Harari National Regional State, Harar City Administration
Urban Local Government Development Project Office

Environmental and Social Impact Assessment Report for the Kile Sanitary Landfill

(First draft report)

Afran Consultancy Services P.L.C

December, 2013

Harar

Table of Contents

List of figures vi
List of Tables vii
Executive Summary viii
1. Introduction 19
1.1. Background to the ESIA Study 19
1.2. Objective of the ESIA Study 20
1.3. Methodology of the ESIA Study 20
2. Project Description 22
2.1. Project Location 22
2.2. Slope and Topography 23
2.3. Soil 25
2.4. Description of the Sanitary Landfill Project 26
2.4.1. Sanitary Landfill 26
2.4.2. Leachate Management 26
2.4.3. Litters 27
2.4.4. Gas Management System 27
2.4.5. Ancillary Facilities 27
2.4.6. Sanitary Landfill Operation 27
3. Policy, Legislative and Institutional Framework 30
3.1. Policy Framework 30
3.1.1Conservation Strategy of Ethiopia 30
3.1.2. Environmental Policy of Ethiopia 30
3.1.3. National water and Sanitation Polices and Legislatives 30
3.1.4. The Health Policy of Ethiopia 31
3.1.5. National Hygiene and Sanitation Strategy for Ethiopia 31
3.2. World Bank Safe Guard Policies 32
3.3. Legal Frameworks 32
3.3.1. Establishment of Environmental Protection Organs (Proclamation No. 295/2002) 32
3.3.2. Environmental Impact Assessment (Proclamation No. 299/2002) 33
3.3.3. Environmental Pollution Control (Proclamation No. 300/2002) 33

3.3.4. Solid Waste Management Proclamation No. 513/2007 33
3.3.5. Regional Level Proclamation and Regulations 34
3.4. Institutional Set Up 34
3.4.1. Federal Environmental protection Authority (EPA) 34
3.4.2. Environmental Protection Authority of Harari Region 34
4. Baseline Environmental Conditions 35
4.1. Bio-Physical Environment 35
4.1.1. Location 35
4.1.2. Topography 35
4.1.3. Climate 35
4.1.4. Geology and soils 37
4.1.5. Soil depth 37
4.1.6. Ground Water 37
4.1.7. Land Use in the Area 38
4.1.8. Local Flora and Fauna 38
4.1.9. Water Supply 38
4.2. Socio Economic Condition 39
4.2.1. Population and Settlements 39
4.2.2. Health 39
4.2.3. Education 40
4.2.4. Existing Solid Waste Management Practice 40
5. Analyses of Alternatives 45
5.1. Assessment of proposed sanitary landfill sites 45
5.2. Assessment of Geology and Hydrogeology characteristics 47
5.2.1.Muti Area 47
5.2.2. Sofi Area 48
5.3. Assessment of Socio economic Characteristics 52
5.3.1. Sofi area 52
5.3.2. Muti area 53
5.4. Assessment of Surface Water Condition 54
5.4.1. Sofi area 54

5.4.2.Mutti Area 55
5.5. Environmental Baseline Conditions of the Proposed Landfill Sites 56
5.5.1. Sofi area 56
5.5.2.Muti Area (Behind St. George Church Hill) 57
5.6. Required Land Area Capacity 58
5.6.1. Available land in Sofi area 58
5.6.2. Available land in Mutti Area 58
5.7. Comparative Site Analysis and Scoring 58
6. Potential Environmental Impacts of Project 59
6.1. Positive Impacts of the Project 62
6.2. Adverse Impacts of the Project 62
2.2.1. Construction phase 62
2.2.2. Operational phase 63
7. Mitigation Measures 65
7.1. Design Phase 65
7.2. Construction Phase 65
7.2.1. Preserving the Biological Environment 65
7.3. Operation Phase 65
7.3.1. Mitigation measures for Impacts on water sources 66
7.3.2. Mitigation Measures for Air Pollution Impacts 66
7.3.3. Mitigation Measures for Impacts on Land Resource and Soil Erosion 66
7.3.4. Mitigation Measures for Public Health and Safety Impacts 66
7.3.5. Mitigation Measures for Hazardous and Loss of Amenity 67
7.3.6. Mitigation Measures for Fire Accidental and Traffic Load 67
8. Environmental Management and Monitoring Plan 70
8.1. Operational Monitoring 70
8.2. Water Quality Monitoring 70
8.3. Operational Controls 71
8.4. Access Control 71
9. Conclusion and Recommendation 73
References 74

Annexes .Rating of criteria for selecting proposed sites 75

List of figures

Figure 1. Integrated solid waste management model diagram 19
Figure 2: sofi woreda, Kile peasant association Location Map 23
Figure 3. Kile Kebele project site 24
Figure 4. Facilities on site (electric power pole) 24
Figure 5. Morphology of Churchura area in the North – South direction 25
Figure 6. Qalacho valley on site that pass from west to south 25
Figure 7. The site with loose sandy soil bounded by hills in north-west side 26
Figure 8. Location map of prposed landfill sites for Harar 46
Figure 9. Gully development in Gelmesheera area (Digital Elevation Model (DEM) of N09°E042) 47
Figure 10. Partial view of the proposed landfill 47
Figure 11. Morphology of Churchura area in the North – South direction 49
Figure 12. Partial view of the proposed landfill 49

List of Tables

Table 1. summary of mitigation measures xiii
Table 2. Rating value of proposed sanitary landfill sites. xvi
Table 3. Monthly Rainfall and Mean Annual Rainfall 35
Table 4. Wind Speed m/s, at Harar Station 36
Table 5. Average monthly maximum and minimum temperatures (0C) 37
Table 6. Harar Regional State 10 Top Diseases, 1987 - 1999 E.C 39
Table 7. Quantity of solid waste produced per week 41
Table 8. Total solid waste generated in the sample House holds 42
Table 9. Per capita solid waste generated per week and per day ,kg 42
Table 10. Type of solid waste generated (%) 42
Table 11. Type of solid waste storage facility in the sample households (%) 43
Table 12. Practice of solid waste disposal by HHs (%) 43
Table 13. Summary of Chirosh/dug wells in Churchura valley 49
Table 14 Water Balance (mm) 54
Table 15. Interceptor Design Parameters 55
Table 16. Interceptor Design Parameters 55
Table 17. Criteria and their value to evaluate landfill sites 59
Table 18. Rating value of proposed sanitary landfill sites. 59
Table 19. Summary of mitigation measures 67

Executive Summary

Waste generation increases with population expansion and economic development. Improperly managed solid waste poses a risk to human health and the environment. Uncontrolled dumping and improper waste handling causes a variety of problems, including contaminating water, attracting insects and rodents, and increasing flooding due to blocked drainage canals or gullies. In addition, it may result in safety hazards from fires or explosions. Improper waste management also increases greenhouse gas (GHG) emissions, which contribute to climate change. Planning for and implementing a comprehensive program for waste collection, transport, and disposal along with activities to prevent or recycle waste can eliminate these problems.

Objective of the ESIA Study

Since the 1950s, growing environmental awareness is increasingly focussing attention upon the interactions between development actions and their environmental consequences. In developed countries this has led to the public demanding that environmental actors be explicitly considered in the decision-making process and a similar situation is now occurring in developing countries.

Early attempt at project assessment were crude and often based upon technical feasibility studies and const benefit analysis (CBA) which was developed as means of expressing all impacts in terms of resource costs valued in monetary terms. It has now evolved as a comprehensive approach to evaluation, in which social, environmental as well as economic and technical considerations are given their weight in the decision-making process.

Environmental and social Impact Assessment can be defined as a formal process used to predict the environmental and social consequences prior to any development project implementation. The ESIA process ensures that the potential problems are foreseen and addressed at an early stage in the projects planning and design. The objective of this ESIA process was to investigate and assess the suitability of the proposed Sofi woreda, Kile Kebele landfill site and provide decision makers with environmental and social setting.

Methodology of the ESIA Study

The environmental and social assessment process incorporates a number of key steps. The assessment process constitutes a systematic approach to the evaluation of the proposed project in the context of the natural, regulatory and socio-economic environments in which development is proposed.

Apart from obtaining environmental permits as required by law, any proposed project would also require “social license to operate” from the community where it will be situated. This is seen to be a crucial element to ensure the successful implementation of any project. The methodology proposed was therefore focus on collecting date from the local people (focus group discussion, meetings), and site/field visit. Moreover, analyses of alternative sites and site selection for landfill construction, identification of possible impacts due to the project and proposals for mitigation of adverse impacts have been made.

Project Location

The proposed Sanitary Land fill Project will be implemented in the Sofi woreda of Harari Regional State, in Kile Kebele. Kile Kebele is found at 522km distance from Addis Ababa. Kile

Kebele is located at about 11km from Harar town at the south-east side, on Harar to Jijiga asphalt road and 1km far from the main asphalt road to east direction.

Positive Impacts of the Project

Harar is a capital of the Regional State and also historical place that attracts international visitors. But its current waste management condition is not found to be at the level it requires. Therefore, it deserves a modern urban management that includes proper waste management system, for safe collection, transporting and disposal of solid wastes generated in the town.

Safe disposal of solid waste in a landfill site will play important role in the improvement of public health in Harar. Moreover it protects the biophysical environment from pollution that goes beyond Harar. This in turn improves the status of Harar and makes it a place of choice to live, work or recreate. With this, Harar's development will be enhanced through more investment on industries and other economic and social services. Harar being a historic town, more tourists will be attracted, which increases its historical value and popularity in the world as well as contributes a lot to economic social development in and around the town. More specifically the positive impacts are:

Adverse Impacts of the Project

Landfill development comprises different activities, which might have potentially negative impact to the environment. The development of landfill could have potential negative impacts at different stages of the project that require appropriate mitigation measures. Impacts can be direct or indirect, short term or long-term consequences. The most important environmental components that are sensitive to be affected by this intervention include quality of ground and surface water, air quality, soil quality, aesthetics and landscape, historical heritages, public health and biological resources. The most possible negative impacts which occur during the construction and operation phases of the landfill development are discussed below.

Construction phase

The construction phase includes the activities like site preparation, clearance and putting up the infrastructure. Hence, this phase involves activities, which are, to some extent averse to the following.

Biological Environment

(a.) **Clearance of natural vegetation -** Felling of trees and clearing of shrubs to construct the landfill, access roads and service areas has negative impact on the environment.

Physical Environment

(a.) **Air pollution** – during the construction phase of this project air pollution could occur due to mobile equipment exhaust, construction dust, road dust, car exhaust and chemicals like fuel, oil, etc.

(b.) **Soil pollution** – This is caused due to disturbance in soil strata/ structure caused by construction works and plastics and chemicals like fuel, soil & grease that are used during the process.

(c.) **Enhanced soil erosion** – Clearing of the plants and digging during construction could be the cause for intensified soil erosion especially on hilly areas. Wind erosion can also be enhanced on such places.

Social Environment

(a.) **Spread of Diseases –** The construction of this scheme draws many skilled and unskilled labourers and professionals to project area from different part of the country and may be from other countries as well. The movement of these people could be the cause to introduce and/or spread different types of contagious and infectious diseases into the town and its surrounding.

Operational phase

During this phase the major consequence of sanitary landfill is leachate. Related to the specific condition of the landfill site the major environmental components to be affected by this project are

Surface and ground water pollution by Leachate

- Pollution of the surface water (river) at the downstream by the leachate as a result of surface run-off and rainfall entering into the solid waste disposed in the fill;
- Pollution of ground water supply source downstream of the landfill area by leachate.

Soil contamination by Leachate

- Contamination of the soil in the surrounding by uncontrolled Leachate

Landfills can also cause a localized loss of amenity due to litter, dust, and odour, noise, and vermin problems. Proximity to existing and proposed developments and the strength and direction of prevailing winds will be key issues in this regard. The potential hazards and amenity impacts from landfills include fire, birds, dust, odour, pests, vermin and litter. Each of these potential impacts may occur on-site or offsite.

Accidental Fire and Traffic load

Fire accident can be caused either due to flammable materials brought along with the solid waste or due to gasses (like methane) emitted from the landfill itself as a decomposition product of the waste.

The traffic load will increase in the rural area where the landfill operates. Numbers of trucks makes several trips to the plant every day. In addition, those trucks share the same road route used by heavy trucks and machineries operating in the area. The dust pollution and noise disturbance can also pose some adverse impacts to the workers and to passerby road users. Sometimes, there might be traffic accidents that might result in loss of life and damage to property both during construction and operation phase of facility.

Mitigation Measures

Mitigation measures are actions to be taken to reduce or eliminate an adverse environmental impact of any intervention on the biophysical or social environment. They can be engineering or management works. Therefore they should be considered at each stage of development process.

Design Phase

During designing of the proposed landfill the following mitigation measures should be considered for indicated negative impacts.

(a.) To avoid pollution of surface and ground water sources from leachate, the design should provide natural or geo-membrane and appropriate leachate collection and treatment.

(b.) The entire landfill area has to be enclosed with durable fencing facilities in order to minimize the entrance of external bodies, which might contribute additional pollution.

(c.) Plantation of the buffer zone for the purpose of creating good scenery, reduction of smell and protection of possible soil erosion.

(d.) Prohibit settlement on any form around the landfill site.

Construction Phase

Plan and facilitate the construction work in such a way that it will not encourage soil erosion in the site and its vicinity. Some of the identified mitigation measures to be followed during the construction phase are discussed in the following sections.

Preserving the Biological Environment

(a.) Minimizing wherever possible cutting of indigenous trees in the construction areas;

(b.) Putting in place an organized system so that unwanted destruction of trees of small size and shrubs will not occur during felling of necessary big trees;

(c.) Replanting of the area after the construction is completed.

Operation Phase

To mitigate environmental impacts, which could exist during the operational phase of the landfill system, day-to-day control and monitoring is decisive. This includes covering the waste with soil layer daily at the close of the day's operation; locating possible leachate generation through constant inspection and supervision; surveillance of any possible pollution of the area (land, ground water and surface water) within the landfill vicinity is important. The person in charge of the landfill operation must make sure that incoming trucks dump the waste in the designated place. No littering of the area should be allowed.

The method to correctly implement all possible mitigation measures at the operational phase is to have suitable landfill operational plan and execute it strictly. With this understanding the following should get due attention during landfill operation.

The development of a workable operating schedule, a filling plan for the placement of solid wastes, landfill operating records, and load inspection plan for hazardous wastes are important elements of a landfill operation plan.

Mitigation measures for Impacts on water sources

Avoid entry of spoil soil in to water body by timely carting and stockpiling at designated disposal site. Site selection should avoid catchments where water sources are located as far as possible.

Leachate must be controlled within the landfill site, ensuring that neither groundwater nor surface water is polluted. The design has to consider leachate treatment facilities within the land fill design project and at the same location. The treatment of the leachate should enable to prevent pollutants' migration into the water sources; either by percolation into ground water source or by runoff into surface water body. A leachate treatment pond can stabilize the pollutants by natural processes, while infiltration is avoided by use of proper sealant material for the pond bottom. In addition, adequate side drainage facility should be provided to avoid run on and runoff water from the landfill areas.

Mitigation Measures for Air Pollution Impacts

1. To reduce impacts of car exhaust and other mobile equipments on the air, machineries with good ignition systems should be used.
2. Spraying water to suppress dust before and in the interval of excavation works.
3. Take precaution not to release or spill fuels, oil and other chemicals in the area and have proper controlling mechanism for effective handling of chemicals, fuel, oil, etc.

Mitigation Measures for Impacts on Land Resource and Soil Erosion

(b.) Backfilling of excavation as per its normal sequence of structure or layer.

(c.) Constructing retaining walls along gullies, loose soil structure & ground cuts with steep slopes.

(d.) Growing grasses & trees on excavated bare lands.

(e.) Doing proper soil compaction where applicable.

(f.) Have proper controlling mechanism for effective handling of chemicals, fuel, oil, etc. and take precaution not to spill fuels, oil and other chemicals.

(g.) Put in place proper collection and recycling system of used plastics. If condition will allow disposing of plastics should be done at a designated safe area.

Mitigation Measures for Public Health and Safety Impacts

To minimize such health hazards, proper safety and precautionary procedures need to be followed. Measures include; training and awareness creation programs for workers on safe waste handling and hazards protection measures, provision of protective cloths and devices like gloves, goggles, protective cloths, provision of adequate water and soaps for bathing, and adequate bathrooms to enable them day to day bathing after work, their periodical health check-ups, vaccinations etc. The workers should have free health services and medical checkups.

a) Conduct regular health check-ups, immunization and treatment of the workers;
b) Design and conduct regular health education programme, including awareness on HIV AIDS and STDs among the work force and the residents in and around the project area.
c) Strengthen the capacity of the health institutions in the project area and make them capable to meet the increasing demand of service from the incoming workforce.

Mitigation Measures for Fire Accidental and Traffic Load

Fire accident should be prevented by taking the proper measures and preparatory works in advance; these measures should include controlling type of waste received at the land fill, preventing gas emissions from the land fill; assuring quality of design, construction and Operation of the landfill, organizing adequate fire-fighting capacity and providing adequate staffing and training for the workers.

The design and construction of landfill should provide properly designed gas release or collector pipe to minimize fire risk due to gas emission from the decomposition of the waste.

All fuels or flammable solvents for operational use should be stored in an appropriately ventilated and secure store. This store should be located on unfilled land, and all flammable liquids should not be stored full tank, but with provisions of open volume so that any release of raw or burning fuel would not cause a fire in the filled waste.

Therefore, strict traffic regulations should be put in place and traffic signals posted at critical locations along the route and within the plant compound. Bumpers and speed breakers need to be constructed at the approach of, and within the plant compound

Table 1. Summary of mitigation measures

Sr.no	Aspect	Mitigation
1.	Topography	• Cap and shape all waste cells on completion of filling. • Capped and shaped areas must be slightly convex so as to encourage runoff and minimise infiltration. Slopes should not to exceed a gradient of 1 in 3. • Even out mounds and hollows during the contouring and shaping process to avoid the creation of low points in which the ponding of water can occur. • Capped waste cells are to be rehabilitated with indigenous vegetation.
2.	Climate	• Extent of unvegetated, exposed surfaces should be kept to the minimum necessary to enable work to proceed. • Ensure immediate and continuous rehabilitation of non-active cells is undertaken. • Revegetate long-term stockpiles, surface water diversion structures and other berms. • After a high intensity or long duration rainfall event, identify and repair erosion and wash away sites immediately. • Dust abatement measures (i.e. dampening of roads) should be employed during windy conditions.
3.	Air Quality	• An AQMP is to be compiled for the proposed site (including benzene). The AQMP is to consider the production of landfill gas from the site and a comprehensive Landfill Gas Management Plan should be established. • The operational phase mitigation measures recommended are to be considered and included in the EMP for the proposed site. • Follow-up (comparative) ambient air sampling to be conducted during construction and operational phases. • The recommended health, dust and odour impact zones should be considered a management zone and control measures be implemented to minimize the impacts within these areas.
4.	Geology and Soils	• Specific engineering measures aimed at capturing and controlling leachate generated within the landfill body are implemented and managed proficiently. • DSW propose to investigate alternative sources and methods of landfill cover should the proposed landfill site be approved.
5.	Ground water	Application of modern landfill practices including: • Liner system • Phased cell development • Leachate management • Monitoring

6.	Surface water	• Lined surface water interceptor drains should be installed up-gradient of each cell to prevent any surface run-off into the active landfill area and active landfill areas should be limited to minimise rainfall recharge through these uncapped open zones. • Surface water monitoring points are to be established and a regular monitoring and reporting programme implemented. • Implementation of new generation landfill design principles and sound operational and management practices
7.	Flora and Fauna	• Rare plant species must be removed from site prior to construction and replanted in nearby open areas or in an onsite nursery. • Completed cells must be landscaped and revegetated with local species as soon as possible. • Development in the planning area should be set back from drainage lines and scarp edges.
8.	Socio-economic	• Consider the feasibility of establishing a recovery and recycling area. • Where possible the landfill development must be linked to local economic development plans. • Appropriate site management and the implementation of buffer areas with compatible land use will reduce potential negative impacts on the value of adjacent properties. • Establish and maintain a monitoring committee for the landfill. • A relocation plan would need to be prepared to ensure that the entire relocation process, from the initial discussions to the movement of families to new homes, is implemented in an appropriate manner. • Discussions with the local community with regard to possible end uses of the site need to be undertaken at the time of imminent site closure. • Proper site management and vegetation screening are mitigation measures that will ensure that the impact on the receiving environment is reduced as far as possible. • The multiple use of the site would have significant positive social impacts and is highly recommended. This issue has implications for land use planning.
9.	Traffic	• The access intersection must operate under priority control with single entry and exit lanes and that this intersection is formalised to the local authority's geometric standards.
10.	Noise	• Acoustic treatment of equipment and machinery should be implemented (silencers, maintenance and control). • Should noise complaints be received, a noise study may be required. Such an investigation which would consider the applicability of noise attenuation that could be offered by the use of physical barriers (i.e. acoustic screens such as wooden fences, brick / concrete walls or man made earth bunds).
11.	Visual and Aesthetics	• Green walls themselves can obstruct views and look out of scale and place because of their shape and size. The green wall landscaping should try to replicate natural features and not appear alien in the

		landscape. This can be aided by the use of indigenous vegetation that mirrors the seasonal colour variations of the surrounding environs. • The landfill has an anticipated lifespan of approximately 100 years, and the commencement of construction from the south might reduce impacts on land uses to the north.
12.	Cultural and Heritage Resources	• Structure associated with farming activities – may be altered or destroyed with a permit from municipality • Structural remains – may be removed with/with no permit from municipality • Archaeological sites - may be altered or destroyed with a permit from municipality if no graves are present; if graves are present permission from families also required

Environmental Management and Monitoring Plan

The general objective of operation monitoring is to verify that the landfill operation does in fact conform to the required standards and proposed planning procedures. It also serves as a performance indicator (and early warning system), and hence as a control or management tool, for the operator. It is the duty of the Responsible Person to ensure that the Minimum Requirements for the monitoring of a landfill site operation are applied to a degree commensurate with the class of landfill and hence to the satisfaction of Department of Environmental Affairs.

Operational Monitoring

The minimum requirements applicable to landfill operation monitoring are vital except air quality monitoring which requires special consideration. These include:

- Responsible Person;
- Landfill Monitoring Committee;
- Conduct Audits;
- Conduct external audits twice per annum;
- Appropriate records and data collection;
- Record deposition rate;
- Waste stream records;
- Landfill volume surveys;
- Collect climate statistics;
- Water quality monitoring;
- Gas monitoring and control;
- Air quality monitoring (Special Consideration);
- Monitoring of progressive rehabilitation;
- Ongoing maintenance.

In their capacity as the Responsible Person, DSW remains responsible for monitoring throughout the operational life of the landfill site and for up to 30 years after closure

Water Quality Monitoring

Water quality monitoring begins before the commissioning of a landfill site and continues throughout and beyond its operation. Monitoring water quality in the vicinity of a landfill is essential in order to indicate whether pollution of the surrounding or adjacent water regime is occurring. The general objective of water quality monitoring is to serve as an early warning system to indicate any escape of contaminants into the water environment and to quantify any effect that the landfill has on the water regime. As a Kile Kebele landfill site, all Requirements applicable to water quality monitoring are required including pre-operation monitoring, operation monitoring and post-closure monitoring. Water quality monitoring is the responsibility of the Permit Holder and thus the Responsible Person, (i.e. DSW), who will ensure that the level and extent of monitoring is commensurate with the class of site under consideration, and hence to the satisfaction of DEA. A long term pollution monitoring programme for the site will be implemented.

Ranking Criteria

Based on the criterion, the sites got their respective value and result is depicted in the table below. The detail analysis is in annex 1.

Table 2. Rating value of proposed sanitary landfill sites

No.	Description	Weight (%)	Proposed Landfill Sites	
			Sofi Area	Muti Area
I	**SOCIO-ECONOMICS**	**20**		
	Accessibility		4	5
	Settlement and Land Use		5	1
	Livelihood and Income		3	3
	Trees and plantation		4	2
	Social infrastructure		5	5
	Sub-total		**21**	**16**
	Weighted Sum		***4.2***	***3.2***
II	**GEOLOGY & HYDROGEOLOGY**	**20**		
	Soil Cover/thickness		2	4
	Ground Water		2	5
	Borrow Material and Type		2	5
	Water wells		2	5
	Soil Permeability		2	4
	Sub-total (%)		**10**	**23**
	Weighted Sum		***2.0***	***4.6***
III	**Earthquake Safety & Slope Stability**	**5**		
	Earthquake safety		5	5
	Slope stability		4	5
	Sub-total (%)		**9**	**10**

	Weighted Sum		**0.5**	**0.5**
IV	**Surface Water**	**15**		
	Topography & Drainage		4	3
	Surface runoff		3	3
	Surface water pollution		2	4
	Wind direction		4	2
	Sub-total (%)		**13**	**12**
	Weighted Sum		***2.0***	***1.8***
V	**ENVIRONMENT**	**20**		
	Using the site after closure		3	1
	Land improvement		3	1
	Effect on flora & fauna		4	1
	Odour & Nuisance		4	1
	Sub-total (%)		**14**	**4**
	Weighted Sum		***2.8***	***0.8***
VI	**PROPOSED LANDFILL CAPACITY**	**20**		
	Initial capacity		4	2
	Possible extension		4	1
	Sub-total (%)		**8**	**2**
	Weighted Sum		***1.6***	***0.6***
TOTAL Weighted Sum			**13.1**	**11.5**
RANK			**1st**	**2nd**

Conclusion

The overall objective of the ESIA is to provide sufficient information to enable informed decision-making by the authorities. This is done by assessing the impacts identified in the ESIA Phase and identifying possible mitigation measures for each of the identified impacts.

A comprehensive public participation process was undertaken during the ESIA phase, which has included availability of reports for review and meetings. During the ESIA phase, studies were conducted on the air quality, traffic and social impacts, visual impacts, geotechnical impacts, ground and surface water impacts, and heritage impacts associated with the proposed expansion. The specialist studies did not identify any environmental fatal flaws and provided a range of mitigation measures for implementation.

The potential impacts associated with the development of the proposed Sofi Landfill Site have been assessed and the significance of these potential impacts evaluated with consideration of proposed mitigation measures. The majority of the potential impacts identified are considered to be of low significance. In order to secure waste disposal facilities in both and short, medium and long term and both the proposed Sofi and Muti landfill sites were investigated for final approval.

As per the detailed social, environmental and other criteria the Sofi site is chosen in the first rank. Based on the information collected and assessed in this ESIA, it is concluded that the proposed site is suitable landfill development.

1. Introduction

1.1. Background to the ESIA Study

Waste generation increases with population expansion and economic development. Improperly managed solid waste poses a risk to human health and the environment. Uncontrolled dumping and improper waste handling causes a variety of problems, including contaminating water, attracting insects and rodents, and increasing flooding due to blocked drainage canals or gullies. In addition, it may result in safety hazards from fires or explosions. Improper waste management also increases greenhouse gas (GHG) emissions, which contribute to climate change. Planning for and implementing a comprehensive program for waste collection, transport, and disposal along with activities to prevent or recycle waste can eliminate these problems.

Integrated Solid Waste Management (ISWM) is a comprehensive waste prevention, recycling, composting, and disposal program. An effective ISWM system considers how to prevent, recycle, and manage solid waste in ways that most effectively protect human health and the environment. ISWM involves evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities for those conditions. The major ISWM activities are waste prevention, recycling and composting, and combustion and disposal in properly designed, constructed, and managed landfills. Each of these activities requires careful planning, financing, collection, and transport.

Figure 1. Integrated solid waste management model diagram

Urbanization is now becoming a global phenomenon, but its ramifications are more pronounced in developing countries. High rate of population growth, declining opportunities in rural areas and shift from stagnant and low paying agriculture sector to more paying urban occupations, largely contribute to urbanization. The unexpected immigration has also caused the burgeoning of slums and the growth of squatters and informal housing all around the rapidly expanding cities of the developing world. In many cites the rapid population growth has overwhelmed the capacity of municipal authorities to provide even basic services. Urbanization directly contributes to waste generation, and unscientific waste handling causes health hazards and urban environment degradation (Vij, 2012).

Solid Waste Management which is already a mammoth task in Harar is going to be more complicated with the increase in urbanization, changing lifestyles and increase in consumerism. Financial constraints, institutional weaknesses, improper choice of technology

and public apathy towards Municipal Solid Waste (MSW) have made this situation worse. The current practices of the uncontrolled dumping of waste on the outskirts of towns/cities have created a serious environmental and public health problem

In some parts of the Town, the solid waste collection process is aggravated due to the problem of inadequate road infrastructure for the passage of waste collection vehicles, making formal collection services physically impossible to provide. On the other hand, shortage of containers, poor access to some parts of the Town, lack of proper and suitable vacant site for placing containers is the major problems. These made the resident of the Town to dump significant portion of the waste into streams, empty sites, road drains and roadsides. Uncollected solid wastes have been observed accumulating on streets corners, drain ditches, under bridges and become nuisance, sometimes to the point of actually blocking roads.

The involvement of private sector or micro-enterprises is minimal and collection of waste from low-income and squatter settlements is often nonexistent because of community and organizational setup.

1.2. Objective of the ESIA Study

Since the 1950s, growing environmental awareness is increasingly focussing attention upon the interactions between development actions and their environmental consequences. In developed countries this has led to the public demanding that environmental actors be explicitly considered in the decision-making process and a similar situation is now occurring in developing countries.

Early attempt at project assessment were crude and often based upon technical feasibility studies and const benefit analysis (CBA) which was developed as means of expressing all impacts in terms of resource costs valued in monetary terms. It has now evolved as a comprehensive approach to evaluation, in which social, environmental as well as economic and technical considerations are given their weight in the decision-making process.

Environmental and social Impact Assessment can be defined as a formal process used to predict the environmental and social consequences prior to any development project implementation. The ESIA process ensures that the potential problems are foreseen and addressed at an early stage in the projects planning and design. The objective of this ESIA process was to investigate and assess the suitability of the proposed Sofi woreda, Qalecho peasant association landfill site and provide decision makers with environmental and social setting. Briefly,

- To provide social and environmental background information of the proposed landfill site
- To identify actual and potential environmental and social impacts
- To propose mitigation measures
- To factors are considered in the decision-making process

1.3. Methodology of the ESIA Study

The environmental and social assessment process incorporates a number of key steps. The assessment process constitutes a systematic approach to the evaluation of the proposed project in the context of the natural, regulatory and socio-economic environments in which development is proposed.

Apart from obtaining environmental permits as required by law, any proposed project would also require “social license to operate” from the community where it will be situated. This is

seen to be a crucial element to ensure the successful implementation of any project. The methodology proposed was therefore focus on collecting date from the local people (focus group discussion, meetings), and site/field visit. Moreover, analyses of alternative sites and site selection for landfill construction, identification of possible impacts due to the project and proposals for mitigation of adverse impacts have been made.

2. Project Description

2.1. Project Location

The proposed Sanitary Land fill Project will be implemented in the Sofi woreda of Harari Regional State, in Kile Kebele. Kile Kebele is found at 522km distance from Addis Ababa. Kile Kebele is located at about 11km from Harar town at the south-east side, on Harar to Jijiga asphalt road and 1km far from the main asphalt road to east direction.

Currently the site is used as farmland by the local farmers and the site location, its topography and geology are found to be favorable for the proposed solid waste treatment plant project. In addition, no settlement is found in the proximity of the proposed site, but at far distances in about 2km in the adjacent and after buffer zone Qalecho depressed areas (valley), there are five household settlements are observed.

Kile solid waste management system consists of Sanitary landfill, leachate evaporation pond, inter-facility access road and other ancillary structures as solid waste management units. The sanitary landfill construction project will be lying on an area of 10 hectare.

The required landfill area is calculated on the assumption that all the waste generated during the design year will be collected and disposed on the landfill site. There is sufficient area for the facility for the entire design horizon. The life of the landfill assumed to use for two decays and could be further increased by applying waste minimization and alternative waste management systems discussed as integrated waste management systems.

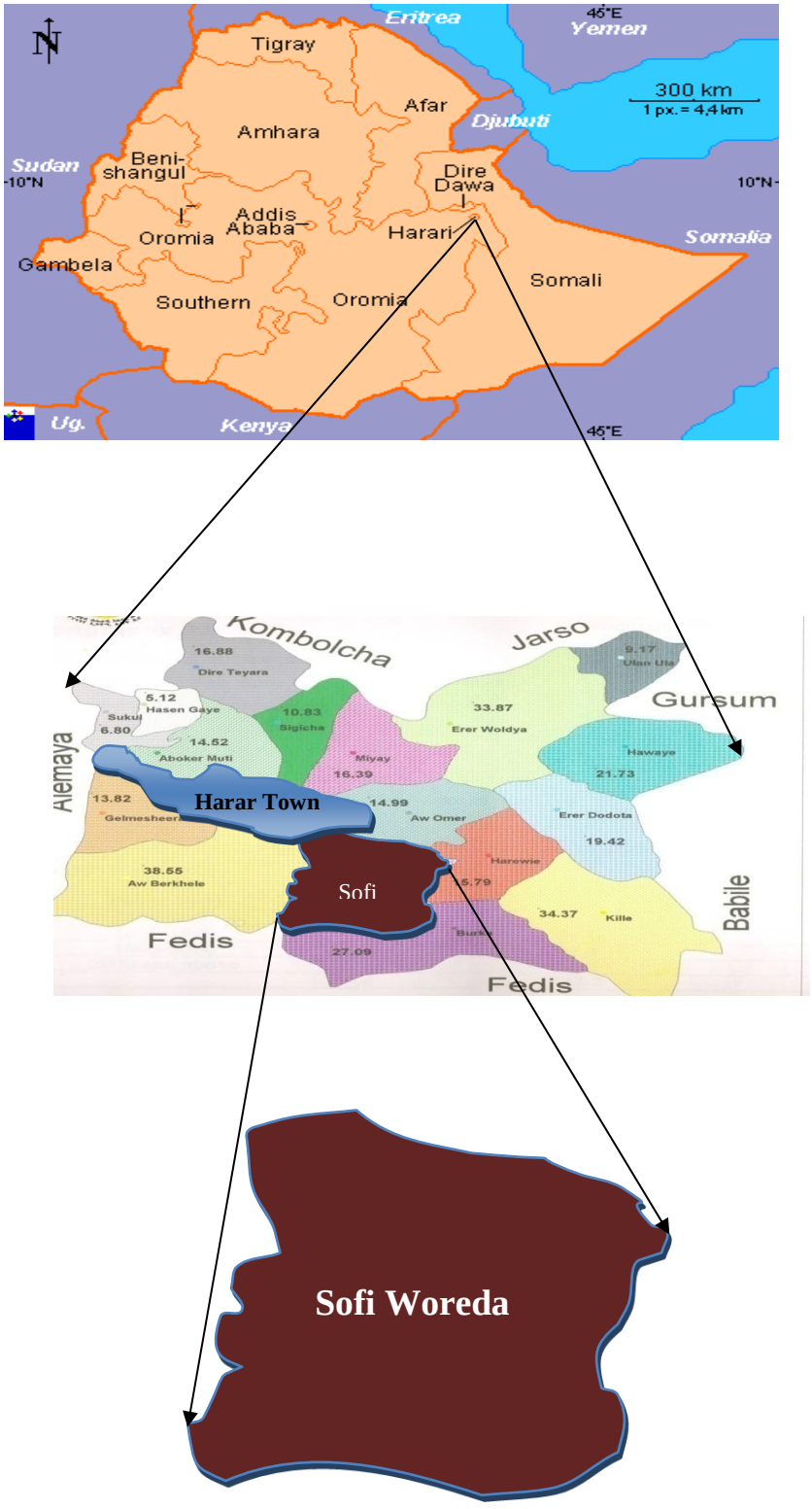


Figure 2: sofi woreda, Kile peasant association Location Map

2.2. Slope and Topography

The area of this site is approximately 300,000 m^2 with elevation difference from the gully to the main road being about 30 m. Further, the site is characterized by stepped landform in the east-west direction. The Jijiga-Harar road at the upper side of the site has currently has no side

drain, but it is assumed that it will be constructed by the ongoing road project to accommodate flood discharge as interceptor. Moreover the site is on the ridge where left and right natural drainage is conducive. However, if the depression site on the eastern side is used as a sanitary landfill there is a need to construct storm drainage canals to intercept the road drainage.

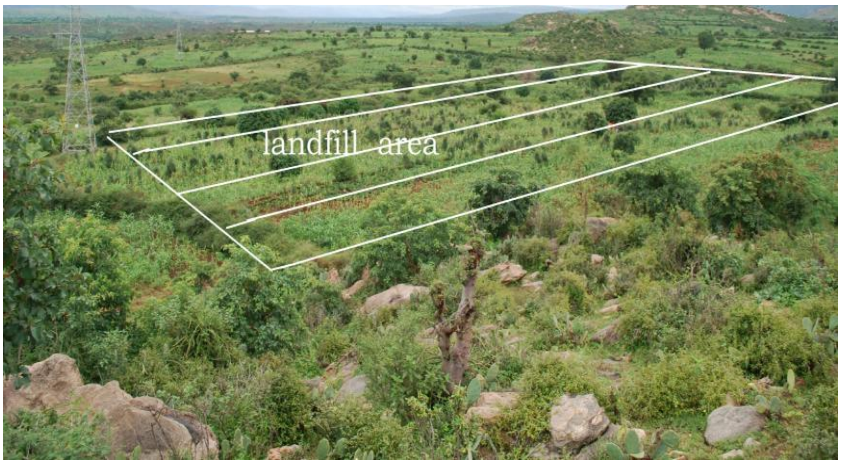


Figure 3. Kile Kebele project site

The area is free of any constructions and utilities except some electric poles which is located at the east border of the project site.

Figure 4. Facilities on site (electric power pole)

The site is located at about 5 km from centre of the town close to Jijiga road at UTM 187032 mE, 10227413 mN and elevation 1749 masl. The area of this site is approximately 10 hectare with elevation difference from the gully to the main road being about 30 m. Further; the site is characterized by stepped landform in the east-west direction with sandy soil cover with varying thickness. Previously the site was used to dump solid waste indiscriminately as evidenced by litters spread all around the area.

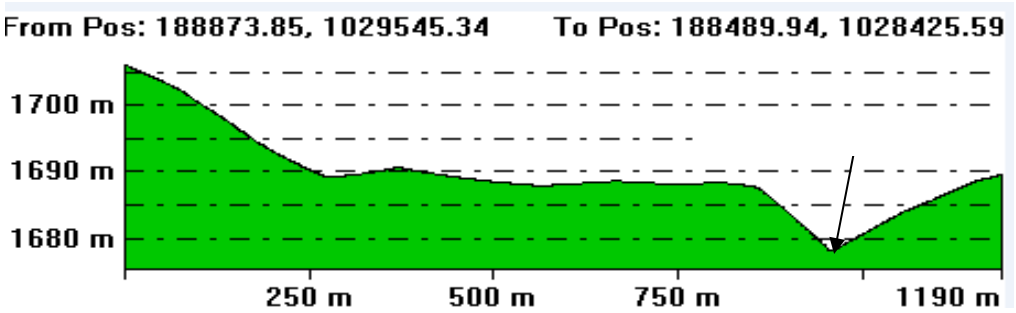


Figure 5. Morphology of Churchura area in the North – South direction

Figure 6. Qalacho valley on site that pass from west to south

2.3. Soil

The valley is characterized by 3m reddish sandy/gravely soil above the weathered metamorphic rock. The basement is fractured and weathered as observed in the gully downstream of the site. This weathered rock under the gravely sandy soil cover is highly porous.

The soil type of site mainly is sandy soil cover with varying thickness. Previously the site was used to dump solid waste indiscriminately as evidenced by litters spread all around the area. The road to Jijiga passes through the valley on the upper side of the site. But there is enough distance between the road and the actual landfill site.

Figure 7. The site with loose sandy soil bounded by hills in north-west side

2.4. Description of the Sanitary Landfill Project

2.4.1. Sanitary Landfill

Landfills are a mechanism for effectively treating and disposing of those wastes which, at the present time, it is neither technically feasible nor economically viable to avoid, re-use, recycle or reprocess (EPA, 2006). However, we have to ensure that this unavoidable waste disposal is conducted in an environmentally responsible way. This includes ensuring that existing and potential landfill occupiers are aware of the risks land filling poses to the quality of air, water, and land and community amenity. It also involves ensuring that these occupiers take responsibility for managing these risks in the most effective way possible, e.g. by encouraging stabilisation of land filled waste within one generation.

2.4.2. Leachate Management

Landfill leachate is generated from liquids existing in the waste as it enters a landfill or from rainwater that passes through the waste within the facility. The leachate consists of different organic and inorganic compounds that may be either dissolved or suspended. Part of landfill management requires collecting, containing and treating the leachate to protect surface and groundwater in areas near the landfill. In the design, a thick plastic layer forms a liner that pre-vents leachate from leaving the landfill and entering the environment. This geomem-brane is typically constructed of a special type of plastic called high-density polyeth-ylene or HDPE. Then, perforated pipes will be placed throughout the landfill to collect leachate. The leachate then drains into a pipe and afterward into a leachate collection pond. The pipes and containers that transport or hold leachate must be made of special materials that prevent leakage and hold up to the acidity of the liquid. The collection pond or lagoon having different compartment should be constructed to accommodate all the generated leachate in different seasons. Evaporation could be used as means of treatment and volume reduction. Finally, the water should be tested and it could be treated like any other sewage and discarded on-site or off-site.

2.4.3. Litters

The effect of wind can have on litter being blown around a landfill site would be controlled though daily operating procedures such as placing a daily comer of clean fill cover refuse, minimizing the working face at the site and placing litter control fences at the site. Staff would be involved in a clean-up in the event of sever winds.

2.4.4. Gas Management System

Landfill gas is produced from organic waste disposed of in landfill. The waste is covered and compressed mechanically and by the pressure of higher levels. As conditions become anaerobic the organic waste is broken down and landfill gas is produced. At the proposed landfill site, these gases would be handled though a venting system in accordance with the EPA guideline.

2.4.5. Ancillary Facilities

Guardhouse: - In order to keep the guard attendant on the site the guardhouse has to be constructed at the disposal site. A fulltime attendant must be needed to monitor the landfill site.

Roads: all weather access road as shown on the design drawing has to be constructed.

Surface water management: - Control of storm water runoff at landfill disposal facility is provided to minimize the potential of environmental damage due to storm water run-on and runoff.

2.4.6. Sanitary Landfill Operation

Techniques used at the working face of the landfill can help to reduce the amount of infiltration (that is, precipitation) into the landfill. Appropriately compacting and covering completed cells promotes reduced waste infiltration and increased run-off away from the active area. Good compaction of waste and daily cover materials reduces waste settlement, thus, reducing the potential for depressions in the active area.

Depressions can fill with water (pond) and allow precipitation to infiltrate directly into the waste mass. Temporary diversion berms can also be created near the working face to capture and direct surface water flow away from the active portions of the landfill. When depressions and ponding occur, particularly in intermediate and final cap areas, the water should be appropriately drained and the depression should be filled.

Compatibility:

Landfill disposal operations should be compatible with engineered structures and environmental control and monitoring systems, and should be consistent with the Site Development Plan and other aspects of facility operations.

Waste unloading

Develop waste unloading procedures for incoming vehicles and inspection procedures to identify and isolate prohibited or unacceptable wastes. The refuse vehicles are directed to the operations area for the day. Unloading must be confined to the smallest area possible in order to control birds, dust, and blowing litter. Specially trained site workers then check for hazardous or unpermitted wastes. If present, these wastes are safely removed for disposal at a facility approved for such wastes.

First layer of fill

Establish precautions to protect the geomembrane liner when the first layer of waste is placed and compacted in lined disposal areas. The first operations layer should be "select waste". “Select waste” includes household waste but not demolition or land-clearing debris or other materials that may damage the liner system.

Spreading and Compacting

Bulldozers quickly spread and compact the waste in layers of about 2 feet. This process eliminates voids where rodents might seek harbourage, and conserves valuable landfill volume. It is repeated until the compacted waste reaches a height of 8 to 10 feet.

Active face

Specify the nominal size of the active working face, and establish compatible waste unloading and filling procedures.

Consider the following in determining the size of the working face:

- The width of the working face should only be wide enough to accommodate waste unloading and compaction equipment operation
- The cell height and length should be selected based on the daily volume of refuse received
- Cell end slopes should be kept as steep as possible (20 to 30 degrees)

Compaction

Establish procedures for waste spreading and compaction including layer thickness, maximum lift height, daily cell configuration and slopes, compaction equipment and compactive effort (i.e., minimum number of compactor passes over each layer of waste), and the intended density of solid waste. It is recommended to be spread in thin (about 1-foot-thick) layers and compacted with 3 to 5 passes of the compactor on slopes of about 3 horizontal to 1 vertical. The most effective compaction occurs with the compactor operating on a level surface.

Daily cover

Place "daily cover" on all exposed solid waste at the end of each operating day, or more often if necessary to control problems such as fly propagation, blowing litter, vectors, and fires. Place at least six inches of earthen material on exposed solid waste at the end of each working day, unless alternative cover designs or procedures are approved by the Department.

Intermediate cover

Place "intermediate cover" on the top and side slopes of an advancing lift which will not receive additional waste for at least two months. Design the intermediate cover to control surface water infiltration, disease vectors, fires, odors, blowing litter and scavenging. Intermediate cover should consist of at least one foot of compacted low-permeability soil. A geomembrane cover may also be required in areas where average annual rainfall exceeds 25 inches.

Interim cover

Place “interim cover” on segments of the landfill that reach final elevations before final cover installation. During the rainy season, place interim cover immediately after a cell reaches final elevations.

Nuisance Control

During all of these steps, site workers in water trucks spray the interior roads and operations areas to control dust. Wires are strung between high poles to discourage birds. Earthen sound barriers are used to control noise.

Surveying

This is done to ensure proper surface drainage and slope stability, to measure in-place volumes and densities of the wastes, and to control the height and extent of the fill area.

Materials Recovery

Many landfills salvage wood, metal objects, broken paving, and green wastes. Some landfills are operated in conjunction with a materials recovery facility for recycling glass, paper, plastics, aluminum, and other materials. Unauthorized salvaging, or scavenging, is strictly prohibited.

Site Security

A security fence or topographic barrier must be maintained around the perimeter of the site to prevent unauthorized entry.

Supervision

All site operations must be supervised by qualified personnel trained in safety, health, environmental controls, and emergency procedures. During all of these steps, site workers in water trucks spray the interior roads and operations areas to control dust. Wires are strung between high poles to discourage birds. Earthen sound barriers are used to control noise.

3. Policy, Legislative and Institutional Framework

3.1. Policy Framework

Projects to be implemented under the (Urban Local Government Development Plan (ULGDP) should adhere to acceptable environmental and social safeguards. The projects should, as far as possible with the objective of harmonizing sustainable management of natural resources and development without harming the environment. All development policies, programmes and projects take environmental considerations into account.

The aspect of waste management through a sustainable approach is one of the categories of development issues. The policy recommends the need for enhanced re-use/recycling of residues including waste water, use of low non-waste technologies (e.g. landfills as opposed to landfill), increased public awareness, and use of waste disposal facilities and appreciation of clean environment. It also encourages participation of stakeholders in the management of wastes within their localities.

The governments new long term national planning strategy, focus on equitable social development in a clean and secure environment, among other issues. The issues of sustainable waste management in this planning strategy have also been emphasized.

3.1.1Conservation Strategy of Ethiopia

The Conservation Strategy of Ethiopia (CSE) was launched in 1989. Its aim was to study the natural resources, environmental imperatives and development demands in the country and to harmonize them. The harmonization process was to be activated through the formulation of an appropriate environmental policy, which was it to be translated into action through the development of laws and the setting of standards on the one hand, and through the development of action plans and their implementation on the other, as well as through environmental education and awareness-raising. The Environmental Policy, which impinges on all sectors of development and all sections of society, was approved in 1997, the laws are being drafted and the standards are being set.

3.1.2. Environmental Policy of Ethiopia

The overall policy goal is to improve and enhance the health and quality of life of all Ethiopians and to promote sustainable social and economic development through the sound management and use of natural, human-made and cultural resources and the environment as a whole so as to meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

3.1.3. National water and Sanitation Polices and Legislatives

The geographical location of Ethiopia and its endowment with favourable climate provides a relatively higher amount of rainfall in the region. Much of the water, however, flows across the borders being carried away by the Tran boundary rivers to the neighbouring countries. Although we cannot be definite due to lack of researched data as yet, preliminary studies and professional estimates indicate that the country has an annual surface runoff of close to 122 billion cubic meters of water excluding ground water.

It has become necessary to issue a water resources management, protection and utilization proclamation to put the water resources of Ethiopia to the highest social and economic benefit for its people through appropriate protection and due management.

Ethiopian Water Resources Management Policy (EWRMP),1997 deals with the general water resources management policy and different sub sectoral issues; Water supply and sanitation , irrigation development, & hydropower. The policy, under section - 2.2.2 discusses the issue of environment, water shade management and water resources protection and conservation issues.

The policy discusses the sanitation policy under the water supply and sanitation sub sector. The policy among other issues emphasizes the adoption and promotion of affordable and culturally acceptable low cost sanitation technology options, setting of frameworks, coordination of efforts and encouraging involvement of stakeholders both government and non government institutions, the integration of water supply and sanitation, need for setting frame works affirming the inseparable nature of water supply and sanitation activities and need for decentralized approaches for sanitation projects implementation and management are some of the guiding principles indicated in the policy.

3.1.4. The Health Policy of Ethiopia

The government of Ethiopia issued its health policy in 1993, which emphasizes the importance of achieving access to a basic package of quality primary health care services by all segments of the population, using the decentralized state of governance. The health policy stipulates that the health services should include preventive, promotive and curative components.

In order to achieve the goals of the health policy, a twenty-year health sector development strategy has been formulated, which is being implemented through a series of five-year plans. The implementation of the first health sector development program (HSDP) was launched in 1997, and now the second HSDP is under way. The main trust of the HSDP implementation is based on sector-wide approach, encompassing the following eight components:

- Service delivery and quality of care
- Health facility rehabilitation and expansion
- Human resource development
- Pharmaceutical services
- Information, education and communication
- Health sector management and management of information systems
- Monitoring and evaluation
- Health care financing

3.1.5. National Hygiene and Sanitation Strategy for Ethiopia

This National Strategy for Improved Hygiene and Sanitation has been developed to complement the existing health policy (developed by the MoH) and the national water sector strategy (developed by the Ministry of Water Resources) in placing greater emphasis on 'on-site' hygiene and sanitation. The primary focus is on blocking faeces from entering the living environment through the safe management of faeces, hand washing at critical times and the safe water chain from source to mouth. It places responsibility for improving 'on-site' household hygiene and sanitation firmly in the hands of the household with the direct support of the health extension worker and other resources at community level. The strategy is harmonised with the Health Sector Development Programme which places a strong focus on high impact, broad reach, and public health interventions.

This improved sanitation and hygiene strategy is a 'living' document which has been developed through consultation with the Ministries of Health, Water Resources, Education, Agriculture and the Environmental Protection Agency as well as Regional Health, Water and

Education Bureaus, donors and NGOs. The document is designed to bring together policy guidelines and lessons learnt to help forge consensus among the many stakeholders on the development of a 'road map' which will lead to 100% adoption of improved sanitation and hygiene in Ethiopia.

A considerable amount of urban solid waste is contaminated with human and animal faeces making safe disposal and management an important domestic priority in rural areas, and a civic or communal responsibility in towns.

Sanitation Benefits

There are many convincing arguments which support the benefits of improving sanitation.

Political

Women stand most to gain from sanitation and represent 50 percent of the electorate. This means that there are potential votes in sanitation

Socio-economic

- Savings on cost of treating sickness (diarrhoea).
- Reduced days lost being sick, caring for the sick, visiting health facilities.
- Increased earnings potential.

Educational

- Less diarrhoea and better nutrition equals improved intellectual development.
- Girl child school attendance is enhanced by access to safe, private, convenient, hygienic latrines with hand washing facilities
- Girl child school attendance is increased because they spend less time caring for sick siblings.

3.2. World Bank Safe Guard Policies

Environmental Assessment is one of the 10 environmental, social, and legal Safeguard Policies of the World Bank. Environmental Assessment is used in the World Bank to identify, avoid, and mitigate the potential negative environmental impacts associated with Bank lending operations.

In World Bank operations, the purpose of Environmental Assessment is to improve decision making, to ensure that project options under consideration are sound and sustainable, and that potentially affected people have been properly consulted.

The World Bank's environmental assessment policy and recommended processing are described in Operational Policy (OP)/Bank Procedure (BP) 4.01: Environmental Assessment. This policy is triggered to prepare environmental impact assessment for the sanitary landfill.

3.3. Legal Frameworks

3.3.1. Establishment of Environmental Protection Organs (Proclamation No. 295/2002)

In response to the requirements of the Constitution, Environmental Protection Authority (EPA) was established by Proclamation No 295/2002, provided for the establishment of environmental protection organs. As one of its first responsibilities, the EPA developed the

Environmental Policy of Ethiopia (EPE) that was adopted in April 1997, which provides sectoral and cross-sectoral environmental policies and affirms the need to ensure sustainable use and management of environmental resources and the wise use of non-renewable resources.

The commitment of FDRE for the sustainability of the environment is clearly shown by its Constitution. The Federal constitution of 1995 sets out important articles related to Development and Environmental rights, Article 43 and Article 44 discus the right to development and about environmental rights it stated that "all persons have the right to a clean environment." Moreover, it indicates that "all persons who have been displaced or whose livelihoods have been adversely affected as a result of state programs have the right to commensurate monetary or alternative means of compensation, including relocation with adequate state assistance."

In addition, in Article 92; Environmental objectives are identified as Government shall endeavour to ensure that all Ethiopians live in a clean and healthy environment. The design and implementation of programs shall not damage or destroy the environment. People have the right to full consultation and to the expression of their views in the planning and implementation of environmental policies and projects that affect them directly and then government and citizens shall have the duty to protect the environment

3.3.2. Environmental Impact Assessment (Proclamation No. 299/2002)

Environmental Impact Assessment proclamation No. 299/2002 is promulgated in December 2002. The primary objectives are to make ESIA mandatory for defined categories of activities undertaken either by the public or private sector. The proclamation under its General provision Article-3 sub Article 1 states that without authorisation from the Authority (EPA) or from the revenant regional environmental agency, no person shall commence implementation of any project that requires environmental impact assessment as determined in a directive issued pursuant to this proclamation.

Article-5 describes that projects requiring environmental impact assessment and directive provided under sub-article-1 of Article 6 should among other things, determine categories of:

(a.) Project not likely to have negative impacts and so do not require ESIA;

(b.) Projects likely have negative impacts and thus require environmental impact assessment

3.3.3. Environmental Pollution Control (Proclamation No. 300/2002)

Environmental pollution control proclamation No 300/2002 has been promulgated in December 2002. The proclamation under Chapter 2 describes control of pollution, management of municipal wastes, and management of hazardous wastes and under its chapter-three it discusses environmental standards and other relevant issues there off,

3.3.4. Solid Waste Management Proclamation No. 513/2007

Solid Waste Management Proclamation: Regarding solid waste handling Solid Waste Management Proclamation No. 513/2007 has been proclaimed in February 2007 with the objective of enhancing at all levels and capacities to prevent the possible adverse impacts while creating economically and socially beneficial assets out of solid waste. It describes the obligation of urban administrations in solid waste management.

3.3.5. Regional Level Proclamation and Regulations

Harari Regional State established Environmental Protection Authority of the state by Proclamation No. 67/2007 to ensuring the effectiveness of the process of the implementation of federal and regional environmental policies, strategies, regulations and standards which foster socials and economic development in a manner that enhances the welfare of residents and the safety of the environment sustainably.

3.4. Institutional Set Up

For the purpose of implementing the environmental regulation of the country there are responsible offices to guide and monitor the process at both federal and regional levels.

3.4.1. Federal Environmental protection Authority (EPA)

The EPA was established under proclamation No. 295/2002 with the responsibilities of environmental development and management as well as environmental protection. The proclamation states that EPA shall prepare directives and systems necessary for evaluating the impact or social and economic development projects on the environment follow up and supervise their implementation.

3.4.2. Environmental Protection Authority of Harari Region

According the federal regulations, regional Environmental Authorities are being organized to deal with their share of responsibilities at regional level. Accordingly Harari Regional State has established its Environmental Protection Authority (Proclamation No.67/2007) stating its responsibility and authority to lead the implementation of federal and regional policies and regulations to protect the environment and enhance sustainable development.

4. Baseline Environmental Conditions

4.1. Bio-Physical Environment

4.1.1. Location

The Town of Harar is the capital of Harari People National Regional State and is located in eastern part of Ethiopia and lies on in the south-western part of the region just off the southern edge of the south-eastern plateau dividing the Great Rift Valley from the plains of the Ogaden lowlands. Harar is one of the oldest towns in East Africa with two main parts; the old Town of Jegol encircled with the external wall constructed around the 16th century and the town outside the fence, which has been developing since late 19th century. Harar is the administrative and commercial capital of the region and covers about 1,950 hectares of land. The proposed landfill site is located 5km from the center of the Harar town in the south-east direction which covers 10 hectare of land.

4.1.2. Topography

Project site, Kile, is bounded by a series of mountain ridges on western and northwestern and relatively flatter hills at eastern side. The site is located in relatively flat topography. Generally, the topographic feature of the project site makes the surrounding mountains drain towards the age of the site. But, the place has no perennial river. The main drainage line starts at north-western mountain ridge towards the southeast direction.

4.1.3. Climate

Precipitation

From weather stations located in Harar and Babile, the monthly average rainfall data for the two stations show records of very high rainfall in few years. As a result of this, the annual rainfall variation was low with a coefficient of variation of 28.4% for Harar and 29% for Babile. The mean annual rainfall for Harar and Babile from 1967 to 2000 is 724.4 mm and 779.9 mm respectively.

Rainfall is characterized by its intensity and duration. High rainfall intensity and short duration creates quick response, but flow also decreases very rapidly in its recession time.

Table 3. Monthly Rainfall and Mean Annual Rainfall

Station	Record Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Harar	1967-2000	12.8	22.4	57.1	117.3	94.8	61.4	90.7	107.9	92.6	43.1	15.5	8.8	724.4
Babile	1967-2000	17.9	21.3	56.7	108.8	104.3	77.9	88.3	111.1	108.2	66.5	8.1	10.7	779.9

The above table shows that the project area like in any tropical country sustains considerable variations in rainfall. It not only varies from month to month, but rainfall in a particular month may be different in different years.

The average annual rainfall of Harar and Babile area is 724.4 mm and 779.9 mm respectively. In all the stations above 65% of the Mean Annual Rainfall occurs during the two rainy seasons. The rest 35% is distributed in the 7 months long dry season. Figure 1-1 shows the mean monthly rainfall at the 2 stations. The symmetry of the shape of the monthly rainfall

distribution at all the stations is identical. The monthly total rainfall recorded from 1967-2000 for both stations is attached as Annex 1.

Generally, the Climate of Harar Town and its surroundings have moderate climatic condition and experiences two distinct wet and dry seasons. As per the study report of the regions potential resources the rainfall in the region has a weak bi-modal pattern with first peak in April-May and the second and main peak occurring in July – August, and the mean annual rainfall varies from about 650 to 1000 mm.

The Town of Harar and the region as a whole is the upper part of the water shed of the Wabi Sheble River Basin and drains towards the south direction. The river basins in the region, Hamaresa, Bisidimo and Erer Rivers flow from north to southward direction following the general slope of the region and drain to the Wabi Sheble River which flows southeast direction of the country.

Wind Speed and direction

Wind speed describes how fast the air is moving past a certain point and Wind direction describes the direction on a compass from which the wind emanates. The annual average wind speed Harar town is 1 m/s with the highest value of 2.1 m/s in February 1985 and 1.9 m/s in January. The minimum wind speed has been recorded in October (0.4 m/s) 1999. The monthly variation of wind speed is shown in the table 3-7 below.

According to the Regions Potential Recourses Study Report, 2006, wind direction, southeast, northeast, and northwest wind, account for about 20.5 %, 19.7% and 19.1% of all observations, respectively. Easterly winds are the most prevailing winds, in the Town. Therefore, highly pollutant urban activities in terms of smoke, dust particles and stench smells are recommended to be located opposite to the prevailing wind direction. However, non-pollutant activities that can be easily protected by simple mechanisms such as buffer zone can be located in all parts of the Town if they would be compatible with other urban functions.

Table 4. Wind Speed m/s, at Harar Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1982	1.2	1.2	1.5	x	x	x	x	0.7	0.8	0.8	0.9	1.3	**1.1**
1983	1.5	1.1	1.3	1.0	0.8	0.8	0.7	0.7	0.7	0.8	1.1	1.6	**1.0**
1984	1.9	1.6	1.3	1.2	0.9	0.9	0.9	0.8	0.7	0.8	1.0	1.4	**1.1**
1985	1.3	2.1	1.3	1.0	0.9	0.9	0.8	0.8	0.8	0.8	1.0	1.2	**1.1**
1986	1.8	1.1	1.3	0.9	0.8	0.8	0.8	0.8	0.7	0.8	1.1	1.6	**1.0**
1987	1.7	1.2	1.0	x	0.8	0.8	0.9	0.8	0.6	0.6	x	1.2	**1.0**
1988	1.8	1.0	1.3	0.9	0.9	0.8	0.6	0.7	0.7	0.7	x	x	**0.9**
1999	0.9	0.8	0.7	0.7	0.7	0.7	0.5	0.5	0.5	0.4	0.7	0.7	**0.7**
Mean	**1.5**	**1.3**	**1.2**	**1.0**	**0.8**	**0.8**	**0.7**	**0.7**	**0.7**	**0.7**	**1.0**	**1.3**	**1.0**

Temperature

The average annual maximum and minimum temperatures are 20.68^0C and 18.55^0C respectively. The average monthly maximum and minimum temperatures are shown in table below.

Table 5. Average monthly maximum and minimum temperatures (0C)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Aver
$T_{min}{}^0C$	12.91	13.62	14.24	14.19	14.09	13.64	14.08	13.28	13.14	12.58	12.72	12.55	**12.91**
$T_{max}{}^0C$	25.52	26.38	26.97	25.63	25.82	25.25	24.65	24.05	24.40	25.79	26.12	25.27	**25.52**

4.1.4. Geology and soils

Various construction activities i.e. excavations and earth grading will be undertaken. Depending on location, this may encourage soil erosion, soil compaction, chemical soil pollution and soil degradation. These impacts will be localized as the activities will occur on a footprint or on the development boundaries and also where access roads will be constructed. The selected site does not exhibit fatal flaws in so far as unstable areas, steep slopes, shallow bedrock or pans and vleis are concerned as per the findings of the geotechnical assessment.

Suitability for extension

The possibility exists that land may be required to increase the capacity of the landfill in the future. Ideally this expansion should take place adjacent to the existing facility since the infrastructure such as roads, weigh bridges and offices will be in place. So, this site is therefore the more preferable for future expansion relative to other alternative sites.

State of the site

This reflects the degree of disturbance to which the site has been subjected to in the past. This site is have been extensively disturbed and ideally development on a disturbed site is preferable to that on an undisturbed site.

4.1.5. Soil depth

This refers to the thickness of soil available for use as cover material during operations and at closure. Ideally the landfill should not be placed within a depression or an excavation lower that the surrounding ground, since water can collect in it. This situation arises when the cover material is excavated from beneath the foot print of the landfill. The optimal sitting of the facility is therefore at ground level and sourcing the cover material from a nearby location. Therefore, Sand soils of alluvium type are available in Kile. According to the configuration of the site, alluvium with rather good characteristics is found.

In-situ permeability

As the soil cover is thin especially on the flat areas of the site and the groundwater of the alluvial aquifer at the site is in an unconfined condition, it requires that clay cover be applied to protect the groundwater contamination. Therefore, a one meter silt/clay composed material has to be implemented in order to lead contaminant flow toward lagoons. Therefore, this site is more vulnerable to pollution of underground water resources.

4.1.6. Ground Water

Harar is located at the beginning part of Bisidimo-Erer River Basin and the major part of the City is comprised of metamorphic rock and with some limestone rock and localized sediments in the valleys and depression. The general rugged topography and relatively thin sediment cover and poor geometry for storing water, confined to the potential subsurface sources to localized sediment and weathered zone (saprolith) of the metamorphic rock. In the proposed landfill area, there are no boreholes or hand dug wells.

Landfills are required to have clay or synthetic liners and leachate (liquid from a landfill containing contaminants) collection systems to protect ground water and ground waters should be at least 1.5 meters below the proposed base of any excavation or site preparation to enable and fill cell development. Field geological observation has shown that two major unit: underneath granitic rock is low or no groundwater potential due to the massive nature of the rock and the thin upper alluvial deposit have sandy silt nature and it is moderate aquifer, but no indication for the shallow groundwater. The expected aquifer for Sofi woreda, Kile Kebele is alluvial deposit along the valley. This is evidenced from the river side chirosh/seepages, which are being exploited by the local people through hand dug wells.

4.1.7. Land Use in the Area

Agriculture is the main source of income for the community. Trees like mango, which is the major sources of household income, acacia, junipers, lemon, and angora are also grown limited number of households. Sorghum, maize, ground nut are the major crops grown in the area. As per the site survey and observations made on the proposed sanitary landfill site chat is growing in some of the plots and it constitutes as a major source of income to some households. Accordingly, compensation was paid for the loss of property and livelihood of the affected community.

The survey result revealed that basic social facilities like potable water; school, health, telephone, access road etc are not available within the proposed site.

4.1.8. Local Flora and Fauna

An observation based biodiversity assessment was made in the site proposed for the landfill. The area proposed for the landfill site has not been identified as an area of significant sensitivity. No threatened, near threatened or any rare and declining species as identified to occur on the study site. There are no sensitive bird species that would occur in the vicinity of each of the site. Most of the immediate habitat surrounding the proposed development is vacated. No drainage lines transverses the site and does not pose any significant risk in terms of potential impacts during construction and operational phases to surface water resources and wetland ecosystems.

Therefore, conservational issue is insignificant and the project can have minimal impact on local fauna and flora.

4.1.9. Water Supply

In the region there are a number of small streams and three rivers. The three rivers (Hamaresa, Bisidimo and Erer rivers together with streams flow to Wabe Shebelle river in Somali region. The above stated water resources and various springs were used to provide the region with considerable amount of water for domestic use and even for irrigation purposes. Due to various environmental problems climatic change some streams and springs were dried, while the volume of the existing small streams and river as well as the discharge rate of springs have been decreasing from time to time. leave alone for other purposes water resource for basic use (domestic consumption) have been a critical issue both in urban and rural area of the region since adduced. (Specially Harar town is suffering a lot for the last 2 deceased due to drying of Haromaya Lake, between of high temperature and erosion, that were serving as a source of drinking water. According to the recent data, water supply coverage of urban and rural area of the region is 25 and 56 percents respectively. The source of drinking water 73.3% is safe water and 26.6% unsafe water. All kinds of traditional and few developed water supply source are

being used by people. Currently, the town is getting its water supply from deep ground water of Dire-Dawa town and problem of water is seams partially resolved.

4.2. Socio Economic Condition

4.2.1. Population and Settlements

Administratively; Harari people's regional state divided in six urban and three rural administrative waredas (main kebeles). These administrative kebeles are further divided into 19 sub-kebeles (inurbane) and 17 sub-kebeles (in rural). The region is mainly categorized in two agro-ecological zones. 90% of the land area of the region is estimated to be mid-high land (weyna dega), between 1400-2200 meter above sea level, while the remaining 10% is kola (approximately found below 1500 meter above sea level). The settlement pattern of the region is different from other regions of the country where 62% of the population reside in urban area. According to information from the local community and during the field visit, the current population of Kile site is estimated at 30 people (in 5 households). The livelihood of the population is basically depending on farming.

4.2.2. Health

The town might be one of the oldest towns to have a health facility starting 1894 E.C. In 1997 E.C public hospitals alone have the capacity to provide service for 656 inpatients. The health sector has 309 medical staffs in1997 (E.C) of which 180 men and 129 female. According to the 1997 (2004/05) health related indicators, the region has 3 health centers, 5 hospitals, 20 health posts, 23 clinics, 4 pharmacies, 13 drug shops and 3 Rural Drug Vendors. The health institutions are equipped with 656 beds (2004/05) and more than 300 qualified staff.

The predominant top thirteen diseases of the region are shown in Table 2-5. As it has been shown in the table in the last twelve years acute upper respiratory, pneumonia, malaria and gastro-enteritis, intestinal infection, dysentery and infection of skin & subcutaneous Tissue are among the thirteen top diseases that affect the people of Harar and surrounding. Though difficult to quantify exactly, the magnitude of the problem seems high and there is an indication that associate the cause with waste management. The offensive smell of some place, mismanaged liquid and solid waste along the open ditches and waste bins could cause such disease.

Table 6. Harar Regional State 10 Top Diseases, 1987 - 1999 E.C

No	Type of Disease	1987-1996	1997-1999	Total	Relation with Sanitation
1	**Acute Upper Respiratory Infection**	46708	16813	63521	**Y**
2	**Pneumonia**	41305	12879	54184	**Y**
3	**Malaria**	37635	12897	50532	**Y**
4	**Urinary Tract Infection**	36680	13395	50075	X
5	**All forms of TB**	36090	7742	43832	X
6	**Gastro Enteritis**	32780	8661	41441	**Y**
7	**Accidental causes**	28401	9590	37991	X

8	**Intestinal Infection**	23502	0	23502	**Y**
9	**Parasitic Diseases**	21931	4061	25992	X
10	**Homicide & Injury**	13263	10045	23308	X
11	**Dysentery**	12268	3525	15793	**Y**
12	**Infection of Skin & Subcutaneous Tissue**	6831	3509	10340	**Y**
13	**Bronchial asthma**	2405	1802	4207	X

Source: Harari Health Bureau, 2008

In the last ten years due to design and implementation of different health policies and strategies that were resulted additional health institutions construction and increment of health professional for the sector the potential health coverage increased. The health service coverage of the region reached to 100% according to the federal ministry of standard even if the service quality, accessibility, availability and service utilization rate is in a questionable manner.

There is also a burden in the health sector due to high morbidity and mortality in the society which is related to different socio economic and cultural aspect of the community as well environmental risk factors affecting health. So it needs maximum effort to insure and keep those broader aspects of health to the people.

4.2.3. Education

According to the information from Harari Education Bureau currently, 2008, there are 16 private and public colleges, 1 Technical Vocational Training collage, One Preparatory School, 4 high schools (9-10), 56 (1-8) cycle schools and 33 kindergartens. There is also one high school (9-12 cycles), which is under SOS. Currently the education sector is relatively the biggest public sector by creating job for more than 1,600 people. Gross enrollment at primary (1-8) level of the region as reported by the Federal Ministry of Education in 2005/06 is 103.1% while the national average is 85.8%.

In 2010, 3015 students were put out of primary schools. As the prevalence of poverty become higher families have to use child labor for instance, in Sofi wereda most school age children are involving in smuggling baseness which causes additional problem to the existing rises in the region. In this area children are used as carrier of goods which enter in the region illegally from the neighboring countries. Regarding the education system in the project site there is no governmental and nongovernmental schools in and around the project site. As per the information from local community most students learn their education in the Harar city.

4.2.4. Existing Solid Waste Management Practice

The major sources of solid waste in Harar city could be categorized in to domestic, commercial, institutional, municipal and construction and demolition. The predominant quantities of wastes generated in the city are from domestic and commercial followed by others.

In Harar waste collection systems are not properly planned to effectively utilize available resources. It is estimated that about 38.8 tons of municipal waste per day or 14,162 tons per year is generated in 2008. Less than half of this gets collected and almost all of the collected waste is dumped haphazardly in a crude manner. The current solid waste collection practice

in Harar city includes communal containers, curb side truck collection and in some areas of the town door- to-door collection is used.

In Harar, the other major solid waste contribution comes from the streets and open markets of the City where different organic material like vegetables, fruits, chat etc. are generated daily in huge quantities. The Municipality commences a regular cleaning and collection of solid wastes from streets and open markets as one of its major activity of solid waste management. For this purpose, the municipality has hired around 135 street sweepers who are taking care of the main streets and open markets. They manually clean and transport the waste using wheel barrows to the nearby municipal container. This activity has generally contributed to keep the streets and open markets in good condition, but it is limited to the main streets only.

Presently, Harar municipality owns 3 containers hauling trucks and 1 manually loaded waste hauling truck for provision of transportation service of solid waste from the collection points to the disposal site. The waste hauling truck is old and requires frequent maintenance.

Solid waste collection containers in the city are not transported and emptied on a daily basis except from the market area. Unfortunately, this service is performed very inefficiently and in an unhygienic manner.

Solid waste collected from households & other sources is dumped on the open field on the east side of Jegol fence in Awmer peasant association. This resulted in unhygienic waste scattering all over the surrounding (especially non-biodegradable plastics, which are easy to be carried far away from the site by wind and pollute wider environment) and also producing bad smell, which is unhealthy.

Because no segregation of waste at its source takes place, domestic waste of all types, and even hazardous medical & industrial waste used to be disposed at the dumpsite that is actually designated for domestic waste. The solid waste is left uncovered to degrade under natural conditions. The sites generate leachate and thus pollute surrounding water bodies, contaminate the air with methane emissions and uncontrolled burning create serious health and environmental problems for the city as a whole and, more particularly, for the poor people living in the vicinity of the dumping ground.

4.2.4.1. Quantity of solid waste

Te survey has also made and assessment on the quantity and characteristics of solid waste generated in the town. The finding of the survey revealed that, about 57% of the sample households produced 5 – 10 kg of solid waste per week followed by 27% less than 5 kg and 16% greater than 10 kg. The survey data collected from kebeles inside and outside Jegol indicate that majority of the households in Jegol, 43%, and in kebeles outside Jegol, 65%, produced 5 – 10 kg of solid waste as shown in Table 4-1 below.

Table 7. Quantity of solid waste produced per week

Indicator	Solid waste in KG	Location				Kebele Category				Total	
		Jegol		Outside Jegol		High impact		Middle impact			
		%	No of HH	%	No of HH	%	No of HH	%	No of HH	%	No of HH
Solid waste produced per week	<5	34.2	137	23.3	157	27.7	178	26.8	116	27.3	294
	5-10	42.6	171	65.9	444	54.2	348	59.6	258	57.2	615
	>10	23.2	93	10.8	73	18.1	116	13.6	59	15.4	166
Group Total		100	401	100	674	100	642	100	433	100	1075

Source: Socio-economic Baseline Survey, Harar, MCE, 2008.

4.2.4.2. Generation rate of solid waste

As per findings of the survey, the total quantity of solid waste generated per week in the sample households is about 8,151 kg. Out of the total, 62.7% (5,107 kg) of solid waste is produced in kebeles outside Jegol while the remaining 37.3% (3,044 kg) has been generated in Jegol as indicted in Table 4-2.

Table 8. Total solid waste generated in the sample House holds

Category	Total (KG)	%
Jegol	3,044	37.3
Outside Jegol	5,107	62.7
Total	**8,151**	**100.0**
High impact	4,894	60.0
Middle impact	3,257	40.0
Total	**8,151**	**100.0**

Source: Socio-economic Baseline Survey, Harar, MCE, 2008.

Consequently, the average per capita solid waste generated per week and per day is calculated as 2.46 kg/capita/week and 0.35 kg/capita/day. The per capita weekly average generation of solid waste for Jegol and for kebeles outside Jegol is about 2.37 kg and 2.51 kg respectively and the average daily per capita is for Jegol and for kebeles outside Jegol around 0.34 kg and 0.36 kg, respectively as shown in Table 9.

Table 9. Per capita solid waste generated per week and per day ,kg

Solid waste generation	Location						Average, kg		
	Jegol			Outside Jegol					
	Max.	Mean	Min	Max.	Mean	Min	Max.	Mean	Min.
Per capita per week	13.00	2.37	.14	12.00	2.51	0.08	13.00	2.46	0.08
Per capita per day	1.86	0.34	.02	1.71	0.36	0.01	1.86	0.35	0.01

Source: Socio-economic Baseline Survey, Harar, MCE, 2008.

4.2.4.3. Type of solid waste

The type of solid waste generated by the households varies depending on their level of income and life style. A mixed waste items like food, chat residue, plastic, paper, ash and grass are mostly produced in residential areas. Accordingly, the survey result revealed that, ash is the dominant solid waste type, 24%, followed by plastic, 22.4%, paper 17.1% and residue of chat (geraba) 13%. The detail of the survey result in the sample households is presented in Table 4-4 below.

Table 10. Type of solid waste generated (%)

Type of solid waste	Location		Kebele Category		Average, %
	Jegol	Outside Jegol	High impact	Middle impact	
Food	10.4	10.5	10.7	10.0	10.4
Paper	17.3	17.5	17.6	16.0	17.1
Plastic	23.0	22.0	24.5	20.0	22.4
Texture	4.5	5.0	4.6	5.0	4.8

Wood	3.2	3.4	3.0	5.5	3.8
Grass	3.5	4.6	1.6	10.0	4.9
Residue of Chat	15.0	12.0	12.5	11.5	12.8
Ash	23.0	25.0	25.5	22.0	23.9
Total	100.0	100.0	100.0	100.0	100.0

Source: Socio-economic Baseline Survey, Harar, MCE, 2008.

As observed above, the community has followed a traditional way of managing solid waste that is burning which directly has an adverse impact on human health and the environment. Different studies shows that, a simple household solid waste burring (especially in urban areas) has produced a considerable harmful chemicals which causes heart/lung and respiratory and eye diseases. The problem has also become sever depending up on the level of exposure of a person.

4.2.4.4. Type of solid waste storage facility in the HH

The survey has assessed the type of storage facility used by the sample households before disposing the solid waste. As per the findings, about 77% of the community store in plastic bags, 17% in basket/carton and 6% use pit. The percentages of households that use plastic bag in Jegol and in kebeles outside Jegol are 80% and 76% respectively. The detail of the survey result is presented in Table 11.

Table 11. Type of solid waste storage facility in the sample households (%)

Type of solid waste storage facility	Location		Kebele category		Average, %	
	Jegol	Outside Jegol	High impact	Middle impact		
Plastic bag	79.8	75.5	79.4	73.7	77.1	77.1
Basket and Carton	6.5	5.2	5.6	5.8	5.7	5.7
Pit	13.7	19.3	15.0	20.6	17.2	17.2
Group Total	100	100	100	100	100	100

Source: Socio-economic Baseline Survey, Harar, MCE, 2008.

4.2.4.5. Method of solid waste disposal

Discussion outcomes and secondary data show that, the Municipality is providing containers at a designated collection point for disposal of solid waste. However, due to insufficient number of containers, inadequacy of community awareness and lack of organized collection system, indiscriminate dumping of solid waste into open field, on the road side and down into gullies are observed. The survey data disclosed that, about 47% of the sample households dump their solid waste at open field and in the surrounding gullies while 45% use municipal containers. The rest, 8% are disposing solid waste in ditches along the road. The detail of the survey result is shown in Table 12.

Table 12. Practice of solid waste disposal by HHs (%)

Practice of solid waste disposal by HHs	Category		Kebele category		Average, %
	Jegol	Outside Jegol	High impact	Middle impact	
Municipal container	60.6	35.9	54.7	30.9	45.1
Ditches along road	4.7	10.1	3.6	14.8	8.1
Open field and in the surrounding gullies	34.7	54.0	41.7	54.3	46.8
Group Total	100	100	100	100	100

Source: Socio-economic Baseline Survey, Harar, MCE, 2008.

The findings on Table 9-7 has also shown that, 61% of the sample household in Jegol kebele use solid waste containers as compared with 36% of the community in kebeles outside Jegol. This implies that, most of the households, 54%, in kebeles outside Jegol dump their solid waste at open field and in the surrounding gullies. Similarly, about 54% of the sample households in middle impact kebeles dispose their solid waste at open field and inside gorges relative to 42% in high impact kebele settlers. On the other hand, households who use municipal container in high impact kebele is on the higher side, 55%, as compared with 31 percent of the households in middle impact kebeles.

As per discussion and observation, solid waste containers in the middle impact kebeles are placed at a very wide interval and there are also some areas that are not provided solid waste container at all. This is mainly due to lack of access to the new settlement area of the town. The discussion held with the community has also indicated that, though the households claimed that they dispose the waste in to the containers, sometimes they cannot verify if the disposed waste is in to municipal containers since they are using laborers and children to dispose the waste.

5. Analyses of Alternatives

5.1. Assessment of proposed sanitary landfill sites

Proper landfill site selection is the fundamental step in sound waste disposal and the protection of the environment, public health and quality of life. Proper landfill site selection determines many of the subsequent steps in the landfill process, which, if properly implemented, should ensure against nuisances and adverse long-term effects(Ball, 2005). The inappropriate selection of a site can contribute to the bad image and reputation affecting landfill operations. Landfill site selection is a step-by-step process, in which environmental, engineering and economic criteria are applied successively. Environmental Impact Assessment (ESIA) constitutes the first and most crucial stage in this selection process, aiming to quantify the impacts according to the natural characteristics of the sites. A method is presented to facilitate the proper selection of a landfill site for municipal waste. The method follows specific principles, called "selection criteria", the aim of which are to compare the considered sites to a hypothetical "ideal one". As a result the more a site matches the ideal and fulfils the criteria requirements, the more suitable it is as a landfill site(Frantzis, 1993).

The selection of a site for developing a landfill is one of the most important decisions to be made by the municipality in developing and implementing its waste management plan. A poorly chosen site is likely to require unnecessarily high expenditure on waste transport, site development, site operations, or environmental protection. It may also cause long-term political problems from public opposition.

The existing master plan of the Town has not designated a site for solid waste disposal or sanitary landfill. Consequently, the Consultant team in consultation with the Client, particularly the Municipality, conducted exhaustive field visit to every corner of the Town including traditional waste disposal sites for the purpose of selecting the most appropriate sites for landfill development.

The sites assessed and evaluated for sanitary landfill are listed as follows

- Muti area
- Sofi area (Kile peasant association)

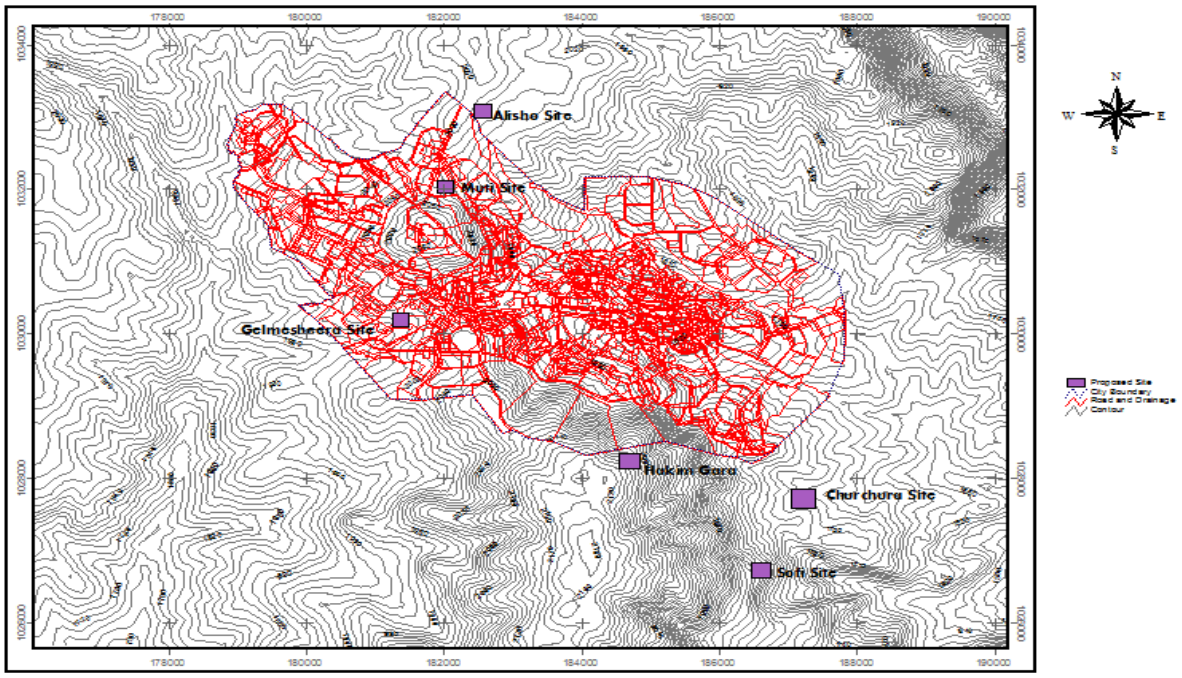
These sites have different geomrphological setup and geology varying from alluvium, colluviums and pediment deposition on the plain and sedimentary and metamorphic rock on the rugged part.

These sites were assessed at this preliminary phase with the objective in addressing issues, which will be related to the sanitary landfill development. The assessment gave stress on the following points.

- From the point of view of selecting the most degraded and area under no economic activity;
- From the perspective of optimizing site selection with rehabilitation of degraded area with the development of landfill site;
- From the point of view of enhancing the opportunity for minimizing land ownership and compensation issues;
- To adopt previous dumpsites and to incorporate Client’s interest on the assessment.

Repeated field visit and study was conducted to selecte environmentally, geographically, technically and economically most viable site for the solid waste disposal. The sites are discussed in the following sections.

Figure 8. Location map of prposed landfill sites for Harar



.

5.2. Assessment of Geology and Hydrogeology characteristics

5.2.1. Muti Area

Location and Topography

This site is located behind the Abubekher hill and on the way to Kombolcha at about 3.5 km from the center of the town. The location of the centre of the site is at about UTM coordinates of 181985 mE, 1032508 mN and altitude 2040 m amsl. This site covers approximately an area of 10 hectare. The geomorphology of the site is defined by gently sloping landform at the western face of Abubekehre hill draining to the easterly direction. The site is relatively gently sloping to the north and covered with eucalyptus trees and shrub. The longitudinal section and picture of the proposed landfill site at Muti is depicted in Figure 9-3 and Photo 11 below.

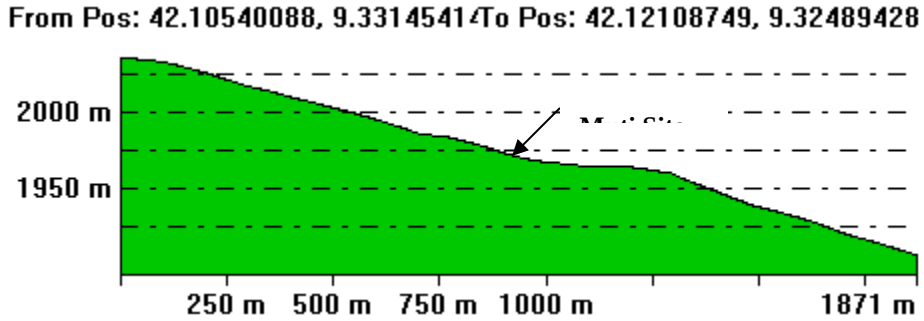


Figure 9. Gully development in Gelmesheera area (Digital Elevation Model (DEM) of N09°E042)

Figure 10. Partial view of the proposed landfill

Soils

The site is coverd with a reddish clay residual soil of thickness ranging from 2 to 4 meter above the weathered limestone, gypsum–marl interlayering as observed in the gulley close to the Harar - Kombolcha road left side.

Lithological study of the dry gullies close to the main Harar – Kombolcha road reveals that four layers define the ground stratification of the site. These are:

- Layer 1: Top soil
- Layer 2: Dark brown clay soil
- Layer 3: Residual red soil
- Layer 4: Limestone intercalated with marl, gypsum

The two prominent soil layers above the slightly fractured limestone are the dark brown clay and the residual red soil having nodular and uniform clay layers.

Groundwater Condition

The proposed landfill site is situated on an upland area that subsurface water storage is minimum. The site observation showed that its location is close to surface water divide. However, due to the weathered limestone under the clay soil, potential recharge into the subsoil is expected. Moreover, localized alluvial aquifers in the downstream areas where residents use the subsurface water through hand dug wells needs to be protected from pollution. Therefore it is important to check the insitu permeability of the soils on site. Detailed geo-technical investigation shall define the hydraulic properties of the soil underneath.

Surface Water Condition

As such no surface water sources are available at the site but Moqora River is downstream of the site. Interception of storm water from Abubeker hill is required to protect runoff entering the site. The area downstream of the site is gulley that feeds the Moqora drainage system. The watershed area should be protected from potential pollution that may arise from any leachate of the proposed landfill site.

Availability of Construction Material

The thick residual soil cover of the site is in abundant quantity for clay material for construction of embankments and clay lining. The limestone at the site can be used for construction stone. Sand may be imported from Bisidimo valley. The quality of the clay material as construction material shall be checked during the detail design phase.

Conclusion & Recommendation

Considering all the required design parameters the area is suitable for sanitary landfill site. Even though the area is included in the master plan of Harar town, currently it is under the adminstration of Tiyo Wereda Farmers Association and there is no urban infrastructure so far developed. Taking this fact into account the area has been considred for further evaluation as a sanitary landfill site.

5.2.2. Sofi Area

Location and Topography

The site is located at about 5 km from center of the town close to Jijiga road at UTM 187032 mE, 10227413 m N and elevation 1749 m. The area of this site is approximately 10 hectare with elevation difference from the gully to the main road being about 30 m. Further; the site is characterized by stepped landform in the east-west direction with sandy soil cover with varying thickness. Previously the site was used to dump solid waste indiscriminately as evidenced by litters spread all around the area.

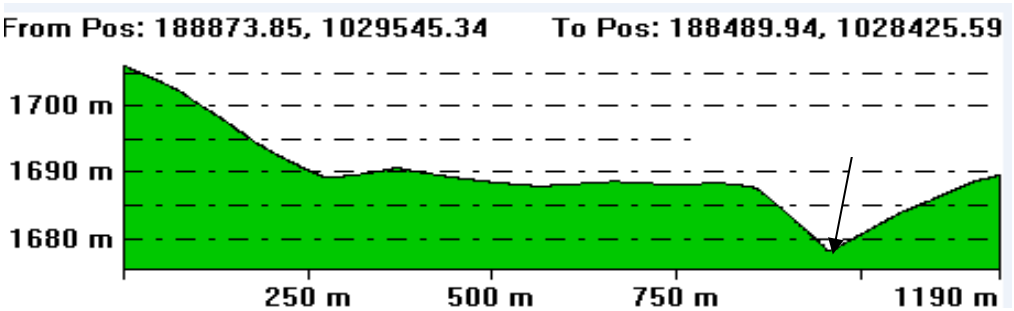


Figure 11. Morphology of kile area in the North – South direction

Figure 12. Partial view of the proposed landfill

Soil

The valley is characterized by 3 m reddish sandy/gravely soil above the weathered metamorphic rock. The basement is fractured and weathered as observed in the gully downstream of the site. This weathered rock under the gravely sandy soil cover is highly porous. The excavation depth and soil thickness at the treatment site will be investigated during the detail geo-technical phase of the project if this site is selected.

Groundwater Condition

Following the Churchura valley downstream of the proposed site a number of river bank chirosh/dug wells are developed as a traditional source used during the dry season.

Table 13. Summary of Chirosh/dug wells in Churchura valley

No	Site Name	UTM Coordinates	Geology	Abstraction of Water
1	Genda Kotay	187478 mE, 1027320 mN, 1721 amsl	Sandy soil of thickness 3m above weathered basement	Unprotected HDW

2	Negaadras-1	187798 mE, 1027268 mN, 1708 amsl	• 20cm top soil • 1.5 m brownish sandy soil • 1.5 m Decomposed basement	Unprotected HDW
3	Negaadras-2	187871 mE, 1027252 mN, 1701 amsl	Sandy soil of thickness 3m above weathered basement	Unprotected HDW, located at about 600m downstream of the centre of the proposed landfill site
4	Negaadras-3	188157 mE, 1027338 mN, 1696 amsl	Sandy soil of thickness 3m above weathered basement	Proposed HDW, World Bank R-WaSH program

Upstream of the proposed landfill site close Jijiga Road in Sofi area Chirosh/river bed seepage was also observed at the very upstream side of the Churchura valley at 186684 mE, 1027721 mN and elevation 1760 m.

The downstream users of the aquifer should be protected from any contamination arising from the proposed solid waste disposal. The proposed landfill site is at about 600 m upstream of the Chirosh/HDW. Therefore, it is important to construct observation wells to monitor water quality. The observation wells need to be as close as possible to the actual landfill site for timely monitoring of the probable contamination of the water in the downstream direction. The site should also be supplied with one water point in the upstream direction for monitoring the change of the water quality before reaching the landfill site.

Water Quality

Water sample was taken from Churchura valley at Genda Koyat at UTM coordinates of 187487 mE, 1027315 mN and 1731 m for bacteriological and physico-chemical analysis. The bacteriological analysis was conducted in Harari Region Health Bureau Regional Laboratory and the physico-chemical test result was conducted in Water Works Design and Supervision Enterprise Laboratory. The result of the physio chemical and bacteriological water analysis is attached in **Annex -III** for future monitoring purpose.

Surface Water Condition

The main stream close to the site is Churchura stream, which starts from the Hakim Gara east area. The stream draining the Hakim Gara foothill includes the flow of springs from the limestone-basement interface.

The site preparation for landfill calls for proper designing and control of leachate discharge in the downstream area to ensure protection of streams from pollution. The stream water should also be monitored at upstream and downstream area of the treatment site during operation of the treatment plant.

Availability of Construction Material

The area is characterized by sandy soils of sufficient amount especially along the stream valleys. Base liner soil should be impermeable to retard the infiltration of leachate into the underground. Location of clay material for lining and cover will be investigated and located during the detail design stage if this area is selected as landfill site. The soils around the treatment site are sandy that it is important to check the permeability level. Sand can be imported from Bisidimo valley. With regards to construction stone, the major area of source is the Hakim Gara Limestone.

Conclusion & Recommendation

As stated earlier this site has been used as solid waste dumping site and considering degraded land, accessibility, location, outside the town's boundary etc this site has been considered for further evaluation as a sanitary landfill site.

5.3. Assessment of Socio economic Characteristics

5.3.1. Sofi area

Settlement and land use

The proposed site is predominantly used for agriculture. During the site visit no residence was observed at the proposed site. As per informants about 12 households (30 farmers) own the area proposed for the sanitary landfill. The area proposed includes the sanitary landfill, buffer zone, access road etc. However, the delineation of the site and exact number of farmers affected by this activity can only be ascertained during the design stage when detailed survey and registration is carried out.

Livelihood and source of income

The area is predominantly a farming area and the farmers reside out of the site in close proximity either at Gende Gobena or at Deker settlements. The farmers commonly grow sorghum, peanut, and maize in mixed form/intercropping technique. There are also few perennial crops such as mango and chatt. However, it is worthy to note that regardless of the current use of the land for agricultural, Harar municipality has used the area as one of the solid waste-dumping site as depicted in picture 1 below. .

According to estimates made to during the site visit, perennial trees are about 100 young mango plants, 50 mangos that start producing and chatt at an area of about 200 m2. Based on the information obtained from the site the main source of livelihood of the farmers is the agricultural produce.

According to the regional potential resources study report, 2006, average cereal production per hectors has declined from 8.62qt/ha in 2003/04 to 6.02 qt/ha in 2004/05 at the regional level. Further, according the regional Statically Abstract Report, 2006 the yield of peanut has also declined from about 13 qt/ha in 2001 to 1.3 qt/ha in 2005. Though there might be reasons for the decline of production during the different seasons it is difficult to adopt these figures. Considering lack of other substantial data the consultant is inclined to take average of the production figure of the different years for the purpose of this study.

Trees and Plantation

Trees and plantation are important to keep the environment. However, due to high human interaction the rate of plantation cover is highly degraded nationally, regionally and at the site level. At the proposed site plantation is almost non-existent. There are only very few bush and shrubs and less than 20 big trees.

Social Infrastructure

The location is out of the town along the main road to Jijiga and is predominantly used for solid waste dumping and agriculture, and does not have any infrastructure. Except that the proposed site is close to the road, there is no other infrastructure to be affected at the proposed site.

Conclusion and Recommendation

The proposed site is used mainly for agricultural activity, in which the livelihood of the farmers is believed to depend on the produce of the land. Currently farmers are planting sorghum, peanuts and maize in an intercropping technique. Agricultural productivity at a regional level is gradually declining. The situation at the proposed site might be much worst because of the solid waste dumped on the farm. The site has no major plantation to be affected as a result of the proposed

project. The constitution of the country proclamation 1/1995, Proclamation 455/2005 and regulation 135/2007 has clear provisions with regards to land use right, expropriation of landholding and framework of compensation payment. The region has also recent experience of expropriation while constructing the ongoing Water supply and sanitation project and land allocation for Millennium Village.

Thus, the area is ideal sanitary landfill site, as it has been already used for the same purpose without proper management. The only limitation is the number of farmers using the land regardless of the decline in productivity.

5.3.2. Muti area

Settlement and Land use

There is one residential house at the proposed site. The site is used commonly for plantation of eucalypts trees with small size of farm. As per informants about 15 farmers own the area proposed for the sanitary landfill. The area proposed includes the sanitary landfill, buffer zone, access road etc. However, the delineation of the site and exact number of farmers affected by this activity can only be ascertained during the design stage when detailed survey and registration is carried out. The proposed site even though not yet developed it is within the limit of the town master plan and close to Muti village.

Most part of the land is covered with eucalyptus trees. According to our observation there are about 5 trees per m^2. The trees are mix of both young and second generations with about 80 mm of diameter.

Livelihood and source of income

The area is mostly covered with eucalyptus trees and limited plot of farming is observed, where most farmers reside out of the site at Muti village. On the small plots some farmers grow sorghum and maize in mixed form/intercropping techniques. Most of the farmers make dependent their livelihood on the sale of eucalyptus trees for construction and energy purposes. The price per piece of tree is getting increasing, which will increase the income of owners as well.

Trees and Plantation

Eucalyptus tree is the dominant species in the area while other indigenous trees are not observed.

Social Infrastructure

The location is within the master plan of town and has a potential for development as there is power supply and telephone lines stretching to Mutie village along the road. However, currently there is no infrastructure to be affected at the proposed site.

Conclusion and Recommendation

The site is located within the boundary of the town and nearby Mutie Village, where people might start settling soon. Currently, the site is occupied by eucalyptus trees, which serve for construction and source of energy. The livelihood of the owners is dependent on the income generated from sales of the tree. The area looks ideal for the proposed purpose. The only limitation is that the land is occupied by eucalyptus trees and within the limits of the urban master plan and close to Muti village.

5.4. Assessment of Surface Water Condition

5.4.1. Sofi area

Topography & Drainage

The site is characterized by stepped landform in the east-west direction with sandy soil cover with varying thickness. The Jijiga-Harar road at the upper side of the site has currently has no side drain, but it is assumed that it will be constructed by the ongoing road project to accommodate flood discharge as interceptor. Moreover the site is on the ridge where left and right natural drainage is conducive. However, if the depression site on the eastern side is used as a sanitary landfill there is a need to construct storm drainage canals to intercept the road drainage.

Surface Water Condition

The main stream close to the site is Churchura stream which starts from the Hakim Gara eastern area. The stream draining the Hakim Gara foothill includes the flow of side springs from the limestone-basement interface.

This site is on the ridge where no surface runoff can affect it except from direct rainfall sheet flow as long as interceptor side ditch is provided either along the road or at its head.

Water Balance

The general but simple water balance equation of a watershed based on the concept of continuity is:

(P - E)-R = Ds

Where,

P = Precipitation

E = Evapo-transpiration

R = Runoff

Ds = Change in storage

Table below shows that PET far exceeds the rainfall input except August & September which both are almost equivalent in magnitude. In addition to this measured runoff and rainfall are taken from Erer catchment due to their nearness and climatic homogeneity. Anything in the form of soil moisture storage is immediately evaporated.

Table 14 Water Balance (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rain	**17.90**	**21.30**	**56.70**	**108.08**	**104.30**	**77.90**	**88.30**	**111.10**	**108.20**	**66.50**	**8.10**	**10.70**	**779.90**
PET	**98.89**	**98.48**	**116.25**	**108.3**	**110.05**	**103.20**	**107.00**	**103.23**	**102.60**	**105.4**	**101.40**	**94.86**	**1249.66**
Runoff	**0.51**	**0.52**	**0.83**	**13.41**	**15.68**	**2.07**	**10.64**	**23.19**	**15.40**	**6.13**	**2.36**	**1.26**	**92.01**
dS													
Act.Ev	**17.39**	**20.78**	**55.87**	**94.67**	**88.62**	**75.83**	**77.66**	**87.91**	**92.80**	**60.37**	**5.74**	**9.44**	**687.08**

From the above analysis out of the Mean Annual Rainfall, 11.8% belong to runoff (surface runoff and base flow), 0% infiltrate to ground water storage, and the rest 98.2% return to the atmosphere as actual evapo-transpiration.

Peak Rate of Runoff

The peak rate of runoff is required to design the drainage structures and interceptor drain, etc.

The 1 in 25 year return period will be adopted to design the required facilities.

Hence, the 1 in 25 year 24-hour rainfall of Harar is 110 mm as previously estimated.

Table 15. Interceptor Design Parameters

Parameter	Unit	Dimension
Peak Discharge (Q)	m3/sec	1.44
Manning's Coefficient (n)		0.025 (Masonry channel)
Side Slope		1V : 0.5H (Trapezoidal channel)
Channel Slope	%	1.0
Bottom width (b)	m	0.60
Water Depth (y)	m	0.51
Free board	m	0.25

Wind Direction

The wind direction on the proposed site is from southeast to northwest as discussed in section 3.4.5 of this report therefore the proposed site will not affect any settlement due to wind direction.

Conclusion & Recommendation

This site has been used as solid waste dumping site and considering availability of land topography and drainage conditions there is no hydrological constraint as a landfill site.

5.4.2. Mutti Area

Topography & Drainage

The site is defined by gently sloping landform at the western face of Abubeker hill draining to the easterly direction. The site is also relatively gently sloping to the north and surrounded with eucalyptus trees and shrub.

Surface Water Condition

As such no surface water sources are available at the site but Moqora river is downstream of the site. Interception of storm water from Abubeker hill is required to protect runoff entering the site. The area downstream of the site is gully, which feeds the Moqora drainage system.

Water Balance

All climatic features and water balance is the same as Sofi area.

Peak Rate of Runoff

The peak rate of runoff is required to design the drainage structures and interceptor drain at the head of the landfill area. The 1 in 25 year return period will be adopted to design the required facilities for Muti landfill site and hence, the 1 in 25 year 24-hour rainfall of Harar is 110 mm as previously estimated.

Table 16. Interceptor Design Parameters

Parameter	Unit	Dimension
Peak Discharge (Q)	m3/sec	3.3
Manning's Coefficient (n)		0.025 (Masonry channel)

Side Slope		1V : 0.5H (Trapezoidal channel)
Channel Slope	%	1.0
Bottom width (b)	m	1.0
Water Depth (y)	m	0.664
Free board	m	0.25

Wind direction

The wind direction on the proposed site is from southeast to northwest as discussed in section 3.4.5 of this report currently the proposed site will not affect any settlement due to wind direction, however, considering Mutti's proximity to settlement areas when the wind direction changes in different season it will have adverse effect.

Conclusion & Recommendation

The hydrological constraints against the development of the site for sanitary landfill include:

- The deep gullies and the lose soil formation may pose very easy land sliding;
- The construction of storm drainage structure or retaining wall at the side of the road is mandatory to protect the further gully formation uphill;
- The pollution on Moqora River downstream.

The site appears to be the second choice appropriate for landfill as long as the protections are built.

5.5. Environmental Baseline Conditions of the Proposed Landfill Sites

5.5.1. Sofi area

Bio-Physical environment

The area of this site is approximately 300,000 m^2 with elevation difference from the gully to the main road being about 30 m. Further, the site is characterized by stepped landform in the east-west direction. The soil type of site mainly is sandy soil cover with varying thickness.

Previously the site was used to dump solid waste indiscriminately as evidenced by litters spread all around the area. The road to Jijiga passes through the valley on the upper side of the site. But there is enough distance between the road and the actual landfill site.

Following the Churchura valley downstream of the proposed site a number of riverbank chirosh/ hand dug wells (about 600 m downstream) are developed as a traditional source used during the dry season. The downstream users of the aquifer should be protected from any contamination arising from the proposed solid waste disposal, which requires proper design to protect the possibility of contamination.

Biological Environment

Scattered Acacia albida, Euphorbia sp., eucalyptus and shrubs cover the area. The area is not known for any type of medicinal plant to grow in it. Regarding the animal community no wildlife that has economic value for residents nearby or the town exists in the site. Exceptionally, scavenging birds were observed since the site was used as solid waste disposal site.

Social Environment

The nearest residential area is Dekor Gobena village which is located 2 km away from the site. The wind direction is usually to the direction of the hills (from southeast to northwest) and not to the direction of the village or Harar town. Since there were no habitants in the areas, the municipality of Harar was already using the area as waste disposal site, it is already assumed to be the area set for this service, which only needs construction of sanitary landfill with proper management. Hence the issue of land replacement may not be in question from the communities.

Cultural, Religious and Archaeological Resources

No cultural, religious and archaeological resources are found to be affected by the project at Muti site.

5.5.2. Muti Area (Behind St. George Church Hill)

Biophysical Environment

The geomorphology of the site is defined by gently sloping landform at the western face of Abubekehre hill draining to the easterly direction. The site is relatively gently sloping to the north. It covers an area of 100,000m^2. There are settlers in the proposed site and its surrounding. Regarding vegetation of the area, the most part of the proposed site is mainly covered by eucalyptus trees and some jacaranda and others, which indicates the intensive use of the land by the owners. These trees are planted by settlers which live in the area. Plants of medicinal value do not exist. Because of the nature of the sites being settlement area and lack forests no wildlife that has economic value for residents has been observed. Some proportion of land is also used as agricultural land. The site is accessible through the Kombolcha outlet from the Town.

Social Environment

The major environmental issues of this area for the development of sanitary landfill is the social problem related with the settlers of the site and also the surrounding which may also be affected by loss of land, loss of property and livelihood as well as nuisance and other effects during construction as well as the actual operation periods.This even needs the resettlement or relocation of the current settlers to an other places. Relocation of these families could have an undesirable social and psychological impact on the part of the families. The families' attachment to the area, which is their birthplace, may be difficult to forget. Adaptation to a new area may not be easy. It is also an extra cost to the client who has to provide compensation to the families. The other issue which should be considered is that the project affected people should get proper and equivalent compensations for their trees, agricultural land, houses and other assets.

Cultural, Religious and Archaeological Resources

No cultural, religious and archaeological resources to be affected by the project at Muti site.

Conclusion and Recommendation

It is well known that it is hard to find an ideal landfill site for all such projects. But the impacts are evaluated from the point of their magnitude, reversibility, duration and scope and mitigation measures, which do have great role in reducing or eliminating the anticipated negative impacts, are designed starting from the beginning.

The environmental baseline data indicates that the sites at Muti and sofi area have both positive and negative impacts. The major environmental problems of the sites under consideration are

1. The proposed site at Muti area is located in the boundary of the town and near to the site there is Muti village. Hence the there will be serious social problem resulting from the project activities at all stages of its development (construction, operation), which may even require relocation of settlers.
2. On the other hand the major drawback of the site at sofi is related to the chance of water pollution.

Accordingly, the impact in Sofi could be mitigated by proper design, quality of construction, environmental management and monitoring, whereas the problem in Muti has social and economical effect and its mitigation will face more obstacles. This ranks sofi area as first alternative. Based on the findings of the environmental assessment the consultant recommends the sofi area to be the landfill development site for Harar town.

5.6. Required Land Area Capacity

In selecting potential land disposal sites, it is important to ensure that sufficient land area is available including an adequate buffer zone to operate at least five years at a given site.

5.6.1. Available land in Sofi area

The total area of land available in Sofi area is about 10 ha. The land area available for sanitary land fill after deducting the buffer zone and area for construction of auxiliary buildings, and control station, is estimated 10 ha. This has an estimated holding capacity of 544,875 m^3, which can serve for the next 11 years.

5.6.2. Available land in Mutti Area

The total area of land available in Mutti area is about 10 ha. The land area available for sanitary landfill after deducting the buffer zone and area for construction of auxiliary buildings, and control station, is estimated 7ha. This has an estimated holding capacity of 205,831 m^3, which can serve for the next 5 years.

5.7. Comparative Site Analysis and Scoring

The landfill sitting consists of a complex problem due to its multifaceted character. To come up with the best available solution, the two sites have been compared based on a variety of criteria, by using the methodology of multi-criteria analysis.

The selection of the most appropriate criteria, up on which the choice will be done, has been inter-disciplinary and covered the entire landfill sitting process from every perspectives:

a) Socio-economic characteristics of the proposed landfill sites
b) Geology & hydrogeology
c) Surface water
d) Environment
e) Capacity

In this multi-criteria analysis system, the comparative evaluation of the alternative scenarios, took place in two steps:

Definition of the criteria groups mentioned above, each one consisting of a series of individual criteria. The criteria themselves are scored with a relative importance factor from 0 (poor) to 5 (very good). Note that score can be the same for the sites.

Each of the criteria has been multiplied by the values of relative importance. This is done in order to give them the correct overall weight in the decision-making. Finally the score have been added up and compared. The site that got the highest point is the choice.

In order to locate the most suitable site for sanitary landfill, criteria have been developed to rank the two identified sites. Once the criteria have been finalized, they have been applied to the study areas and the most suitable landfill sites have been identified. The top site for the landfill will be further evaluated in the design phase of this assignment.

All criteria were evaluated between 0 and 5. Then, weights have been applied onto groups of the criteria in order to consider more or less the power of influence for each. Groups and weight that have been chosen are listed below:

Table 17. Criteria and their value to evaluate landfill sites

No.	Criteria	Value
1.	Socio-economic	20
2.	Geology & hydrogeology	20
3.	Surface water conditions	20
4.	Environment	20
5.	Capacity	20
Total		100

The most influencing criteria are those related to capacity of the landfill area, socio economic characteristics and environment since the other conditions related to geology and surface water can be controlled and mitigated with proper design and operation of the landfill.

Based on the criterion, the sites got their respective value and result is depicted in the table below. The detail analysis is in annex 1.

Table 18. Rating value of proposed sanitary landfill sites

No.	Description	Weight (%)	Proposed Landfill Sites	
			Sofi Area	Muti Area
I	**Socio-economics**	**20**		
	Accessibility		4	5
	Settlement and Land Use		5	1
	Livelihood and Income		3	3
	Trees and plantation		4	2
	Social infrastructure		5	5

	Sub-total		**21**	**16**
	Weighted Sum		***4.2***	***3.2***
II	**Geology & Hydrogeology**	**20**		
	Soil Cover/thickness		2	4
	Ground Water		2	5
	Borrow Material and Type		2	5
	Water wells		2	5
	Soil Permeability		2	4
	Sub-total (%)		**10**	**23**
	Weighted Sum		***2.0***	***4.6***
III	**Surface Water**	**20**		
	Topography & Drainage		4	3
	Surface runoff		3	3
	Surface water pollution		2	4
	Wind direction		4	2
	Sub-total (%)		**13**	**12**
	Weighted Sum		***2.0***	***1.8***
IV	**Environment**	**20**		
	Using the site after closure		3	1
	Land improvement		3	1
	Effect on flora & fauna		4	1
	Odour & Nuisance		4	1
	Sub-total (%)		**14**	**4**
	Weighted Sum		***2.8***	***0.8***
V	**Proposed Landfill Capacity**	**20**		
	Initial capacity		4	2
	Possible extension		4	1
	Sub-total (%)		**8**	**2**
	Weighted Sum		***1.6***	***0.6***
TOTAL Weighted Sum			**12.6**	**11**
RANK			**1st**	**2nd**

According to the table of analysis, Sofi site comes in first position. This site is the most ideal site for sanitary landfill because of the following**:**

- The area is already used in an informal way for the same purpose;
- The productivity of the land is declining;
- No settlement around the area;
- The site is located on outskirt of the urban zone;
- Road accessibility, close to Harar – Jijiga road;
- Possibilities of extension or creation of new site within the area located opposite side of the road;
- Rehabilitations can be made with ease and the environment would more easily accept opening of new site for future needs;
- Construction material and soil for cell cover is available within short distance.

6. Potential Environmental Impacts of Project

6.1. Positive Impacts of the Project

Harar is a capital of the Regional State and also historical place that attracts international visitors. But its current waste management condition is not found to be at the level it requires. Therefore, it deserves a modern urban management that includes proper waste management system, for safe collection, transporting and disposal of solid wastes generated in the town.

Safe disposal of solid waste in a landfill site will play important role in the improvement of public health in Harar. Moreover it protects the biophysical environment from pollution that goes beyond Harar. This in turn improves the status of Harar and makes it a place of choice to live, work or recreate. With this, Harar's development will be enhanced through more investment on industries and other economic and social services. Harar being a historic town, more tourists will be attracted, which increases its historical value and popularity in the world as well as contributes a lot to economic social development in and around the town. More specifically the positive impacts are:

- Provision of reliable and adequate solid waste management system with proper landfill operation will highly reduce the amount of solid waste thrown in the water sources, open land and farms resulting environmental improvement – i.e. reduction of water, air, soil contamination and their effect on the biological environment.
- The project contributes in the reduction of diseases related to the current unhygienic waste management system.
- The project improves the aesthetic value of Harar and the surrounding.
- Creation of jobs and skill transfer for skilled and unskilled labour during construction is a noticeable advantage.
- The initiation of private sector to invest and involve in the waste management sector will be one of the outcomes of the project.
- Since sanitary condition is important in attracting outsiders, the improvement of waste management will boost commerce and trade through creating conducive environment for different investments, including industrial development as well as tourism.

6.2. Adverse Impacts of the Project

Landfill development comprises different activities, which might have potentially negative impact to the environment. The development of landfill could have potential negative impacts at different stages of the project that require appropriate mitigation measures. Impacts can be direct or indirect, short term or long-term consequences. The most important environmental components that are sensitive to be affected by this intervention include quality of ground and surface water, air quality, soil quality, aesthetics and landscape, historical heritages, public health and biological resources. The most possible negative impacts which occur during the construction and operation phases of the landfill development are discussed below.

2.2.1. Construction phase

The construction phase includes the activities like site preparation, clearance and putting up the infrastructure. Hence, this phase involves activities, which are, to some extent averse to the following.

- **Biological Environment**

- **Clearance of natural vegetation -** Felling of trees and clearing of shrubs to construct the landfill, access roads and service areas has negative impact on the environment.

➢ **Physical Environment**

- **Air pollution** – during the construction phase of this project air pollution could occur due to mobile equipment exhaust, construction dust, road dust, car exhaust and chemicals like fuel, oil, etc.
- **Soil pollution** – This is caused due to disturbance in soil strata/ structure caused by construction works and plastics and chemicals like fuel, soil & grease that are used during the process.
- **Enhanced soil erosion** – Clearing of the plants and digging during construction could be the cause for intensified soil erosion especially on hilly areas. Wind erosion can also be enhanced on such places.

➢ **Social Environment**

- **Spread of Diseases –** The construction of this scheme draws many skilled and unskilled laborers and professionals to project area from different part of the country and may be from other countries as well. The movement of these people could be the cause to introduce and/or spread different types of contagious and infectious diseases into the town and its surrounding.

2.2.2. Operational phase

During this phase the major consequence of sanitary landfill is leachate. Related to the specific condition of the landfill site the major environmental components to be affected by this project are

Surface and ground water pollution by Leachate

- Pollution of the surface water (river) at the downstream by the leachate as a result of surface run-off and rainfall entering into the solid waste disposed in the fill;
- Pollution of ground water supply source downstream of the landfill area by leachate.

Soil contamination by Leachate

- Contamination of the soil in the surrounding by uncontrolled Leachate

➢ ***Hazardous and Loss of Amenity***

Hazardous wastes pose the most significant management challenge given their higher potential to cause harm as a result of their:

- flammability
- corrosively
- potential to cause infection
- Reactivity (violently reactive, oxidizing or explosive)
- Toxicity.

Landfills can also cause a localized loss of amenity due to litter, dust, and odour, noise, and vermin problems. Proximity to existing and proposed developments and the strength and direction of prevailing winds will be key issues in this regard. The potential hazards and amenity impacts from landfills include fire, birds, dust, odour, pests, vermin and litter. Each of these potential impacts may occur on-site or offsite.

- **Accidental Fire and Traffic load**

Fire accident can be caused either due to flammable materials brought along with the solid waste or due to gasses (like methane) emitted from the landfill itself as a decomposition product of the waste.

The traffic load will increase in the rural area where the landfill operates. Numbers of trucks makes several trips to the plant every day. In addition, those trucks share the same road route used by heavy trucks and machineries operating in the area. The dust pollution and noise disturbance can also pose some adverse impacts to the workers and to passerby road users. Sometimes, there might be traffic accidents that might result in loss of life and damage to property both during construction and operation phase of facility.

7. Mitigation Measures

Mitigation measures are actions to be taken to reduce or eliminate an adverse environmental impact of any intervention on the biophysical or social environment. They can be engineering or management works. Therefore they should be considered at each stage of development process.

7.1. Design Phase

During designing of the proposed landfill the following mitigation measures should be considered for indicated negative impacts.

- To avoid pollution of surface and ground water sources from leachate, the design should provide natural or geo-membrane and appropriate leachate collection and treatment.
- The entire landfill area has to be enclosed with durable fencing facilities in order to minimize the entrance of external bodies, which might contribute additional pollution.
- Plantation of the buffer zone for the purpose of creating good scenery, reduction of smell and protection of possible soil erosion.
- Prohibit settlement on any form around the landfill site.

7.2. Construction Phase

Plan and facilitate the construction work in such a way that it will not encourage soil erosion in the site and its vicinity. Some of the identified mitigation measures to be followed during the construction phase are discussed in the following sections.

7.2.1. Preserving the Biological Environment

(d.) Minimizing wherever possible cutting of indigenous trees in the construction areas;

(e.) Putting in place an organized system so that unwanted destruction of trees of small size and shrubs will not occur during felling of necessary big trees;

(f.) Replanting of the area after the construction is completed.

7.3. Operation Phase

To mitigate environmental impacts, which could exist during the operational phase of the landfill system, day-to-day control and monitoring is decisive. This includes covering the waste with soil layer daily at the close of the day's operation; locating possible leachate generation through constant inspection and supervision; surveillance of any possible pollution of the area (land, ground water and surface water) within the landfill vicinity is important. The person in charge of the landfill operation must make sure that incoming trucks dump the waste in the designated place. No littering of the area should be allowed.

The method to correctly implement all possible mitigation measures at the operational phase is to have suitable landfill operational plan and execute it strictly. With this understanding the following should get due attention during landfill operation.

The development of a workable operating schedule, a filling plan for the placement of solid wastes, landfill operating records, and load inspection plan for hazardous wastes are important elements of a landfill operation plan.

7.3.1. Mitigation measures for Impacts on water sources

Avoid entry of spoil soil in to water body by timely carting and stockpiling at designated disposal site. Site selection should avoid catchments where water sources are located as far as possible.

Leachate must be controlled within the landfill site, ensuring that neither groundwater nor surface water is polluted. The design has to consider leachate treatment facilities within the land fill design project and at the same location. The treatment of the leachate should enable to prevent pollutants' migration into the water sources; either by percolation into ground water source or by runoff into surface water body. A leachate treatment pond can stabilize the pollutants by natural processes, while infiltration is avoided by use of proper sealant material for the pond bottom. In addition, adequate side drainage facility should be provided to avoid run on and runoff water from the landfill areas.

7.3.2. Mitigation Measures for Air Pollution Impacts

- To reduce impacts of car exhaust and other mobile equipments on the air, machineries with good ignition systems should be used.
- Spraying water to suppress dust before and in the interval of excavation works.
- Take precaution not to release or spill fuels, oil and other chemicals in the area and have proper controlling mechanism for effective handling of chemicals, fuel, oil, etc.

7.3.3. Mitigation Measures for Impacts on Land Resource and Soil Erosion

- Backfilling of excavation as per its normal sequence of structure or layer.
- Constructing retaining walls along gullies, loose soil structure & ground cuts with steep slopes.
- Growing grasses & trees on excavated bare lands.
- Doing proper soil compaction where applicable.
- Have proper controlling mechanism for effective handling of chemicals, fuel, oil, etc. and take precaution not to spill fuels, oil and other chemicals.
- Put in place proper collection and recycling system of used plastics. If condition will allow disposing off plastics should be done at a designated safe area.

7.3.4. Mitigation Measures for Public Health and Safety Impacts

To minimize such health hazards, proper safety and precautionary procedures need to be followed. Measures include; training and awareness creation programs for workers on safe waste handling and hazards protection measures, provision of protective cloths and devices like gloves, goggles, protective cloths, provision of adequate water and soaps for bathing, and adequate bathrooms to enable them day to day bathing after work, their periodical health check-ups, vaccinations etc. The workers should have free health services and medical checkups.

- Conduct regular health check-ups, immunization and treatment of the workers;
- Design and conduct regular health education programme, including awareness on HIV AIDS and STDs among the work force and the residents in and around the project area.
- Strengthen the capacity of the health institutions in the project area and make them capable to meet the increasing demand of service from the incoming workforce.

7.3.5. Mitigation Measures for Hazardous and Loss of Amenity

Landfill design, constructions, monitoring, management and remediation must comply with the following Environmental Goals:

- The waste type received should be checked before acceptance at the landfill. Hazardous waste should be treated separately and should not be allowed for direct disposal at municipal waste landfill
- Unauthorized entry to the landfill site and to the waste tipping face needs to be prevented.
- Vehicles leaving a landfill site must not distribute litter and site materials in surrounding streets. Odors, dust, vermin, weeds and litter must be effectively controlled on-site.
- Noise emissions from the landfill operation must be kept to the minimum and must comply with noise control requirements of the localities.
- The landfill site must have adequate fire-fighting plans, equipment and staff to effectively manage fire outbreaks at any part of the landfill site.
- The level and nature of staffing the landfill site must be adequate for environmentally responsible and safe management of the landfill.

7.3.6. Mitigation Measures for Fire Accidental and Traffic Load

Fire accident should be prevented by taking the proper measures and preparatory works in advance; these measures should include controlling type of waste received at the land fill, preventing gas emissions from the land fill; assuring quality of design, construction and Operation of the landfill, organizing adequate fire-fighting capacity and providing adequate staffing and training for the workers.

The design and construction of landfill should provide properly designed gas release or collector pipe to minimize fire risk due to gas emission from the decomposition of the waste.

All fuels or flammable solvents for operational use should be stored in an appropriately ventilated and secure store. This store should be located on unfilled land, and all flammable liquids should not be stored full tank, but with provisions of open volume so that any release of raw or burning fuel would not cause a fire in the filled waste.

Therefore, strict traffic regulations should be put in place and traffic signals posted at critical locations along the route and within the plant compound. Bumpers and speed breakers need to be constructed at the approach of, and within the plant compound

Table 19. Summary of mitigation measures

Sr.no	Aspect	Mitigation
1	Topography	• Cap and shape all waste cells on completion of filling. • Capped and shaped areas must be slightly convex so as to encourage runoff and minimise infiltration. Slopes should not to exceed a gradient of 1 in 3. • Even out mounds and hollows during the contouring and shaping process to avoid the creation of low points in which the ponding of water can occur. • Capped waste cells are to be rehabilitated with indigenous vegetation.
2	Climate	• Extent of unvegetated, exposed surfaces should be kept to

		the minimum necessary to enable work to proceed. • Ensure immediate and continuous rehabilitation of non-active cells is undertaken. • Revegetate long-term stockpiles, surface water diversion structures and other berms. • After a high intensity or long duration rainfall event, identify and repair erosion and wash away sites immediately. • Dust abatement measures (i.e. dampening of roads) should be employed during windy conditions.
3	Air Quality	• An AQMP is to be compiled for the proposed site (including benzene). The AQMP is to consider the production of landfill gas from the site and a comprehensive Landfill Gas Management Plan should be established. • The operational phase mitigation measures recommended are to be considered and included in the EMP for the proposed site. • Follow-up (comparative) ambient air sampling to be conducted during construction and operational phases. • The recommended health, dust and odour impact zones should be considered a management zone and control measures be implemented to minimize the impacts within these areas.
4	Geology and Soils	• Specific engineering measures aimed at capturing and controlling leachate generated within the landfill body are implemented and managed proficiently. • DSW propose to investigate alternative sources and methods of landfill cover should the proposed landfill site be approved.
5	Ground water	Application of modern landfill practices including: • Liner system • Phased cell development • Leachate management • Monitoring
6	Surface water	• Lined surface water interceptor drains should be installed up-gradient of each cell to prevent any surface run-off into the active landfill area and active landfill areas should be limited to minimise rainfall recharge through these uncapped open zones. • Surface water monitoring points are to be established and a regular monitoring and reporting programme implemented. • Implementation of new generation landfill design principles and sound operational and management practices
7	Flora and Fauna	• Rare plant species must be removed from site prior to construction and replanted in nearby open areas or in an on site nursery. • Completed cells must be landscaped and revegetated with local species as soon as possible. • Development in the planning area should be set back from

		drainage lines and scarp edges.
8	Socio-economic	• Consider the feasibility of establishing a recovery and recycling area. • Where possible the landfill development must be linked to local economic development plans. • Appropriate site management and the implementation of buffer areas with compatible land use will reduce potential negative impacts on the value of adjacent properties. • Establish and maintain a monitoring committee for the landfill. • A relocation plan would need to be prepared to ensure that the entire relocation process, from the initial discussions to the movement of families to new homes, is implemented in an appropriate manner. • Discussions with the local community with regard to possible end uses of the site need to be undertaken at the time of imminent site closure. • Proper site management and vegetation screening are mitigation measures that will ensure that the impact on the receiving environment is reduced as far as possible. • The multiple use of the site would have significant positive social impacts and is highly recommended. This issue has implications for land use planning.
9	Traffic	• The access intersection must operate under priority control with single entry and exit lanes and that this intersection is formalised to the local authority's geometric standards.
10	Noise	• Acoustic treatment of equipment and machinery should be implemented (silencers, maintenance and control). • Should noise complaints be received, a noise study may be required. Such an investigation which would consider the applicability of noise attenuation that could be offered by the use of physical barriers (i.e. acoustic screens such as wooden fences, brick / concrete walls or man made earth bunds).
11	Visual and Aesthetics	• Green walls themselves can obstruct views and look out of scale and place because of their shape and size. The green wall landscaping should try to replicate natural features and not appear alien in the landscape. This can be aided by the use of indigenous vegetation that mirrors the seasonal colour variations of the surrounding environs. • The landfill has an anticipated lifespan of approximately 100 years, and the commencement of construction from the south might reduce impacts on land uses to the north.
12	Cultural and Heritage Resources	• Structure associated with farming activities – may be altered or destroyed with a permit from municipality • Structural remains – may be removed with/with no permit from municipality • Archaeological sites - may be altered or destroyed with a permit from municipality if no graves are present; if graves are present permission from families also required

8. Environmental Management and Monitoring Plan

The general objective of operation monitoring is to verify that the landfill operation does in fact conform to the required standards and proposed planning procedures. It also serves as a performance indicator (and early warning system), and hence as a control or management tool, for the operator. It is the duty of the Responsible Person to ensure that the Minimum Requirements for the monitoring of a landfill site operation are applied to a degree commensurate with the class of landfill and hence to the satisfaction of Department of Environmental Affairs.

8.1. Operational Monitoring

The minimum requirements applicable to landfill operation monitoring are vital except air quality monitoring which requires special consideration. These include:

- Responsible Person;
- Landfill Monitoring Committee;
- Conduct Audits;
- Conduct external audits twice per annum;
- Appropriate records and data collection;
- Record deposition rate;
- Waste stream records;
- Landfill volume surveys;
- Collect climate statistics;
- Water quality monitoring;
- Gas monitoring and control;
- Air quality monitoring (Special Consideration);
- Monitoring of progressive rehabilitation;
- Ongoing maintenance.

In their capacity as the Responsible Person, DSW remains responsible for monitoring throughout the operational life of the landfill site and for up to 30 years after closure

8.2. Water Quality Monitoring

Water quality monitoring begins before the commissioning of a landfill site and continues throughout and beyond its operation. Monitoring water quality in the vicinity of a landfill is essential in order to indicate whether pollution of the surrounding or adjacent water regime is occurring. The general objective of water quality monitoring is to serve as an early warning system to indicate any escape of contaminants into the water environment and to quantify any effect that the landfill has on the water regime. As a Sofi landfill site, all Requirements applicable to water quality monitoring are required including pre-operation monitoring, operation monitoring and post-closure monitoring. Water quality monitoring is the responsibility of the Permit Holder and thus the Responsible Person, (i.e. DSW), who will ensure that the level and extent of monitoring is commensurate with the class of site under consideration, and hence to the satisfaction of DEA. A long term pollution monitoring programme for the site will be implemented.

8.3. Operational Controls

Solid waste personnel work in all types of weather, with many types of heavy equipment, with a variety of materials setting. The types of accidents possible at landfills include injury from explosion or fire, inhalation of contaminants and dust, asphyxiation from poorly vented leachate collection system manholes or tanks, falls from vehicles, injury associated with operation heavy earth-moving equipment, injury from attempting to repair equipment while engines are operating exposure to extreme cold or heat, and traffic accidents at or near the site. Safety guidelines specific to the operation of landfill will be given in operation and management manual.

8.4. Access Control

Public access to landfills must be controlled by use of artificial barriers, natural barriers, or both to prevent unauthorized vehicular traffic and illegal dumping of wastes. These barriers can include fences, ditches, berms, trees, etc. Access should be controlled by gates that can be locked when the site is unsupervised.

Good housekeeping `procedures are necessary for landfill operations. A well-planned and maintained landfill effectively controls for the following:

- **Aesthetics**: Although making the site pleasing to look at is cosmetic, it is not frivolous. Addressing aesthetic concerns may include using fences, berms, plantings, or other landscaping to screen the landfill's daily operations from roads or nearby residents, and providing an attractive entrance with good roads and easy-to-read signs.
- **Wind-Blown Paper**: On-site litter control is accomplished by using fences to stop blowing paper and plastic. Frequent manual or mechanical litter pick up is also needed.
- **Insects**: Flies and mosquitoes are the most common insects of concern to neighbors. They are best controlled by covering the solid waste daily and eliminating any open standing water, such as in appliances stored for recycling or in surface depressions.
- **Rodents and Wildlife**: Rats were once a problem at open dumps, but at sanitary landfills, burying all food wastes with daily cover material usually eliminates rat problems.
- **Birds:** Birds can be a nuisance or even cause problems with planes if the landfill is near an airport. Federal Aviation Administration (FAA) should be notified if the landfill is within five miles of an airport runway used by jet aircraft. Methods to discourage birds include use of noisemakers, wire grids, and liberal use of cover soil. The best approach is to keep the working face small and to provide adequate cover.
- **Odors and Fires**: Odors are best controlled by daily cover, as well as by adequate compaction. Daily cover also forms cells that reduce the ability of inadvertent fires to spread throughout the landfill. Any burning or smoking waste should be dumped off to the side and extinguished before placing it in the working face. Fire-fighting equipment and an emergency water supply should be available on site or arranged for with local authorities.
- **Noise**: Equipment should be operated behind berms, which shield the surrounding area from noise as much as possible. Access should be designed to minimize the impact that landfill site traffic has on nearby neighbourhoods.
- **Dust and Tracking**: Roads should be watered in dry periods to keep dust to minimum roads should be crowned and well-drained to minimize mud tracking. Adequate wheel-cleaning and mud knock-off areas should be provided. Entrance roads should be paved or have all weather surface concrete or asphalt to keep mud tracking on-site and should be cleaned whenever a mud build up occurs.

- **Scavenging:** While recycling at a landfill may be desirable, scavenging (or uncontrolled picking through waste to recover useful items) is not desirable. Because scavengers have been injured, sometimes fatally, while picking through the wastes, the practice should be prohibited. Salvaging, which is the controlled separation of recoverable items, should be distinguished from scavenging. Any salvage operations should be kept away from the landfill, usually at the gate area, and residues should not be allowed to accumulate.

9. Conclusion and Recommendation

The overall objective of the ESIA is to provide sufficient information to enable informed decision-making by the authorities. This is done by assessing the impacts identified in the ESIA Phase and identifying possible mitigation measures for each of the identified impacts.

A comprehensive public participation process was undertaken during the ESIA phase, which has included availability of reports for review and meetings. During the ESIA phase, studies were conducted on the air quality, traffic and social impacts, visual impacts, geotechnical impacts, ground and surface water impacts, and heritage impacts associated with the proposed expansion. The specialist studies did not identify any environmental fatal flaws and provided a range of mitigation measures for implementation.

The potential impacts associated with the development of the proposed Sofi Landfill Site have been assessed and the significance of these potential impacts evaluated with consideration of proposed mitigation measures. The majority of the potential impacts identified are considered to be of low significance.

In order to secure waste disposal facilities in both and short, medium and long term and both the proposed Sofi and Muti landfill sites were investigated for final approval. As per the detailed social, environmental and other criteria the Sofi site is chosen in the first rank.

Based on the information collected and assessed in this ESIA, it is concluded that the proposed site is suitable for sanitary landfill development.

References

BALL, J. Year. Landfill site selection. *In:* Tenth International Waste Management Symposium S. Margherita di Pula, Cagliari. Italy, 2005. 3-7.

EPA 2006. ENVIRONMENTAL GUIDELINES: SOLID WASTE LANDFILLS.

FRANTZIS, I. 1993. Methodology for municipal landfill sites selection. *Waste management & research,* 11**,** 441-451.

VIJ, D. 2012. Urbanization and solid waste management in India: present practices and future challenges. *Procedia-Social and Behavioral Sciences,* 37**,** 437-447.

Annexes. Rating of criteria for selecting proposed sites

1. Socio-economic characteristics – 20/100

1.1. Accessibility

The necessity of an appropriate access road to the site is obvious. There is three cases, either anything doesn't exist, or is there an existing tracks, or road.

In addition to minimize operational costs for solid waste disposal, sites with shorter haul distances have been ranked higher. The existing road distance from center of the town has been considered for comparison of haul distance, in this case Ras Hotel has been taken as center of the town.

- **Sofi area - 4/5**

Sofi area is located about 5km from center of the town close to Jijiga road. It is accessible directly from Jijiga road. But there is a need to construct internal access road.

- **Muti Area – 5/5**

Muti area is located about 3.5km from center of the town next to Kombolcha road. It is accessible directly from Kombolcha road. But there is a need to construct internal access road.

1.2. Settlement and land use

- **Sofi area - 5/5**

There is no house at the proposed site. The land is used for agricultural purposes but dumping of solid waste of the town has reduced its productivity.

- **Muti Area – 1/5**

There is already one house at the proposed site and land is used for plantation. The area is within the master plan of the town and though there is no evidence at hand there are some people who have secured the plot for construction of houses.

1.3. Livelihood and source of income

- **Sofi area - 3/5**

There are about 30 farmers that depends their livelihood on the income generated from the farmland though it is declining. The impact on the livelihood is significant.

- **Muti Area – 3/5**

There are about 15 households that depends their livelihood on the income generated from the eucalypts tree. The impact on the livelihood of the resident is significant.

1.4. Trees and Plantation

- **Sofi area - 4/5**

The area doesn't have any major plantation and already deforestation has taken place long ago. There are only few indigenous trees.

- **Muti area – 2/5**

Eucalypts trees that are used for construction and energy purpose occupy the area. There is no other indigenous plantation at the proposed site.

1.5. Social Infrastructure

- **Sofi area - 5/5**

There is nothing to be affected in the area.

- **Muti area – 5/5**

There is nothing to be affected in the area.

1.6. Geology and Hydrogeology – 20/100

1.6.1. Soil Cover / Thickness

Proximity of bedrock and groundwater can limit the feasibility of necessary earthworks so that natural condition can become a major economic factor involving material transport, expensive earthworks. The component have been separated in order to consider them separately

- **Sofi area – 2/5**

According to the field observation, the area is covered with sandy soil above the weathered basement rock.

- **Muti Area– 4/5**

Thick residual soil cover underlain by weathered limestone characterizes the area. Large amount of soil cover is an advantage for maintaining suitable permeability as well as for providing materials for covers and rehabilitation.

1.6.2. Ground Water

The water bearing zone in the subsurface should be well protected from contaminant infiltration. The depth of water table, water bearing zone and the condition of the upper confining layer and the groundwater flow direction should be thoroughly investigated.

- **Sofi area – 2/5**

The expected aquifer for this site is alluvial deposit along the valley. This is evidenced from the river side chirosh/seepages, which are being exploited by the local people through hand dug wells.

- **Muti Area– 5/5**

As such, no groundwater potential is reported so far. The field survey showed that no water wells are found at the area or within 1 km radius. No water seepage from the ground was seen in the gullies.

1.6.3. Available material for cell preparation and cover

Construction of sanitary landfill requires different construction material. The availability, the quality and the proximity of the material with respect to the proposed site are very important consideration in the site selection and study.

- **Sofi area – 2/5**

Sand soils of alluvium type are available all along the gullies and banks of the Churchura. This would have to be confirmed by investigation but according to the configuration of the site, alluvium with rather good characteristics is expected to be found. The permeability of these sandy soils should be checked in the detail geotechnical investigation.

- **Muti Area– 5/5**

The land can be described as gently sloping landscape with 3 to 4 m average thickness of residual soils cover. Thick soil deposits for sealing, embankment and top cover is available at the site. Therefore, silts or clay materials can be found in nearby area.

1.6.4. Water Wells

The location of landfill will not be close to water supply wells. The assessment phase of this study made exhaustive inventory of existing water points at proximal distances from the proposed landfill site.

- **Sofi area – 2/5**

The site is located at major outlets of the drainage system of Harar Town. River bank seepage/springs are common at the valley. Inventory conducted on water points revealed that a number of unprotected hand dug wells are under use by the local community downstream of the site. The nearest hand dug well is at about 600 m down stream of the proposed site. Study of the current water quality and establishment of monitoring wells is necessary to study any contamination level of the groundwater around the area.

- **Muti Area– 5/5**

No water supply point is identified within 1 km radius from the site.

1.6.5. Permeability of the Soil Cover

Restrictions have to be applied for landfills from being constructed in areas where bedrock is shallow. The geological criteria, regarding hydro-geological characteristics of the sites should be thoroughly examined. The vulnerability of the sites to pollution of underground water resources have been given due attention.

- **Sofi area – 2/5**

As the soil cover is thin especially on the flat areas of the site and the groundwater of the alluvial aquifer at the site is in an unconfined condition, it requires that clay cover be applied to protect the groundwater contamination. Therefore, a one meter silt/clay composed material has to be implemented in order to lead contaminant flow toward lagoons.

- **Muti Area– 4/5**

Field study showed that the soils are residual soils with the characteristics of low to medium plastiTown and low degree of swelling. The soils at Muti are developed on limestone.

1.6.6. Earthquake Safety and Slope stability – 5/100

1.6.6.1. Earthquake Safety

Earthquake hazard considerations have been discussed under chapter 9. Although plate movements are to be seriously considered in the region, there are neither hazardous effects nor differential between the areas assessed. The value for both site place them in equal position.

- **Sofi area – 5/5**
- **Muti Area– 5/5**

1.6.6.2. Unstable Areas – Slope Stability

In natural conditions these areas would be eliminated to ensure structural stability of the landfill. However, land stabilisation can be done and effect of earth fill can sometimes be benefits.

- **Sofi area – 4/5**

Although local erosion can occur there is no possibility of landslide. However material stocks have to be store carefully without creation of undesirable loading on slopes.

- **Muti Area– 5/5**

The site is located in a flat and horizontal area. In these conditions the load doesn't modify any equilibrium of slopes condition.

1.6.7. Surface water – 15/100

1.6.7.1. Topography & Drainage

The parameter takes into account the possibility to evacuate fluids after treatment toward the natural hydrographical network without pumping station.

- **Sofi area – 4/5**

The site has gentle slope with terraces, which is not exposed for erosion. Moreover the site is on the ridge where left and right natural drainage is conducive.

- **Muti Area– 3/5**

The site is sloping towards easterly direction, and the deep gullies and the lose soil formation may pose very easy land sliding unless retaining wall at the side of the road is constructed;

1.6.7.2. Surface Runoff

- **Sofi area – 3/5**

This site is on the ridge where no surface runoff can affect it except from direct rainfall sheet flow as long as interceptor side ditch is provided either along the road or at its head, however if the

landfill site is extended to the depression located to the southern side of the existing solid waste dumping area there is a need to extend the existing road culvert outlet.

- **Muti Area– 3/5.**

Interception of storm water from Abubeker hill is required to protect runoff entering the site

1.6.7.3. Surface water pollution

- **Sofi area – 2/5**

The main stream close to the site is Churchura stream, the site preparation for landfill calls for proper designing and control of leachate discharge in the downstream area to ensure protection of the stream from pollution

- **Muti Area– 4/5**

As such no surface water sources are available at the site but Moqora river is downstream of the site. Interception of storm water from Abubeker hill is required to protect runoff entering the site.

1.6.7.4. Wind direction

- **Sofi area – 4/5**
- **Muti Area– 2/5**

1.6.8. Environment (20/100)

1.6.8.1. Possibility of using the site in the future (after closure use)

Landfill site is not a place to be used, closed and left with out service. There are many possibilities for post closure use. This is the main reason that landfill site selection considers the possibility of the site to be used in the future with out imposing any health or other environmental hazard. This could be recreation area, sport filed etc.

- **Sofi area – 3/5**

Churchura is out of the town and has wider area. Its location is suitable to be a public service area, where residents of the town could walk out of the town for a change and get service. Moreover it could be green area, which serves as recreation site.

- **Muti Area– 1/5**

This site is found in the master plan of the town and will be of better use as future extension area for residents of the town. It is not recommended to use Landfill site close to residential buildings.

1.6.8.2. Possibility for land improvement

Land improvement is the process of making the land for more useful purposes to the community or making it more productive. This includes protection of the land from degradation, both structural and fertility, by erosion, landslide, or improper production system and management.

- **Sofi area – 3/5**

Currently the valley is not exploited properly and is not productive. On the other hand soil erosion is obvious and as result gullies are developing. No soil conservation structures are put in place. Keeping the area under this condition will degrade the environment. Hence if the land is used for landfill, loss of soil by erosion and the developing gully will be controlled. The contribution of the landfill development to health improvement of the residents and the surrounding is an important service that should be considered. .

- **Muti Area– 1/5**

The area is used as agricultural area. It looks that the farmers who own the land, are producing crops and also plant trees, which are supplied to Harar for fuel food - important commodity. On the other hand, since the area is included in the master plan of Harar, in a very near future it will be used for residential and service area. Hence it will have more improvement possibility by being part of the town than a landfill area.

1.6.8.3. The effect of the landfill on the surrounding flora and fauna

Landfill development demands wide area land not only for the actual landfill site and its service area, but also during construction. At this time cutting of trees, clearing of bushes is unavoidable. Moreover, the animal community will be affected as their habitat is destroyed. As a result some may die and others may migrate.

- **Sofi area – 4/5**

The site at this valley has few scattered trees and shrubs. There are no animals of significant value except scavengers since it was serving as solid waste dumping area. The effect of the landfill to the fauna and flora is insignificant.

- **Muti Area– 1/5**

Muti is an area most of which is covered by eucalyptus trees of various size. There are also some bushes. Landfill development will have great high impact on the vegetation of the area. There are no animals.

1.6.8.4. Effect on Air Quality – Odour and nuisance

There are impacts during construction and operation phases of landfill development which includes air pollution, odour and nuisance. The dust produced during the period of excavation, transport, loading, unloading etc. produces dust and causes air pollution and also machineries produce sound, which seriously affects the people living near by construction area. During the operation of the landfill there is bad odour which is produced by fermentation process of the waste. Transportation of solid waste to the land fill and the machineries in the process of leveling and covering also produce sound. These are some impacts which affect the surrounding.

- **Sofi area – 4/5**

Churchura valley is located outside the master plan and there is no settlement around the proposed site, hence effect of odour and nuisance is minimal during construction and operation.

- **Muti Area– 1/5**

The Muti village is located very near to the proposed site at Muti. There during construction the sound of the machineries will affect the residents. During operation it is likely that odour and nuisance will seriously affect the village.

1.6.9. Capacity of Land fill site (20/100)

In the siting process, the available land area is a key consideration. In order to minimize the transaction costs associated with design, permitting, siting, and closure and post-closure requirements, it is desirable to have a facility that will operate for at least at least five years at a given site. In practice, many short-term facilities turn into long-term facilities, so it is important that all aspects of the siting process be observed even when planning a short-term controlled dump. Ideally, a site should be sought with sufficient capacity for 10 - 20 years of operation, particularly in the case of sanitary landfills.

1.6.9.1. Initial capacity

- **Sofi area – 4/5**

The land area available for sanitary landfill after deducting the buffer zone and area for construction of auxiliary buildings, and control station, is estimated 18 hectare. This has an estimated holding capacity of 544,875 m^3, which can serve for the next 11 years

- **Muti Area– 2/5**

The land area available for sanitary landfill after deducting the buffer zone and area for construction of auxiliary buildings, and control station, is estimated 7 hectare. This has an estimated holding capacity of 205,831m^3, which can serve for the next 5 years.

1.6.10. Extension Capacity

This refers to the possibility of extension or creation of new sanitary landfill site within the proposed area

- **Sofi area – 4/5**

There is a possibility of extension or creation of new site within the area located opposite side of the road and on the other side of Churchura stream. Also rehabilitations can be made with ease and the environment would more easily accept opening of new site for future needs.

- **Muti Area– 1/5**

Since the proposed area is within the master plan of Harar town and clos to a settlement possibility of acquiring land for extension or creation of new sanitary landfill is difficult.