death can occur from being trapped, entangled, or struck by machinery parts due to unexpected starting of equipment or unobvious movement during operations. Mitigation measures related to rotating and moving equipment on workers are provided below:

- Designing machines to eliminate trap hazards and ensuring that extremities are kept out of harm's way under normal operating conditions.
- Where a machine or equipment has an exposed moving part or exposed pinch point that may endanger the safety of any worker, the machine or equipment should be equipped with, and protected by, a guard or other device that prevents access to the moving part or pinch point. Guards should be designed and installed in conformance with appropriate machine safety standards.

¹⁸ <https://www.ifc.org/wps/wcm/connect/1d19c1ab-3ef8-42d4-bd6b-cb79648af3fe/2%2BOccational%2BHealth%2Band%2BSafety.pdf?MOD=AJPERES&CVID=ls62x8l>

- Turning off, disconnecting, isolating, and de-energizing (Locked Out and Tagged Out) machinery with exposed or guarded moving parts, or in which energy can be stored (e.g. compressed air, electrical components) during servicing or maintenance.
- Designing and installing equipment, where feasible, to enable routine service, such as lubrication, without removal of the guarding devices or mechanisms.

Vibration

405. Exposure to hand-arm vibration from equipment such as hand and power tools, or whole-body vibrations from surfaces on which the worker stands or sits, should be controlled through choice of equipment, installation of vibration dampening pads or devices, and limiting the duration of exposure. Limits for vibration and action values. Exposure levels should be checked on the basis of daily exposure time and data provided by equipment manufacturers.
406. Other sources of vibration at construction site are rollers, compactors or any loose part of machinery exposure which may cause serious injury or workplace sickness. No equipment and machinery with loose or vibratory parts will be allowed to work. Such issues will be fixed through maintenance of the machinery on periodic basis. Use of rollers for land grading will be carried out during day times and with intermittent intervals to reduce the impacts of vibration on surrounding environment.
407. Considering the project setting, which is not in a congested urban environment and instead is a rural agriculture land, there is no potential risks with regards to vibration.

Electrical

408. Exposed or faulty electrical devices, such as circuit breakers, panels, cables, cords and hand tools, can pose a serious risk to workers. Overhead wires can be struck by metal devices, such as poles or ladders, and by vehicles with metal booms. Vehicles or grounded metal objects brought into close proximity with overhead wires can result in arcing between the wires and the object, without actual contact. Recommended actions include:
 - Marking all energized electrical devices and lines with warning signs; .
 - Locking out (de-charging and leaving open with a controlled locking device) and tagging-out (warning sign placed on the lock) devices during service or maintenance;
 - Checking all electrical cords, cables, and hand power tools for frayed or exposed cords and following manufacturer recommendations for maximum permitted operating voltage of the portable hand tools; .
 - Double insulating / grounding all electrical equipment used in environments that are, or may become, wet; using equipment with ground fault interrupter (GFI) protected circuits; .
 - Protecting power cords and extension cords against damage from traffic by shielding or suspending above traffic areas; .
 - Conducting detailed identification and marking of all buried electrical wiring prior to any excavation work.

Eye Hazards

409. Solid particles from a wide variety of industrial operations, and/or a liquid chemical spray may strike a worker in the eye causing an eye injury or permanent blindness. Recommended measures include:

- Use of machine guards or splash shields and/or face and eye protection devices, such as safety glasses with side shields, goggles, and/or a full-face shield. Specific Safe Operating Procedures (SOPs) may be required for use of sanding and grinding tools and/or when working around liquid chemicals. Frequent checks of these types of equipment prior to use to ensure mechanical integrity is also good practice. Machine and equipment guarding should conform to standards published by organizations such as CSA, ANSI and ISO.

Welding/Hot Work

410. Welding creates an extremely bright and intense light that may seriously injure a worker's eyesight. In extreme cases, blindness may result. Additionally, welding may produce noxious fumes to which prolonged exposure can cause serious chronic diseases. Recommended measures include: -

- Provision of proper eye protection such as welder goggles and/or a full-face eye shield for all personnel involved in, or assisting, welding operations. Additional methods may include the use of welding barrier screens around the specific work station (a solid piece of light metal, canvas, or plywood designed to block welding light from others). Devices to extract and remove noxious fumes at the source may also be required. -
- Special hot work and fire prevention precautions and Standard Operating Procedures (SOPs) should be implemented if welding or hot cutting is undertaken outside established welding work stations, including 'Hot Work Permits, stand-by fire extinguishers, stand-by fire watch, and maintaining the fire watch for up to one hour after welding or hot cutting has terminated. Special procedures are required for hot work on tanks or vessels that have contained flammable materials.

Industrial Vehicle Driving and Site Traffic

411. Poorly trained or inexperienced industrial vehicle drivers have increased risk of accident with other vehicles, pedestrians, and equipment. Industrial vehicles and delivery vehicles, as well as private vehicles on-site, also represent potential collision scenarios. Industrial vehicle driving and site traffic safety practices include:

- Training and licensing industrial vehicle operators in the safe operation of specialized vehicles such as forklifts, including safe loading/unloading, load limits.
- Ensuring drivers undergo medical surveillance.
- Ensuring moving equipment with restricted rear visibility is outfitted with audible back-up alarms.
- Establishing rights-of-way, site speed limits, vehicle inspection requirements, operating rules and procedures (e.g. prohibiting operation of forklifts with forks in down position), and control of traffic patterns or direction.
- Restricting the circulation of delivery and private vehicles to defined routes and

areas, giving preference to 'one-way' circulation, where appropriate.

Ergonomics, Repetitive Motion, Manual Handling

412. Injuries due to ergonomic factors, such as repetitive motion, overexertion, and manual handling, take prolonged and repeated exposures to develop, and typically require periods of weeks to months for recovery. These OHS problems should be minimized or eliminated to maintain a productive workplace. Controls may include:

- Facility and workstation design with 5th to 95th percentile operational and maintenance workers in mind.
- Use of mechanical assists to eliminate or reduce exertions required to lift materials, hold tools and work objects, and requiring multi-person lifts if weights exceed thresholds.
- Selecting and designing tools that reduce force requirements and holding times and improve postures. .
- Providing user adjustable workstations.
- Incorporating rest and stretch breaks into work processes and conducting job rotation.
- Implementing quality control and maintenance programs that reduce unnecessary forces and exertions.
- Taking into consideration additional special conditions such as left-handed persons.

Working at Heights

413. Fall prevention and protection measures should be implemented whenever a worker is exposed to the hazard of falling more than two meters; into operating machinery; into water or other liquid; into hazardous substances; or through an opening in a work surface. Fall prevention / protection measures may also be warranted on a case-specific basis when there are risks of falling from lesser heights. Fall prevention may include:

- Installation of guardrails with mid-rails and toe boards at the edge of any fall hazard area. .
- Proper use of ladders and scaffolds by trained employees. .
- Use of fall prevention devices, including safety belt and lanyard travel limiting devices to prevent access to fall hazard area, or fall protection devices such as full body harnesses used in conjunction with shock absorbing lanyards or self-retracting inertial fall arrest devices attached to fixed anchor point or horizontal life-lines. .
- Appropriate training in use, serviceability, and integrity of the necessary PPE. .
- Inclusion of rescue and/or recovery plans, and equipment to respond to workers after an arrested fall.

Fire and Explosions

414. Fires and or explosions resulting from ignition of flammable materials or gases can lead to loss of property as well as possible injury or fatalities to project workers. Prevention and control strategies include:

- Fuel storage areas and generators will have secondary containment in the form of concrete or brick masonry bunds. The volume of the containment area should be equal to 120% of the total volume of fuel stored.
- Storing flammables away from ignition sources and oxidizing materials. Further, flammables storage area should be:
 - Remote from entry and exit points into camps
 - Away from facility ventilation intakes or vents
 - Have natural or passive floor and ceiling level ventilation and explosion venting
 - Use spark-proof fixtures
 - Be equipped with fire extinguishing devices and self closing doors, and constructed of materials made to withstand flame impingement for a moderate period of time .
- Defining and labeling fire hazards areas to warn of special rules (e.g. prohibition in use of smoking materials, cellular phones, or other potential spark generating equipment). .
- Providing specific worker training in handling of flammable materials, and in fire prevention or suppression.

Corrosive, oxidizing, and reactive chemicals

415. Corrosive, oxidizing, and reactive chemicals present similar hazards and require similar control measures as flammable materials. However, the added hazard of these chemicals is that inadvertent mixing or intermixing may cause serious adverse reactions. This can lead to the release of flammable or toxic materials and gases, and may lead directly to fires and explosions. These types of substances have the additional hazard of causing significant personal injury upon direct contact, regardless of any intermixing issues. The following controls should be observed in the work environment when handling such chemicals: .

- Corrosive, oxidizing and reactive chemicals should be segregated from flammable materials and from other chemicals of incompatible class (acids vs. bases, oxidizers vs. reducers, water sensitive vs. water based, etc.), stored in ventilated areas and in containers with appropriate secondary containment to minimize intermixing during spills. .
- Workers who are required to handle corrosive, oxidizing, or reactive chemicals should be provided with specialized training and provided with, and wear, appropriate PPE (gloves, apron, splash suits, face shield or goggles, etc).
- Where corrosive, oxidizing, or reactive chemicals are used, handled, or stored, qualified first-aid should be ensured at all times. Appropriately equipped first-aid stations should be easily accessible throughout the place of work, and eye-wash

stations and/or emergency showers should be provided close to all workstations where the recommended first-aid response is immediate flushing with water.

Mitigation Measures for Biological Hazards

416. Biological agents represent potential for illness or injury due to single acute exposure or chronic repetitive exposure. Biological hazards can be prevented most effectively by implementing the following measures: -

- The contractor should review and assess known and suspected presence of biological agents at the place of work and implement appropriate safety measures, monitoring, training, and training verification programs.
- Project contractor must provide good working and sanitation conditions at camp and work sites. Disease surveillance should be carried out to identify any exposure to parasites, such as hookworm, ascaris, and various mites, chiggers, ticks and dengue.
- Measures to eliminate and control hazards from known and suspected biological agents at the place of work should be designed, implemented and maintained in close co-operation with the local health authorities and according to recognized international standards.

6.3.5 High Noise Levels

Impacts

417. The landfill development will result in different construction equipment and machinery being used which will generate high noise levels at the project site and in the project area.

418. The detailed mapping of sensitive receptors has been conducted and the types of receptors and their respective distances from the work sites are provided earlier. However, any required mitigation measures that shall be proposed will be to control potential impacts on noise to prevent any long-term impacts within the project area.

419. The assessment of the noise impacts on the sensitive receptors that have been identified at various locations in the project area depends upon:

- Characteristics of noise source (instantaneous, intermittent or continuous in nature)
- Time of day at which noise occurs, and
- Location of noise source

420. Each construction activity has its unique noise characteristics due to use of different equipment items. The potential sources of noise during the preparation, construction, and worksite closure phases for the landfill works include equipment, machinery, and transportation used for the construction activities. The equipment used for construction will be the major source of noise.

421. The construction activities will include use of a large number of trucks, generators, excavators etc., which can generate significant noise.

422. Since various modern machines are acoustically designed to generate low noise levels, any high noise levels that might be generated will only be for a short duration during the construction phase.
423. Depending on the construction equipment used and its distance from the receptors, the community and the workers may typically be exposed to intermittent and variable noise levels. During the day, such noise results in general annoyance and can interfere with sleep during the night. In general, human sound perception is such that a change in sound level of 3 dB is just noticeable, a change of 5 dB is clearly noticeable, and a change of 10 dB is perceived as a doubling or halving of sound level.
424. Due to the various construction activities, there will be temporary noise impacts in the immediate vicinity of the project site. The movement of heavy vehicles, loading, transportation and unloading of construction materials produces significant noise during the construction stage. However, these increased noise levels will prevail only for a short duration during the construction phase.
425. The **Table 6.4** below represents typical noise levels from various construction equipment items. It should be noted that the values indicated in the table may differ depending on the brand and age of machinery provided/used by construction contractors.

Table 6.4: Construction Equipment Noise Ranges, dB(A)

Equipment	Peak Noise Range at 15 m	Typical Peak Sound Level in a Work Cycle ^a at 15 m	Typical 'Quieted Equipment' Sound Level ^b at 15 m	Construction Phase		
				Earthworks	Structures	Installation
Batching plant	82-86	84	81		Y	
Concrete mixers	76-92	85	82		Y	
Cranes	70-94	83	80		Y	Y
Excavators	74-92	85	82	Y		
Front loader	77-94	85	82	Y	Y	Y
Water bowsers	85-93	88	85	Y	Y	Y
Graders	72-92	85	82	Y		
Bulldozers	65-95	85	80	Y		
Pavers	87-89	88	80	Y		
Pumps	68-72	76	75	Y	Y	Y
Diesel generators	72-82	81	77		Y	Y
Drilling machines	82-98	90	87		Y	Y
Compressors	74-88	81	71		Y	

Equipment	Peak Noise Range at 15 m	Typical Peak Sound Level in a Work Cycle^a at 15 m	Typical 'Quieted Equipment' Sound Level^b at 15 m	Construction Phase		
				Earthworks	Structures	Installation
Dumpers	77-96	88	83	Y	Y	
Dump/flatbed Truck	75-85	80	77	Y	Y	Y

Sources: USEPA, 1971; <http://www.waterrights.ca.gov/EIRD/text/Ch11-Noise.pdf>; http://www.lacsd.org/LWRP%202020%20Facilities%20Plan%20DEIR/4_6_Noise.pdf; <http://newyorkbiz.com/DSEIS/CH18Construction.pdf>

Notes:

- a. Where typical value is not cited in literature, mean of the peak noise range is assumed
- b. Quieted equipment can be designed with enclosures, mufflers, or other noise-reducing features. Where data is not available, a 3 dB reduction is assumed

426. Precise information on the type, quantity and location of equipment to be used during the construction phase is not available at this stage and will be dependent on the working methods of the selected contractors. However, preliminary calculations have been conducted to provide a general magnitude of the noise levels during various construction phases.
427. Nearest sensitive receptors with respect to noise are located at a distance of more than 250 meters and also these are scattered settlements, therefore, no significant impacts from noise are envisaged. Furthermore, no equipment which is generating high noise levels will be permitted to work at site.
428. The mitigation measures listed below shall be implemented to minimize noise levels during the construction activity as far as possible.

Mitigation Measures

429. The following mitigation measures will be implemented:
- Equipment noise will be reduced at source by proper design, maintenance and repair of construction machinery and equipment. Noise from vehicles and power generators will be minimized by use of proper silencers and mufflers.
 - Excessive noise emitting equipment will not be allowed to operate and will be replaced.
 - Blowing of horns will be prohibited on access roads to work sites.
 - As a rule, the operation of heavy equipment shall be conducted in daylight hours.
 - Construction equipment, which generates excessive noise, shall be enclosed or fitted with effective silencing apparatus to minimize noise.
 - Well-maintained haulage trucks will be used with speed controls.
 - Use of ear plug and ear muffs must be ensured during construction. No employee should be exposed to a noise level greater than 85 dB(A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear

should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C).

- Prior to the issuance of hearing protective devices as the final control mechanism, use of acoustic insulating materials, isolation of the noise source, and other engineering controls should be investigated and implemented, where feasible.
- Periodic medical hearing checks should be performed on workers exposed to high noise levels.
- All the equipment and machinery used during construction phase should be well maintained and in compliance with NEQS.
- Grievance redress mechanism will be established.

6.3.6 Hazardous and Non-Hazardous Waste Management

Impacts

430. During construction/civil works potential sources of waste will include spoils generated during landfill cells excavation, excavation waste for other civil works, domestic wastes (solid & wastewater), fuel or oil leakages or spills, onsite effluents from vehicle wash & cleaning, and cement spills.
431. Waste disposal of materials containing contents of both hazardous and non-hazardous nature such as scrap wood, bricks, concrete, asphalt, plumbing fixtures, piping, insulation (asbestos and non-asbestos), metal scraps, oil, electrical wiring and components, chemicals, paints, solvents etc. can potentially become a serious environmental issue, particularly with the local contractors. To avoid any potential issue, the PMU in collaboration with focal agencies will need to impose adequate internal controls.
432. Domestic wastes generated during construction Mardan SWF will include sewage, grey water (from kitchen, laundry, and showers), kitchen wastes, combustible wastes and recyclable wastes from contractor camps.

Mitigation measures

433. A waste management plan will be developed prior to the start of construction. This plan will cater to sorting of hazardous and non-hazardous materials prior to disposal, placing of waste bins at the project sites for waste disposal and an onsite hazardous waste storage facility i.e. designated area with secondary containment.
434. Licensed waste contractors will be engaged to dispose off all non-hazardous waste material that cannot be recycled or reused.
 - Excavated material from landfill cells will be stored at site and it will be used as daily cover within landfill cells.
 - All types of combustible and non-combustible waste including plastic or glass bottles and cans will be temporarily stored on site and later sold/handed over to a waste/recycling contractor who will utilize these wastes for recycling purposes.
 - Waste management training for all site staff to be included in Contractor's training plan.

- Fuel storage areas and generators will have secondary containment in the form of concrete or brick masonry bunds. The volume of the containment area should be equal to 120% of the total volume of fuel stored.
- Fuel and hazardous material storage points must be included in camp layout plan to be submitted for approval. Hazardous material storage areas shall include a concrete floor to prevent soil contamination in case of leaks or spills. Fuel tanks will be checked daily for leaks and all such leaks will be plugged immediately.
- Designated vehicles/plant wash down and refuelling points must be included in camp layout plan to be submitted for approval.
- Hazardous waste will be initially stored on site at designated area and then handed over to EPA certified contractor to final disposal.
- Record of waste generation and transfer shall be maintained by project contractors.
- Spill kits, including sand buckets (or other absorbent material) and shovels must be provided at each designated location.
- At the time of restoration, septic tanks will be dismantled and backfilled with at least 1m of soil cover keeping in view landscape of surrounding natural surface.
- It will be ensured that after restoration activities, the campsite is clean and that no refuse has been left behind.
- Clinical wastes will be temporarily stored onsite separately and will be handed over to approved waste contractor for final disposal.
- Training will be provided to personnel for identification, segregation and management of waste.
- The structure of a Framework waste management plan has been prepared for the project and attached as **Annexure O** and contractors will be required to prepare waste management plan for the site in light of guidelines provided in the waste management plan and submit to PMU for approval.

6.3.7 Camp & Batching Plant Effluent

Impacts

435. The staff and labor camps for the construction of the proposed landfill will be a source of wastewater generated from the toilets, washrooms and the kitchen. The wastewater will not meet the national environmental standards and will therefore need treatment prior to disposal.
436. The project sites where construction is being conducted must not be treated by the project staff and/or labor as a public toilet or for disposal of camp effluent.

Mitigation measures

- It will be ensured that no untreated effluent is released to the environment.
- A closed sewage treatment system including soak pits and septic tank will be constructed to treat the effluent from the construction/labor camps.

- Sewage treatment system will be installed at each respective labor camp based on the number of laborers residing at the respective camp.
- Wastewater from laundry, kitchen washings and showers will be disposed-off into soak pits or septic tank (where soak pit cannot be constructed) and after treatment it will be disposed of in TMA provided drains in the project area.
- Soak pits will be built in absorbent soil and shall be located 300 m away from a water well, hand pump or surface water body. Soak pits in non-absorbent soil will not be constructed.
- Ensure that the soak pits remain covered all the time and measures are taken to prevent entry of rainwater into them.
- Sprinkling of grey water or sewage will not be allowed; in case the septic tank gets filled with sludge, septic tank shall be emptied through vacuum truck and material shall be transferred to treatment facility or approved municipal drain.
- Water being released from any batching plant(s) must be treated as per requirements of NEQS prior to release to sewerage system/any other water body.
- Sewage at the end of construction period to be disposed of in nearest municipal drains after getting approval from concerned municipal authorities.

6.3.8 Soil Erosion and Sedimentation

Impacts

437. The majority of the works proposed for development of the landfill may result in soil erosion and sedimentation. Spoils will be generated from the excavation activities, particularly during construction of landfill cells. Potential impacts from spoils and their disposal are (i) land for disposal of spoil, (ii) potential erosion from the spoil areas and spoil material reaching the waterways, and (iii) aesthetic impacts. Excavated soil will be stored at site and will be used as daily cover during landfill operations. Approximately 6,253,848 ft³ of soil will be generated from excavation of the four landfill cells and this soil will be stored at designated area for use as daily cover.

Mitigation measures

438. Any drainage structures, culverts or pipes crossing the project site may need to be modified or protected and the detailed designs must make provisions to protect or re-provision all infrastructure that may be affected by the construction works.

6.3.9 Soil Contamination

Impacts

439. During the project construction, spills of fuel, lubricants and chemicals can take place while transferring from one container to another or during refueling. Also, during maintenance of equipment and vehicles, through leakages from equipment and containers and as a result of traffic accidents.
440. Depending on the nature of the material, location of spill and quantity of spill, the soil can get contaminated.

Mitigation measures

- It will be ensured that spill prevention trays are provided and used during refueling. Also, on-site maintenance of construction vehicles and equipment will be avoided as far as possible. In case on-site maintenance is unavoidable, tarpaulin or other impermeable material will be spread on the ground to prevent contamination of soil.
- Regular inspections will be carried out to detect leakages in construction vehicles and equipment and all vehicles will be washed in external commercial facilities.
- Fuels, lubricants and chemicals will be stored in covered bounded areas, underlain with impervious lining. Appropriate arrangements, including shovels, plastic bags and absorbent materials will be available near fuel and oil storage areas.

6.3.10 Employment Conflicts***Impacts***

441. The proposed construction of Mardan SWMF is not likely to create any significant permanent job opportunities. Even unskilled and semi-skilled employment opportunities that are likely to be created will be for a short period, while the landfill project is constructed. As persons with relevant skills may be available locally, people from the project area are likely to fill a significant number of the semi-skilled and skilled jobs.
442. This issue of provision of jobs can become particularly problematic if it is perceived by the local population that a significant number of construction-related jobs opportunities are not given to people from the local community. This can result in friction between local residents and construction workers from outside of the community.

Mitigation measures

- The Construction Contractor will adopt a transparent hiring policy. Prior to the commencement of the construction activity, the local communities in the project area will be informed of the employment policy in place and number of people that can be employed for this project.
- It will be ensured that maximum number of unskilled and semi-skilled jobs will be provided to the residents of the project area.
- The PMU KP LGE&RDD will ensure a balanced process of employment of the communities in the project area with preference given to those most directly affected by the project.

6.3.11 Communicable diseases incl. COVID-19***Impacts***

443. Communicable diseases such as COVID-19 and HIV may be introduced due to the immigration of workers associated with the project.
444. Ministry of National Health Services, Regulations and Coordination, GoP has issued guidelines in April, 2020 for Health & Safety of Building and Construction Workers during COVID-19 outbreak. These guidelines are prepared for the workers involved in building and construction work during the current epidemic of COVID-19. These guidelines provide the safety measure to be implemented at the construction site

having a dusty environment, continuous flow of different materials and make-shift type of arrangements for storage, food and sanitation calls for implementation of safety precautions at the very basic level of personal hygiene only.

Mitigation measures

445. A communicable diseases prevention program will be prepared for construction workers or residents near the construction sites.

COVID-19 specific measures WHO

- All workers must perform complete sanitization at the site as per SOPs/guidelines issued by WHO and the national guidelines issued by the Government of Pakistan (GOP)¹⁹.
- All workers must wear a mask and gloves as soon as they arrive at site and must keep wearing it at all times while present at the work site/hospital premises. The WHO guidelines on biosafety and use of masks are provided as **Annexures M and N**.
- As soon as workers arrive at work site, their body temperature must be checked and in case any worker is assessed to be running a fever or suffering from a flu or cough, he must be informed to leave immediately and self-isolate for a two week period and not report for work until this two week mandatory period has been completed.
- At the work site(s), social distancing measures must be strictly implemented and gathering of workers at any location at the work site(s) must be strictly forbidden. In case of workers not taking this measure seriously, strict penalties must be imposed to ensure implementation.
- The work tasks must be divided into shifts, as far as possible, to reduce the workforce present at the work site(s) at any one moment and improve the working speed/efficiency.
- All workers will be strictly advised to wash their hands as frequently as practicable and not to touch their face during work.
- A supply of safe drinking water will be made available and maintained at the project site(s).
- Chlorinated disinfecting spraying must be conducted at the work site(s)
- COVID awareness sign boards must be installed at the camp clinic and at the work site(s).
- Contact details of all workers will be kept in a register on site in order to efficiently trace and manage any possible workers that might experience symptoms of COVID-19.
- Prohibition of entry for local community/any unauthorized persons at work sites.
- Proper hygiene practices in the toilets and washrooms will be implemented with

¹⁹ <https://covid.gov.pk/guideline>

proper and adequate use of soaps and disinfectant spray.

- Social distancing must be maintained during the pick-up and dropping off of workers from their residences to and from the work site(s).

COVID-19 specific measures GOP

Advice for Site Managers:

- Every construction project shall make proper arrangements for uninterrupted building services including but not restricted to, electricity, fuel, water supply, water disposal and sanitation, communication links, washrooms with hand hygiene and shower facility and with proper and adequate supply of soaps and disinfectants.
- Workers should not use biometric attendance machines or crowd during attendance, entry or exit to the premises of the construction site.
- Ensure the availability of the thermal gun at the entry and exit of the construction site and no worker should be allowed without getting his/her temperature checked.
- Site manager must maintain a register of all contact details with NID number and addresses of all present at the site in case a follow up or tracing and tracking of contacts is required at a later stage.
- Develop the employee roaster to decrease the number of people on the site very day. Split the shifts of the workers in morning and evening with limit of each shift to 8 working hours.
- Every worker must change into standard working attire at the time of commencement of duty and change back to their regular dress after taking shower when their duty hours end.
- In addition to all other internationally recognized safety precaution for construction workers and other staff, every individual must be provided with a face mask. It must be ensured that everyone during his or her presence at the site continues to wear the mask. Face mask shall be replaced as and when soiled or otherwise removed. Outer surface of face mask must not be touched with hands.
- Non-essential work trainings must be postponed avoiding gathering of people.
- Ensure the physical distance by creating more than one route of entry and exit to the site.
- Instruct the workers to inform the construction manager (or authorities) if
 - They develop any symptoms of cough, flu or fever.
 - They have been exposed to someone suspected or confirmed with COVID 19.
 - They have met someone who has a travel history of COVID 19 endemic country. They have travelled in last couple of days or plan to travel soon.
- All incidences of appearance of the symptoms of COVID-19 shall be immediately documented and maintained at the site and information regarding which shall be immediately communicated through e-mail or else, to the designated health facility, and the sick worker shall be transported to the health facility for further advice and

action. The site manager must establish a link with a nearby healthcare facility with arrangements for quick transportation of workers in case of an emergency.

- Persuade the workers to inform the authorities for their safety and of other if they observe any signs and symptoms in a colleague
- Do not allow any worker at the construction site who has the symptoms
- Display the awareness banners about hand hygiene and physical distancing, where you can, around the work site.
- Everyone on the construction site must observe sneezing and coughing etiquettes.
 - Workers shall be requested and required to wash their hands as frequently as practicable and shall also be advised not to touch their face with their hands during work.
- Workers must maintain no less than two arm lengths between them before, during after work at all the times. They shall not make physical contact and shall be required to maintain separate personal gears and assets which must be clearly labelled and stored without intermix.
- Only sanitize-able dinning surfaces shall be used, which must be cleaned before each service. Food must be heated to a temperature to no less than 70o C before consumption and shall preferably be served in disposable utensils. If reusable utensils are used, these must be washed with soap and water immediately after use and stored at a safe place.
- The lunch breaks and stretch breaks of the workers must be staggered to avoid the clustering of workers. Workers must not sit at less than 2 meters distance while having meals and while any other activity requiring interpersonal communications.
- In the wake of current restrictions on transportations site mangers will ensure safe transport arrangements for worker which should not be crowded and should have social distancing in place during the entire process from pickups till drops at destination.
- In case of workers sleeping in at the site of construction, a safe distance of 2 meters must be ensured in the sleeping rooms
- A supply of safe drinking water must be made available at the project site and maintained.

Advice for Construction Workers:

- All possible and prescribed measures shall be taken to ensure your and others health. Enter your contact details in the register maintained at the site, in case a follow up or tracing and tracking of contacts is required at a later stage.
- Follow hygiene practices at washrooms and shower facility with proper and adequate use of soaps and disinfectants.
- Every worker must change into standard working attire at the time of commencement of duty and change back to their regular dress after taking shower when their duty hours end.
- In addition to all other internationally recognized safety precaution for construction

workers and other staff, every individual must use face mask. Face mask shall be replaced as and when soiled or otherwise removed. Outer surface of face mask must not be touched with hands.

- Workers should wash their hands as frequently as practicable and shall not touch their face with their hands during work.
- Everyone on the construction site must observe sneezing and coughing etiquettes.
- Workers must maintain no less than two arm lengths between them before, during after work at all the times. They shall not make physical contact and shall be required to maintain separate personal gears and assets which must be clearly labelled and stored without intermix.
- Sick worker should immediately inform the site manager and must get medical advice from nearby health centre.
- Only sanitizable dining surfaces shall be used. Food must be heated to a temperature to no less than 70 °C before consumption and shall preferably be in disposable utensils. If reusable utensils are used, these must be washed with soap and water immediately after use and stored at a safe place.
- Do not sit at less than 2 meters distance while having meals and while any other activity requiring interpersonal communications.
- Do not use biometric attendance machines or crowd during attendance, entry or exit to the premises of the construction site.
- Use safe transport arrangements which should not be crowded and should have social distancing in place during the entire process from pickups till drops at destination.
- In case sleeping in at the site of construction, a safe distance of 2 meters must be ensured in the sleeping rooms.

Deliveries or Other Contractors Visiting the Site:

- Non-essential visits to the construction sites should be cancelled or postponed.
- Delivery workers or other contractors who need to visit the construction site must go through temperature check before entering and should be given clear instructions for precautions to be taken while on site.
- Designate the workers, with protective gears or at least gloved and mask, to attend to the deliveries and contractors.
- Make alcohol-based hand sanitizer (at least 70%) available for the workers handling deliveries.
- Instruct the visiting truck drivers to remain in their vehicles and whenever possible make use of contactless methods, such as mobile phones, to communicate with your workers.

6.3.12 Vegetation and Wildlife Loss

Impacts

446. The project consists of a semi-urban environment located in the outskirts of Mardan city with limited human settlements and activities and thus contains limited vegetation cover and limited wildlife of any significance as common in areas located close to urban centers.
447. No impact on vegetation and wildlife is expected since no trees are expected on the project site. There are only minor shrubs and bushes that will be cleared up, if felt necessary, during the site preparation stage of the project.

Mitigation measures

- consideration will be given to the visual appearance of the landfill site during operation and at the time of closure of the site and its impact on the surrounding land forms. Necessary plantation will be carried out, which will act as buffer zone from surrounding environment. A buffer zone of 10 meters tree lining is proposed for the landfill site within and at boundary of facility to improve landscape of the area. A reasonable area has been allocated for plantation within and at boundary of facility to improve landscape of the area.
- Inside the boundary wall, tree plantation will be conducted to create an environmental barrier between the external and internal environment. Indigenous tree plantation will be carried out, which will serve as the buffer zone. Green belt has been provided in project key plan. For the landfill, to present a clean and aesthetically pleasing view, buffer zone with tree plantation and landscaped berms will be developed. Plantation will commence as one of the earliest activities of site development. Once the design of landfill is approved and necessary funds have been mobilized, plantation activity will be started in collaboration with Mardan Development Authority or WSSM may outsource the activity separately.
- Camp/s will be located in existing clearings; as much as possible.
- Off-road travel will be strictly prohibited and observance of this will be monitored during execution of the project. and
- Vehicle speed will be regulated and monitored to avoid excessive dust emissions.
- No hunting or killing of animals will be permitted.
- No cutting down of vegetation or using vegetation or trees as firewood will be permitted.

6.3.13 Historical/Archaeological Sites

Impacts

448. No historical/archaeological sites have been identified in the project area or project site.

Mitigation measures

449. If evidence of any archaeological remains is found during the construction activities, the excavation work will be stopped immediately, and necessary next steps taken to identify the archaeological discovery based on the 'Chance Find' procedures provided as **Annexure G**.

6.3.14 Construction of Administration Building and Other Infrastructure

Impacts

- 450. Mardan LFS will have proper facilities like administration building, waste reception areas, weigh bridge, CCTV, RFID, access roads, daily soil cover, security, lighting for 24 /7 usage and professionally trained workers to operate and supervise.
- 451. A 3 story Administration building will be constructed within SWMF to house administration staff and manage the facility operations within Mardan SWMF. It is planned such that it can accommodate landfill operations team, has a laboratory for quality control and MIS monitoring room for data acquisition and transfer to head office. The building also contains a conference room for meetings at landfill, an inventory room for storing supplies for repair and maintenance of landfill machinery and vehicles. There are showers, prayer area, rest rooms and a kitchen in the building. A car park outside the building will be constructed for personnel's' vehicles. The area of the administrative building is surrounded by landscaping and greenery. The building has a look-out tower on 4th level for viewing operations at the facility. Lookout tower of height 49'-6" will be constructed for visual surveillance of the landfill facility.
- 452. Roads inside the premises will be constructed. Road 10 m wide with two lanes each 4 m for two-way traffic of waste carrying vehicles will be constructed. Access roads within cells (8 meters wide) will be constructed at 1:10 longitudinal slope. Vehicle parking shed for waste vehicles, a workshop for routine repair and maintenance work will be constructed.
- 453. Soil erosion is main impact during construction of admin building and associated infrastructure. Construction of roads or other facilities has also been historically perceived and in some cases has actually led to soil erosion. The possibility of soil erosion has been assessed in detail in the following paragraphs.
- 454. The possibility of soil erosion from a human activity increases when soil particles are detached from the soil mass. This is true for agricultural lands where a certain landscape is changed and the area is left exposed to wind and water erosion and also for dirt tracks which are developed through continual use by vehicles and the soil surface is subject to continual erosion for as long as the track is used. However, these cases are different from scenarios in which the soil surface initially disturbed is sealed or compacted by engineering means. For example, metalled roads are not subject to soil erosion, similarly neither would the gravel-topped roads which will be compacted to sustain loads.
- 455. Other environmental impacts from construction of administration building include construction debris, unattended concrete and cement waste, brick waste, littering and empty cement bags which required to be disposed off as per waste management plan. Flooring works will add slurry waste resulting from grinding activities. Noise from mixing plants, steel fixing works, wood works is another source of environmental nuisance which need to be managed. Use of generators, vehicles and machinery may be source of air pollution if not managed.
- 456. On the basis of the above it can be assessed that on a macro level environmental impacts from construction of admin building and associated infrastructure will not be a significant issue as all these impacts will be managed through implementation of site specific EMMP prepared by contractors and approved by CSC/PMU.

Mitigation measures

457. Following are the mitigations measures that will be employed to mange impacts from construction of building and associated infrastructure.
- Water will be sprinkled regularly to suppress dust emissions. Off road travelling of vehicles will be prohibited.
 - Stock piles will be appropriately located and out of wind to avoid dust emissions. Dry dusty materials should be sprinkled with water and properly covered to avoid dust emissions.
 - No cement and concrete waste will be left unattended. Construction debris will not be thrown from height to avoid dust emissions. Return unpaved areas to original or improved contours following construction.
 - Solid waste generated from construction of admin building will be managed through site specific EMMP and no waste will be stored at site to improve housekeeping at site and to avoid environmental nuisance.
 - Set protocols for proper and regular maintenance of construction machinery, vehicles and generators. Generators that will be used will be placed at suitable locations.
 - Contractor will not be allowed to store bulk quantities of fuel or hazardous material at site.
 - Any fuel or chemicals stored at site (in small quantities) will be stored at designated site and containers/storage vessels be properly marked for their contents. Storage area will be provided with hard impervious surface and secondary containment.
 - Equipment and machinery with loose vibratory parts will not be allowed to use. Used equipment and machinery will be in compliance to NEQS.
 - Waste bins will be provided at appropriate places to manage waste. Daily housekeeping of the construction area will be carried out.
 - CSC will ensure that proper amounts of insulation in the walls and roof will be used.
 - Proper weather stripping and caulking will be carried out to ensure energy efficiency.
 - High quality windows that utilize low-e coatings and gas filling will be installed.
 - CSC will ensure that energy efficient appliances such as LED lights, energy savers, inverters) are installed in the buildings.

6.3.15 Sexual Abuse, Exploitation and Harrasement (SEAH)

Impacts

458. Acts of violence committed against women and children including, *inter alia*, sexual violence, sexual harassment and other discriminatory practices based on gender, all fall within the ambit of SEAH. Sexual harassment against women might occur as a consequence of mixing of men and women at the construction site however keeping in view the culture of the area women involvement in construction works is not expected.

Mitigation Measures

459. The contractor will manage the potential risks of sexual exploitation and abuse, and sexual harassment by taking following actions:
- The contractor's COC shall cover a program to promote awareness of the construction workers on avoiding any gender-based violence;
 - The contractor's monthly training program will cover topics related to COC such as sexual harassment particularly towards women and children, violence, including sexual and/or gender-based violence;
 - Measures to protect the privacy of women and girls by the contractor, sub-contractors and service providers;
 - The contractor will make sure that no discrimination is made on the basis of gender while hiring of workers;
 - The contractor will set the employment relationship on the code of equal opportunity and fair treatment and develop COC for workers to address these issues;
 - The employment decisions will not be made on the basis of personal characteristics unrelated to inherent job requirements, including race, gender, nationality, religion or belief, disability, age, sexual orientation, or ethnic, social and indigenous origin;
 - Special measures will be taken to address harassment, intimidation, and/or exploitation, especially in relation to women;
 - No Sexual Harassment Policy will be established and strictly endorsed in accordance with provincial law;
 - World Bank Good Practice Note on Addressing GBV will be used as guidance.²⁰

6.4 Impacts Associated with Operation of SWMF

460. The potential impacts from operation of the SWMF are provided as **Table 6.5** below.

Operation Phase

Table 6.5: Screening of Possible Impacts during Operation Phase

S/No.	Potential Issues	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact (Short term, Long term)
1	Generation of Leachate	Likely	Major	Medium	Long term
2	Possible Contamination	Likely	Major	Significant	Long term

²⁰ <http://documents.worldbank.org/curated/en/399881538336159607/Environment-and-Social-Framework-ESF-Good-Practice-Note-on-Gender-based-Violence-English.pdf>

S/No.	Potential Issues	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact (Short term, Long term)
	of Soil and Groundwater				
3	Generation of Landfill Gas	Likely	Major	Medium	Long term
4	Generation of objectionable Odor and impact on air quality	Likely	Major	Medium	Long term
5	Attraction of Vermin and disease vector generation	Likely	Major	Medium	Long term
6	Occupational Health and Safety	Likely	Major	Medium	Long term
7	Waste Collection and Hauling Impacts	Likely	Major	Medium	Long term
8	Wind Blown Litter	Likely	Major	Medium	Long term
9	Improved management of solid waste & health and sanitation	Positive impacts expected			Long term
10	Improvements in Public Health	Positive impacts expected			Long term
11	Improvements in Aesthetic aspects	Positive impacts expected			Long term

■ Critical Risk Level

■ Significant Risk Level

■ Medium Risk Level

■ Low Risk Level

■ Positive Impacts

6.4.1 Generation of Leachate

Impacts

461. The general risks from leachate generated from wastes are due to its normally high organic contaminant concentrations and high ammoniacal nitrogen. Pathogenic microorganisms and hazardous substances that might be present in it are often cited

as most dangerous, but pathogenic organism counts have been found to reduce rapidly with time in the landfill, so this only applies to fresh leachate.

462. The generation of leachate is inevitable in most landfill areas. Leachate generation rates are completely dependent on the amount of liquid the waste originally contains and the amount of rainfall in the area. Some factors that can influence leachate generation are the following:

- Climate;
- Site topography;
- Final landfill cover material;
- Vegetative cover;
- Site phasing and operating procedures;
- Type of waste materials in the landfill

463. The climate at the site will significantly influence the rate of leachate generation in the landfill. Since the site is located in an area of low precipitation, it can be expected that leachate generation is relatively low, although plans to handle and treat even these minute quantities are incorporated in the design.

The temporary and final landfill covering can also influence the amount of water percolating into the landfill.

464. Finally, it is a given that vegetation will, by evapotranspiration, re-direct a portion of the infiltrating precipitation back into the atmosphere. The presence of vegetation in the landfill can also influence the generation of leachate in the landfill.

Mitigation measures

465. Depending on moisture content of the waste, leachate can be generated from the dumped waste. On the other hand, as envisaged that with the low expected precipitation, it is expected that leachate generation will be relatively low. Nonetheless, the following control measures will be implemented:

- A leachate holding tank of 500 m³ sufficient to store (15 days leachate) will collect the leachate before it enters the treatment plant. Leachate treatment is based on DTRO, which is potable arrangement for treatment of leachate and can be operationalized during monsoon for 24/7 basis. During monsoon season, recirculation of leachate will be increased to avoid operational constraints of leachate collection, storage and treatment system at landfill site.
- Operate the landfill in accordance with applicable internationally recognized standards to minimize leachate generation, including the use of low-permeability landfill liners to prevent migration of leachate as well as landfill gas, a leachate drainage and collection system, and landfill cover (daily, intermediate, and final) to minimize infiltration;
- Minimize the daily exposed working face and use perimeter drains and landfill cell compaction, slopes and daily cover materials to reduce infiltration of rainfall into the deposited waste;

- Leachate collection will be augmented by a leachate recirculation system in the landfill design.
- The operators of the landfill must ensure that an effective and efficient leachate control and monitoring system is maintained. This may be complimented by establishment of groundwater monitoring wells and regularly collecting samples for laboratory analysis. Results of the analysis could aid the operators to determine the final fate of the collected leachate and/detect any potential leakages. Final decision rests with the landfill operator on the final number of wells as well as the frequency of sampling for groundwater quality.
- The final vegetative cover plays an integral part in leachate production control. Its basic functions are to limit infiltration by intercepting precipitation directly, thereby improving evaporation from the surface, and to reduce percolation through the cover material by taking up soil moisture and transpiring it back to the atmosphere. Preferred plant species should be of those that do not have deep roots in order to protect the surface sealing. Further, these species should require minimal maintenance and human intervention.
- Landfill operators must be properly and adequately trained to operate and maintain the installed control system.
- A procedure for the rapid repair of leaks in the pipes, pumps and other equipment must be part of landfill operations.
- An inventory of spare parts and repair equipment must be continuously in place to ensure immediate remedial action against breakdowns.
- Strict quality assurance and construction guidelines during the installation of the HDPE liner should be strictly implemented.

6.4.2 Possible Contamination of Soil and Groundwater

Impacts

466. Contamination of the groundwater resources is among the most recognized impact of landfill development. In cases of leakages, the contaminated leachate will percolate into the ground and may find its way into existing groundwater resources.
467. In the case of the proposed site, the ground water level is quite high and thus the risk of groundwater contamination remains high. However, the solid waste will be disposed off on a concrete base with liner lining placed under the concrete base. As a result, the likelihood of the liner bursting for a new landfill site is quite remote since high quality liner will be installed and in addition, it will be ensured that all countermeasures in terms of liner design are in place to prevent breakage of liner. Furthermore, active life of landfill cell is about 4-5 years and after that Final capping will be placed. After that, there are minimal chances of percolation of water in the landfill cell and hence limited leachate production.
468. For (4) storage cells are proposed by the designer of LFS in Mardan. A leachate leak from any of the storage cells may result in the contamination of the water table below the LFS. The geology of the site is Organic clay (Moderate to low permeability) overlaying Silty-Sand aquifer with high permeability. The water table, based on actual data from site as well as the surroundings of LFS, shows that the water table is sloping towards nearby tube wells and passes underneath a Masjid

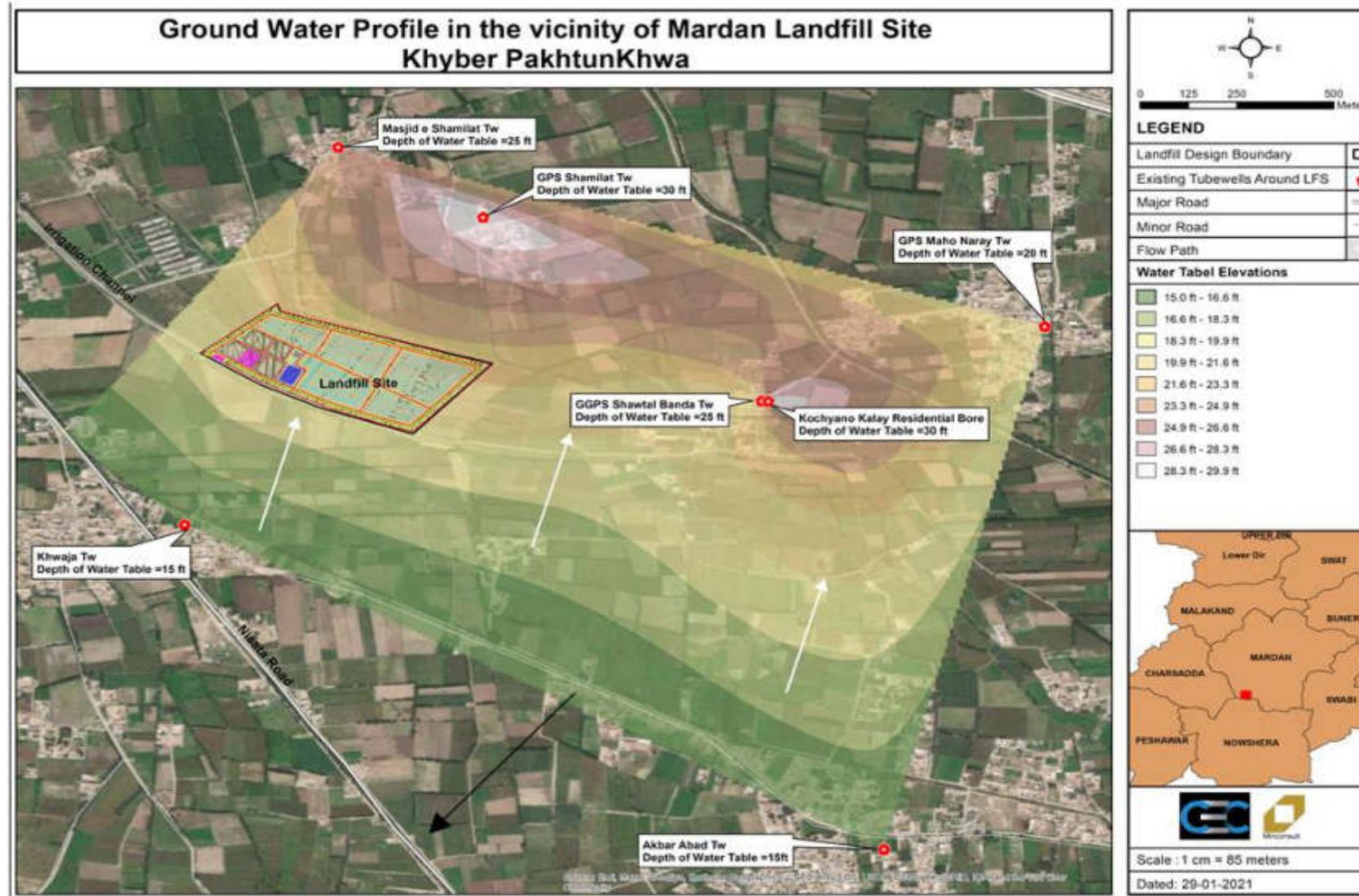
Shamilat, a Primary School and a few households. The Figure 6-1 below shows the location and water table depths at existing water tube wells at the site and in the surrounding of the LFS. It shows the water table sloping from LFS towards the nearby tube wells i.e. Masjid Shamilat TW and GPS Shamilat TW. Data of existing water resources around LFS is shown in **Table 6-6** below.

469. Project design consultant EDCM has estimated the leachate leaking effect on ground water quality of Mardan LFS. This report focuses on checking the source, identify transport mechanisms and potential targets affected by the contamination using a qualitative and quantitative risk assessment of the problem. This involve computation of contaminant concentration at the targets identified in a conceptual model, estimating the concentration at various target points. Analysis findings are discussed below and detailed working for estimation of leachate leaking effect on ground water quality is provided as Annexure Q. Location of tube-wells and ground water level with flow direction is provided as **Figure 6-1**.

Table 6.6: Data of existing water resources around LFS

S.No	Name of TW	Depth of Water Table (ft)	X	Y
1	Masjid Shamilat TW	25	34.1593	71.9686
2	GPS Shamilat TW	30	34.1576	71.9719
3	Khwaja Tw	15	34.1499	71.965
4	GGPS Shwatal TW	20	34.153	71.9784
5	Kochyano Kalay Handbore	30	34.153	71.9785
6	Akbar Abad TW	15	34.1417	71.9812
7	GPA Maho Naray TW	20	34.1401	71.9812

Figure 6-1: Location of Tube-wells and ground water level showing underground direction of flow



470. As per **Figure 6-1** above, the nearest communities with respect to the proposed LFS is at risk in the direction of the flow are about 50 Residential houses (Distance 550m), GPS Shamilat Primary school (Distance 575m), and Jammi Masjid Shamilat (Distance 560m) both being supplied by Shamilat TW (Distance 550m) and GPS Shamilat Primary school TW (Distance 575m). The school and community take the water from the Shamilat TW and GPS shamilat TW both identified as target of possible breach in the case due to the direction of the groundwater flow. The water is also used to supply water for household use (including drinking) to nearby houses. Also, the water level is very shallow in this case and contamination may find its way to the surface by Plant/vegetation uptake. Contaminant concentration graph at target tubewell locations vs. time in days is shown as **Figure 6-2**.

471. Possibility of a liner breakage is not expected to take place for at least 5 years or so from its time of installation. Furthermore, leachate collection system will be in place at bottom lining of the landfill cell and it will work even after final capping of landfill cell to collect and treat any volume of leachate. Keeping in view these design considerations, leachate percolation to ground water is not expected. Input data for Otaga and Banks equations used for calculation of leachate contamination is given in **Table 6.7**. Travel time and leachate contamination from the LFS is provided in **Table 6.8**.

Table 6.7: Input Data for Otaga and Banks Equation

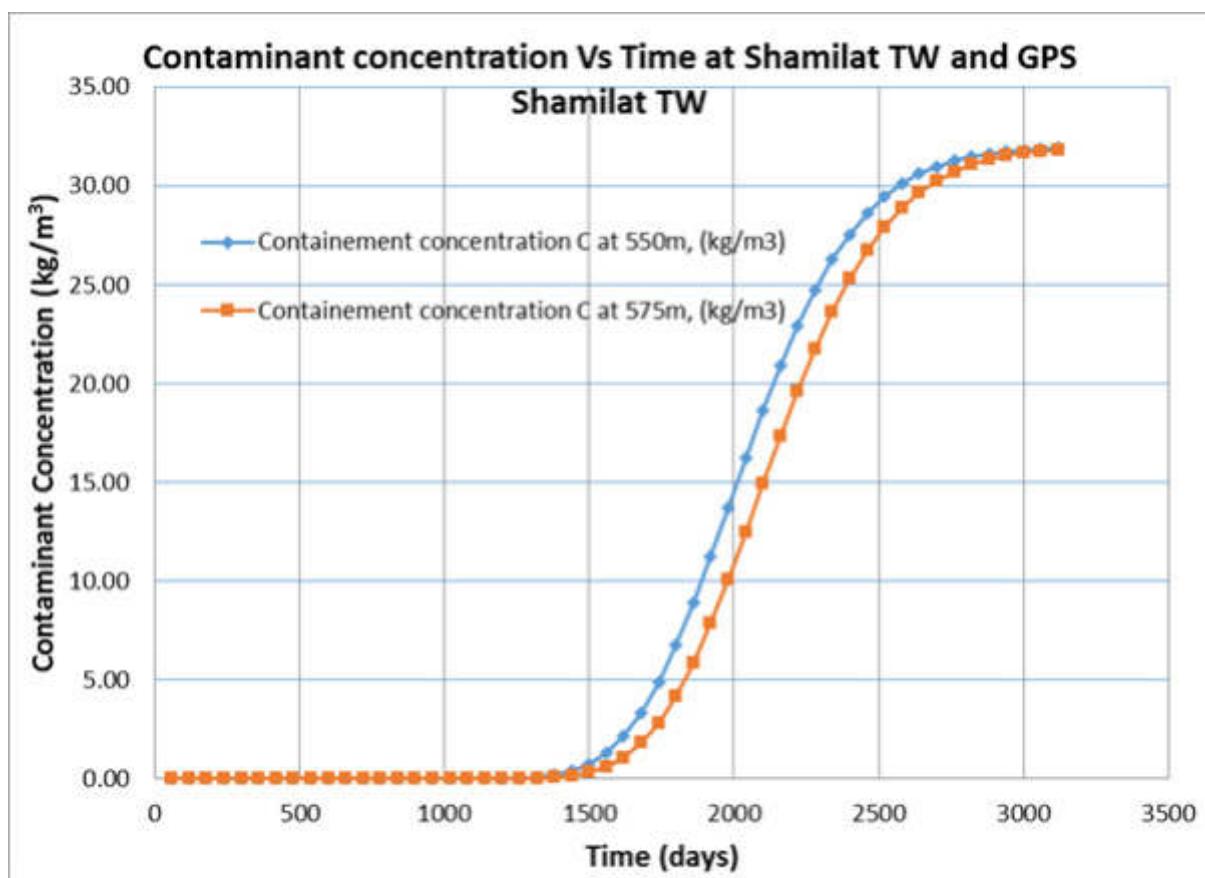
Inputs	Co	31.98	kg/m ³
	K	30	m/day
	dh	4.57	m
	dx	1035	m
	porosity	0.49	
	D, Dispersion Coefficient	1.72	
	x, Distance from Source	550 and 575	m
Calculations			
	Darcy Velocity	0.132463768	m/day
	v, True Velocity	0.270334221	m/day

Table 6.8: Travel time and Leachate concentration at tubewell locations around LFS

Time t (days)	Containment concentration C at 550m, (kg/m3)	Containment concentration C at 575m, (kg/m3)
60	0.00	0.00
120	0.00	0.00
180	0.00	0.00
240	0.00	0.00
300	0.00	0.00
360	0.00	0.00
420	0.00	0.00
480	0.00	0.00
540	0.00	0.00
600	0.00	0.00
660	0.00	0.00
720	0.00	0.00
780	0.00	0.00
840	0.00	0.00
900	0.00	0.00
960	0.00	0.00
1020	0.00	0.00
1080	0.00	0.00
1140	0.00	0.00
1200	0.01	0.00
1260	0.02	0.01
1320	0.07	0.02
1380	0.16	0.05
1440	0.36	0.13
1500	0.71	0.29
1560	1.28	0.58
1620	2.13	1.06
1680	3.32	1.79
1740	4.85	2.82
1800	6.72	4.18
1860	8.88	5.87
1920	11.25	7.85
1980	13.72	10.08
2040	16.22	12.45
2100	18.63	14.90
2160	20.88	17.31
2220	22.93	19.61
2280	24.73	21.74
2340	26.27	23.65
2400	27.55	25.32

Time t (days)	Containment concentration C at 550m, (kg/m ³)	Containment concentration C at 575m, (kg/m ³)
2460	28.60	26.74
2520	29.44	27.92
2580	30.10	28.88
2640	30.61	29.65
2700	30.99	30.25
2760	31.27	30.72
2820	31.48	31.07
2880	31.63	31.33
2940	31.74	31.52
3000	31.82	31.66
3060	31.87	31.76
3120	31.91	31.83

Figure 6-2: Contamination Concentration at target tubewell locations vs. time in days



472. As a result of this leachate leakage estimation at ground water quality, the following key findings were made:

- The hydrogeological analysis was based on a very conservative estimate of contaminant movement through strata considering no bio decay, diffusion or retardation is occurring to model worst-case scenario.
- The water table is at 7m depth, however the hydraulic conductivity and available hydraulic gradient is low resulting in relatively lower groundwater flow below the proposed site. This means that the contaminant flow is relatively slow through the ground water.
- The existing water quality should be measured before that start of construction to establish the existing ground water contamination level due to shallow water table and high organic content observed during soil investigation.
- The water table is shallow in the locality and the leakage resulting in ground contamination may cause Phytotoxicity of plants as well as contaminate groundwater. Phytotoxicity shown in the figure may be used a tell-tale sign for any possible detection of ground water contamination and should be monitored regularly once the site is operational.
- Based on analysis, it will take a total of **1200 Days (40 months)** for contamination to start appearing at the nearest tube well located in the direction of flow at the Shamilat Tube well (550m away) and GPS Shamilat tube well (575m away from the site).
- Once the contamination start appearing in the water supply from the tube well it will take about 1800 more days to reach full concentration at the target tube wells.
- However, there is a significant chance of harm if the amount of groundwater flow reduces or the contamination level increases above the current levels. Therefore it is recommended to use observation boreholes to monitor groundwater quality and also additional checks should be made on monthly basis by collecting water samples from the nearest tube well for detection of any contamination.
- The leachate discharge should be measured on regular basis to indicate barrier breach from loss of leachate.

Mitigation measures

473. The following measures will be implemented:

- Appropriate liner and collection systems in compliance with international guidelines/criteria are part of the design and will be installed.
- An efficient leachate collection and treatment system has been provided to ensure leachate accumulation at the base of the landfill and keep it to a minimum.
- The leachate system will consist of a leachate collection layer of either natural granular (sand, gravel) or synthetic drainage material (e.g. geonet or geo-composite) with pipe network to convey the leachate to treatment facility.
- A total of 600 mm clay liner of permeability of 1×10^{-6} cm/sec will be compacted at the bottom in series of 150mm layers each compacted to 95% of compaction,

followed by 150 mm base layer . This layer will be topped by 1.5 mm HDPE geomembrane.

- As soon as HDPE is placed, 200 mm silty sand or geotextile will be covered on top of HDPE for the protection of the HDPE on the side slopes.
- Above this 300 mm PEA gravel layer will be placed followed by 150 mm compacted (85-90%) sand layer.
- Leachate collection pond shall be in opposite direction from nearest surface water body.
- A leachate treatment facility with a design capacity of 50 m³ /d will be constructed. Leachate treatment is designed on activated sludge treatment with advance level treatments (Disc Tube Reverse Osmosis-DTRO) for heavy metals and other pollutants potentially present in leachate.
- Slope of the landfill site shall be away from nearest surface water body.
- Cut-off drains around active landfill site and peripheral drains around landfill site should be provided
- Ground water monitoring wells should be dug keeping in view of the flow of ground water on both upstream and downstream of the disposal site and monitor the ground water quality of the upper strata for any contamination for disposal site every month.
- In the worst-case scenario, if leachate contamination is detected during ground water monitoring after few years of landfill operation, Ground water modelling to determine possible contamination of leachate will be carried out and necessary design changes will be implemented.
- Detailed ground water quality baseline will be developed during operation phase of the project to trace any ground water contamination from landfill operations.
- Waste hauling vehicles shall be covered during transport of waste to landfill site
- Hauling vehicles shall not wash at the surface water bodies along the route as the wash water shall drain into the canal and will pollute the surface water source which is used by the animals of the nearby communities and for agriculture purpose.
- Domestic sewerage of Mardan facility shall not be discharged untreated in open area and drains,
- Waste water generated from vehicle wash area shall be contained and treated before final discharge
- In order to augment this system, regular quality control checks on the equipment /accessories will be implemented and incorporated during construction and operations.

6.4.3 Impact on Surface Water Resources – Canal passing along Southern Boundary of Landfill Site

Impacts

474. There is a minor 3.9 km long water channel along the southern boundary of the landfill site, originating from bifurcation of the main channel of lower swat canal in Fazalabad area. Distance of channel from landfill site is about 35 meters and this channel is running adjacent to the access road of the site. However, after a distance of approximately 375 meters, this channel reaches its tail end. Project hydrogeological study suggests that there are no surface water sources within a reasonable distance in the direction of ground water flow, which will be toward northern side from the landfill boundary. Irrigation channel is flowing on southern side and is NOT downgradient to the landfill cells, thus, the IFC criteria of 500-meter distance is not applicable to this channel.

475. Impacts related to construction waste management, sewerage disposal and construction dust are anticipated on the irrigation channel during construction which will be managed through effective implementation and monitoring of SSEMPs to avoid degradation of water quality of the channel. Impacts related to windblown litter and poor waste hauling can degrade the surface water quality of the channel during operation phase which will be mitigated and monitored throughout project life span.

Mitigation Measures

476. The following measures will be implemented:

- Labor and construction camps will be located away from the irrigation channel.
- Water from the irrigation channel will not be used for the landfill operations.
- Sewerage from labor/construction camps will not be discharged in the irrigation channel.
- Access road running along the channel will be properly paved and maintained to reduce the dust emission on surface water quality of the channel.
- Speed limit will be followed to avoid dust and litter impacts on channel during construction phase.
- Septic tanks and soak pits will be developed away from the channel to avoid any contamination.
- No solid waste or construction waste will be dumped into the irrigation channels.
- During project works, no damage to irrigation channel structures will be done.
- Construction contractors are not allowed to use water of channel for vehicle/equipment washing purpose.
- Waste carrying vehicles during operation phase are not allowed to be parked along the banks of channel.
- WSSC Mardan will ensure that no windblown litter is entering the irrigation channel.
- Weekly inspection of irrigation channel will be carried out by WSSC Mardan to ensure that surface water quality is not impacted by wind blow litter or waste hauling litter.

6.4.4 Generation of Landfill Gas

Impacts

477. Studies and research indicate that landfill gas is approximately 40-60% methane (CH₄) and the remaining being mostly carbon dioxide (CO₂). There is another group of chemicals, called non-methane organic compounds (NMOCs), which may be present in the air near a landfill, though they are not likely to reach harmful levels. They are nitrogen, oxygen, water vapor, sulfur and hundreds of other contaminants. NMOCs may occur naturally, or be formed by chemical processes. There is concern that long-term exposure to high levels of NMOCs could lead to health problems, but health studies have been largely inconclusive. The **Table 6.6** shows a list of the various components of a typical landfill gas.
478. Though NMOCs usually make up only less than 1% of landfill gas, many of these are hazardous chemicals like benzene, toluene, chloroform, vinyl chloride, carbon tetrachloride and 1,1,1 trichloroethane. At least 41 of these are halogenated compounds. Many others are non-halogenated toxic chemicals. More exhaustive test for contaminants in landfill gas has found hundreds of different NMOC contaminants.

Table 6.9: Typical Landfill Gas Components

Component	Percent by Volume	Characteristics
Methane	45-60	Methane is a naturally occurring gas. It is colorless and odorless. Landfills are the single largest source of U.S. man-made methane emissions
Carbon Dioxide	40-60	Carbon dioxide is naturally found at small concentrations in the atmosphere (0.03%). It is colorless, odorless, and slightly acidic.
Nitrogen	2-5	Nitrogen comprises approximately 79% of the atmosphere. It is odorless, tasteless, and colorless.
Oxygen	0.1-1	Oxygen comprises approximately 21% of the atmosphere. It is odorless, tasteless, and colorless
Ammonia	0.1-1	Ammonia is a colorless gas with a pungent odor
NMOCs (non-methane organic compounds)	0.01-0.6	NMOCs are organic compounds (i.e., compounds that contain carbon). (Methane is an organic compound but is not considered an NMOC.) NMOCs may occur naturally or be formed by synthetic chemical processes. NMOCs most commonly found in landfills include acrylonitrile, benzene, 1, 1-dichloroethane, 1, 2-cis dichloroethylene, dichloromethane, carbonyl sulfide, ethyl-benzene, hexane, methyl ethyl ketone, tetrachloroethylene, toluene, trichloroethylene, vinyl chloride, and xylenes
Sulfides	0-1	Sulfides (e.g., hydrogen sulfide, dimethyl sulfide, mercaptans) are naturally occurring gases that give the landfill gas mixture its rotten egg smell. Sulfides can cause unpleasant odors even at very low concentrations

Component	Percent by Volume	Characteristics
Hydrogen	0-0.2	Hydrogen is an odorless, colorless gas
Carbon Monoxide	0-0.2	Carbon monoxide is an odorless, colorless gas

Source: *Tchobanoglou, Theisen, and Vigil; EPA 2015*

479. These landfill gases are released into the atmosphere. Whenever unabated, these gases might affect the general environment, including the welfare of its employees and host community in general. Landfill gas is the main carrier of landfill generated odor, which is classified to be objectionable.
480. Landfill gas may cause temporary discomfort, but it is not likely to cause permanent health effects. At extremely high concentrations, persons exposed may experience eye irritation, headaches, nausea, and soreness of the nose and throat. People with respiratory ailments such as asthma are especially sensitive to these effects. However, these temporary conditions are reversed as soon as the gases are reduced or eliminated. Engineered Sanitary Landfills normally have landfill gas capture systems.
481. Land GEM results for pollutant emissions resulting from the flaring operations at the site are presented as Figure 6-3. Land GEM results shows that emissions of Sulphur dioxide (SO₂) and Methane (CH₄) are both minimal with only 4.9 kg/day (0.06 g/s) of SO₂ and 110.9 kg/day (1.2 g/s) of CH₄ being emitted. Also result shows very limited yearly volumes of emissions of NMOC and Hazardous Air Pollutants (HAPs) from landfill site. Keeping in view these limited volumes and after controlled flaring no deterioration to air quality is expected from the facility. Further the project area consists of a rural and open setting with no built area located in close proximity to the site, thus any minimal pollutant emissions will be rapidly diluted upon release and thus will not result in any significant impact on the airshed of the project area. Keeping in view the amount of gas production after few years of landfill operation, feasibility for gas reuse will be carried out and accordingly design changes will be executed.

Figure 6-3: Potential Emissions from Landfill Site

Landfill Name: Mardan landfill Treatment : 200TPD MBT Facility			
LANDFILL INFORMATION			
Type of Landfill <input checked="" type="checkbox"/> New <input type="checkbox"/> Existing <input type="checkbox"/> Closed	Time since closure (yrs): c = 0		<input checked="" type="checkbox"/> Used EPA's Software (Landgem) (Attach summary)
Type of Control <input checked="" type="checkbox"/> Flare <input type="checkbox"/> Control System <input type="checkbox"/> Enclosed Combustor <input type="checkbox"/> None	Age of Landfill (yrs): t = 9,234509		<input type="checkbox"/> Based on estimated life
Capture Efficiency (%): 90			
Destruction Efficiency (%): 98	Landfill Design Capacity (cubic meters): 752,716		
Average Annual Waste Acceptance Rate (Tons/yr): R = 69,285	Mass of Solid Waste in Landfill (Tons): 639,809		
Area (Acres) of Landfill: 12.4	Gas Sent off-site (mmcft): 0		
CALCULATION OF EMISSIONS			
Default values are 80m³/Mg for L (Methane Generation Rate Potential), and 0.04/yr for k (Methane Generation Rate Constant)			
Methane Generation Rate (QCH4): (m³/yr)- Before Flaring 3,423,626	Methane Generation Rate: Before Flaring (mmcft) 120.89		
Methane Emission After Flaring (m³/yr) 61,625	Methane Emission After Flaring (m³/yr) 2.18		
SO2 Emissions (Kg/yr): 688	HCl Emissions (Kg/yr): 337.1		
NMOC (VOC) Fugitive Emissions (Kg/yr): 884.5	NMOC (HAP only) Fugitive Emissions (Kg/yr): 112.40		
NMOC (VOC) Collected, Uncontrolled (kg/yr): 7,980.5	NMOC (HAP only) Collected Uncontrolled (Kg/yr): 1,348.7		
NMOC (VOC) Emissions From Control (Kg/yr): 159.2	NMOC (HAP only) Emissions from Control (Kg/yr): 357.4		
Here HAP Hazardous Air Pollutants NMOC Non-Methane Organic Compounds VOC Volatile Organic Compounds HCl Hydrochloric Acid			
CALCULATION OF EMISSION FACTORS			
VOC Fugitive Emission Factor: (Kg/acre) 101.1	HAP Fugitive Emission Factor: (Kg/acre) 12.8		
VOC to Control Emission Factor: (Kg/mmcft) 73.2	HAP to Control Emission Factor: (Kg/mmcft) 12.4		

Mitigation Measures

- Landfill gas capture and flaring systems will be in place as part of the landfill design and thus no significant impacts on occupational or community health and safety are envisaged from landfill gas exposure.
- Landfill gas will be collected through installation of perforated pipes within the cells. This gas transferred to gas recovery unit where it receives subsequent treatment and utilization, or disposal in a safe manner through flaring or venting.

- The vertical gas recovery wells will be designed keeping in view the capacity of the landfill.
- The passive gas collection system is planned with simple venting of landfill gas to the atmosphere without any treatment before release. This is appropriate considering that only a small quantity of gas will be produced and no people live or work nearby. Common methods to treat landfill gas include combustion and non-combustion technologies, as well as odor control technologies. For KPCIP landfills, Open flame flare technology, consisting of a pipe through which the gas is pumped, a pilot light to spark the gas, and a means to regulate the gas flow is proposed. The simplicity of the design and operation of an open flame flare is an advantage of this technology.
- For Mardan, flaring is proposed for landfill gas management. Keeping in view the amount of gas production after few years of landfill operation, feasibility for gas reuse will be carried out and accordingly design changes will be executed. As presently amount of gas generation is not known, therefore, quantitative assessment is not possible at this stage.
- PMU KP LGE&RDD shall ensure that during operation phase of the project, if there are changes in the baseline ambient air quality based on monitoring results, then quantitative assessment will be carried out for flaring and necessary design changes will be incorporated to avoid air quality impacts from flaring.
- As part of closure plan of existing dumping site, GHG monitoring will be carried out and necessary gas venting system will be done.
- Periodic GHG monitoring will be carried out during operation phase of the project and accordingly, necessary design changes will be incorporated, if required.
- PMU KPCIP/WSSM will explore the waste to energy options keeping in view the future waste generation rate of Mardan.

6.4.5 Generation of objectionable Odor and impact on air quality

Impacts

482. Objectionable odor is expected at the landfill site from landfill cells, composting facility and material recovery facility, depending on various factors. Some of which are the types of wastes being handled, humidity, temperature and moisture content, among others. Uncontrolled composting and poor house keeping at site will be the source of objectionable odor. Furthermore, ambient dust may be generated from sorting lines of MRF which need to be managed through proper ventilation and necessary arrangements for dust collection/suppression. Haphazard waste tipping at unloading bay and weighbridge will create nuisance and objectionable odour, if not attended on at frequent intervals.
483. At composting plant, odors originate with the incoming ingredients, which may have been stored anaerobically (without oxygen) for a week or more before transport to the site. Once these ingredients are incorporated into the composting system, subsequent odor problems are usually a result of low oxygen or anaerobic conditions. Anaerobic odors include a wide range of compounds, most notoriously the reduced sulfur compounds (e.g. hydrogen sulfide, dimethyl sulfide, dimethyl disulfide, and methanethiol), volatile fatty acids, aromatic compounds and amines. Ammonia is the

most common odor that can be formed aerobically as well as anaerobically, and thus has its own set of management options.

484. The closest receptors will be the personnel who will be onsite monitoring the status of the facility. Some of the anticipated problems that may be raised during the operation of the landfill are as follows:
- Discomfort of working with offensive odors; and
 - Concerns for the mental or psychological welfare of exposed communities
485. It is noted that based on the prevailing wind patterns, communities or settlements lying in South-West and South-East directions of the site may also be affected.
486. The Wind Rose for Mardan City (shows that the predominant wind direction is from the North-West and North-East directions. As a result, the potential impact on the households from any airborne related impacts, particularly during landfill operations, such as odor, can be seen in the Corridor of Impact provided as **Figure 6.4** below. Since most of the houses which are being used for residential purposes are falling located at a minimum distance of over 250 meters from the proposed landfill, therefore, any potential impacts from objectionable odor are expected to be minimal and manageable.
487. Daily cover will be provided at end of each day to avoid risk of fire, wind littering, odor, vector breeding and dust hazards in the landfill. Working surface of waste will be covered with a soil layer called “daily cover” at the end of each working day. Amount of soil to be used in daily cover will be about 10% of the waste volume. Suitable quality of excavated material will be used as daily cover material.
488. Keeping in view these design considerations and operational modalities, no significant impact of odour and air quality is anticipated.

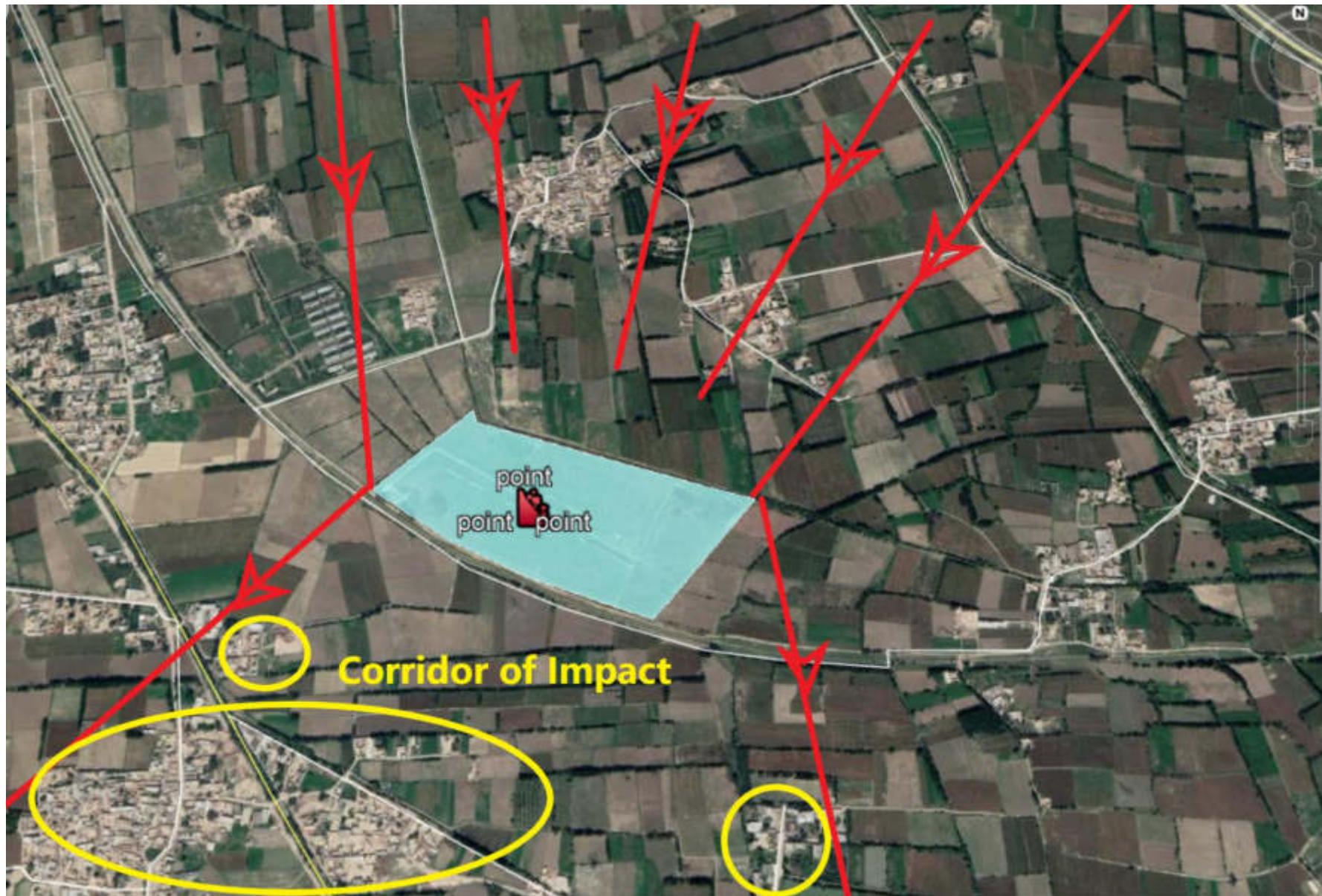
Mitigation measures

489. Best management practices and good housekeeping measures will be implemented to minimize the release of objectionable odours. Potential odours impacts can be minimized or eliminated by adopting the following measures:
- Daily cover will be placed on working surface of waste in order to reduce the risk of fire, wind littering, odor, vector breeding and dust hazards in the landfill.
 - Suitable amount of daily cover will be stocked at the landfill site.
 - Final capping of landfill cells will be carried out in order to limit and control the amount of precipitation that enter the waste and to limit wind and water erosion and burrowing animal activity. This will not only prevent the odor of decaying waste from escaping from the landfill but also protect the site against intrusion of vermin and pests.
490. The top cover system consists of following arrangements.
- Thick top soil layer of 45 cm capable of supporting vegetation in order to protect the landfill surface from wind and water erosion.
 - Drain Layer of 15 cm at bottom to maximize runoff of precipitation while minimizing

infiltration and preventing ponding of water on the landfill.

- Compacted soil layer or barrier of 60 cm of low permeability to limit and control the amount of precipitation that enters the waste.
- Vent layer of 15 cm thickness comprised of sand and gravel
- Appropriate and regular housekeeping (i.e. cleaning) will be done in all areas
- Strict use of Personal Protective Equipment (PPE) by all personnel (e.g. inspectors at the Weigh Bridge, MRFs, material handler and waste compactor operators) must be ensured.
- All the incoming ingredients that are anaerobic will be converted to aerobic state through combining them with a coarse, dry bulking amendment to increase the porosity and allow oxygen penetration.
- Air should be thoroughly dispersed throughout the organic waste. This is done by frequently turning and mixing the wastes.
- Oxidizing chemicals like hydrogen peroxide, potassium permanganate, and chlorine will be used by the wastewater treatment industry for odor control.
- Organic waste lot which is creating objectionable odor will be attended immediately and introduced in the composing system on priority basis.
- Controlled composting conditions will be maintained throughout the operation.
- Mandatory health and medical check-ups for all employees especially workers working at MRF as they may be exposed to general airborne dust above the level where it is considered a substance hazardous to health (10 mg/m³ as an 8-hr TWA). This should ideally be complimented by obtaining an Insurance Policy for Workmen's especially engaged in the daily activities of the landfill;
- Control of inhalation exposure to hazardous substances by the effective use of general ventilation within MRF and Local Exhaust Ventilation (LEV) the appropriate use of respiratory protective equipment (RPE); where solid waste will be processed (i.e. weigh bridge area). This will prevent the reproduction of flies, generation of obnoxious odors, scattering of plastic and papers, etc.

Figure 6-4: Corridor of Impact of AirBorne Impacts from Landfill Operation



6.4.6 Attraction of Vermin and disease vector generation

Impacts

491. The operation of the landfill may attract presence of pests such as rats, cockroaches, flies, ants and other pests in the immediate area along with various other vectors such as foxes, feral cats and dogs, birds and other animals. These pests can freely move around the area and may find their way to buildings and areas adjacent to the landfill. Since these pests are known to be carriers of diseases, they may trigger the sudden occurrence of illnesses and unacceptable conditions among people of weak resistance and children.
492. Each type of vector can live and multiply at a landfill and is potentially of concern to site operators, regulators, public health professionals and the general public. Fortunately, vectors are controllable and should rarely, and even then only intermittently, be present on a well controlled landfill.

Mitigation measures

493. The most important control measure used to minimise vector problems at landfills is the application of daily cover. Cover should be present on all solid waste at all times, except the tipping face while it is being worked. Daily cover of at least 150mm of compacted soil or similar material or an effective layer of alternate daily cover (ADC) should be applied on finished portions of the daily cell during operation and at the conclusion of daily operations, and not less frequently than once per day. Alternative daily cover materials such as tarpaulins, foams, granular waste, etc, can be effective as vector control after careful site-specific evaluation.
494. Intermediate cover of 300mm (minimum) compacted soil should be used on all areas not at finished levels, but not to be further landfilled for a period of 30 days or more.
495. Final cover is typically applied as each area is brought to finished level through the operational life of the landfill.
496. There should be no uncontrolled or uncovered (stockpiled) waste, including litter, tyres, brush, appliances, construction/demolition waste or even inert industrial waste on the landfill property. The only exception is compactable soil-like inert wastes, such as ash, but even this waste must be graded and compacted to avoid ponding water.
497. There should be no ponding water on the landfill property except as designed for runoff storage or sedimentation. Sedimentation ponds can, however, aid vector reproduction if not designed and controlled properly so as to minimise stagnant water, nutrient build-up and plant growth.
498. Finally, the waste must be compacted and graded at reasonable maximum slopes (see the Working Face Guideline) to minimise voids within the waste that can harbour rodents in particular. Rodents and foxes can readily dig into cover soil, but have much more difficulty digging into compacted solid waste.
499. On-site landfill site personnel must be trained and must monitor the levels of key vectors on a daily basis as part of daily management. A simple monthly site walk-over can provide a baseline of vector activity so changes can be noted and translated into action. Observations of various droppings, sightings, tracks, insect counts, etc are useful indicators of activity. Written reports from regular walk-over assessments should

be kept on file so changes that occur over time and in response to control measures can be assessed.

6.4.7 Occupational Health and Safety

Impacts

500. There are considerable risks associated with the operation of the proposed landfill site from an occupational health and safety perspective, keeping in view the scope of work to be conducted on a daily basis and the use of heavy machinery to be involved in the daily operations. Moreover, Organic dust which may lead to exposure to airborne microorganisms and their toxic by-products exposure cause work-related symptoms and effects among waste recycling workers in Materials Recovery Facilities (MRFs) are also a concern.

The equipment in a MRF is likely to expose employees to excessive noise levels. Unless suitable precautionary protocols in accordance with international good practices are put in place, there is a high risk of injury and accidents taking place at the landfill site during its day-to-day operations. Draft Occupational Health and Safety Plan has been attached as **Annexure E**.

Mitigation Measures

501. In order to ensure a safe and healthy working environment for the employees of the landfill and all its auxiliary facilities, the following measures have to be strictly enforced, implemented and monitored:

- OHS management system will be prepared and implemented prior to commencement of operation of the SWMF.
- Designation of an Environment, Health and Safety (EHS) officer dedicated to the site;
- All employees must be able to reach their work stations safely. All path, walkways, staircases, ladders and platforms must be stable and suitable for the tasks to be undertaken;
- Strict use of Personal Protective Equipment (PPE) by all personnel (e.g. inspectors at the Weigh Bridge, material handler and waste compactor operators) must be ensured.
- Mandatory health and medical check-ups for all employees, especially workers working at MRF as they may be exposed to general airborne dust above the level where it is considered a substance hazardous to health (10 mg/m³ as an 8-hr TWA). This should ideally be complimented by obtaining an Insurance Policy for Workmen especially engaged in the daily activities of the landfill;
- Develop a written program (i.e. health information, instruction and training) which sets forth procedures, equipment, personal protective equipment, and work practices that are capable of protecting employees from the health hazards of working in a landfill and its auxiliary facilities;
- Mandatory monitoring of air quality and noise levels in the working stations i.e. MRFs, compactors and brazier etc to maintain the same within local standards and whenever possible near ambient levels;

- Control of inhalation exposure to hazardous substances by the effective use of general ventilation within MRF and Local Exhaust Ventilation (LEV) the appropriate use of respiratory protective equipment (RPE);
- Accidental fires must be addressed immediately. Appropriate operational procedures involving the spreading and smothering of burning waste, rather than the use of water, must be implemented;
- Emergency plan (including fire management) must be developed and implemented;
- Availability of first-aid kits and vehicles that can be used to bring any injured employee to the nearest doctor in cases of accidents;
- Mandatory reporting of all accidents or incident of near misses of accidents and immediate adoption of corrective measures; and
- Management must provide all the necessary financial and manpower resources for the implementation and enforcement of all health and safety programs and activities of the project;
- Regular training and orientation on safety practices will be implemented to impart knowledge of safe and efficient working environment. Furthermore, regular health checkups of all employees including contract workers will be conducted. Effective and proper housekeeping is recommended to reduce dust exposures to its direct vicinity. Heat levels must be monitored as well. Spot checks should be done to ensure that workers' welfare is addressed especially during summer months.

6.4.8 Waste Collection and Hauling Impacts

Impacts

502. The operation of the proposed landfill will result in the movement of a higher volume of trucks and heavy vehicles in general, transporting solid waste between Mardan city and the proposed landfill site. The movement of these heavy vehicles could result in a higher risk of accidents along with the risk of increased congestion events taking place along the route of these vehicles, particularly during the times of peak traffic, such as during the morning and evening times of the day.
503. Increased traffic volume of waste carrying vehicles will result in increased noise levels and dust issues if such impacts are not managed properly. Waste hauling through mechanically unfit vehicles will result in increased noise levels in the project area. Waste transport without purpose built vehicles or waste transport on dirt roads will result in increased dust levels.
504. There is general practice by citizens to throw waste on streets instead of communal bins. WSSM workers needs to collect all scattered waste manually. There are multiple transactions of waste till disposal site resulting in poor waste management.
505. Communal storage constraints include shortage of containers, lack of financial resources leading to broken and ill maintained bins; Lack of planning for waste storage depots or temporary storage locations and Inaccessible areas and narrow lanes that do not allow sufficient space for container. If such constraints are not addressed it will result in poor waste management and environmental/public nuisance.

506. Currently WSSM is under capacity with respect to daily manual sweeping and waste collection on Sunday and public holiday resulting in poor waste collection and environmental nuisance.

507. There is lack of public/civic sense with respect to waste management at source, segregation of recyclables and waste collection system. Public don't practice responsible behavior and throw litter outside their premises in open streets, along roads, canals and other places which is resulting in operational constraints for WSSM towards solid waste management.

Mitigation measures

508. The following measures will be implemented to ensure that no traffic related issues take place due to the landfill operation:

- Capacity of WSSM will be increased through increase in its collection fleet. It will be done through procurement of both solid waste and non-solid waste carrying machinery under this project.
- Door to Door collection of waste will be enhanced through media campaigns. Communication programs would be developed to encourage better management of waste. Proper PPEs will be provided to waste handlers. Key performance indicators will be developed to monitor improvements in the system.
- All type of waste hauling will be carried out in purpose built vehicles to avoid scattering of waste at hauling routes. Drivers of waste carrying vehicles will be trained with respect to environmental sensitization. Drivers are allowed to commute only on designated routes through purpose built vehicles for waste hauling.
- Multiple transactions of waste will be avoided through use of main and mobile transfer stations. Improved segregation practices will be introduced once door to door collection desired efficiency achieved. Necessary legal bindings with respect to waste storage by Public will be introduced.
- A comprehensive traffic management plan (TMP) must be developed and implemented. Traffic management plan is provided as **Annexure K**.
- As part of the TMP, it will be ensured that the movement of heavy vehicles related to landfill operations is minimized during the peak traffic hours of the day in order to prevent congestion and accidents as far as possible;
- Furthermore, the movement of heavy vehicles within Mardan city related to landfill operations must be restricted to specific routes containing least number of sensitive receptors and low traffic volumes.
- Waste hauling through dirt tracks will be strictly prohibited. Waste hauling though mechanically unfit vehicles or noisy vehicles will not be allowed.
- Waste transporters will be directed to use designated routes and follow recommended speed limit for waste hauling and such routes will be metalled roads instead of dirt tracks.

6.4.9 Wind Blown Litter

Impacts

509. One of many operational concerns in the management of a landfill is the control and management of litter. Litter includes blowing papers and other solid materials that may become airborne and carried by the wind away from the working face where solid waste is being deposited.
510. The control of litter is an integral part of the daily operations of the facility. The goal of the facility operations is to implement best management practices and have all blowing litter contained at the working face. However, due to the type of facility operation and waste materials received, total containment of litter at the working face may be difficult to achieve. The secondary goal of the facility is to strive to pick up all blowing litter that has escaped the working face at the end of each operating day.

Mitigation measures

511. The facility operator, as necessary, will implement the following procedures and techniques to control litter:
- All trucks must be tarped upon entering and exiting the facility. They should only untarp and tarp at the active area. This policy will be strictly enforced.
 - Daily waste entering the landfill site will be subject to immediate compaction to minimize the area and debris subject to the impacts of wind.
 - If possible, on windy days, the daily fill face tipper locations shall be selected for its protection to minimize effects of wind.
 - Waste that is more susceptible to windblown distribution may, on windy days, be worked immediately into the fill face and covered with a layer of daily cover, as needed, or the waste may be excluded from the site.
 - Portable skid-mounted litter fences may be provided for deployment downwind as close as practical to the working area, as needed.
 - Semi-permanent fencing may be provided around the fill area as an additional barrier to the migration of litter off-site when litter has not been contained by the portable litter fences. (Examples of additional barriers include but not limited to, a four-foot minimum temporary construction fence and/or a ten-foot or higher semi-permanent fence.) The utilization will be continually evaluated and the fence will be relocated or added as needed.
 - Permanent fencing (ten-foot high with an additional three-foot kicker) may be constructed with possibility of placement on an eight-foot high berm.
 - On very windy days, when all other procedures are not successful in controlling blowing litter, the operator may apply cover material more frequently or immediately to the incoming waste load.
 - Buffer zones resulting from required facility setbacks along the site's perimeter should provide some protection of adjacent properties.

- As a final control measure, personnel will be dispatched, as needed or daily if conditions require, to collect any litter that has escaped the above control measures.
- Portable litter vacuums may be used to collect litter that has accumulated on litter fences. If fences are positioned properly, this can be a very efficient method of collecting litter.
- The main highway leading to the site will be routinely inspected for litter. If the highway has litter associated with the trucks entering the facility, then the litter will be picked up on a routine basis. All necessary safety precautions must be followed.
- Before and after photos of any litter removal effort may be taken in the event anyone questions the level of effort spent on litter collection.
- Site management's cell phone numbers may be provided to community/neighbors.
- The management of litter at the landfill is a daily activity. In most instances the above procedures and techniques should properly manage litter effectively. However, there will be occasions and situations when litter will be distributed by the wind in such a manner that the above procedures will not totally manage the litter and contain the litter on-site. In these situations, the facility operator may not be able to collect all litter within the day the litter problem occurred. However, the facility operator should proceed with collecting the litter off site and complete the retrieval of wind-blown litter at the earliest practicable time.

6.4.10 Impacts on Scavengers/Waste Pickers

Impacts

49. Most of the existing waste pickers are under age children. The waste is brought to the store by local waste pickers who work on small scale. They sell out the waste to the bigger scrap stores in the locality. Amount of income generated from waste collection is linked to the quantity of waste collected. Small waste pickers earn an amount of only PKR 300-500 daily and they collect recyclable waste upto 5-10 kg. Small scrap dealers who buy recyclable waste from waste pickers upto 25-30 kg usually earn PKR 6000-7000/day. Medium size scrap dealers with waste collection of 70-100 kg usually earn 10,000-15,000 on daily basis. After execution of ISWM project, scavenging business will be impacted, resulting in loss of income of small waste pickers.
50. Furthermore, existing scavenging practices are not formalized and/or regulated. Facilitation in the form of better streamlined movement of waste within this informal system is missing and is not well integrated within the ISWM system. There shall be some form of government formalization, management or oversight in order to better take care of the operation and all the operators involved, regardless of their position or significance in the system chain.

Mitigation measures

- WSSM will carry out assessment of scavenging business in their respective city to identify waste picker and scrap dealers which will be impacted.
- WSSM will provide resources and tools to efficiently collect and sort out the waste onsite, as these waste pickers are the first one to deal with the waste.
- WSSM will train these waste pickers to optimize their waste collection process.

- WSSM will hire waste pickers at MRF facility that will be established at landfill site.
- WSSM will hire services of scrap dealers for waste collection and transportation to landfill site on need basis.
- WSSM will prepare communication strategy and will run community based operation to integrated SWM operations including waste pickers and scrap dealers.
- PMU KPCIP will prepare guidelines to involve scavengers/waste pickers in IWMS through formalization and regulations of their business. These guidelines will be adopted by WSSM to encourage involvement of scavengers and waste pickers working at all levels regardless of their position in present system chain.

6.4.11 Improved management of solid waste & health and sanitation

Impacts

512. The landfill development will greatly improve solid waste management system in Mardan city and the project area and improve overall aesthetic value and quality of urban area of Mardan city.
513. Community development programs that may be undertaken, including health and hygiene education, reduction, reuse and recycling of solid waste, skill training of low-income people would be of great benefit to local community. The magnitude of the impact shall be high, local, long term and impact is very significant.

Mitigation measures

No measures required.

6.4.12 Improvements in Public Health

Impacts

514. The operation of the proposed landfill will result in solid waste management in integrated way resulting in fixing issues like odor, vector born diseases from open dumped waste, poor sanitation and ground water contamination in the area.
515. The operation of the proposed landfill will limit risk of vector spread, fire and explosion of dump site gas.
516. It will result in an overall positive impact on the public health by preventing issues such as infectious diseases, disease vector generation, groundwater aquifer contamination etc.
517. Successful operation of Mardan landfill site will limit the child scavenging activity who are directly at risk as they are not using any PPEs.
518. Further, it will provide promising opportunities to people involved in scavenging activity in terms of jobs and other economic incentives to accelerate recycling potential at the facility.

Mitigation measures

No measures required.

6.4.13 Improvements in Aesthetic Aspects

Impacts

519. Open dumping of solid waste creates poor aesthetics in the project area. However, landfill site shall be walled and the aesthetic impacts will be far less as compared to open dumping. However, due to the movement of the waste truck on the streets will create a little aesthetic nuisance.

Mitigation measures

- The boundary walls shall be constructed alongside the facility.
- The indigenous plants shall be planted alongside the access road and around the landfill site which will act as buffer zone.
- The waste transfer vehicles shall be covered.
- Reasonable area will be allocated for plantation within and at boundary of facility to improve aesthetic appeal of the area.
- Plantation will start as one of the earliest activities of site development. Once the design of landfill is approved and necessary funds mobilized, plantation activity can be started in collaboration with Mardan Development Authority or WSSM can outsource the activity separately.

6.5 Closure and Post Closure Impacts

Impacts

520. Even after closure, landfills required long-term care, including maintenance of the cap system, collection and treatment of leachate, collection and flaring or utilization of landfill gas, and monitoring of groundwater so that the waste remains isolated.
521. Impacts associated with closure and post closure phase of the SWMF include poor aesthetics of the area, runoff issues, leachate/odors issues, uncontrolled gases and long term environmental nuisance. There is need of routine inspection of the facility infrastructure particularly landfill cells and gas/leachate collection system to avoid and monitor any contamination released to environment. The need to manage leachate and gas continues after landfill closure, which should be an integral component of the total landfill management together with restoration and surveillance.
522. As moisture enters the landfill through an ineffectively maintained cover after the landfill has been closed, leachate will also again be generated. If the leachate collection and removal system is no longer functioning to collect and remove from the landfill all the leachate generated, and/or the landfill operator is no longer operating/maintaining the such system, the leachate will accumulate in the landfill, leading to increased potential for leachate to penetrate through the liner and potentially begin to pollute groundwaters.

Mitigation measures

- Appropriate selection of soil type for final cover will be ensured to prevent water infiltration and minimize infiltration of precipitation into the waste and the

subsequent generation of leachate; control landfill gas migration; and minimize long term maintenance needs.

- Appropriate selection of soil type for final cover will be ensured to prevent direct or indirect contact of living organisms with the waste materials and their constituents;
- Application of final cover components that are consistent with post closure use and local climatic conditions.
- Necessary environmental objectives and controls (including technical specifications) will be defined and implemented.
- Necessary surveillance protocols for final capping, lachate and gas monitoring will be established and implemented.
- Future Land use of the site will be defined in consultation with local communities and government agencies.
- It will be ensured that financial resources, and monitoring arrangements are in place for closure and post closure activities.
- PMU KP LGE&RDD will ensure that financial instruments are in place to cover the costs of closure and post-closure care and monitoring.
- Long term integrity and security of the site will be maintained.

6.6 Cumulative Impacts

523. Based on the scoping exercise of the site and based on discussions with the public sector agencies responsible for development in the project area, no other infrastructure works are planned to be conducted in the landfill project area while these project works shall be conducted. Thus, no cumulative impacts are expected.

6.7 Indirect and Induced Impacts

524. The potential impact of development of the landfill in the project area has been examined, which indicated that the existing and planned infrastructure such as water supply, wastewater collection and treatment, municipal solid waste collection and disposal would be adequate to accommodate any potential population intake as a result of the proposed landfill development. Impacts on the environment from air emissions, traffic and community noise have also been assessed and have found to be acceptable and within the carrying capacities of the environmental media.
525. Thus, negative indirect and induced impacts from the proposed landfill works are not expected.

7 Environmental Management Plan & Institutional Requirements

7.1 Introduction

526. The EIA has identified potential impacts that are likely to arise during development of Mardan SWMF in detail, both negative and positive impacts at each stage of the project. To minimize the effects of adverse impacts the EIA has recommended mitigation measures in the EMP. The proposed mitigation measures have been based on the understanding of the sensitivity and behaviour of environmental receptors in the project area, the legislative controls that apply to the project and a review of good industry practices for projects of similar nature. For residual impacts (impacts remaining after applying the recommended mitigation measures) and for impacts in which there can be a level of uncertainty in prediction at the EIA stage, monitoring measures have been recommended to ascertain these impacts during the course of the project activities.
527. The Environmental Management Plan (EMP) is developed to eliminate and/or mitigate the impacts envisaged at the design, construction and operation stages.
528. The detailed EMP provided in this document as **Table 7.1** ensures that development of Mardan SWMF has no detrimental effect on the surrounding environment. The Plan shall act as a guideline for incorporating environmental measures to be carried out by the contractors engaged for the proposed project. It shall also be used for other parties concerned for mitigating possible impacts associated with each project and will form part of the Contract documents to be considered alongside the specifications. This Plan shall act as the Environmental Management and Monitoring Plan during the construction and operation phase of the project and will allow for prompt implementation of effective corrective measures.

7.2 Environmental Management Plan (EMP)

529. The EMP attached with this report ensures the following:
- Delivery of the prescribed environmental outcomes during all phases of this sub-project;
 - Formulating a system for compliance with applicable legislative requirements and obligations and commitments for this sub-project;
 - Ensure that project design process incorporates best practice environmental design and sustainability principles to minimize potential impacts of construction on the environment and community.
 - Ensure that the construction work procedures minimize potential impacts on the environment and community.
 - Develop, implement and monitor measures that minimize pollution and optimize resource use.

7.3 Objectives of EMP

530. The EMP provides a delivery mechanism to address potential impacts of the project activities, to enhance project benefits and to outline standardized good practice to be adopted for all project works. The EMP has been prepared with the objectives of:
- Defining the roles and responsibilities of the project proponent for the implementation of EMP and identifying areas where these roles and responsibilities can be shared with other parties involved in the execution and monitoring of the project;
 - Outlining mitigation measures required for avoiding or minimizing potential negative impacts assessed by environmental study;
 - Developing a monitoring mechanism and identifying requisite monitoring parameters to confirm effectiveness of the mitigation measures recommended in the study;
 - Defining the requirements for communication, documentation, training, monitoring, management and implementation of the mitigation measures.

7.4 Environmental Management/Monitoring and Reporting

531. During the construction phase, the overall responsibility for the implementation and monitoring of the EMP rests with the Project Director (PD), Project Management Unit (PMU), KP LGE&RDD. The PD at the PMU, using the Construction Supervision Consultant (CSC), will supervise the implementation of the proposed mitigation measures and monitor the implementation progress in the field.
532. During the operation phase, the overall responsibility for the implementation and monitoring of the EMP rests with CEO WSSM. For initial two years of LFS operation, relevant Contractor will be responsible for running of relevant plant (e.g AD composting vendor, MRF Vendor, Lechate treatment plant vendor etc.) and also responsible for implementation of EMP. This requirement will be reflected in the bidding document of such Contractors/Suppliers. Furthermore, these Contractors will train designated staff of WSSM with respect to technical matters as well as EMP requirements.
533. The specific roles and responsibilities for environmental management and monitoring are provided in **Table 7.1** below. The expected costs for implementing any required mitigation measures are provided in **Table 7.7** below.

7.4.1 Inclusion of EMP in Contract documents

534. In order to make Contractors fully aware and responsible of the implications of the EMP and to ensure compliance, it is recommended that mitigation measures be treated separately in the tender documentation and that payment milestones should be linked to performance, measured by execution of the prescribed mitigation measures. Such a procedure would help ensure adequate management of project impacts is carried out during the construction and operation phases, where a consistent approach will be expected on behalf of the Contractor and its sub-contractors so that data and information collected from monitoring programs is comparable with baseline monitoring data.

535. The Contractor shall be made accountable through contract documents and/or other agreements for fulfilling the environmental safeguard obligations and delivering on the environmental safeguard components of the Project. Contractors shall be prepared to co-operate with the executing agency and supervising consultants and local population for the mitigation of adverse impacts. After the EMP's inclusion in the contract documents, the Contractor will be bound to implement the EMP and will engage appropriately trained environmental and social management staff to ensure the implementation and effectiveness of the mitigation measures.
536. The Contractor is required to bid for executing the EMP, including the recommended mitigation measures and monitoring programs, as part of its Bill of Quantities (BoQ).

7.5 Institutional Arrangements

537. The environmental management plan will require involvement of the following organizations for its implementation during construction and operation phases of the project:

7.5.1 Role of PMU, KP LGE & RDD

538. The PMU will:
 - Provide support to ADB missions;
 - Coordinate activities with all stakeholders, review consultants, proposals, and provide overall guidance during various stages of project preparation;
 - Manage and ensure safeguard due diligence and disclosure requirements including resettlement and environmental safeguards in accordance with ADB's Safeguard Policy Statement (2009) and KP government requirements;
 - Manage and ensure effective implementation of the gender action plan;
 - Ensure submission of all EIA requirements as per law by responsible entities; and
 - Monitoring of activities of the entire project.

7.5.2 Role of the ADB

539. The ADB will:
 - Support the coordination and administration of the project;
 - Provide guidance to PMU and WSSM on implementation issues and project design;
 - Disclose all safeguards documents, and monitor safeguards implementation;
 - Monitor and report project performance;
 - Conduct periodic review of the project;

7.5.3 Role of Construction Supervision Consultant (CSC)

540. The CSC will be responsible for the following items:
 - Incorporates into the project design the environmental protection and mitigation

measures identified in the EMP for the design stage;

- Assists PMU to ensure that all environmental requirements and mitigation measures from the EIA and EMP are incorporated in the bidding and contracts documents
- Prior to construction, reviews the updated SSEMPs prepared by the contractor.
- Undertakes environmental management capacity building activities for relevant project focal staff.

7.5.4 Role of KP EPA

541. The KP EPA will have the following responsibilities with regards to this SWMF project:

- Provides regulatory compliance works for the project.
- Reviews and approves environmental assessment report of SWMF, submitted by PMU.
- Issues environmental clearance certification for the Project based on their mandate and regulations.
- Undertakes monitoring of the project's environmental performance based on their mandate.

7.5.5 Role of Project Contractor

542. The project contractor will be responsible for following items:

- Implementation of, or adherence to, all provisions of the EIA and EMP;
- Preparation of site specific EMPs (SSEMPs) as required. SSEMPs will be prepared by Contractor's Environment Specialist, site incharge, HSE staff and project technical team before their mobilization and it will be submitted to Engineer of construction supervision consultant/PMU for review and approval. Site specific EMP template for project contractor guidance is provided as **Annexure I**.
- Contractor's environmental performance will rest with the person holding the highest management position within the contractor's organization. Reporting to their management, the contractor's site managers will be responsible for the effective implementation of the EMP.
- The Contractor will be required to have qualified Environmental Specialists in their team to ensure all mitigation measures are implemented during the different development phases of the project.

7.5.6 Role of WSSM

543. The WSSM will be responsible for following items:

- Implementation of, or adherence to, all provisions of the EIA and EMP
- Preparation of site specific EMPs for operations phase
- WSSM would be responsible to ensure that contractors engaged during operation phase of landfill site are executing activities in compliance to EIA/EMP.

- WSSM will be required to have qualified Environmental Specialist designated for LFS to ensure all mitigation measures are implemented in true letter and spirit.

7.5.7 Role of Third-Party Monitor

544. The Third-party monitor will be responsible for following items:
- Monitoring and reporting of all provisions of the EIA and EMP.
 - Periodic environmental monitoring during operation phase.
 - Reporting of environmental non-compliances to project stakeholders including ADB, PMU, WSSM and Supervision consultants.
 - Suggest corrective actions for close out of EMP non compliances.
 - Train the contractors and project stakeholder toward EMP implementation.
545. Independent environmental monitoring consultant will perform third party monitoring of construction of SWMF on quarterly basis. General TORs for third party monitoring are provided as **Annexure J** of this EIA report.

7.6 Monitoring Parameters

546. A monitoring plan for the construction phase of the project, indicating environmental parameters, frequency and applicable standards is provided below as **Table 7.3** below.
547. During the procurement/pre-construction period, the monitoring activities will focus on (i) checking the contractor's bidding documents, particularly to ensure that all necessary environmental requirements have been included; and (ii) checking that the contract documents' references to environmental mitigation measures requirements have been incorporated as part of contractor's assignment and making sure that any advance works are carried out in good time.
548. During the construction period, the monitoring activities will focus on ensuring that any required environmental mitigation measures are implemented to address possible impacts.
549. In general, the construction impacts will be manageable, and no insurmountable impacts are predicted, provided that the EMP is implemented to its full extent as required in the Contract documents. However, experience suggests that some Contractors may not be familiar with this approach or may be reluctant to carry out some measures. For the proposed project, in order that the Contractor is fully aware of the implications of the EMP and to ensure compliance, environmental measures must be costed separately in the tender documentation and listed as BoQ items, and that payment milestones must be linked to environmental performance, vis a vis the carrying out of the EMP.
550. The effective implementation of the EMP will be audited as part of the loan conditions by ADB, and as part of regulatory/NOC compliance by KP EPA. In this regard, the PMU/PMC will guide the design engineers and Contractors on the environmental aspects and necessary EMP documentation. Monitoring during operation phase will be carried out by WSSM throughwith support from PMU.

7.7 Environmental Training

7.7.1 Capacity Building and Training

551. Capacity building and training programs are necessary for the project staff in order to control the negative impacts resulting from the project construction and during its operation phase. They will also require trainings on monitoring and inspecting of such a project for environmental impacts and for implementation of mitigation measures.
552. The details of this capacity building and training program are presented in the **Table 7.7** below.

7.8 Environmental Staffing and Reporting Requirements

553. EMP implementation would be responsibility of all project stakeholders including PMU, WSSM, Project Construction contractors, O&M contractor and other suppliers involved in the project. Requirement of environmental staffing will be part of bidding documents and necessary cost will be allocated as BOQ item by the bidder.
554. PMU will maintain environmental safeguard staffing (Environmentalist/Environment Associate) for construction and operation phase of the project to monitor and supervise EMP implementation and performance. Environment expert will also be part of CSC technical time and will produce bi-weekly and monthly environmental compliance reports during construction phase.
555. Environment expert of CSC will be responsible to monitor the implementation of EMP during construction phase by project contractors. Project contractors will also hire sufficient environmental officers to implement the EMP requirements and prepare necessary EMP documentation. Project contractor EMP staff will prepare daily environmental reports and submit to CSC for approval and record.
556. WSSM will hire qualified environmental specialist during operation phase of the project who will be responsible for EMP implementation and reporting by WSSM and its O&M contractors during operation.
557. Monthly environmental compliance report will be prepared by WSSM and circulated to concerned authorities. Furthermore, third party environmental monitoring consultant will be hired on intermittent basis to monitor the EMP implementation and to report environmental non-compliances. Independent environmental monitoring consultant will perform third party monitoring of construction of SWMF on quarterly basis.
558. Semi-annual environmental monitoring reports (SAEMRs) will be prepared by the Project CSC and submitted to ADB for review, clearance and disclosure on the ADB website as part of the ADB SPS, 2009 guidelines on environmental due diligence for projects being financed by ADB.

Table 7.1: Environmental Management Plan

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
Design/Pre-Construction Phase	1.1	Improper designing of landfill site leading to various impacts (leachate leakage causing groundwater contamination, landfill gas leakage etc.)	<ul style="list-style-type: none"> ▪ Landfill has been designed in accordance with international standards and guidelines for landfill development, including but not limited to the IFC Guidelines on Waste Management Facilities for Landfills. ▪ Consideration shall be given to the stability of the sub-grade, the base liner system, the waste mass and the capping system. The sub-grade and the base liner will be sufficiently thick and stable as per international standards to prevent excessive settlement or slippage. ▪ Bottom and cap lining system for each landfill cell must be designed for the protection of soil, groundwater and surface runoff. ▪ An efficient leachate collection system must be provided to ensure leachate accumulation at the base of 	EDCM	PMU	BC: during detailed designing of the sub-project

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>the landfill and keep it to a minimum.</p> <ul style="list-style-type: none"> ▪ The accumulation and migration of gases from landfill facility must be controlled. Landfill gas will be collected through installation of perforated pipes within the cells. ▪ Consideration will be given to the visual appearance of the landfill site during operation and at termination of landfill site and its impact on the surrounding landforms. Necessary plantation will be carried out which will act as buffer zone from surrounding environment. Reasonable area has been allocated for plantation within and at boundary of facility to improve landscape of the area. ▪ Daily cover will be provided at end of each day to avoid risk of fire, wind littering, odor, vector breeding and dust hazards in the landfill. ▪ One groundwater monitoring well 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
1.2		Improper selection of landfill site due to non-compliance with IFC guidelines for Landfills	<p>will be maintained out of the drills made for geotechnical investigation. However, more wells may be constructed if required once the landfill starts operations.</p> <ul style="list-style-type: none"> ▪ To incorporate advancement in technology and changes, a periodic review of the design will be carried out, as the lifespan of a disposal site from commencement to completion is long compared to other construction projects. 			
			<ul style="list-style-type: none"> ▪ Site selection for the proposed landfill site must be conducted in accordance with international standards and guidelines for landfill development, including but not limited to the IFC Guidelines on Waste Management Facilities for Landfills. 	EDCM	PMU	BC: during detailed designing of the sub-project

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Factors such as site capacity, accessibility, acceptability, stability, environmental sensitivity, landuse, socio-economic receptros and climate hazards shall be assessed and evaluated at the time of site selection ▪ Proposed selection of landfill site must take into account impacts from leachate, litter, dust, vector and odors on surrounding environment. 			
	1.3	Lack of Integration of EIA/EMP requirements into bidding documents	<ul style="list-style-type: none"> ▪ The proposed ‘Safeguards unit’ that will be developed at the PMU will be assigned the task to check that design and bid documents are responsive to key environmental, social and safety considerations, and that the proposed method of work reflects the boundaries defined in the EMP. The bid documents must include the EMP and its implementation cost must be reflected in the BoQ. 	PMU	-	BC: during detailed designing of the sub-project

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ EIA/EMP implementation and monitoring requirements must be part of bidding documents and necessary contractual binding must be agreed by project contractors before award of contract. ▪ Project contractors shall have qualified and experienced environmental staff to plan, arrange, implement, monitor and report EIA/EMP requirements. 			
			The construction vehicles hauling materials along the Mardan city roads and anywhere where there are sensitive receptors such as hospitals, schools and/or roadside residences will be limited and the PMU in collaboration with the focal agencies will establish a route plan to minimize this disruption which shall be appended to the EMP.	EDCM	PMU	BC: during detailed designing of the sub-project
	1.5	Improper location of worker camps and	<ul style="list-style-type: none"> ▪ In order to prevent a nuisance, specific locations shall be 	EDCM	PMU	BC: during detailed designing of the

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
1.6		ancillary facilities	<p>designated for development of the labor camps. All necessary facilities and amenities shall be provided in these camps such as electricity, sufficient supply of water, solid and liquid effluent waste disposal facilities etc.</p> <ul style="list-style-type: none"> ▪ The use of proper planning while identifying locations for the labor camps will ensure there is minimal disturbance to all key receptors and the traffic is not disrupted by labor camps being set up roadside next to the construction sites. 			sub-project
						BC: during detailed designing of the sub-project

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>of cement dust, and use of Personal Safety Equipment. These procedures shall be developed and approved by the PMU in collaboration with the focal agencies before the Contractor commences any physical works on ground.</p> <ul style="list-style-type: none"> ▪ PMU KP LGE&RDD shall ensure the project contractors are selected on merit and necessary funds has been allocated in the contract documents for EMP implementation and monitoring. 			
	1.7	Land Acquisition and Resettlement	<p>The PMU KP LGE&RDD shall ensure the following:</p> <ul style="list-style-type: none"> ▪ Pending payment to all land owners must be paid before mobilization of construction contractors. ▪ Social safeguard unit shall ensure that project affected people has been paid following appropriate procedures and there are no grievances about land 	PMU		BC: during detailed designing of the sub-project

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>acquisition process.</p> <ul style="list-style-type: none"> ▪ Accelerating the pending resettlement process in collaborataiton with DC Mardan and WSSM. 			
1.8		Impacts due to Natural Hazards	<ul style="list-style-type: none"> ▪ Mardan SWMF infrastructure shall be designed keeping in view the seismic zone 2 B building considerations. ▪ Surface water diversion shall be included in the design to protect landfill from urban/flash flooding. ▪ Extreme precipitation events analysis shall be performed for landfill life i.e. 25 years to predict and manage impacts of flash flooding. ▪ On site waste storage at loading bay shall be kept to minimum during high precipitation events. ▪ Emergency response plan shall be prepared by construction and operation phase Contractors and will be submitted to PMU for approval to manage impacts of natural hazards 	EDCM	PMU	BC: during detailed designing of the sub-project

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			such as earth quakes and floods.			
Construction Phase	2.1	Construction of landfill not in accordance with finalized design	<ul style="list-style-type: none"> ▪ Method statements must be prepared by the Contractor and approved by the Construction Supervision Consultant (CSC) prior to commencement of construction works; ▪ The CSC must closely monitor the construction works being conducted by the Contractor to ensure the finalized design is implemented in full and the landfill design is developed completely in compliance of the approved finalized designs. ▪ Any deviation by the Contractor from following the finalized design must be immediately highlighted and corrective measures must be implemented to ensure full compliance with the finalized design of the landfill. ▪ PMU KP LGE&RDD shall ensure that construction activities are being carried out in compliance to project 	Contractors	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
Construction Phase (Continued...)			design following best international practices. It will closely review and monitor the activities of CSC and contractors involved in construction activities.			
	2.2	Degradation of air quality due to construction works	<ul style="list-style-type: none"> ▪ At the landfill site and the immediately adjoining areas, water will be sprinkled every three hours and at a higher frequency if felt necessary, at all construction sites to suppress dust emissions. ▪ All heavy equipment and machinery shall be fitted in full compliance with the national and local regulations. ▪ Stockpiled soil and sand shall be slightly wetted before loading, particularly in windy conditions. ▪ Fuel-efficient and well-maintained haulage trucks shall be employed to minimize exhaust emissions. ▪ Vehicles transporting soil, sand and other construction materials shall be 	Contractors	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
Construction Phase (Continued...)			<p>covered with tarpaulin.</p> <ul style="list-style-type: none"> ▪ Limitations to speeds of such vehicles as felt necessary. Transport through densely populated area shall be avoided. ▪ Concrete plants to be controlled in line with statutory requirements and shall not be close to sensitive receptors. ▪ Stack height of generators will be at least 3 meters above the ground. ▪ Project traffic will maintain maximum speed limit of 20 km/hr on all unsealed roads within project area. ▪ A minimum distance of 300 meters will be ensured between batching plant(s) and the nearest community. ▪ The need for large stockpiles shall be minimized by careful planning of the supply of materials from controlled sources. Stockpiles shall not be located within 50 m of schools, hospitals or other public amenities and 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>shall be covered with tarpaulin when not in use and at the end of the working day to enclose dust. If large stockpiles (>25m³) of crushed materials are necessary, they shall be enclosed with side barriers and also covered when not in use.</p> <ul style="list-style-type: none"> ▪ Dust emissions due to road travel shall be minimized through good construction practices (such as keeping stock piles down wind and away from communities) and sprinkling water over the access road. ▪ Maintaining levels of contaminant dusts, vapors and gases in the work environment at concentrations below those recommended as TWA-TLV's (threshold limit value)—concentrations to which most workers can be exposed repeatedly (8 hours/day, 40 hrs/week, week-after week), without sustaining adverse health effects. . ▪ Developing and implementing work 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>practices to minimize release of contaminants into the work environment including:</p> <ul style="list-style-type: none"> ○ Direct piping of liquid and gaseous materials ○ Minimized handling of dry powdered materials; Enclosed operations ○ Local exhaust ventilation at emission/release points ○ Vacuum transfer of dry material rather than mechanical or pneumatic conveyance ○ Indoor secure storage, and sealed containers rather than loose storage ▪ Where ambient air contains several materials that have similar effects on the same body organs (additive effects). <p>Vehicular & Equipment Emissions</p> <p>It shall be ensured that the following measures are taken to control emissions from vehicles being used in the construction activity:</p> <ul style="list-style-type: none"> ▪ Periodically check and conduct maintenance of the construction 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>machinery and haul vehicles.</p> <p>Generators, compressors and vehicles used during construction works will be maintained in a good condition to ensure that emissions are kept to a minimum level.</p> <ul style="list-style-type: none"> ▪ Regularly change the engine oil and use new engines/machinery/equipment having good efficiency and fuel burning characteristics. ▪ Controlled technology generator and batching plants will be used to avoid excessive emissions. ▪ Burning of wastes at any site will not be allowed. ▪ The stack height of generators will be at least 3 meters above the ground. ▪ Training of the technicians and operators of the construction machinery and drivers of the vehicles. ▪ All type of machinery and generator 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
2.3		Potential accidents and injuries to communities in project area during construction works	<p>must comply with the NEQS.</p> <p>Vehicles, which are not in compliance with NEQS are not allowed to use.</p> <ul style="list-style-type: none"> ▪ Idling of construction vehicle will be minimized to reduce air pollution. ▪ Periodic emission monitoring of vehicles, generator and batching plants is proposed. ▪ Project activities shall be planned to avoid harsh weather conditions. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>will be briefed on traffic safety, especially women who are the main care providers to children.</p> <ul style="list-style-type: none"> ▪ Speed limit of 20 km/hr will be maintained by all project related vehicles and nighttime driving of project vehicles will be limited where possible. ▪ Educate drivers on safe driving practices to minimize accidents and to prevent spill of hazardous substances and other construction materials during transport. ▪ Contractor must take proper safety measures (placing warning tapes around excavations) to avoid people, especially children, accidentally falling into excavations. ▪ All the working platforms must be cordon off with special care by well-trained skilled workers. ▪ Contractor will prepare construction 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>management plan which will include the hazard prevention and safety plan, which will address health and safety of the people in the project area.</p> <ul style="list-style-type: none"> ▪ PMU KP LGE&RDD shall ensure the contractor staff working in the the project are well trained and educated in the Health, Safety and Environment (HSE) hazards associated with their duties, and that of the public, in the project area. 			
2.4		Injuries to workers from lack of necessary training and/or not using PPEs etc.	<p>General</p> <p>The Contractor will be required to prepare and implement an effective OHS Plan that is supported by trained first aid personnel and emergency response facilities. Construction contracts will include standard OHS measures and contractors will be bound to implement these fully.</p> <p>Monitoring will be required to ensure that the OHS plan based on contract specifications is followed.</p> <ul style="list-style-type: none"> ▪ Cement feed hopper areas will be inspected daily to ensure compliance with the requirement of dust masks. 	Contractors	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Surfaces (including flooring and work surfaces) in camps, kitchens, dining areas and workshops shall be solid and easy to clean. Flooring for work camps must be float finished concrete or better. ▪ All drivers engaged by Contractors must hold a valid license for the vehicle they are operating. ▪ Work in confined space shall be executed with available safety standards. Adequate monitoring and equipment shall be available to detect deficient oxygen levels. ▪ The Contractor shall submit to the Engineer of CSC for approval an emergency evacuation plan and practice the procedure annually. ▪ The Contractor shall submit to the Engineer of CSC for approval a site layout plan, identifying work areas, accommodation, kitchen, dining area, 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>sanitary facilities, location of generators, plant and vehicle parking, transport routes through the camp, pedestrian routes through the camp, evacuation routes, emergency exits, batching plants, storage areas, waste facilities etc.</p> <ul style="list-style-type: none"> ▪ Fire extinguishers shall be provided throughout camps and work sites. Fire extinguishers shall be inspected monthly and maintained as necessary. ▪ An adequate and reliable supply of safe drinking water shall be made available at readily accessible and suitable places including at all camps. ▪ The Contractor shall take samples from each supply of drinking water and arrange for analysis of these samples at EPA certified laboratory prior to its use by the Contractor's staff. The results of these tests for each supply must be submitted to the 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>Engineer of CSC and must demonstrate that each water supply meets national and World Health Organisation standards for drinking water.</p> <ul style="list-style-type: none"> ▪ The Contractor shall provide and maintain adequate hygienic kitchens which are sheltered and separated from the living quarters. Kitchens shall include raised and washable surfaces suitable for food preparation. ▪ The Contractor shall provide and maintain adequate hygienic dining areas for staff. Work places and camps shall be provided with both natural& artificial light. Artificial lighting shall be powered by generator in the event of power cuts. ▪ Public sensitization training shall be provided to workers to avoid social conflicts between residents and the construction contractor, Occurrence of any such impacts can be avoided by 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>community sensitive project planning and implementation and through effective involvement of local administration.</p> <ul style="list-style-type: none"> ▪ All HSE protocols shall be implemented in true letter and spirit. ▪ Contractor must appoint an HSE resource to implement, monitor and report the HSE management plan to concerned authorities. ▪ Contractor must ensure the provision of first aid facility at construction site and camps through hiring medics and establishing a dispensary at the campsite. ▪ Reasonable number of first aid kits shall be available on construction sites and within contractor camps. <p>Based on the type of hazard applicable during the proposed works at site, the following mitigation measures as per IFC guidelines for</p>			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>Occupational Health and Safety (OH&S) must be implemented:²¹</p> <p><u>Mitigation Measures for Physical Hazards</u></p> <p><i>Rotating and Moving Equipment</i></p> <ul style="list-style-type: none"> ▪ Designing machines to eliminate trap hazards and ensuring that extremities are kept out of harm's way under normal operating conditions. ▪ Where a machine or equipment has an exposed moving part or exposed pinch point that may endanger the safety of any worker, the machine or equipment shall be equipped with, and protected by, a guard or other device that prevents access to the moving part or pinch point. Guards shall be designed and installed in conformance with appropriate machine safety standards. ▪ Turning off, disconnecting, isolating, 			

²¹ <https://www.ifc.org/wps/wcm/connect/1d19c1ab-3ef8-42d4-bd6b-cb79648af3fe/2%2BOccupational%2BHealth%2Band%2BSafety.pdf?MOD=AJPERES&CVID=ls62x8l>

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>and de-energizing (Locked Out and Tagged Out) machinery with exposed or guarded moving parts, or in which energy can be stored (e.g. compressed air, electrical components) during servicing or maintenance.</p> <ul style="list-style-type: none"> ▪ Designing and installing equipment, where feasible, to enable routine service, such as lubrication, without removal of the guarding devices or mechanisms. <p>Vibration</p> <p>Exposure to hand-arm vibration from equipment such as hand and power tools, or whole-body vibrations from surfaces on which the worker stands or sits, shall be controlled through choice of equipment, installation of vibration dampening pads or devices, and limiting the duration of exposure. Limits for vibration and action values. Exposure levels shall be checked on the basis of daily exposure time and data provided by equipment manufacturers.</p> <p>Electrical</p>			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Marking all energized electrical devices and lines with warning signs; ▪ Locking out (de-charging and leaving open with a controlled locking device) and tagging-out (warning sign placed on the lock) devices during service or maintenance; ▪ Checking all electrical cords, cables, and hand power tools for frayed or exposed cords and following manufacturer recommendations for maximum permitted operating voltage of the portable hand tools; · ▪ Double insulating / grounding all electrical equipment used in environments that are, or may become, wet; using equipment with ground fault interrupter (GFI) protected circuits; · ▪ Protecting power cords and extension cords against damage from traffic by shielding or suspending above traffic areas; · 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Conducting detailed examination and marking of all buried electrical wiring prior to any excavation work. ▪ Appropriate labeling of service rooms housing high voltage equipment ('electrical hazard') and where entry is controlled or prohibited; <p><i>Eye Hazards</i></p> <ul style="list-style-type: none"> ▪ Use of machine guards or splash shields and/or face and eye protection devices, such as safety glasses with side shields, goggles, and/or a full-face shield. Specific Safe Operating Procedures (SOPs) may be required for use of sanding and grinding tools and/or when working around liquid chemicals. Frequent checks of these types of equipment prior to use to ensure mechanical integrity is also good practice. Machine and equipment guarding shall conform to standards published by organizations such as CSA, ANSI 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>and ISO.</p> <p><i>Welding/Hot Work</i></p> <ul style="list-style-type: none"> ▪ Provision of proper eye protection such as welder goggles and/or a full-face eye shield for all personnel involved in, or assisting, welding operations. Additional methods may include the use of welding barrier screens around the specific work station (a solid piece of light metal, canvas, or plywood designed to block welding light from others). Devices to extract and remove noxious fumes at the source may also be required. . ▪ Special hot work and fire prevention precautions and Standard Operating Procedures (SOPs) shall be implemented if welding or hot cutting is undertaken outside established welding work stations, including 'Hot Work Permits, stand-by fire extinguishers, stand-by fire watch, and maintaining the fire 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>watch for up to one hour after welding or hot cutting has terminated. Special procedures are required for hot work on tanks or vessels that have contained flammable materials.</p> <p><i>Industrial Vehicle Driving and Site Traffic</i></p> <ul style="list-style-type: none"> ▪ Training and licensing industrial vehicle operators in the safe operation of specialized vehicles such as forklifts, including safe loading/unloading, load limits. . ▪ Ensuring drivers undergo medical surveillance. . ▪ Ensuring moving equipment with restricted rear visibility is outfitted with audible back-up alarms. . ▪ Establishing rights-of-way, site speed limits, vehicle inspection requirements, operating rules and procedures (e.g. prohibiting operation of forklifts with forks in down position), 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>and control of traffic patterns or direction.</p> <ul style="list-style-type: none"> ▪ Restricting the circulation of delivery and private vehicles to defined routes and areas, giving preference to 'one-way' circulation, where appropriate. <p><i>Ergonomics, Repetitive Motion, Manual Handling</i></p> <ul style="list-style-type: none"> ▪ Facility and workstation design with 5th to 95th percentile operational and maintenance workers in mind. ▪ Use of mechanical assists to eliminate or reduce exertions required to lift materials, hold tools and work objects, and requiring multi-person lifts if weights exceed thresholds. ▪ Selecting and designing tools that reduce force requirements and holding times and improve postures. ▪ Providing user adjustable workstations. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Incorporating rest and stretch breaks into work processes and conducting job rotation. . ▪ Implementing quality control and maintenance programs that reduce unnecessary forces and exertions. . ▪ Taking into consideration additional special conditions such as left-handed persons. <p><i>Working at Heights</i></p> <ul style="list-style-type: none"> ▪ Installation of guardrails with mid-rails and toe boards at the edge of any fall hazard area. . ▪ Proper use of ladders and scaffolds by trained employees. . ▪ Use of fall prevention devices, including safety belt and lanyard travel limiting devices to prevent access to fall hazard area, or fall protection devices such as full body harnesses used in conjunction with shock absorbing lanyards or self-retracting 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>inertial fall arrest devices attached to fixed anchor point or horizontal life-lines. .</p> <ul style="list-style-type: none"> ▪ Appropriate training in use, serviceability, and integrity of the necessary PPE. . ▪ Inclusion of rescue and/or recovery plans, and equipment to respond to workers after an arrested fall. <p><i>Fire and Explosions</i></p> <ul style="list-style-type: none"> ▪ Storing flammables away from ignition sources and oxidizing materials. Further, flammables storage area shall be: <ul style="list-style-type: none"> ▪ Remote from entry and exit points into camps ▪ Away from facility ventilation intakes or vents ▪ Have natural or passive floor and ceiling level ventilation and explosion venting ▪ Use spark-proof fixtures 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Be equipped with fire extinguishing devices and self closing doors, and constructed of materials made to withstand flame impingement for a moderate period of time. ▪ Defining and labeling fire hazards areas to warn of special rules (e.g. prohibition in use of smoking materials, cellular phones, or other potential spark generating equipment). ▪ Providing specific worker training in handling of flammable materials, and in fire prevention or suppression. <p><i>Corrosive, oxidizing, and reactive chemicals</i></p> <ul style="list-style-type: none"> ▪ Corrosive, oxidizing and reactive chemicals shall be segregated from flammable materials and from other chemicals of incompatible class (acids vs. bases, oxidizers vs. reducers, water sensitive vs. water based, etc.), stored in ventilated areas and in 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>containers with appropriate secondary containment to minimize intermixing during spills. .</p> <ul style="list-style-type: none"> ▪ Workers who are required to handle corrosive, oxidizing, or reactive chemicals shall be provided with specialized training and provided with, and wear, appropriate PPE (gloves, apron, splash suits, face shield or goggles, etc). . ▪ Where corrosive, oxidizing, or reactive chemicals are used, handled, or stored, qualified first-aid shall be ensured at all times. Appropriately equipped first-aid stations shall be easily accessible throughout the place of work, and eye-wash stations and/or emergency showers shall be provided close to all workstations where the recommended first-aid response is immediate flushing with water. <p>Mitigations for Biological Hazards</p> <ul style="list-style-type: none"> ▪ The Contractor shall review and assess known and suspected 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>presence of biological agents at the place of work and implement appropriate safety measures, monitoring, training, and training verification programs.</p> <ul style="list-style-type: none"> ▪ Project contractor must provide good working and sanitation conditions at camp and wok sites. Disease surveillance shall be carried out to identify any exposure to parasites, such as hookworm, ascaris, and various mites, chiggers, ticks and dengue. ▪ Measures to eliminate and control hazards from known and suspected biological agents at the place of work shall be designed, implemented and maintained in close co-operation with the local health authorities and according to recognized international standards. 			
	2.5	High noise levels from construction activities	<ul style="list-style-type: none"> ▪ Equipment noise will be reduced at source by proper design, 	Contractors	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>maintenance and repair of construction machinery and equipment. Noise from vehicles and power generators will be minimized by use of proper silencers and mufflers.</p> <ul style="list-style-type: none"> ▪ Excessive noise emitting equipment will not be allowed to operate and will be replaced. ▪ Blowing of horns will be prohibited on access roads to work sites. ▪ As a rule, the operation of heavy equipment shall be conducted in daylight hours. ▪ Construction equipment, which generates excessive noise, shall be enclosed or fitted with effective silencing apparatus to minimize noise. ▪ Well-maintained haulage trucks will be used with speed controls. ▪ Use of ear plug and ear muffs must be ensured during construction. No employee shall be exposed to a noise 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>level greater than 85 dB(A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear shall be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C).</p> <ul style="list-style-type: none"> ▪ Prior to the issuance of hearing protective devices as the final control mechanism, use of acoustic insulating materials, isolation of the noise source, and other engineering controls shall be investigated and implemented, where feasible. ▪ Periodic medical hearing checks shall be performed on workers exposed to high noise levels. ▪ All the equipment and machinery used during construction phase shall be well maintained and in compliance with NEQS. 			
	2.6	Improper handling	<ul style="list-style-type: none"> ▪ A waste management plan will be 	Contractors	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
		and/or disposal of hazardous and non-hazardous waste	<p>developed prior to the start of construction. This plan will cater to sorting of hazardous and non-hazardous materials prior to disposal, placing of waste bins at the project sites for waste disposal and an onsite hazardous waste storage facility i.e. designated area with secondary containment.</p> <ul style="list-style-type: none"> ▪ Licensed waste contractors will be engaged to dispose off all non-hazardous waste material that cannot be recycled or reused. ▪ Excavated material from landfill cells will be stored at site and it will be used as daily cover within landfill cells. ▪ All types of combustible and non-combustible waste including plastic or glass bottles and cans will be temporarily stored on site and later sold/handed over to a waste/recycling contractor who will utilize these wastes for recycling purposes. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Waste management training for all site staff to be included in Contractor's training plan. ▪ Fuel storage areas and generators will have secondary containment in the form of concrete or brick masonry bunds. The volume of the containment area shall be equal to 120% of the total volume of fuel stored. ▪ Fuel and hazardous material storage points must be included in camp layout plan to be submitted for approval. Hazardous material storage areas shall include a concrete floor to prevent soil contamination in case of leaks or spills. Fuel tanks will be checked daily for leaks and all such leaks will be plugged immediately. ▪ Designated vehicles/plant wash down and refuelling points must be included in camp layout plan to be submitted for approval. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Hazardous waste will be initially stored on site at designated area and then handed over to EPA certified contractor to final disposal. ▪ Record of waste generation and transfer shall be maintained by project contractors. ▪ Spill kits, including sand buckets (or other absorbent material) and shovels must be provided at each designated location. ▪ At the time of restoration, septic tanks will be dismantled and backfilled with at least 1m of soil cover keeping in view landscape of surrounding natural surface. ▪ It will be ensured that after restoration activities, the campsite is clean and that no refuse has been left behind. ▪ Clinical wastes will be temporarily stored onsite separately and will be handed over to approve waste 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>contractor for final disposal.</p> <ul style="list-style-type: none"> ▪ Training will be provided to personnel for identification, segregation and management of waste. 			
2.7		Untreated disposal of effluent from worker camps and batching plant(s) and construction sites	<ul style="list-style-type: none"> ▪ It will be ensured that no untreated effluent is released to the environment. ▪ A closed sewage treatment system including soak pits and septic tank will be constructed to treat the effluent from the construction/labor camps. ▪ Sewage treatment system will be installed at each respective labor camp based on the number of laborers residing at the respective camp. ▪ Wastewater from laundry, kitchen washings and showers will be disposed-off into soak pits or septic tank (where soak pit cannot be constructed) and after treatment it will disposed of in TMA provided drains in 	Contractors	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>the project area.</p> <ul style="list-style-type: none"> ▪ Soak pits will be built in absorbent soil and shall be located 300 m away from a water well, hand pump or surface water body. Soak pits in non-absorbent soil will not be constructed. ▪ Ensure that the soak pits remain covered all the time and measures are taken to prevent entry of rainwater into them. ▪ Sprinkling of grey water or sewage will not be allowed; in case the septic tank gets filled with sludge, septic tank shall be emptied through vacuum truck and material shall be transferred to treatment facility or approved municipal drain. ▪ Water being released from any batching plant(s) must be treated as per requirements of NEQS prior to release to sewerage system/any other water body. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Sewage at the end of construction period to be disposed of in nearest municipal drains after getting approval from concerned municipal authorities. 			
2.8		Soil Erosion and Sedimentation	<p>Any drainage structures, culverts or pipes crossing the project site may need to be modified or protected and the detailed designs must make provisions to protect or re-provision all infrastructure that may be affected by the construction works.</p>	Contractors	CSC, PMU	DC
2.9		Soil Contamination	<ul style="list-style-type: none"> ▪ It will be ensured that spill prevention trays are provided and used during refueling. Also, on-site maintenance of construction vehicles and equipment will be avoided as far as possible. In case on-site maintenance is unavoidable, tarpaulin or other impermeable material will be spread on the ground to prevent contamination of soil. ▪ Regular inspections will be carried out to detect leakages in construction 	Contractors	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>vehicles and equipment and all vehicles will be washed in external commercial facilities.</p> <ul style="list-style-type: none"> ▪ Fuels, lubricants and chemicals will be stored in covered bounded areas, underlain with impervious lining. Appropriate arrangements, including shovels, plastic bags and absorbent materials will be available near fuel and oil storage areas. 			
2.10		Employment Conflicts	<ul style="list-style-type: none"> ▪ The Construction Contractor will adopt a transparent hiring policy. Prior to the commencement of the construction activity, the local communities in the project area will be informed of the employment policy in place and number of people that can be employed for this project. ▪ It will be ensured that maximum number of unskilled and semi-skilled jobs will be provided to the residents of the project area. ▪ The PMU will ensure a balanced 	Contractors	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			process of employment of the communities in the project area with preference given to those most directly affected by the project.			
2.11		Communicable diseases incl. COVID-19	<p>A communicable diseases prevention program will be prepared for construction workers or residents near the construction sites.</p> <p><u>COVID-19 specific measures</u></p> <ul style="list-style-type: none"> ▪ All workers must perform complete sanitization at the site as per SOPs/guidelines issued by WHO. ▪ All workers must wear a mask and gloves as soon as they arrive at site and must keep wearing it at all times while present at the work site/hospital premises. ▪ As soon as workers arrive at work site, their body temperature must be checked and in case any worker is assessed to be running a fever or suffering from a flu or cough, he must be informed to leave immediately and 	Contractors	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>self-isolate for a two week period and not report for work until this two week mandatory period has been completed.</p> <ul style="list-style-type: none"> ▪ At the work site(s), social distancing measures must be strictly implemented and gathering of workers at any location at the work site(s) must be strictly forbidden. In case of workers not taking this measure seriously, strict penalties must be imposed to ensure implementation. ▪ The work tasks must be divided into shifts, as far as possible, to reduce the workforce present at the work site(s) at any one moment and improve the working speed/efficiency. ▪ All workers will be strictly advised to wash their hands as frequently as practicable and not to touch their face during work. ▪ A supply of safe drinking water will be 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>made available and maintained at the project site(s).</p> <ul style="list-style-type: none"> ▪ Chlorinated disinfecting spraying must be conducted at the work site(s) ▪ COVID awareness sign boards must be installed at the hospital premises and at the work site(s). ▪ Contact details of all workers will be kept in a register on site in order to efficiently trace and manage any possible workers that might experience symptoms of COVID-19. ▪ Prohibition of entry for local community/any unauthorized persons at work sites. ▪ Proper hygiene practices in the toilets and washrooms will be implemented with proper and adequate use of soaps and disinfectant spray. ▪ Social distancing must be maintained during the pick-up and dropping off of workers from their residences to and 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
2.12		Vegetation and Wildlife Loss	<p>from the work site(s).</p> <ul style="list-style-type: none"> ▪ GoP and GoKPK guidelines issued for Health & Safety of Building and Construction Workers during COVID-19 outbreak shall be implemented. ▪ Any future issue or revisions in existing COVID-19 guidelines by GOP and GoKPK shall be adopted and implemented. 			
			<ul style="list-style-type: none"> ▪ Necessary plantation will be carried out, which will act as buffer zone from surrounding environment. Reasonable area has been allocated for plantation within and at boundary of facility to improve landscape of the area. ▪ Indigenous tree plantation will be carried out, which will serve as the buffer zone. Green belt provided in project key plan. For the landfill, to present a clean and aesthetically pleasing view, buffer zone with tree plantation and landscaped berms will be done. Plantation will start as one of 	Contractors	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>the earliest activities of site development. Once the design of landfill is approved and necessary funds mobilized, plantation activity can be started in collaboration with WSSM can outsource the activity separately.</p> <ul style="list-style-type: none"> ▪ Camp/s will be located in existing clearings; as much as possible. ▪ Off-road travel will be strictly prohibited and observance of this will be monitored during execution of the project ▪ Vehicles speed will be regulated and monitored to avoid excessive dust emissions. ▪ No hunting or killing of animals will be permitted. ▪ No cutting down of vegetation or using vegetation or trees as firewood will be permitted. 			
	2.13	Historical/Archaeological Sites	If evidence of any archaeological remains is found during the construction activities, the excavation work will be stopped immediately and	Contractor	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			necessary next steps taken to identify the archaeological discovery based on the 'Chance Find' procedures.			
2.14		Construction of Administration Building and Other Infrastructure	<ul style="list-style-type: none"> ▪ Water will be sprinkled regularly to suppress dust emissions. Off road travelling of vehicles will be prohibited. ▪ Stock piles will be appropriately located and out of wind to avoid dust emissions. Dry dusty materials shall be sprinkled with water and properly covered to avoid dust emissions. ▪ No cement and concrete waste will be left unattended. Construction debris will not be thrown from height to avoid dust emissions. Return unpaved areas to original or improved contours following construction. ▪ Solid waste generated during construction of admin building will be managed through SEMMP. 	Contractor	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Set protocols for proper and regular maintenance of construction machinery, vehicles and generators. Generators that will be used will be placed at suitable locations. ▪ Contractor will not be allowed to store bulk quantities of fuel or hazardous material at site. ▪ Any fuel or chemicals stored at site (in small quantities) will be stored at designated site and containers/storage vessels be properly marked for their contents. Storage area will be provided with hard impervious surface and secondary containment. ▪ Equipment and machinery with loose vibratory parts will not be allowed to use. Used equipment and machinery will be in compliance to NEQS. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Waste bins will be provided at appropriate places to manage waste. ▪ Daily housekeeping of the construction area will be carried out. ▪ CSC will ensure that proper amounts of insulation in the walls and roof will be used. ▪ Proper weather stripping and caulking will be carried out to ensure energy efficiency. ▪ High quality windows that utilize low-e coatings and gas filling will be installed. ▪ CSC will ensure that energy efficient appliances such as LED lights, energy savers, inverters) are installed in the buildings. 			
	2.15	Sexual Abuse, Exploitation and Harrasement (SEAH)	<ul style="list-style-type: none"> ▪ The contractor's COC shall cover a program to promote awareness of the construction workers on avoiding any gender-based violence; ▪ The contractor's monthly training program will cover topics related to COC such as sexual harassment particularly towards women and children, violence, including sexual and/or gender-based violence; ▪ Measures to protect the privacy of women and girls by the contractor, 	Contractor	CSC, PMU	DC

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> sub-contractors and service providers; ▪ The contractor will make sure that no discrimination is made on the basis of gender while hiring of workers; ▪ The contractor will set the employment relationship on the code of equal opportunity and fair treatment and develop COC for workers to address these issues; ▪ The employment decisions will not be made on the basis of personal characteristics unrelated to inherent job requirements, including race, gender, nationality, religion or belief, disability, age, sexual orientation, or ethnic, social and indigenous origin; ▪ Special measures will be taken to address harassment, intimidation, and/or exploitation, especially in relation to women; ▪ No Sexual Harassment Policy will be established and strictly endorsed in accordance with provincial law; ▪ World Bank Good Practice Note on Addressing GBV will be used as guidance. 			
Operation Phase	3.1	Generation of Leachate	<ul style="list-style-type: none"> ▪ Operate the landfill in accordance with applicable internationally recognized standards to minimize 	O&M Contractor/WSSM	WSSM, PMU	DO

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>leachate generation, including the use of low-permeability landfill liners to prevent migration of leachate as well as landfill gas, a leachate drainage and collection system, and landfill cover (daily, intermediate, and final) to minimize infiltration;</p> <ul style="list-style-type: none"> ▪ A leachate holding tank of 500 m³ will collect the leachate before it enters the treatment plant. Leachate treatment will be based on DTRO, which is potable arrangement for treatment of leachate and can be operationalized during monsoons for 24/7 basis. During monsoons, recirculation of leachate will be increased to avoid operational constraints of leachate collection, storage and treatment system at landfill site. ▪ Minimize the daily exposed working face and use perimeter drains and 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>landfill cell compaction, slopes and daily cover materials to reduce infiltration of rainfall into the deposited waste;</p> <ul style="list-style-type: none"> ▪ Leachate collection will be augmented by a leachate recirculation system in the landfill design. ▪ The operators of the landfill must ensure that an effective and efficient leachate control and monitoring system is maintained. This may be complimented by establishment of groundwater monitoring wells and regularly collecting samples for laboratory analysis. Results of the analysis could aid the operators to determine the final fate of the collected leachate and/detect any potential leakages. Final decision rests with the landfill operator on the final number of wells as well as the frequency of sampling for 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>groundwater quality.</p> <ul style="list-style-type: none"> ▪ The final vegetative cover plays an integral part in leachate production control. Its basic functions are to limit infiltration by intercepting precipitation directly, thereby improving evaporation from the surface, and to reduce percolation through the cover material by taking up soil moisture and transpiring it back to the atmosphere. Preferred plant species shall be of those that do not have deep roots in order to protect the surface sealing. Further, these species shall require minimal maintenance and human intervention. ▪ Landfill operators must be properly and adequately trained to operate and maintain the installed control system. ▪ A procedure for the rapid repair of leaks in the pipes, pumps and other 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>equipment must be part of landfill operations.</p> <ul style="list-style-type: none"> ▪ An inventory of spare parts and repair equipment must be continuously in place to ensure immediate remedial action against breakdowns. ▪ Strict quality assurance and construction guidelines during the installation of the HDPE liner shall be strictly implemented. ▪ In worst case, if leachate contamination is detected during ground water monitoring after few years of landfill operation, Ground water modelling to determine possible contamination of leachate will be carried out and necessary design changes will be done. ▪ Detailed ground water quality baseline will be developed during operation phase of the project to trace any ground water 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			contamination from landfill operations.			
3.2	Possible Contamination of Soil and Groundwater		<ul style="list-style-type: none"> ▪ Appropriate liner and collection systems in compliance with international guidelines/criteria are part of the design and will be installed. ▪ An efficient leachate collection and treatment system has been provided to ensure leachate accumulation at the base of the landfill and keep it to a minimum. ▪ The leachate system will consist of a leachate collection layer of either natural granular (sand, gravel) or synthetic drainage material (e.g. geonet or geo-composite) with pipe network to convey the leachate to treatment facility. ▪ A total of 600 mm clay liner of permeability of 1×10^{-6} cm/sec will be compacted at the bottom in series of 150mm layers each 	O&M Contractor/WSSM	WSSM, PMU	DO

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>compacted to 95% of compaction. This layer will be topped by 1.5 mm HDPE geomembrane.</p> <ul style="list-style-type: none"> ▪ As soon as HDPE is placed, 200 mm silty sand or geotextile will be covered on top of HDPE for the protection of the HDPE on the side slopes. ▪ Above this 300 mm PEA gravel layer will be placed followed by 150 mm compacted (85-90%) sand layer. ▪ Leachate collection pond shall be in opposite direction from nearest surface water body. ▪ A leachate treatment facility with a design capacity of 50 m³ /d will be constructed. Leachate treatment is designed on activated sludge treatment with advance level treatments (Disc Tube Reverse Osmosis-DTRO) for heavy metals and other pollutants potentially 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>present in leachate.</p> <ul style="list-style-type: none"> ▪ Slope of the landfill site shall be away from nearest surface water body. ▪ Cut-off drains around active landfill site and peripheral drains around landfill site shall be provided ▪ Detailed analysis of leachate leakage detection on ground water quality will be carried out and necessary design changes/improvements will be done. ▪ Ground water monitoring wells shall be dug keeping in view of the flow of ground water on both upstream and downstream of the disposal site and monitor the ground water quality of the upper strata for any contamination for disposal site every month. ▪ Waste hauling vehicles shall be 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>covered during transport of waste to landfill site</p> <ul style="list-style-type: none"> ▪ Hauling vehicles shall not wash at the surface water bodies along the route as the wash water shall drain into the canal and will pollute the surface water source which is used by the animals of the nearby communities and for agriculture purpose. ▪ Domestic sewerage of Mardan facility shall not be discharged untreated in open area and drains, ▪ Waste water generated from vehicle wash area shall be contained and treated before final discharge ▪ In order to augment this system, regular quality control checks on the equipment /accessories will be implemented and incorporated during construction and operations. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
	3.3	Impact on Surface Water Resources – Canal passing along Southern Boundary of Landfill Site	<ul style="list-style-type: none"> ▪ Labor and construction camps will be located away from the irrigation channel. ▪ Water from the irrigation channel will not be used for the landfill operations. ▪ Sewerage from labor/construction camps will not be discharged in the irrigation channel. ▪ Access road running along the channel will be properly paved and maintained to reduce the dust emission on surface water quality of the channel. ▪ Speed limit will be followed to avoid dust and litter impacts on channel during construction phase. ▪ Septic tanks and soak pits will be developed away from the channel to avoid any contamination. ▪ No solid waste or construction waste will be dumped into the 	O&M Contractor/WSSM	WSSM, PMU	DO

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>irrigation channels.</p> <ul style="list-style-type: none"> ▪ During project works, no damage to irrigation channel structures will be done. ▪ Construction contractors are not allowed to use water of channel for vehicle/equipment washing purpose. ▪ Waste carrying vehicles during operation phase are not allowed to be parked along the banks of channel. ▪ WSSC Mardan will ensure that no windblown litter is entering the irrigation channel. ▪ Weekly inspection of irrigation channel will be carried out by WSSC Mardan to ensure that surface water quality is not impacted by wind blow litter or waste hauling litter. 			
	3.4	Generation of Landfill Gas	<ul style="list-style-type: none"> ▪ Landfill gas capture and flaring 	O&M Contractor/WSSM	WSSM, PMU	DO

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>systems will be in place as part of the landfill design and thus no significant impacts on occupational or community health and safety are envisaged from landfill gas exposure.</p> <ul style="list-style-type: none"> ▪ Landfill gas will be collected through installation of perforated pipes within the cells. This gas transferred to gas recovery unit where it receives subsequent treatment and utilization, or disposal in a safe manner through flaring or venting. ▪ The vertical gas recovery wells will be designed keeping in view the capacity of the landfill. ▪ For KPCIP landfills, Open flame flare technology, consisting of a pipe through which the gas is pumped, a pilot light to spark the gas, and a means to regulate the gas flow is proposed. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ For Mardan, flaring is proposed for landfill gas management. Keeping in view the amount of gas production after few years of landfill operation, feasibility for gas reuse will be carried out and accordingly design changes will be executed. ▪ PMU KP LGE&RDD shall ensure that during operation phase of the project, if there are changes in the baseline ambient air quality, then a quantitative assessment will be carried out for flaring and necessary design changes will be incorporated to avoid air quality impacts from flaring. ▪ As part of closure plan of existing dumping site, GHG monitoring will be carried out and necessary gas venting system will be done. ▪ Periodic GHG monitoring will be carried out during operation phase of the project. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
	3.5	Generation of objectionable Odor and impact on air quality	<p>Best management practices and good housekeeping measures will be implemented to minimize the release of objectionable odours. Potential odours impacts can be minimized or eliminated by adopting the following measures:</p> <ul style="list-style-type: none"> ▪ Daily cover will be placed on working surface of waste in order to reduce the risk of fire, wind littering, odor, vector breeding and dust hazards in the landfill. ▪ Suitable amount of daily cover will be stocked at the landfill site. ▪ Final capping of landfill cells will be carried out in order to limit and control the amount of precipitation that enter the waste and to limit wind and water erosion and burrowing animal activity. This will not only prevent the odor of decaying waste from escaping from the landfill but also protect the site against intrusion of vermin and pests. 	O&M Contractor/WSSM	WSSM/PMU	DO

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>The top cover system consists of following arrangements.</p> <ul style="list-style-type: none"> ▪ Thick top soil layer of 45 cm capable of supporting vegetation in order to protect the landfill surface from wind and water erosion. ▪ Drain Layer of 15 cm at bottom to maximize runoff of precipitation while minimizing infiltration and preventing ponding of water on the landfill. ▪ Compacted soil layer or barrier of 60 cm of low permeability to limit and control the amount of precipitation that enters the waste. ▪ Vent layer of 15 cm thickness comprised of sand and gravel ▪ Appropriate and regular housekeeping (i.e. cleaning) will be done in all areas where solid waste will be processed (i.e. weigh bridge area). This will prevent the reproduction of flies, generation of 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>obnoxious odors, scattering of plastic and papers, etc.</p> <ul style="list-style-type: none"> ▪ Strict use of Personal Protective Equipment (PPE) by all personnel (e.g. inspectors at the Weigh Bridge, MRFs, material handler and waste compactor operators) must be ensured. ▪ All the incoming ingredients that are anaerobic will be converted to aerobic state through combining them with a coarse, dry bulking amendment to increase the porosity and allow oxygen penetration. ▪ Air shall be thoroughly dispersed throughout the organic waste. This is done by frequently turning and mixing the wastes. ▪ Oxidizing chemicals like hydrogen peroxide, potassium permanganate, and chlorine will be used by the wastewater treatment industry for odor control. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Organic waste lot which is creating objectionable odor will be attended immediately introduced in the composing system on priority basis. ▪ Controlled composting conditions will be maintained throughout the operation. ▪ Mandatory health and medical check-ups for all employees especially workers working at MRF as they may be exposed to general airborne dust above the level where it is considered a substance hazardous to health (10 mg/m³ as an 8-hr TWA). This shall ideally be complimented by obtaining an Insurance Policy for Workmen's especially engaged in the daily activities of the landfill; ▪ Control of inhalation exposure to hazardous substances by the effective use of general ventilation within MRF and Local Exhaust 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			Ventilation (LEV) the appropriate use of respiratory protective equipment (RPE);			
3.6		Attraction of Vermin and disease vector generation	<ul style="list-style-type: none"> ▪ The most important control measure used to minimise vector problems at landfills is the application of daily cover. Cover shall be present on all solid waste at all times, except the tipping face while it is being worked. Daily cover of at least 150mm of compacted soil or similar material or an effective layer of alternate daily cover (ADC) shall be applied on finished portions of the daily cell during operation and at the conclusion of daily operations, and not less frequently than once per day. Alternative daily cover materials such as tarpaulins, foams, granular waste, etc, can be effective as vector control after careful site-specific evaluation. 	O&M Contractor/WSSM	WSSM, PMU	DO

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Intermediate cover of 300mm (minimum) compacted soil shall be used on all areas not at finished levels, but not to be further landfilled for a period of 30 days or more. ▪ Final cover is typically applied as each area is brought to finished level through the operational life of the landfill. ▪ There shall be no uncontrolled or uncovered (stockpiled) waste, including litter, tyres, brush, appliances, construction/demolition waste or even inert industrial waste on the landfill property. The only exception is compactable soil-like inert wastes, such as ash, but even this waste must be graded and compacted to avoid ponding water. ▪ There shall be no ponding water on the landfill property except as designed for runoff storage or 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>sedimentation. Sedimentation ponds can, however, aid vector reproduction if not designed and controlled properly so as to minimise stagnant water, nutrient build-up and plant growth.</p> <ul style="list-style-type: none"> ▪ Finally, the waste must be compacted and graded at reasonable maximum slopes (see the Working Face Guideline) to minimise voids within the waste that can harbour rodents in particular. Rodents and foxes can readily dig into cover soil, but have much more difficulty digging into compacted solid waste. ▪ On-site landfill site personnel must be trained and must monitor the levels of key vectors on a daily basis as part of daily management. A simple monthly site walk-over can provide a baseline of vector activity so changes can be noted and 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>translated into action. Observations of various droppings, sightings, tracks, insect counts, etc are useful indicators of activity. Written reports from regular walk-over assessments shall be kept on file so changes that occur over time and in response to control measures can be assessed.</p>			
3.7	Occupational Health and Safety		<ul style="list-style-type: none"> ▪ OHS management system will be prepared and implemented. ▪ Designation of an Environment, Health and Safety (EHS) officer dedicated to the site; ▪ All employees must be able to reach their work stations safely. All path, walkways, staircases, ladders and platforms must be stable and suitable for the tasks to be undertaken; ▪ Strict use of Personal Protective Equipment (PPE) by all personnel (e.g. inspectors at the Weigh 	O&M Contractor/WSSM	WSSM, PMU	DO

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>Bridge, material handler and waste compactor operators) must be ensured.</p> <ul style="list-style-type: none"> ▪ Mandatory health and medical check-ups for all employees especially workers working at MRF as they may be exposed to general airborne dust above the level where it is considered a substance hazardous to health (10 mg/m³ as an 8-hr TWA). This shall ideally be complimented by obtaining an Insurance Policy for Workmen's especially engaged in the daily activities of the landfill; ▪ Mandatory training of all employees, including sub-contractors, on Health and Safety Practices for Landfill and its auxiliary facilities. Tool Box talks are also recommended; ▪ Mandatory health and medical check-ups for all employees. This 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>shall ideally be complimented by obtaining an Insurance Policy for Workmen's especially engaged in the daily activities of the landfill;</p> <ul style="list-style-type: none"> ▪ Develop a written program (i.e. health information, instruction and training) which sets forth procedures, equipment, personal protective equipment, and work practices that are capable of protecting employees from the health hazards of working in a landfill and its auxiliary facilities; ▪ Mandatory monitoring of air quality and noise levels in the working stations to maintain the same within local standards and whenever possible near ambient levels; ▪ Control of inhalation exposure to hazardous substances by the effective use of general ventilation within MRF and Local Exhaust Ventilation (LEV) the appropriate 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>use of respiratory protective equipment (RPE);</p> <ul style="list-style-type: none"> ▪ Accidental fires must be addressed immediately. Appropriate operational procedures involving the spreading and smothering of burning waste, rather than the use of water, must be implemented; ▪ Emergency plan (including fire management) must be developed and implemented; ▪ Availability of first-aid kits and vehicles that can be used to bring any injured employee to the nearest doctor in cases of accidents; ▪ Mandatory reporting of all accidents or incident of near misses of accidents and immediate adoption of corrective measures; and ▪ Management must provide all the necessary financial and manpower resources for the implementation 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>and enforcement of all health and safety programs and activities of the project;</p> <ul style="list-style-type: none"> ▪ Regular training and orientation on safety practices will be implemented to impart knowledge of safe and efficient working environment. Furthermore, regular health checkups of all employees including contract workers will be conducted. Effective and proper housekeeping is recommended to reduce dust exposures to its direct vicinity. Heat levels must be monitored as well. Spot checks shall be done to ensure that workers' welfare is addressed especially during summer months. 			
3.8	Waste Collection and Hauling Impacts		<ul style="list-style-type: none"> ▪ Capacity of WSSM will be increased through increase in its collection fleet. It will be done through procurement of both solid waste and non-solid waste carrying 	O&M Contractor/WSSM	WSSM, PMU	DO

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>machinery under this project.</p> <ul style="list-style-type: none"> ▪ Door to Door collection of waste will be enhanced through media campaigns. Communication programs would be developed to encourage better management of waste. Proper PPEs will be provided to waste handlers. Key performance indicators will be developed to monitor improvements in the system. ▪ All type of waste hauling will be carried out in purpose built vehicles to avoid scattering of waste at hauling routes. Drivers of waste carrying vehicles will be trained with respect to environmental sensitization. Drivers are allowed to commute only on designated routes through purpose built vehicles for waste hauling. ▪ Multiple transactions of waste will be avoided through use of main 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>and mobile transfer stations.</p> <p>Improved segregation practices will be introduced once door to door collection desired efficiency achieved. Necessary legal bindings with respect to waste storage by Public will be introduced.</p> <ul style="list-style-type: none"> ▪ A comprehensive traffic management plan (TMP) must be developed and implemented; ▪ As part of the TMP, it will be ensured that the movement of heavy vehicles related to landfill operations is minimized during the peak traffic hours of the day in order to prevent congestion and accidents as far as possible; ▪ Furthermore, the movement of heavy vehicles within Mardan city related to landfill operations must be restricted to specific routes containing least number of sensitive receptors and low traffic volumes. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
3.9		Wind Blown Litter	<ul style="list-style-type: none"> ▪ Waste hauling through dirt tracks will be strictly prohibited. Waste hauling through mechanically unfit vehicles or noisy vehicles will not be allowed. ▪ Waste transporters will be directed to use designated routes and follow recommended speed limit for waste hauling and such routes will be metaled roads instead of dirt tracks. 	O&M Contractor/WSSM	WSSM, PMU	DO

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>selected for its protection to minimize effects of wind.</p> <ul style="list-style-type: none"> ▪ Waste that is more susceptible to windblown distribution may, on windy days, be worked immediately into the fill face and covered with a layer of daily cover, as needed, or the waste may be excluded from the site. ▪ Portable skid-mounted litter fences may be provided for deployment downwind as close as practical to the working area, as needed. ▪ Semi-permanent fencing may be provided around the fill area as an additional barrier to the migration of litter off-site when litter has not been contained by the portable litter fences. (Examples of additional barriers include but not limited to, a four-foot minimum temporary construction fence and/or a ten-foot or higher semi-permanent fence.) 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>The utilization will be continually evaluated and the fence will be relocated or added as needed.</p> <ul style="list-style-type: none"> ▪ Permanent fencing (ten-foot high with an additional three-foot kicker) may be constructed with possibility of placement on an eight-foot high berm. ▪ On very windy days, when all other procedures are not successful in controlling blowing litter, the operator may apply cover material more frequently or immediately to the incoming waste load. ▪ Buffer zones resulting from required facility setbacks along the site's perimeter shall provide some protection of adjacent properties. ▪ As a final control measure, personnel will be dispatched, as needed or daily if conditions require, to collect any litter that has escaped the above control 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>measures</p> <ul style="list-style-type: none"> ▪ Portable litter vacuums may be used to collect litter that has accumulated on litter fences. If fences are positioned properly, this can be a very efficient method of collecting litter. ▪ The main highway leading to the site will be routinely inspected for litter. If the highway has litter associated with the trucks entering the facility, then the litter will be picked up on a routine basis. All necessary safety precautions must be followed. ▪ Before and after photos of any litter removal effort may be taken in the event anyone questions the level of effort spent on litter collection. ▪ Site management's cell phone numbers may be provided to community/neighbors. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ The management of litter at the landfill is a daily activity. In most instances the above procedures and techniques shall properly manage litter effectively. However, there will be occasions and situations when litter will be distributed by the wind in such a manner that the above procedures will not totally manage the litter and contain the litter on-site. In these situations, the facility operator may not be able to collect all litter within the day the litter problem occurred. However, the facility operator shall proceed with collecting the litter off site and complete the retrieval of wind-blown litter at the earliest practicable time. 			
	3.10	Impacts on Scavengers and Waste Pickers	<ul style="list-style-type: none"> ▪ WSSC Swat will carry out detailed assessment of scavenging business in their respective jurisdiction to identify waste picker and scrap dealers which will be impacted. ▪ WSSC Swat will provide resources 	O&M Contractor/WSSM	WSSM, PMU	DO

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>and tools to efficiently collect and sort out the waste onsite, as these waste pickers are the first one to deal with the waste.</p> <ul style="list-style-type: none"> ▪ WSSC Swat will train these waste pickers to optimize their waste collection process. ▪ WSSC Swat will hire waste pickers at MRF facility that will be established at landfill site. ▪ WSSC Swat will hire services of scrap dealers for waste collection and transportation to landfill site on need basis. ▪ WSSC Swat will prepare communication strategy and will run community based operation to integrated SWM operations including waste pickers and scrap dealers. ▪ PMU KPCIP will preapre guidelines to involve scavengers/waste pickers in IWMS through formalization and regulations of their business. These guidelines will be adopted by WSSC Swat to encourage involvement of scavengers and waste pickers working at all levels regardless of their position in present system chain. 			
3.11	Improvement in Aesthetic Aspects		<ul style="list-style-type: none"> ▪ The boundary walls shall be 	O&M Contractor/WSSM	WSSM/PMU	DO

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>constructed alongside the facility.</p> <ul style="list-style-type: none"> ▪ The indigenous plants shall be planted alongside the access road and around the landfill site which will act as buffer zone. ▪ The waste transfer vehicles shall be covered. ▪ Reasonable area will be allocated for plantation within and at boundary of facility to improve aesthetic appeal of the area. ▪ Plantation will start as one of the earliest activities of site development. Once the design of landfill is approved and necessary funds mobilized, plantation activity can be started in collaboration with Mardan Development Authority or WSSM can outsource the activity separately. 			
Closure & Post Closure Phase	4.1	Closure and Post Closure Impacts	<ul style="list-style-type: none"> ▪ Appropriate selection of soil type for final cover will be ensured to 	WSSC M	WSSC M	During Closure & Post Closure

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<p>prevent water infiltration and minimize infiltration of precipitation into the waste and the subsequent generation of leachate; control landfill gas migration; and minimize long term maintenance needs.</p> <ul style="list-style-type: none"> ▪ Appropriate selection of soil type for final cover will be ensured to prevent direct or indirect contact of living organisms with the waste materials and their constituents; ▪ Application of final cover components that are consistent with post closure use and local climatic conditions. ▪ Necessary environmental objectives and controls (including technical specifications) will be defined and implemented. ▪ Necessary surveillance protocols for final capping, lachate and gas monitoring will be established and implemented. 			

Project Activities	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
				Execution	Monitoring	
			<ul style="list-style-type: none"> ▪ Future Land use of the site will be defined in consultation with local communities and government agencies. ▪ It will be ensured that financial resources, and monitoring arrangements are in place for closure and post closure activities. ▪ PMU KP LGE&RDD will ensure that financial instruments are in place to cover the costs of closure and post-closure care and monitoring. ▪ Long term integrity and security of the site will be maintained. 			

CSC	:	Construction Supervision Consultant
BC	:	Before Construction
DC	:	During Construction
PMU	:	Project Management Unit
DO	:	During Operation
WSSM		Water and Sanitation Services, Mardan

Table 7.2: 'Pre-Construction' Environmental Monitoring Plan for Baseline Development

Parameter to be measured	Objective of Monitoring	Parameters to be Monitored	Measurements	Location	Frequency	Responsibility
Ambient Air Quality	To establish baseline air quality levels	CO, NO ₂ , SO ₂ , O ₃ & PM ₁₀ (particulate matter smaller than 10 microns) concentration at receptor level	1-hr and 24-hr concentration levels	At three random receptor locations in the project area, both upwind and downwind	Once	CSC
Ambient Noise	To establish baseline noise levels	Ambient noise level near receptors in project area	A-weighted noise levels – 24 hours, readings taken at 15 s intervals over 15 min. every hour, and then averaged	At three random receptor locations in the project area	Once	CSC
Groundwater Quality in vicinity of landfill site	To establish groundwater quality in project area	Groundwater quality in project area	Water samples for comparison against NEQS parameters	At five locations around the landfill site in the project area	Once	CSC
Surface Water Quality Monitoring	To establish surface water quality for Canal passing along Southern boundary of Site	Surface water quality of Canal	Water samples for comparison against NEQS parameters	At three representative locations along Canal	Once	CSC

Table 7.3: Construction Phase Monitoring Requirements

Project Activity and Potential Impact	Objective of Monitoring	Parameters to be Monitored	Measurements	Location	Frequency	Responsibility
Noise Disturbance due to noise from construction activity	To determine the effectiveness of noise abatement measures on sound pressure levels	Ambient noise level at different locations in project area	A-weighted noise levels – 24 hours, readings taken at 15 s intervals over 15 min. every hour at 15 m from receptors, and then averaged	At three random receptor locations in project area	Quarterly basis on a typical working day	Contractor's Environmental officer, CSC
Air Quality Dust emissions from movement of construction vehicles and equipment Exhaust emission from tailpipes of equipments	To determine the effectiveness of dust control program on dust at receptor level	CO, NO ₂ , SO ₂ , O ₃ & PM ₁₀ (particulate matter smaller than 10 microns) concentration at receptor level	1-hr and 24-hr concentration levels	At three random receptor locations in project area	Quarterly basis on a typical working day	Contractor's Environmental officer, CSC
		Visible dust	Visual observation of size of dust clouds, their dispersion and the direction of dispersion	Construction site	Once daily during peak construction period	Contractor's Environmental officer, CSC
Safety precautions by Safety workers	To prevent accidents for workers and general public	Number of near miss events and accidents taking place	Visual inspections	Construction site	Once Daily	Contractor's Environmental officer, CSC
Soil Contamination	To prevent contamination of soil from oil and toxic chemical spills and leakages	Incidents of oil and toxic chemical spills	Visual inspections	At construction site and at vehicle and machinery refuelling & maintenance areas	Once a month	Contractor's Environmental officer, CSC

Project Activity and Potential Impact	Objective of Monitoring	Parameters to be Monitored	Measurements	Location	Frequency	Responsibility
Solid Waste & Effluent disposal Insufficient procedures for waste collection, storage, transportation and disposal	To check the availability of waste management system and implementation	Inspection of solid and liquid effluent generation, collection, segregation, storage, recycling and disposal will be undertaken at all work sites in project area	Visual inspections	At work sites in project area	Once daily.	Contractor's Environmental officer, CSC
Surface Water Quality Monitoring	To prevent contamination and deterioration of surface water quality for Canal passing along Southern boundary of Site	Surface water quality of Canal	Water samples for comparison against NEQS parameters	At three representative locations along Canal	Quarterly basis	CSC

Table 7.4: 'Operation Phase' Environmental Monitoring Plan

Parameter to be measured	Objective of Monitoring	Parameters to be Monitored	Measurements	Location	Frequency	Responsibility
Groundwater Quality in vicinity of landfill site	To assess whether landfill operation is causing any seepage into the groundwater aquifers in project area and contaminating it.	Groundwater quality in project area	Water samples for comparison against PEQS parameters	At five locations around the landfill site in the project area	Quarterly	WSSM

Ambient Air Quality in vicinity of Landfill site	To assess whether landfill operation is causing deterioration of ambient air due to flaring	Ambient air quality in project area	Ambient air quality monitoring against NEQS parameters	At three locations around the landfill site in the project area	Quarterly	WSSM
Waste Management Monitoring	To ensure Waste Management Plan is being implemented	Management and disposal of waste at SWMF	Implementation of Clauses and conditions of Waste Management Plan	Entire project corridor from waste collection points upto disposal at SWMF	Quarterly	WSSM
Surface Water Quality Monitoring	To assess any potential contamination and/or deterioration in surface water quality of Canal passing along Southern boundary of Site	Surface water quality of Canal	Water samples for comparison against NEQS parameters	At three representative locations along Canal	Quarterly	WSSM

Table 7.5: Capacity Development and Training Programme

Provided by	Organized by	Contents	No. of training events	Duration	Cost (PKR)
Pre-construction Phase Monitoring Consultants/Organizations offering specialized services in environmental management and monitoring	CSC & PMU	Short seminars and courses on: Environmental Management Plan and Environmental Monitoring Plan	Two seminars for Contractor management staff and project staff	1 day	200,000/Training

Construction Phase Monitoring Consultants/Organizations offering specialized services in environmental management and monitoring	CSC & PMU	Short seminars on Environmental risks associated with construction phase. Development of Environmental Performance Indicators Occupational Health and Safety (OHS) issues	Two seminars for Contractor management staff and project staff dealing in environment and social issues	1 day	200,000/Training
Operation Phase Landfill Facility Operator authorized representative or 3rd party trainer	Landfill Facility Operator	Short seminars on Environmental risks associated with operation phase. Development of Environmental Performance Indicators/ Occupational Health and Safety (OHS) issues	Bi-annual seminars	1-2 Day	600,000/Year
Total			1000,000/Year (PKR 1 million)		

7.9 Environmental Management Costs

559. The **Table 7.6** below provides cost estimates for 'Pre-Construction phase' monitoring while **Tables 7.7** and **7.8** provides cost estimates for 'Construction phase' and 'Operation phase' monitoring of key environmental parameters.
560. The costs associated with implementation of the EMP and the necessary mitigation measures are provided as **Table 7.9** below. The **Table 7.10** below provides the 'Capacity development and training programme' for project contractors for the proposed landfill development.

Table 7.6: Annual Cost Estimates for 'Pre-Construction Phase' Environmental Monitoring²²

Monitoring Component	Parameters	Quantity	Amount PKR	Details
Air Quality	CO, NO ₂ , SO ₂ , O ₃ , PM ₁₀	3 (Once only at 3 locations)	90,000	3 readings @ PKR 30,000 per sample
Noise Levels	dB(A)	3 (Once only at 3 locations)	90,000	3 readings @ PKR 30,000 per reading
Ground Water Quality	NEQS	5 (Once only at 5 locations)	150,000	5 readings @ PKR 30,000 per sample
Surface Water Quality	NEQS	3 (Once only at 3 locations)	90,000	3 readings @ PKR 30,000 per sample
Contingencies			21,000	5% of monitoring cost
Total (PKR)			441,000	

Table 7.7: Annual Cost Estimates for 'Construction Phase' Environmental Monitoring²³

Monitoring Component	Parameters	Quantity	Amount PKR	Details
Air Quality	CO, NO _x , PM ₁₀	12 (Quarterly basis at 3 locations)	360,000	12 readings @ PKR 30,000 per sample
Noise Levels	Db(A)	12 (Quarterly basis at 3 locations)	360,000	12 readings @ PKR 30,000 per reading
Surface Water Quality	NEQS	12 (Quarterly basis at 3 locations)	360,000	12 readings @ PKR 30,000 per reading

²² For air quality monitoring: 'Passive samplers' such as test tubes can be used or 'Active samplers' with sorbent turbines can also be used.

²³For noise monitoring: sampling equipment with duration greater than 1 hour can be used.

Contingencies		54,000	5% of monitoring cost
Total (PKR)	1,134,000		

Table 7.8: Annual Cost Estimates for ‘Operation Phase’ Environmental Monitoring²⁴

Monitoring Component	Parameters	Quantity	Amount PKR	Details
Surface Water Quality	NEQS	2 (bi-annual basis)	60,000	2 readings @ PKR 30,000 per sample
Groundwater Quality in vicinity of landfill site	NEQS	20 (Quarterly basis @ 5 locations)	600,000	20 readings @ PKR 30,000 per reading
Ambient Air Quality Monitoring	NEQS	3 (Quarterly basis @ 3 locations)	360,000	12 readings @ PKR 30,000 per reading
Surface Water Quality Monitoring	NEQS	12 (Quarterly basis @ 3 locations)	360,000	12 readings @ PKR 30,000 per reading
Contingencies			69,000	5% of monitoring cost
Total (PKR)			1,449,000	

Table 7.9: Estimated Costs for EMP Implementation

Item	Sub-Item	Estimated Total Cost (PKR)
Staff, audit and monitoring cost²⁵	1 person for 24 months (@ 100,000 per month)	2,400,000
Monitoring Activities	Provided separately in Tables 7.7 and 7.8.	-
Mitigation Measures	As prescribed under EMP and EIA.	40,00,000
(i) Water sprinkling	To suppress dust emissions	800,000
(ii) Solid waste collection & disposal	From construction sites (based on initial estimates)	700,000

²⁵ To cover staff cost and expenses of Environmental Specialist for Contractor

(iii) Plantation around project boundary to control odor levels	To plant vegetation all along the landfill boundary to limit odor emissions	15,00,000
(iv) Chemicals/pesticides to prevent/minimize disease vector generation	Chemicals to be injected into the influent streams in order to minimize/prevent disease vector generation	10,00,000
Contingencies	5% of EMP implementation cost	320,000
Total Estimated Cost (PKR)		6,720,000

Table 7.10: Capacity Development and Training Programme for Project Contractor(s)

Provided by	Organized by	Contents	Target Audience	Venue	Duration
Pre-construction Phase PMC offering specialized services in environmental management and monitoring	CSC & PMU	Short seminars and courses on: Environmental Management Plan and Environmental Monitoring Plan	Contractor staff	PMU Office, Mardan	One day long training seminar
Construction Phase PMC offering specialized services in social management and monitoring	CSC & PMU	Short seminar on Environmental risks associated with construction phase. Development of Environmental Performance Indicators Occupational Health and Safety (OHS) issues	Contractor staff	PMU Office, Mardan	One day long training seminar

8 Public Consultation and Information Disclosure

561. This section describes the process and outcomes of the consultations carried out with various groups of stakeholders as part of the environmental and social assessment. It includes a brief discussion on the concerns expressed by the stakeholders during the consultation meetings and responses provided in order to address the concerns through necessary mitigation measures.
562. The specific objectives of the consultation were: (i) obtaining local and indigenous knowledge about the environment and people living in the project area; (ii) interaction with the project affected population and other stakeholders for the collection of primary and secondary data on environment and people; and (iii) engaging stakeholders for maximization of the project benefits.
563. A total of six comprehensive focus group discussions with stakeholders were organized with a total of over 55 different stakeholders consulted with 26 stakeholders (forty seven percent) being women. The first round of public consultations was conducted in the month of January–February, 2020, while the second round of public consultation was completed in the month of March–April, 2020. Information on positive and negative impacts associated with constructional and operational stage and proper mitigation of adverse impacts were shared at these consultations.
564. Details on the public consultations conducted are provided below with the pictorial evidences and list of persons consulted provided as **Annexure C**.

8.1 Identification of Stakeholders

565. There are three types of stakeholders for the proposed landfill site development as described below.

8.1.1 Primary Stakeholders

566. The primary stakeholders are primarily the Project Affected Persons (PAPs) and general public including women residing in the project area - for example, people living in the project area particularly those affected by the footprint of the Saeedabad Landfill site, Mardan. These are the people who are directly exposed to the project's impacts, though in most cases they may not be receiving any direct benefit from the project.

8.1.2 Secondary Stakeholders

567. The secondary stakeholders are typically institutional stakeholders – for instance, related government department/agencies, local government, and organizations that may not be directly affected by the project; however, they may influence the project and its design. In the case of the proposed landfill site development, the secondary stakeholders are as follows:

- Irrigation, Agriculture and EPA Departments
- The ADB (The Financing Agency)
- Forest and Wildlife Departments, Government of KP
- P&D Department, Government of KP
- Representatives of local communities

- Tehsil Municipal Authority, Mardan
- Irrigation Department, Government of KP
- Revenue Department, Government of KP
- Al-Khidmat Foundation, Government of KP
- Public at large

8.1.3 Key stakeholders

568. The stakeholders considered to possess the ability to significantly influence a project, or who are critical to the success of a project are considered key stakeholders. Key stakeholders may be from the primary and/or secondary stakeholder groups. In this context of the proposed landfill site development, these are considered to be local leaders, influential community members and other local representatives including Imams of mosques and teachers of local schools.

8.2 Information Disclosure and Consultation

8.2.1 Scope of Consultations

569. The consultations were conducted and recorded by Mr. Musaddiq Shah (Sociologist), Mr Zeeshan (Sociologist), Mr Waji Ul Hasan (Sociologist) and Mr.Ibrahim Atiq (Environmentalist). The stakeholders were also briefed by PMU Project associate Mr Asad Jan and Senior Sociologist PMU Hashmat Khan. During these consultations, the primary and secondary stakeholders were briefed on the project components in detail and all their concerns and feedback was recorded.

570. All consultations were carried out in accordance with the 'meaningful consultation' guidelines of ADB's SPS 2009 and their outcome is discussed in the proceeding sections. Consultations were also held with the PMU, Local Government Board and the design consultants.

571. As part of the present environmental and social assessment, detailed consultations with over 55 different stakeholders were conducted through village meetings and focus group discussions (FGDs) with the communities, including women in the project area. Separate meetings were held with the institutional stakeholders in the form of one-to one meetings i.e. with EPA, WSSM, etc. Specially, prepared consultation performa was used during the data collection. Details of this consultation process are described in the **Table 8.1** below and the locations of the Public consultations are provided in **Figure 8.1** below. Photographs of institutional stakeholders are provided in **Figure 8.2**. Photographs of FGDs are provided in **Figure 8.3**. Photogrpahs of scavangers consultations are provided as **Figure 8.4**.

Figure 8-1: Map of Public Consultation Locations

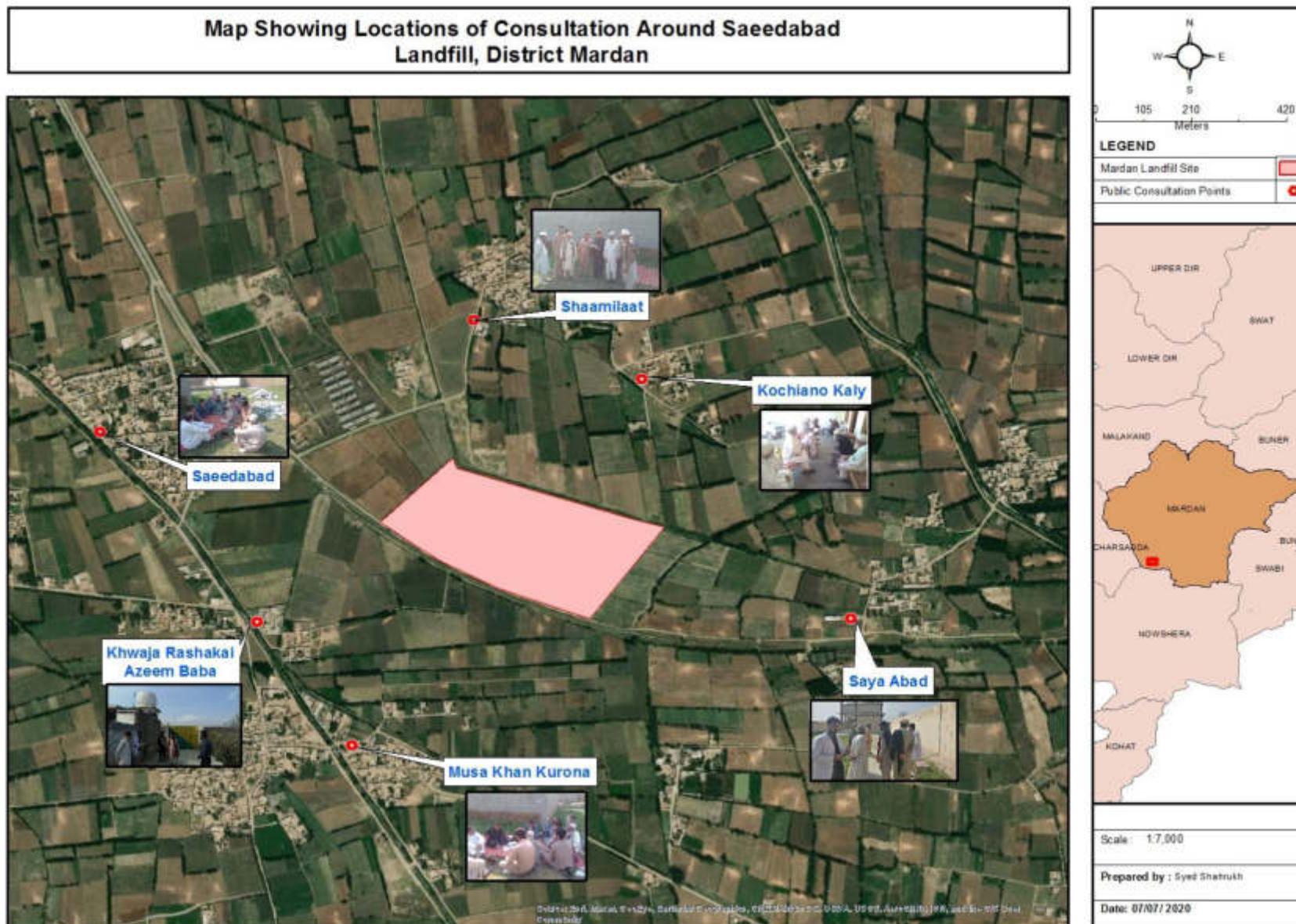


Table 8.1: List of Stakeholder Consultation and Concerns

Sr. No.	Date	Location of Consultation	Total No. of Participants	Comments/Concerns	Consultant Response
i	16/03/20	Village Saeed Abad	22 (07 women, 15 men)	<ul style="list-style-type: none"> • Health infrastructure is in deplorable state • Power load shedding is adversely affecting the daily lives of residents. • Odor and smell issues • Diseases, such as skin allergies, dengue, and typhoid have increased since open dumping of untreated waste. • The locals also stated that an old age lady also died due to a disease spread from the openly dumped untreated waste. 	<ul style="list-style-type: none"> • Waste Management awareness • Educating about the technologies that go into landfills which shall eliminate disease and odor problem • Implementation of EMP i.e. spraying of flees and mosquito killer reagents at site • Preparation of green belt along the boundary limits of the landfill site.
ii	17/03/20	Shotal Banda	04 (men)	<ul style="list-style-type: none"> • Lack of primary education • Lack of medical facilities • No regulated system for waste collection 	<ul style="list-style-type: none"> • As a part of the project, green belt along the project boundaries shall be established as well as other green initiatives in the city shall take place under this project • People were introduced to the new waste management process i.e. construction of Engineered landfill, and its positive impacts on the waste collection process in the District
iii	17/03/20	Khwaja Rashakai	05 (men)	<ul style="list-style-type: none"> • Lack of provision of basic education • Lack of health facilities • Weak road infrastructure 	<ul style="list-style-type: none"> • Road infrastructure shall be improved with the construction of this project and effective measures shall be taken in place to avoid unnecessary damage to the public property • The affiliated government institutions shall be notified regarding the improvement needed in health and education sector

iv	17/03/20	Shaamilaat	24 (05 men, 19 women)	<ul style="list-style-type: none"> • Provision of employment to the residents • Unpaved roads causing dust allergies • Lack of basic health facilities • The old owners wanted their land back as they stated that the government had taken their land by force. • Drinking water quality shall be improved for the city 	<ul style="list-style-type: none"> • People were briefed about Waste Management awareness • Timely compensation against resettlement issues, if any • Educating about the technologies that go into landfills which shall eliminate disease and odor problem • Implementation of EMP i.e. spraying of flees and mosquito killer reagents at site • People were briefed that land is already owned by the proponents • The previous land owners were told that their concerns would be brought in notice of the government officials and only then can be there any decision regarding the acquisition of the land.
----	----------	------------	--------------------------	---	--

Table 8.2: Consultations with Government Stakeholders

Sr. No.	Date	Department of Consultation	Designation of Person	Comments/Concerns	Consultant Response
1	4-2-20	EPA Head Office Peshawar	DD-EIA	The design and project implementation should be in compliance with the KPEPA 2014 and NEQS. Project proponent should obtain the approval before to start any activity at site.	After the detail design and all mandatory financial arrangement project proponents will make a liaison with EPA for necessary applicable approval.
2	4-2-20	PkHA	DD-Env.& reset	The designer should also assess the carrying capacity of road network of the area before selection of the final site	All physical structures and road network assessment is also part of the feasibility and will be considered during the detail design.
3	19-10-20	PkHA	Director-1 (Maintenance)	He emphasized the importance of ensuring environmental safeguards through conducting thorough and comprehensive Environmental Impact Assessments. If any roads providing access to various landfill or treatment plant sites require rehabilitation or expansion and fall under PKHA jurisdiction, he advised and assured that all relevant protocols will be followed.	All necessary protocols will be followed and comprehensive EIA report will be prepared.

4	17-3-20	Alkhidmat Foundation Peshawar Bazar	Office Manager	He appreciated the project and government initiations.	Project design and implementation will be socially and environmentally sustainable.
5	17-3-20	Environment Practitioner	Environment Practitioner	He appreciated the project and government initiations and emphasizes the project implementation in accordance to environmental laws.	Project design and implementation will be socially and environmentally sustainable.
6	19-10-20	P& D Department	Director Sustainable Development Unit (SDU)	He expressed an interest in facilitating the necessary fulfillment of the environmental and social safeguard criteria.	All necessary protocols will be followed as per environmental and social safeguard criteria
7	19-10-20	KP Wildlife Department	District Forest Officer-Wildlife	She stressed the need to conserve the natural environment as best possible. She suggested that GIS database of project sites' surrounding areas may be prepared as it will help track the natural environmental and any changes to it caused by the projects.	Consultation response of KP wildlife department has been noted and it will be made part of EIA report.
8	20-10-20	Irrigation Department	SE Headquarter	He explained that it is not just the solid waste being dumped in canals and streams which are a major concern for the department as far as sources of irrigation are concerned. An even more potent negative impact is caused by the effluent that is directly	Consultation response of KP irrigation department has been noted and it will be made part of EIA report.

				disposed of into these water bodies. He expressed optimism over the various different subprojects of KPCIP, anticipating a synchronized effect of the different waste management, sewerage treatment, water supply and green urban spaces subprojects that will ultimately influence a positive change in the different cities' natural environments and the lives of their many residents.	
9	09-11-20	KP Forestry Department	Conservator, Forestry	The conservator suggested that indigenous species of flora may be planted across the boundaries of the proposed project site. He also suggested assigning some project area to a small nursery from where the plants shall be provided to the locals for plantation as to mitigate the effect of poor air quality due to brick kilns present in the vicinity.	Consultation response of KP Forestry department has been noted and it will be made part of EIA report.

Figure 8-2: Consultations with Institutional Stakeholders

	
Meeting with Conservator, Forestry (KP Forestry Department, Headoffice)	Consultation with DD-EIA, KP-EPA
	
Meeting with DFO, Wildlife (KP Wildlife Department, Headoffice)	Consultation with Irrigation Department
	
Meeting with Director-I PKHA (Pakhtunkhwa Highways Authority)	Meeting with Director SDU (Sustainable Development Unit) P&D Department

	
PMU & EDCM Environmental and Social Safeguards experts meeting with WSSC-Mardan	Meeting on KPCIP with ADC (Revenue) and DC Mardan.

8.2.2 Social Safeguard Focus Group Discussions

572. After initial survey by Social Safeguard team, the overall number of directly affected people from the proposed landfill site was known. Every affected person was reached out and interviewed by social safeguard team as per ADB requirements. These people were interviewed about the land area they share in the project area and their entire social status including details of their income, food expenditure, basic life amenities, living background etc. Till date, 80% of those people including both men and women have been interviewed and their observations have been noted down while the rest is in progress. The process was started in first week of February'20, but due to COVID-19 pandemic and lockdown in the entire country and due to migration of some affectees to foreign countries, the data collection and interviewing process got slowed down.
573. Consultation with the affectees was conducted within their settlements to encourage and facilitate their participation. 66% men and 34% women were interviewed. Separate sessions were arranged for the women. During the consultation process, a verbal detailed description of the Project activities was provided to those interviewed.

Figure 8-3: Focus Group Discussions (FGDs) for Mardan SWMF

	
Consultation with secondary stakeholders in Shamilaat, Mardan	Consultation with secondary stakeholders in Shamilaat, Mardan

	
Consultation with secondary stakeholders in Shamilaat, Mardan	Consultation with secondary stakeholders in Khwaja Rashaka, Mardan
	
Consultation with secondary stakeholders in Shotal Banda, Mardan	Consultation with secondary stakeholders in Khwaja Rashaka, Mardan

8.2.3 Findings of the Public Consultations/Focal Group Discussions

574. All the directly affected people were the owners of proposed landfill property so majority of those affected people had observation regarding land settlement process as they stated that the government always pays less for any land acquitted from the public. Those people demanded that they should be paid a handsome amount for their acquitted land. Some of those affected households demanded for alternate land as a payment method, while the rest demanded cash in return for their acquitted land.
575. All the indirectly affected people included the population living in the vicinity of the project area. Those people complained about the smell issues and spreading of different diseases in the project area due to open dumping of untreated solid waste in the proposed landfill site. Due to variation in direction and flow of wind in summers, the odor problem was observed to be increased and hence causing the spread of fever and skin diseases.
576. Power load shedding is adversely affecting the daily lives of residents as the only source of power in the vicinity of the project area is through solar panels which the locals have installed on their own finances.

- 577. Health, education, and drinking water facilities should be provided, following the Project development.
- 578. There are no public tube wells and pipeline structure to facilitate water source for the people in the vicinity of the project area. The locals have installed private tube wells to keep up with the water resources.

8.2.4 Response from Social Safeguards Team

- 579. Our team made sure that the affected people were given full surety regarding their demands.
- 580. The people directly affected from the project were told on spot that they would be given payment of their acquitted land after completion of the entire process and that they would be called to DC office and the cheques would be issued in the name of each land owner of the proposed landfill site to make sure no one misses out on their right.
- 581. The people indirectly affected from the project were told about the new technological installation in the project area as installation of new engineered landfill would reduce the odor issue and hence reduction in spreading of different diseases.
- 582. There is a big opportunity for the installation of solar powered panels in the surroundings of the project area.
- 583. The people were made sure that their demands reach to the higher authorities and that the basic life amenities be provided to them once work on project gets initiated.

8.2.5 Basic data of affected people

- 584. The basic data of the all directly affected people from the proposed landfill project are provided as **Annexure C** with 106 males and 70 females consulted.

8.2.6 Consultations with Scavengers and Scrap Dealers

- 585. During the scoping of environmental and socioeconomic studies of the project area, these groups were identified as important stakeholders which will be influenced in some form or another. To gather more information on the nature and extent of this influence, a data collection and analysis strategy was devised by the environmental experts, relevant literature consulted and compiled (included previously our project data), questionnaires drafted and site visits conducted. All these activities are described below.
- 586. The process of consultation was planned to begin with contacting the workers collecting waste door-to-door every morning, and progressing step by step through scrap collection and sorting facilities of various capacities, possibly including the transporters associated along the way, up till the larger scrap recycling or management facilities.
- 587. The initial few visits conducted by the environmental team, covering most of the aforementioned groups, yielded some useful data which projects a picture of the current operations within the informal waste management system structure. Details of their operations, income levels and their opinions, particularly concerns, are given in at the end of this section. The summary of the consultation data is provided in the **Table 8.3** below. Photographs of scavenger's consultations are provided in **Figure 8.4**.

588. Based on these consultations, some general conclusions can be derived regarding the prevailing scavenging and informal waste recycling system in operation, as well as its scope of potential involvement in the proposed ISWM system, which are summarized below:

- Majority of stakeholders consulted expressed the need for some form of government formalization, management or oversight is needed in order to better manage the operation of the landfill site, once developed, regardless of their position or significance in the system's chain.
- Improvements in physical equipment and facilities made available to the operators will serve to improve their working conditions and income levels.
- The reason that most scavengers and waste-pickers adopt this line of work is due to necessity born out of a lack of employment opportunities of any other kind.
- Those stakeholders in the waste management business doing well financially appear to have been involved in this line of work for a longer period, pointing to the benefits of persistence and experience in this business. In their position, they are no longer limited by work options and do this type of business more by choice and in anticipation of significant profits.

Table 8.3: Consultations with Scavengers and Scrap Dealers

Sr. No.	Date	Location of Consultation	Total No. of Participants	Comments/Concerns	Consultant Response
1	24/6/20	Achini Main, Hayatabad, Mardan	2	<p>(Small scale scrap dealer)</p> <p>The scrap business does generate a relatively stable income, although low, as the owner and employees have gotten accustomed to the market.</p> <p>Their reason for adopting this line of work is a lack of other employment opportunities.</p> <p>They hope and expect facilitation in the form of better streamlined movement of waste within this informal system or any future proposed system of waste management, particularly regarding its transportation options.</p>	<p>These small-scale scrap dealers would be of great assistance in sorting out the hard waste i.e. aluminum tins, cardboards, steel boxes etc</p> <p>The advanced landfill technology would help those workers learn new and efficient ways of recycling the scrap material in a more productive way</p>
2	24/6/20	Achini Main, Hayatabad, Mardan	3	<p>(PDA Employees)</p> <p>Current system in which PDA employs them is not as organized or regulated as they would expect.</p> <p>They feel that more formal job opportunities in this sector can and</p>	<p>After the introduction of new solid waste dumping technology, the system of managing solid waste will become more organized, hence improving skills of those employees as well.</p>

Sr. No.	Date	Location of Consultation	Total No. of Participants	Comments/Concerns	Consultant Response
				should be provided, along with cleaner and safer working protocols.	
3	24/6/20	Achini Main, Hayatabad, Mardan	6	(Scavengers, waste-pickers) Highly informal income source, necessitated due to lack of education, employment options and government support or supervision of any kind. They feel that their young children who should be in schools also have no option but to assist in their work to generate enough income to survive.	Government shall provide these people with resources and tools to efficiently collect and sort out the waste onsite, as these waste pickers are the first one to deal with the waste dump by WSSM. The government shall train these waste pickers to optimize their potential of waste collection process.
4	25/6/20	Ring Road, Mardan	3	(Small intermediate scrap dealer) For them, this is a steady source of income generation. Their waste sorting activity is not as labour intensive since the waste they receive has already undergone some preliminary sorting. The employee and owner consulted were generally satisfied with their working conditions.	These scrap dealers shall be provided with first aid training to avoid injuries while dealing with scrap which is mostly steel products, plastic, cardboard and paper etc. These people shall also be provided with proper equipment for compressing the scrap material and managing it accordingly.

Sr. No.	Date	Location of Consultation	Total No. of Participants	Comments/Concerns	Consultant Response
5	25/6/20	Ring Mardan Road,	2	<p>(Mid-size intermediate scrap dealer)</p> <p>Their operations generate a decent income.</p> <p>They still feel that a lack of regulation and streamlined processes hinders them from operating optimally.</p> <p>Overall they stressed that this industry has great potential for profit which is still mostly untapped.</p> <p>They particularly emphasized the need for improvement in the waste transportation mechanism, which currently still ignores most of the waste on the dumping sites.</p>	<p>After installation of solid waste landfill and material recovery facility, these scrap dealers shall be trained to sort out and manage scrap material on a larger scale.</p> <p>Proper delivery system of the compacted waste to the treatment plants and scrap industries needs to be focused on.</p> <p>While designing the solid waste landfill, the suggestions of these scavengers shall be incorporated and they shall be made a part of the process to make the waste collection process more efficient.</p>
6	25/6/20	Ring Mardan Road,	1	<p>(Independent Driver)</p> <p>The income is good as long as the process runs smoothly over time.</p> <p>Some lack of regulation and supervision exist. If properly addressed, this will certainly make this industry safer, more efficient and more lucrative to work in.</p>	<p>Provision of health and safety measures for delivery drivers shall be made compulsory.</p> <p>Proper covered transportation of compacted scrap material shall be made compulsory to avoid any kind of falloff.</p>

Table 8.4: Responses from Scavengers based on Survey Questions

Name, Details	Responses
<ul style="list-style-type: none"> • Adnan Khan 52, scrap business, Achini Main Rd, Mardan • Amir Khan 20, employee, Achini Main Rd, Mardan 	<p>Amount of waste collected/day: Waste quantity varies from 5kg to 10 kg everyday</p> <p>Usefulness of that waste: The waste is sorted out on spot and the recyclable material is sold to further bigger waste pickers</p> <p>Procedure for collection: The waste is brought to the store by several small waste pickers and sold in this store. The waste is normally not sorted before.</p> <p>Usual cost and time spent: It takes the entire day in sorting out the waste. The usual cost depends on quantity of waste brought to the store. 15000 rent monthly for the space. 4 employees, 2 for waste collection and 2 for handling facility operations.</p> <p>Amount of income generated: It varies from 3000-5000 rupees/day</p>

Name, Details	Responses
	<p>Source of income: This is their only source of income</p> <p>End use of waste: The waste is further sold to bigger waste collecting dealers.</p> <p>Motivation/reason for this job: Lack of job opportunities.</p> <p>Working relationship with any government authority: Private business</p> <p>Expected improvements in the system: Mode of transportation for waste picking should be improved</p>
<ul style="list-style-type: none"> • Javed <p>42, PDA employee, Mardan</p>	<p>These workers are hired by PDA for dumping of solid waste across the city. They dump the waste in places designated by PDA and put soil layers over the dumped waste.</p>

Name, Details	Responses
<ul style="list-style-type: none"> • Kamaal 59, PDA employee, Mardan • Jamshaid 51, PDA employee, Mardan 	<p>These workers demanded that more jobs should be generated in this sector and that the system should be regulated and made centralized and networks be developed among different waste picking private community, so that the waste picking process is made efficient, clean and productive.</p>
<ul style="list-style-type: none"> • Mujahidullah 40, waste picker, Afghan refugee Mardan • Saddiqullah 21, waste picker, Afghan refugee Mardan • Suleman 20, waste picker, Afghan refugee Mardan • Saleem 17, waste picker, Afghan refugee Mardan • Wahidullah 22, waste picker, Afghan refugee Mardan 	<p>Amount of waste collected: The amount of waste collected by them is around 5-10kg per day</p> <p>Usefulness of that waste: These small scale waste pickers sort out the waste and then sell the useful materials to the relatively bigger scrap dealers</p> <p>Procedure for collection: These waste pickers go around different dump sites early morning every day and collect the waste of their use in their waste collection bags.</p> <p>Usual cost and time spent: Some waste pickers have got themselves different vehicles/carts for transportation of the waste, while others travel by foot to different waste dumps.</p>

Name, Details	Responses
<ul style="list-style-type: none"> • Javaid <p>18, waste picker, Afghan refugee Mardan</p>	<p>Amount of income generated: The income opportunity for these people is relatively very low as compared to bigger scrap dealers. They earn around 300-350 rupees daily</p> <p>Source of income: This is the only source of income for these people.</p> <p>End use of waste: These waste pickers sell the useful materials to further scrap dealers up in the hierarchy cycle of scrap material dealers.</p> <p>Motivation/reason for this job: Lack of options for them to earn a livelihood for their families. Lack of education and government support.</p> <p>Working relationship with any government authority: These small scale waste pickers are working on their own</p>

Name, Details	Responses
	<p>Expected improvements in the system:</p> <p>The government should focus on hiring these waste pickers and develop a network of entire waste scavenger's hierarchy.</p>
<ul style="list-style-type: none"> • Arif Khan 19, employee at scrap business, Ring Road Mardan • Sarfaraz Khan 56, co-owner of scrap business, Ring Road Mardan • Aurangzaib Khan 53, co-owner of scrap business, Ring Road Mardan 	<p>Amount of waste collected:</p> <p>The amount of waste collected daily by their store is around 25-30 kg</p> <p>Usefulness of that waste:</p> <p>The waste is sorted out first by the waste pickers and then used according to its recycling potential.</p> <p>Procedure for collection:</p> <p>The waste is brought to the store by local waste pickers who work on small scale. They sell out the waste to the bigger scrap stores in the locality.</p> <p>Usual cost and time spent:</p> <p>It doesn't take much time for the waste collectors to sort out the waste and then arrange it categorically.</p> <p>Amount of income generated:</p> <p>Rs 6,000-7,000 earned daily</p>

Name, Details	Responses
	<p>Source of income: Buy/Sell of scrap materials</p> <p>End use of waste: The sorted waste is then sold out to bigger scrap companies for their use.</p> <p>Motivation/reason for this job: This is one of biggest business opportunities which offers respectable money in return if done in a systematic manner</p> <p>Working relationship with any government authority: This is a private run business and the place is owned by the owner as well.</p> <p>Expected improvements in the system: Incentives or subsidies from government departments or authorities to make this activity more attractive.</p>
• M. Isa	<p>Amount of waste collected:</p>

Name, Details	Responses
<p>57, owner of scrap business, Ring Road Mardan</p> <ul style="list-style-type: none"> • Meere Khan <p>46, co-owner of scrap business, Ring Road Mardan</p>	<p>Amount of waste generated varies widely every day. But according to a rough estimate, they collect approximately 70-100 kg waste every day</p> <p>Usefulness of that waste:</p> <p>The waste after its sorting is sent to different industries to make ready-to-use products from it. The waste is then melted/molded according to desired end product.</p> <p>Procedure for collection:</p> <p>Usually the waste is bought from small scale waste pickers and then sorted out in separate categories at store.</p> <p>Usual cost and time spent:</p> <p>The time spent on the process depends on the waste brought to the store. But normally it takes 5-6 hours every day to sort out the waste and set them.</p> <p>Amount of income generated:</p> <p>The income normally generate from selling the waste is Rs 10,000-15,000 per day</p> <p>Source of income:</p>

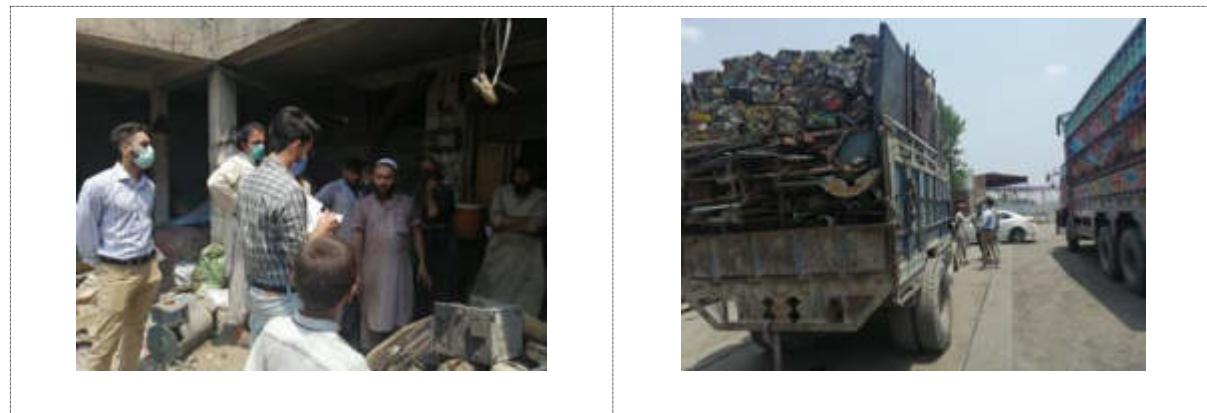
Name, Details	Responses
	<p>This is the only source of income of these people</p> <p>End use of waste:</p> <p>The waste is finally sent to different recycling plants in the outskirts of District Mardan, to convert the scrap material into useful raw material or products</p> <p>Motivation/reason for this job:</p> <p>This business provides a greater profit margin as compared to most small scale businesses.</p> <p>Working relationship with any government authority:</p> <p>This is a private run company</p> <p>Expected improvements in the system:</p> <p>The waste collection process should be made systematic and regulated by the government. Priority should be given to waste delivery system as most of the waste is left untouched on the dump sites because of lack of transportation to the targeted scrap stores.</p>
<ul style="list-style-type: none"> • Hussain Khan <p>38, Private self-employed waste transporter</p>	<p>Amount of waste collected:</p> <p>The capacity of his vehicle is about 9-10 tons every trip</p>

Name, Details	Responses
	<p>Usefulness of that waste:</p> <p>The waste is transported to large godowns, recycling facilities for various uses.</p> <p>Procedure for collection:</p> <p>Usually the waste is bought from small or mid-size intermediate scrap dealers and then transported to any of the large facilities outside the city. According to the respondent, there are 3 such facilities in Jamrud, about 12 in Bara and 8-10 in Shahkas. The respondent leaves it to his own discretion which particular facility he would like to drop the collected waste on any given day.</p> <p>Usual cost and time spent:</p> <p>One round trip of collecting enough waste and then transporting it to any of the large facilities outside the city usually takes one full day of work, but sometimes it can take more than that. The fuel and logistic expense per round trip is around Rs. 10,000.</p> <p>Amount of income generated:</p> <p>Each trip transports roughly Rs 600,000-650,000 worth of waste, from which the driver would earn a margin ranging between Rs 5,000 and 10,000.</p> <p>Source of income:</p> <p>This is the only occupation and source of income for the respondent</p>

Name, Details	Responses
	<p>End use of waste: The waste after its delivery to different recycling plants in the outskirts of Mardan gets converted into useful raw material or products</p> <p>Motivation/reason for this job: Steady income source with a decent profit margin.</p> <p>Working relationship with any government authority: Private enterprise.</p> <p>Expected improvements in the system: Regulation, supervision and support of government.</p>

Figure 8-4: Consultations with Scavengers/Waste Handlers





8.3 Consultation Plan for Construction and Operation Phase

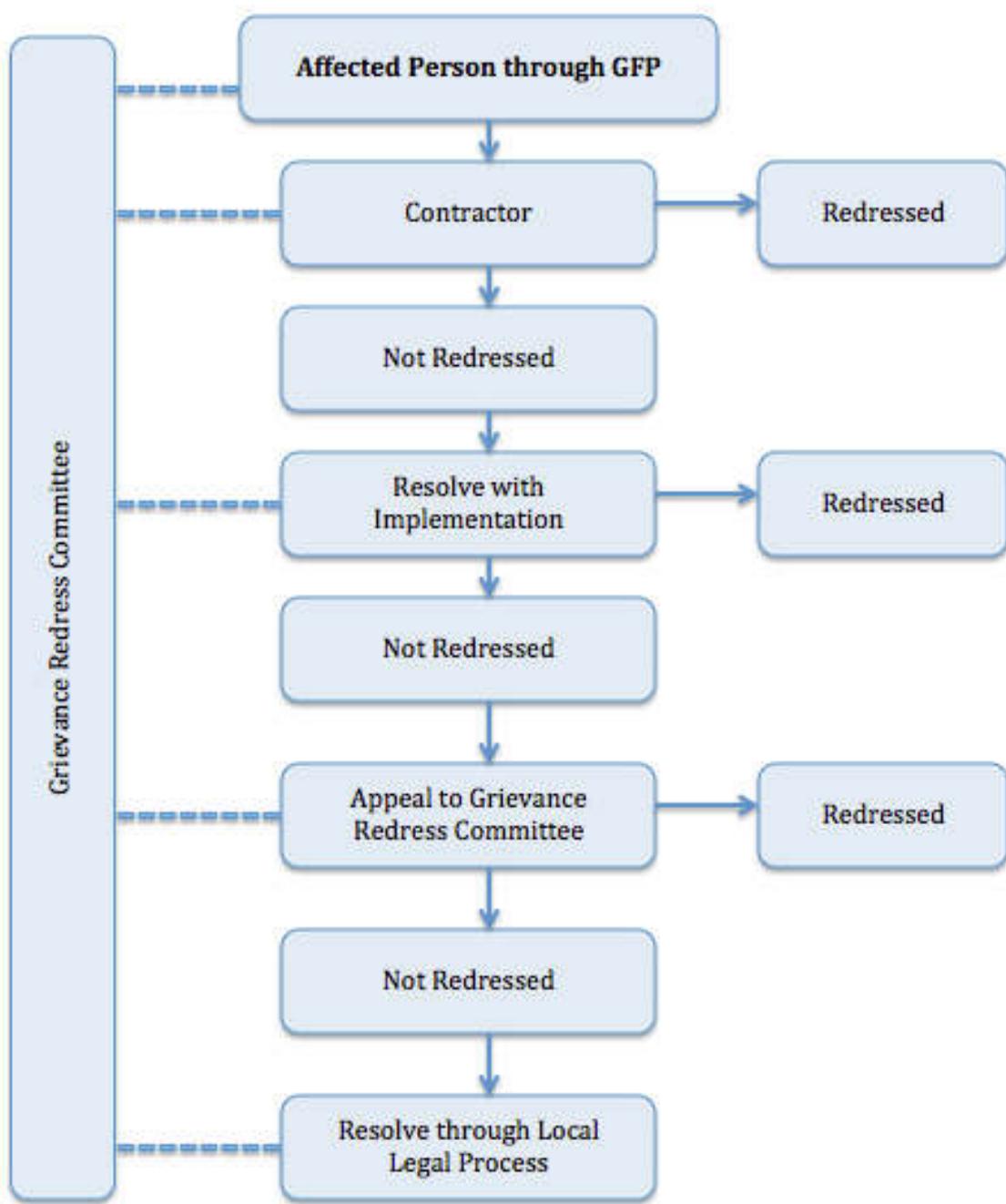
589. Consultation plan for construction and operation phase of Mardan SWMF will be prepared in order to take response of project stakeholders and general public about the project. Periodic consultations and community feed back surveys will be carried out to develop positive perception about the project. Intended stakeholders for such consultations will be all stakeholders that are consulted at the time of EIA preparation and KPCIP PRF processing. Record of such consultations will be maintained at PMU/WSSM offices and necessary changes in operational modalities will be introduced in the system in light of the response provided by the consultees.

9 Grievance Redressal Mechanism

9.1 General

590. The ADB Policy (SPS 2009) requires establishment of a local grievance redress mechanism to receive and facilitate resolution of the Displaced/Affected Persons concerns and grievances regarding the project's social and environment performance. The measures have been identified to mitigate any potential environmental and social impacts to be caused due to implementation of the landfill works.
591. However, in spite of best efforts, there is chance that the individuals / households affected by the project or other stakeholders are dissatisfied with measures adopted to address adverse social impacts of the project. To address, such situation an effective Grievance Redress Mechanism (GRM) will be established to ensure timely and successful implementation of the project. It will also provide a public forum to the aggrieved to raise their objections and the GRM would address such issues adequately. It will receive, evaluate and facilitate the resolution of displaced persons' concerns, complaints and grievances about the social and environmental performance at the level of the project.
592. The GRM will aim to investigate charges of irregularities and complaints receive from any displaced persons and provide a time-bound early, transparent and fair resolution to voice and resolve social and environmental concerns link to the project.
593. The PMU shall make the public aware of the GRM through public awareness campaigns. The name of contact person(s) and his/her phone number, PMU contact numbers will serve as a hotline for complaints and shall be publicized through the media and placed on notice boards outside their offices, construction camps of contractors, and at accessible and visible locations in the project area. The project information brochure will include information on the GRM and shall be widely disseminated throughout the project area. Grievances can be filed in writing, via web-based provision or by phone with any member of the PMU.
594. First tier of GRM. The PMU is the first tier of GRM which offers the fastest and most accessible mechanism for resolution of grievances. The PMU staff for environment and social safeguards will be designated as the key officers for grievance redressal. Resolution of complaints will be completed within seven (7) working days. Investigation of grievances will involve site visits and consultations with relevant parties (e.g., affected persons, contractors, traffic police, etc.). Grievances will be documented and personal details (name, address, date of complaint, etc.) will be included, unless anonymity is requested. A tracking number will be assigned for each grievance, including the following elements:
- Initial grievance sheet (including the description of the grievance), with an acknowledgement of receipt handed back to the complainant when the complaint is registered;
 - Grievance monitoring sheet, mentioning actions taken (investigation, corrective measures);
 - Closure sheet, one copy of which will be handed to the complainant after he/she has agreed to the resolution and signed-off.

- The updated register of grievances and complaints will be available to the public at the PMU office, construction sites and other key public offices in the project area. Should the grievance remain unresolved, it will be escalated to the second tier.
595. **Second Tier of GRM.** The PMU will activate the second tier of GRM by referring the unresolved issue (with written documentation) to the Water Sanitation and Services Company (WSSM), Mardan who will pass unresolved complaints upward to the Grievance Redress Committee (GRC). The GRC will be established by WSSM before start of site works. The GRC will consist of the following persons: (i) Project Director; (ii) representative of District government; (iii) representative of the affected person(s); (iv) representative of the local Deputy Commissioners office (land); and (v) representative of the KP EPA (for environmental-related grievances). A hearing will be called with the GRC, if necessary, where the affected person can present his/her concerns/issues. The process will facilitate resolution through mediation. The local GRC will meet as necessary when there are grievances to be addressed. The local GRC will suggest corrective measures at the field level and assign clear responsibilities for implementing its decision within fifteen (15) working days. The contractor will have observer status on the committee. If unsatisfied with the decision, the existence of the GRC will not impede the complainant's access to the Government's judicial or administrative remedies.
596. The functions of the local GRC are as follows: (i) resolve problems and provide support to affected persons arising from various environmental issues and including dust, noise, utilities, power and water supply, waste disposal, traffic interference and public safety as well as social issues and land acquisition (temporary or permanent); asset acquisition; and eligibility for entitlements, compensation and assistance; (ii) reconfirm grievances of displaced persons, categorize and prioritize them and aim to provide solutions within a month; and (iii) report to the aggrieved parties about developments regarding their grievances and decisions of the GRC.
597. The WSSM officers will be responsible for processing and placing all papers before the GRC, maintaining a database of complaints, recording decisions, issuing minutes of the meetings and monitoring to see that formal orders are issued and the decisions carried out.
598. **Third tier of GRM.** In the event that a grievance cannot be resolved directly by the PMU (first tier) or GRC (second tier), the affected person can seek alternative redressal through the district or sub-district committees as appropriate. The PMU or GRC will be kept informed by the district, municipal or national authority. The grievance redress mechanism and procedure are depicted in the **Figure 9.1** below. The monitoring reports of the EMP and RP implementation will include the following aspects pertaining to progress on grievances: (i) Number of cases registered with the GRC, level of jurisdiction (first, second and third tiers), number of hearings held, decisions made, and the status of pending cases; and (ii) lists of cases in process and already decided upon may be prepared with details such as Name, ID with unique serial number, date of notice, date of application, date of hearing, decisions, remarks, actions taken to resolve issues, and status of grievance (i.e., open, closed, pending).
599. In order to provide greater clarity, the pictorial description of the GRM is provided in **Figure 9.1** below.

Figure 9-1: Grievance Redressal Mechanism

10 Conclusion and Recommendations

600. The development of the proposed SWMF project in Mardan is of high significance considering the urgent need for improving the SWM system of Mardan city.
601. Primary and secondary data has been collected and used to assess the environmental impacts of the Project. This EIA report highlights all potential environmental impacts associated with the Project and recommends mitigation measures. Any environmental impacts associated with the project need to be properly mitigated, through the existing institutional arrangements described in this report.
602. The majority of the environmental impacts are associated with the operation phase of the project since these will be long term, such as Generation of objectionable Odor and impact on air quality, Attraction of Vermin and disease vector generation, Leachate generation, Possible contamination of Soil and Groundwater, Generation of Landfill Gas etc., to name a few.
603. The implementation of mitigation measures during this period will be the responsibility of the Contractor. Therefore, the required environmental mitigation measures will have to be clearly defined in the bidding and contract documents, and appropriately qualified environmental staff retained by the Consultant to supervise the implementation process. The EMP includes measures to minimize project impacts due to noise and air pollution, waste generation etc.
604. The EMP contained within this EIA document is considered sufficient for issuance as part of the Contracts to the successful bidder(s) and for subsequent use during the project works. It should be mentioned that prior to the commencement of works, this EMP must be further updated by the Contractor into site specific EMPs (SSEMPs) for review and approval of ADB. In these SSEMPs, aspects such as a detailed traffic management plan, identification of locations for disposal of debris and spoil and any other details which shall become available later must be included for efficient implementation of all proposed mitigation measures and the subsequent monitoring of these measures.
605. This project has been assigned environmental category 'A' in accordance with the ADB's Safeguard Policy Statement (SPS) 2009 and Schedule II as per EPA, IEE and EIA Gazette Notification, 2000. Thus, a comprehensive EIA report has been prepared for the proposed project.

11 References

- Kharat, M.G., Kamble, S.J., Raut, R.D. Identification and evaluation of landfill site selection criteria using a hybrid Fuzzy Delphi, Fuzzy AHP and DEMATEL based approach. *Model. Earth Syst. Environ.* **2**, 98 (2016). <https://doi.org/10.1007/s40808-016-0171-1>
- Dutta, R.K, Gayathri V. Landfill planning and design considerations. *Ground Improvement and Ground Control including Waste Containment with Geosynthetics* (2012). https://www.researchgate.net/publication/304148141_Landfill_planning_and_design_considerations
- Kumar S, Chiemchaisri C, Muddoo A. Bioreactor landfill technology in municipal solid waste treatment: An overview. *Critical Reviews in Biotechnology* **31**(1):77-97. (2011). DOI: [10.3109/07388551.2010.492206](https://doi.org/10.3109/07388551.2010.492206)
- Sher Alam Shinwari. Future of thousands of street children at stake. *DAWN*. April 2015. www.dawn.com/news/1178251
- Intikhab Alam, Ayesha Jabeen, Niaz Muhammad, Sara Safdar, Mussawar Shah, Asad Ullah annd Madeha Asghar. Scavenging: The Children Role In Surging The Economic Profile Of Families In Pehawar, Pakistan. *Sarhad Journal of Agriculture*. Vol.27, No.1 Pg153-159. 2011
- Sher Alam Shinwari. Street children exposed to serious threats. *DAWN*. April 2017. www.dawn.com/news/1330141
- Mian Maqbool Hussain. Waste Management in Mardan. 2013. www.bioenergyconsult.com/Mardan-swm
- Ahmed, M. and Suphachalasai, S. (2014). Assessing the Cost of Climate Change and Adaptation in South Asia. Manila: ADB
- Anjum, B. F. et al. (2005). Climate Change Perspective in Pakistan. *Pakistan Journal of Meteorology*. **2**(2). pp. 11–21
- Asian Development Bank (2017a): Mainstreaming Climate Risk Management into Urban Infrastructure Investments through Urban Resilience Assessments (URAs), Mardan City, Khyber Pakhtunkhwa, Pakistan (UCCRTF TA-8913 PAK).
- Asian Development Bank (2017b). Climate Change Operational Framework 2017-2030: Enhancing Actions for Low Greenhouse Gas Emissions and Climate-Resilient Development, Retrieved from: <https://www.adb.org/sites/default/files/institutional-document/358881/ccof-2017-2030.pdf>
- Asian Development Bank (2017c). Climate Change Profile of Pakistan. ISBN 978-92-9257-721-6 (Print), 978-92-9257-722-3 (e-ISBN). Publication Stock No. TCS178761. DOI: <http://dx.doi.org/10.22617/TCS178761>. Retrieved from: <https://www.adb.org/sites/default/files/publication/357876/climate-change-profile-pakistan.pdf>
- Asian Development Bank (2014). Midterm Review of Strategy 2020: Meeting the Challenges of a Transforming Asia and Pacific
- Chaudhry, Q. Z. et al. (2009). Climate Change Indicators of Pakistan. Technical Report. No. 22. Islamabad: Pakistan Meteorological Department.

IPCC (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Rehman, N., Adnan, M. and Ali, S. (2018) 'Assessment of CMIP5 climate models over South Asia and climate change projections over Pakistan under representative concentration pathways', *Int. J. Global Warming*, Vol. 16, No. 4, pp.381–415.