4.10 AMBIENT AIR QUALITY

The prime objective of the ambient air quality study is to establish the existing ambient air quality within the study area and its conformity to standards specified. The study area represents mostly rural environment with sparse habitation and the ambient air quality levels are expected to be much less than the standards set by EHS guidelines. The sources of air pollution in the region are dust arising from unpaved roads, vehicular movement, construction activities, etc. Other air pollution sources in the area include, cooking using fuel wood, charcoal production, etc.

The baseline status of the ambient air quality has been established through a scientifically designed ambient air quality monitoring network based on the following considerations:

- Meteorological conditions on synoptic scale
- Topography of the study area
- Representatives of likely impact areas within the study area
- Location of residential areas representing different activities
- Availability of uninterrupted power supply.

The four sampling sites selected are:

- Plant site
- Derba town
- Quarry site
- Lili Chebeka village

The locations of the sampling stations are shown in **Fig. 4.24.** The photoplate below shows the monitoring in progress at site.

The ambient air quality monitoring has been carried out during the period 31st Aug 07 to 13th Sept 07. The parameters monitored include Total Suspended Particulate Matter (TSPM), Respirable Particulate Matter (PM_{10}), Sulphur Dioxide (SO_2), Oxides of Nitrogen (NOx), and Carbon Monoxide (CO). Due to the limited availability of reliable monitoring equipment in Ethiopia, the following instruments have been used for AAQ monitoring:

Environmental Monitoring Station at Quarry site

- Portable air sampling pumps for SPM and PM10
- IOM inhalable dust sampler
- Cyclone/ Spiral sampler for PM10
- Environmental Monitoring Station (EMS) of ELE Interantional for SOx, NOx and CO

4.10.1 RESULTS OF THE AMBIENT AIR QUALITY MONITORING

The results of the air quality monitoring at four locations are detailed in **Annex 4.5** and the summarized results are given in **Table 4.19**. Eight hourly sampling for 24 hours continuously has been carried out on 6 days at each location.

Parameters	Concentration (µg/m³)			
	Plant site	Derba	Mining site	Lilo Chebeka village
SPM				
Maximum	81.30	185.20	92.80	61.10
Minimum	69.44	92.60	85.60	33.10
Average	76.0	118.80	88.90	42.50
PM10				
Maximum	57.90	50.50	60.50	18.90
Minimum	45.90	30.04	49.70	10.90
Average	50.30	43.50	54.30	13.30
Draft Ethiopian Standards	150 µg/m³ (24 hours)			
WHO Guidelines (Interim target-1)	150 µg/m³			
SO_x				
Maximum	24.98	35.32	27.95	24.05
Minimum	18.79	18.02	22.63	17.23
Average	21.60	22.70	24.40	19.50
Draft Ethiopian Standards	125 µg/m^3 (24 hours)			
WHO Guidelines (Interim target-1)	125 µg/m^3			
NO_x				
Maximum	7.92	8.46	10.05	7.54
Minimum	5.92	5.98	9.09	5.45
Average	6.90	6.70	9.50	6.30
Draft Ethiopian Standards	200 µg/m^3 (24 hours)			
WHO Guidelines	200 µg/m^3			
CO				
Maximum	1557.80	1546.89	2931.00	1685.00
Minimum	1073.50	1163.40	1932.00	1073.00
Average	1299.00	1268.00	2199.00	1191.00
Draft Ethiopian Standards	10,000 µg/m^3 (8 hours)			

Table 4.19 : Ambient Air Quality in the Study Area

As can be observed for the above table, all parameters monitored are within the WHO guidelines and the draft Ethiopian standards. PM10 concentrations at the sites ranged between 10 and 60.5 µg/ m^3. The highest value was recorded at the quarry site indicating the possible release of particulate from the existing Muger quarry site and the lowest value

was recorded at Lilo site, which is a residential area. The SPM concentration at the sites ranged between 33.1 and 185.2 µg/ m^3. The SPM is highest at the Derba town site, which could be attributed to the traffic and vehicular movement and dust from gravel roads.

The concentrations of SO_2, CO, and NO_2 are below the national standard and international guideline values. Slightly high concentration is observed at the quarry site and relatively lower values are observed at Lilo village.

4.10.2 DUST FALL

The plant and mining sites were chosen to study the pre-project dust fall rates and the observations are tabulated below. The dust fall rate is higher at the quarry site than at the plant site.

Sn	Parameters	Plant site	Mining site
1	Dust fall rate (mg/m^2/ day)	209.05	722.34
2	Copper (%)	0.03	<0.03
3	Lead (%)	0.03	0.03
4	Chromium (%)	<0.03	<0.03
5	Cadmium (%)	<0.03	<0.03
6	Aluminium (%)	<0.03	<0.03
7	Zinc (%)	0.05	0.03
8	Silica (%)	13	5

4.11 NOISE LEVELS

The noise levels have been monitored at site and at various locations within the study area during the period August-September 2007. The noise levels have been monitored using a sound level meter with octave filters. Measurements have been made for 24 hours at a frequency of 30 minutes. The photoplate below shows the noise monitoring in progress at the plant site.

Noise Level Monitoring in Progress

The noise levels as recorded at four locations are given in **Table 4.20**.

Sn	Location	Noise level dB(A)					
		Leq Day Time (07.00-22.00 hrs)			Leq Night Time (22.00 - 07.00hrs)		
		I	II	III	I	II	III
1	Plant site	54	42	39	56	44	36
2	Quarry site	37	43	36	44	34	35
3	Derba town	42	41	48	47	38	45
4	Lilo Chebeka village	42	41	-	47	38	-
Average		**42**			**42**		
Draft Ethiopian Norms (Residential areas)		**55**			**45**		

I, II & III represent three sampling dates

Table 4.20 : Noise levels in the Study Area

The noise levels are all within the draft Ethiopian standards as well as EHS guidelines.

4.12 TRAFFIC DENSITY

As a part of the pre-project activities in the area, the following roads are proposed to be constructed/ strengthened. The detailed Road designs have been prepared for these sections and construction is in progress.

- Upgradation of Road from Chancho to Derba
- Construction of road from Derba to Plant site
- Construction of road from Plant site to Quarry

The Derba Junction - Derba road branches off from Chancho at Addis Ababa Gondar Trunk road and leads to Derba. The total length of the road is about 23 km.

A detailed traffic survey has been carried out in the area during the month of August 2007. The main objectives of the traffic survey are the following.

- To obtain data on the volume and composition of motorized traffic particularly the volume of heavy trucks
- To obtain data on the volume of non motorized traffic
- To determine trip pattern and characteristics of motorized traffic
- Traffic Count Period

The traffic count survey on Derba Junction - Derba road was conducted for seven consecutive days between 19 and 26 August 2007, which represents the low business season in Ethiopia in general and the project area in particular. The motorized traffic count was conducted for 12 hours (6:00 am to 6:00 pm) for five days and night count was made for the remaining two days (6:00 pm to 6:00 am), of which one is a market day.

Since the volume and composition of traffic is homogeneous throughout this road, Derba village located along the junction of proposed DMC plant was selected as the monitoring station. Since the station has one leg or direction, two way traffic was counted in single form.

The vehicle classification used in the analysis is consistent with Ethiopian Roads Authority's (ERA's) vehicle classes. The motorized traffic is further analyzed group wise in terms of passenger and freight vehicles categorized based on the kind of service rendered. Passenger vehicles include Car, Land Rover, Small Bus, Medium Bus and Large Bus. Freight vehicles group on the other hand comprises Small Truck, Medium Truck, Heavy Truck and Truck Trailer base on their respective load capacity. The type of vehicles represented by each category is as shown in **Table 4.21.**

Vehicle group	Vehicle category	Type of vehicles
Passenger Vehicles	Cars	Small Cars, Taxis
	Land Rover, 4WD	Land Cruisers, Station Wagons, Double Cabin
	Small bus	Bus with 12-24 seats and includes such vehicles as mini bus
	Medium Bus	Bus with 24-45 seats
	Large Bus	Bus with 45 to 60 seats
Freight Vehicles	Small trucks	Truck with up to 3.5 ton load including pickups, Isuzu
	Medium Trucks	Trucks with 3.6 to 7.6 ton load
	Heavy Trucks	Trucks with 12 to 24 ton load
	Truck Trailers	Trucks with above 24 ton load

Table 4.21 : Vehicle Classification

4.12.1 RESULTS OF THE TRAFFIC SURVEY

The raw traffic count data of the road project were processed in order to estimate the required Average Daily Traffic (ADT) and Average Annual Daily Traffic (AADT), which show the 24 hours and all seasons traffic flows, respectively.

The traffic count results have been converted to Average Daily Traffic (ADT) for the road section and are given below**.**

Road Section	Car	L/ Rover	S/Bus	L/Bus	S/Trucks	M/Trucks	L/ Trucks	T/T	Total
Derba Junction-Derba	0	27	25	0	27	5	2	0	**86**

Average Daily Traffic of Derba Junction –Derba Road

As can be seen in the above table, the traffic composition of Derba Junction - Derba road is dominated by L/Rover and S/Truck traffic. It accounts for 63% of the total vehicle traffic along the road section of the road followed by S/Buses and Trucks, which account for 29% and 8 %, respectively.

The detailed Average Daily Traffic (ADT) calculation of Derba Junction-Derba is enclosed as **Annex 4.6.**

4.12.2 CONCLUSIONS

The proposed cement plant would produce 5,600 tonnes of cement per day at full capacity upon commencing of production. This would in turn generate substantial demand for trucks. From the point of view of economy of scale the factory would prefer to use heavy trucks including trucks & trailers and articulated trucks. Transportation of cement (around 5,600 tonnes) from the plant to market would require 235 trucks per day assuming a load factor of 240 quintals.

Such trucks would require a strong standard road. The existing Chancho – Derba gravel road clearly cannot accommodate such heavy trucks. Therefore, the existing road will be upgraded to a black topped road.

The 8 km road from Derba to plant is also being upgraded with asphalt. Construction of roads and heavier movement of trucks would also be beneficial in boosting the economy of the area. It is likely that many trucks would travel empty to the plant to transport cement from the plant to the market. These trucks could transport agricultural inputs such as fertilizers and improved seeds to farmers at a lower price than would be possible otherwise. As a result of lower costs of inputs, farmers would be encouraged to use these and the production of crops could be increased raising the living standard of local farmers.

4.13 LAND USE

A major part of the study area comprises of cultivated and grazing land. The study area comprises of core and buffer zones. The core zone comprises of the plant and mining sites and the buffer zones covers an area of 10 km radius around the plant and mining sites.

The land use map of the plant site is enclosed as **Fig. 4.26** and for the quarry site as **Fig. 4.27**. The land use of the total study area is shown in **Fig. 4.28**.

A view of the proposed Project site

The land use pattern of the buffer zone is given below: It can be seen that the major part of the buffer area is farming/grazing land.

Land Use	Total Area (ha)
Farming	2418.7
Grazing	913.8
Residential	337.4
Tree	0.58
Others	11.33

Land Use Pattern in the Buffer Area of 10 km Radius around Mining and Plant Sites

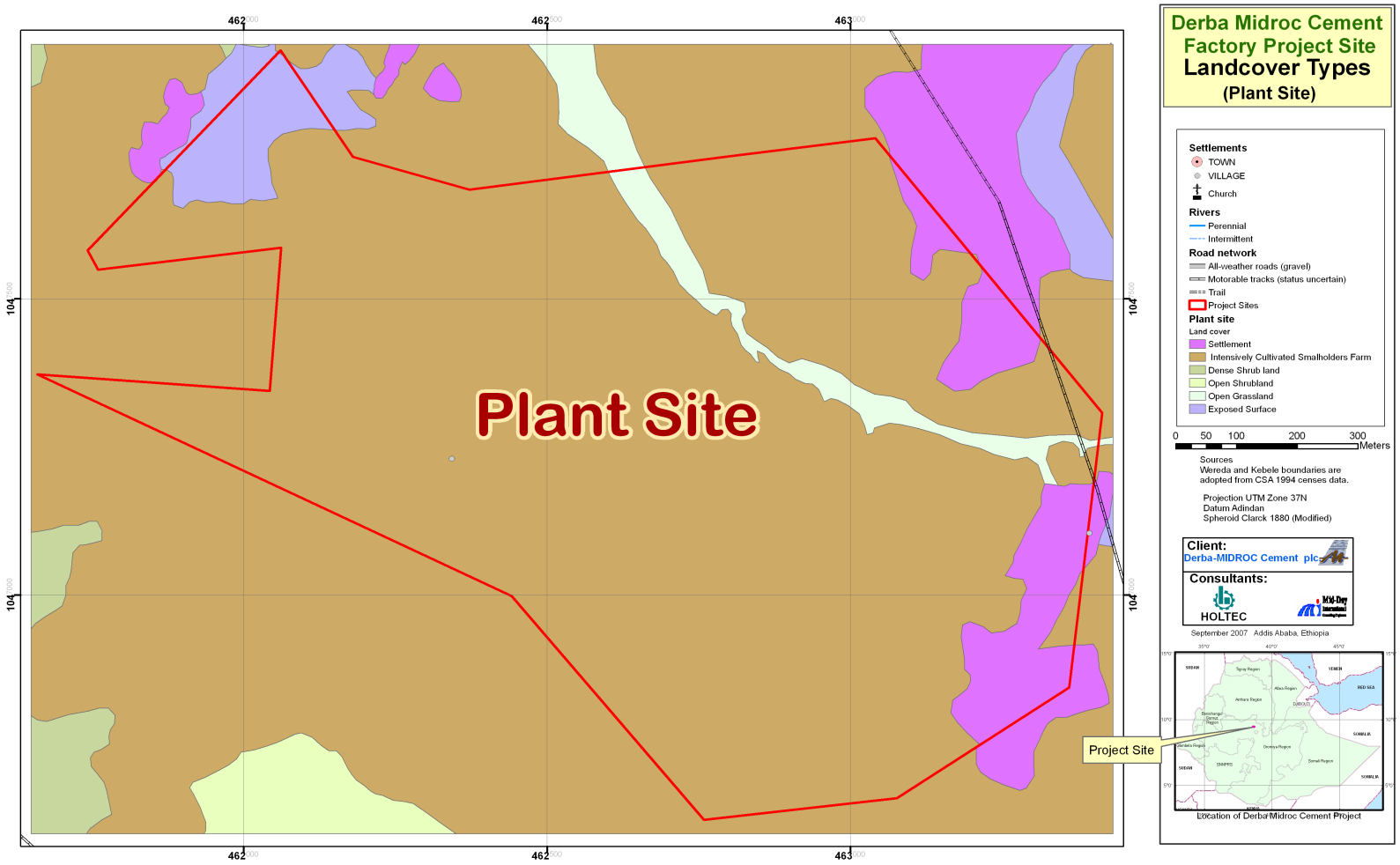

Fig. 4.26 : Land use pattern of the Plant site

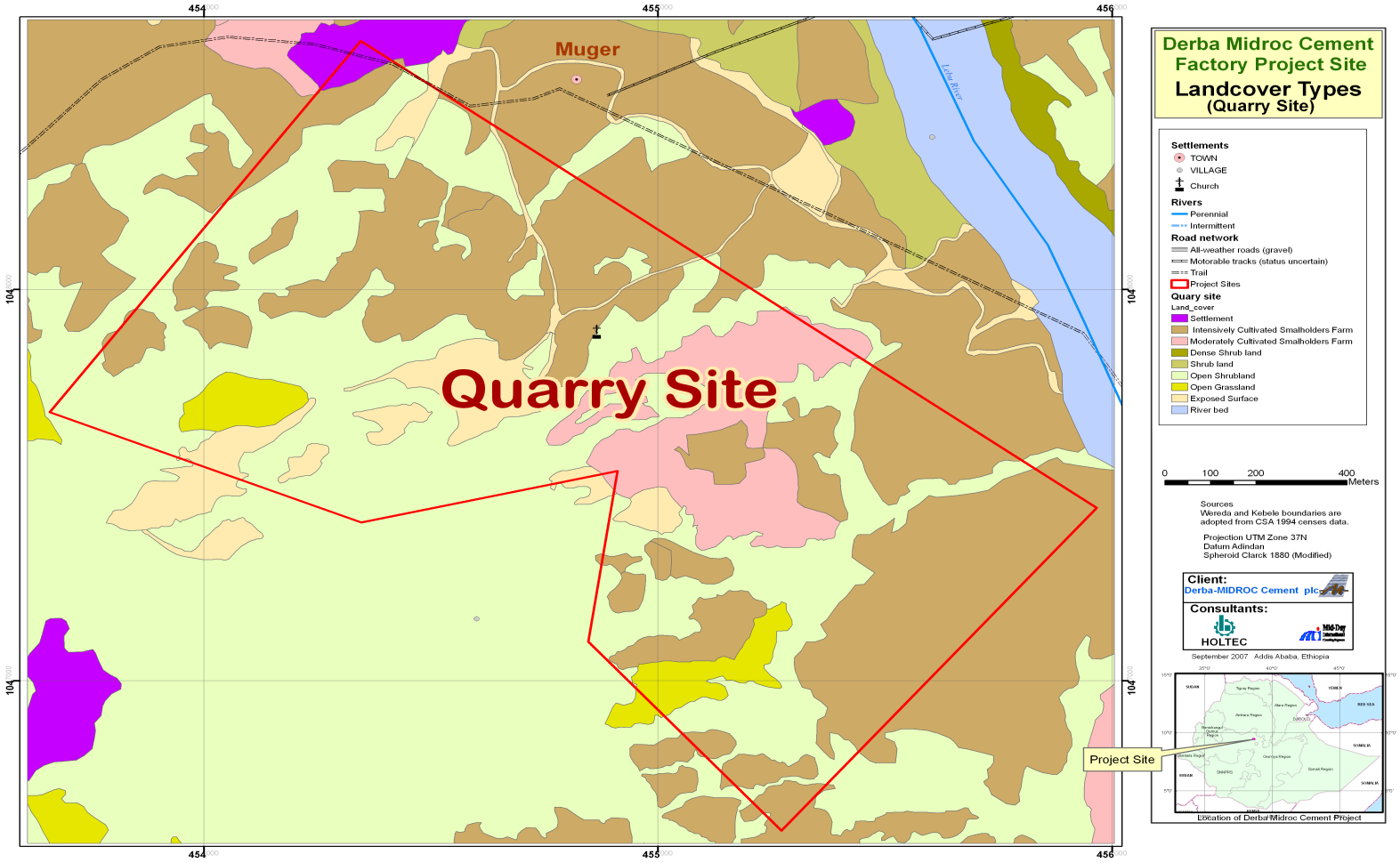

Fig. 4.27 : Land use pattern of the Quarry site

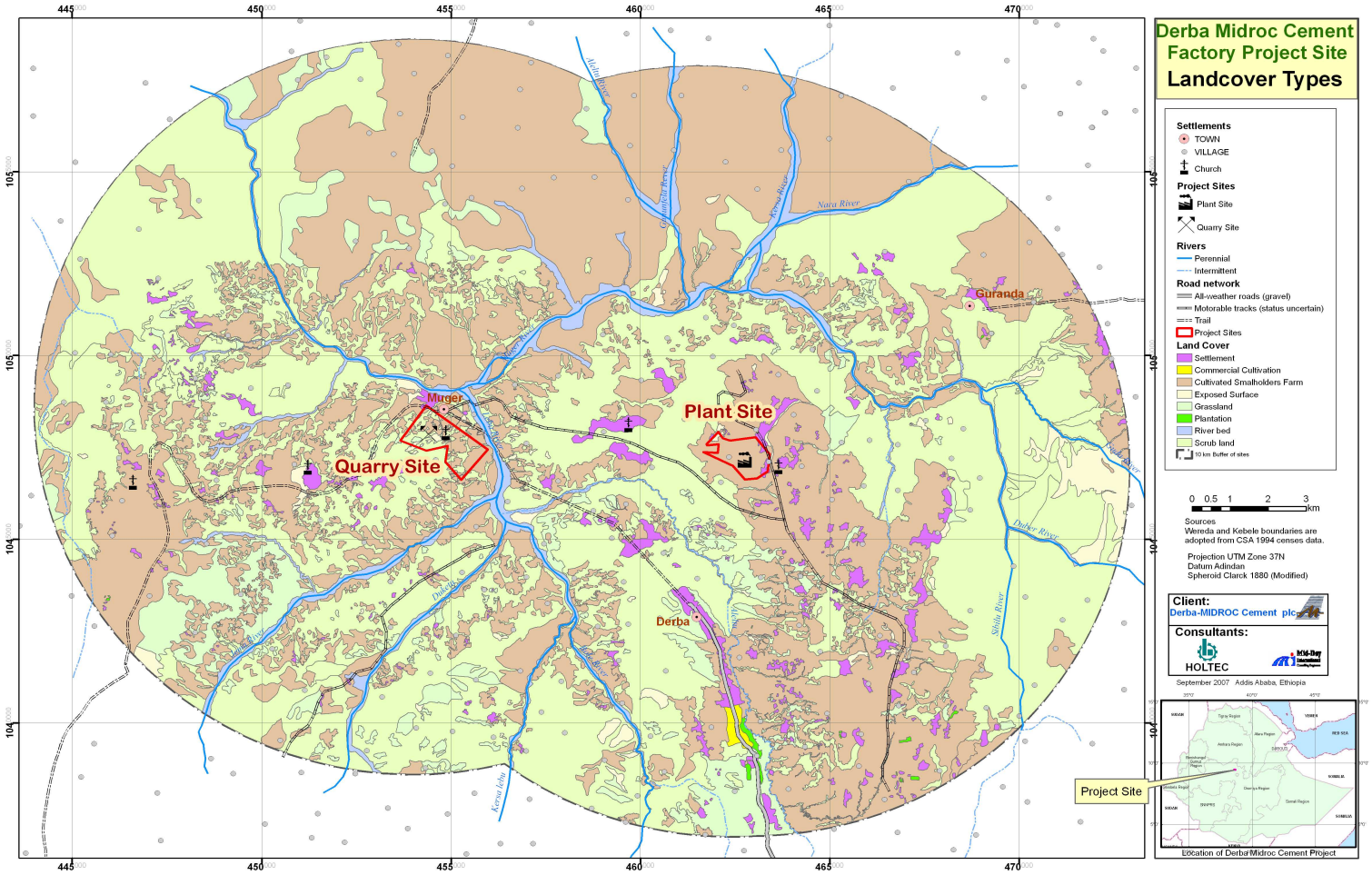

Fig. 4.28 : Land use pattern of the Study Area

4.14 ECOLOGY

4.14.1 FLORA

A reconnaissance survey and detailed data collection of the vegetation composition, abundance, cover, physionomy and other relevant ecological information of the core and buffer area was conducted at different locations in August 2007. The study has been carried out by experts from the University of Addis Ababa.

The following activities were conducted during the field investigation:

1. Extensive survey and sampling of the vegetation
2. Formal and informal discussions with the local communities living in and around the project area
3. Review of published literature and other relevant documents.

Transects were laid across the valley and twenty three plots representing the core and buffer zones were established to collect base line vegetation data. In each plot, the plant species encountered and percent cover of each species were recorded. Exotic plant species found in the area were also recorded. Cultivated plants on the field and those cultivated at other times were recorded with the help of informants. A total of 241 plant species in 79 families were encountered.

These were compared with the IUCN database for endemism and threat status. GPS coordinates of each plot together with altitude were also recorded. Contour Map of the area was obtained and both the GPS coordinates and the map were projected to UTM Adindan 37N.

4.14.1.1 Landscape Description

The landscape and associated vegetation of the core (plant and quarry sites) and the buffer areas can be classified into the following:

1. Highland plateau
2. Valleys dissecting the plateaus
3. River and Stream tributaries of River Muger

4.14.1.2 Highland Plateau

The plateau, which is found in the range between 2300-2450 m above MSL is composed of rolling landscape covering both the core and buffer impact zones. This altitudinal range is favorable for highland mixed cereal-livestock agriculture and supports a high population density. The farmlands are adjacent to each other and there is very little open land. There are grazing areas dotted among the farmlands. The dominant crops such as barley, beans, peas, wheat, and nigerseed are cultivated on the plateau and cattle, sheep, goats and equines are the common livestock component. The crops that are cultivated both in the highlands and the lowlands are presented in **Table 4.22**.

Sn	Species	Family	Status
1	Allium sativum	Alliaceae	Cultivated
2	Allium sepa	Alliaceae	Cultivated
3	Guizotia abyssinicum	Asteraceae	Cultivated
4	Cartamus tinctoria	Asteraceae	Cultivated
5	Helianthus anuus	Asteraceae	Cultivated
6	Ipomoea batatas	Convolvulaceae	Cultivated
7	Vicia faba	Fabaceae	Cultivated
8	Pisum sativum	Fabaceae	Cultivated
9	Ciser arietimum	Fabaceae	Cultivated
10	Lens culinaris	Fabaceae	Cultivated
11	Vicia benghalensis	Fabaceae	Cultivated
12	Trigonella foenicum-graecum	Fabaceae	Cultivated
13	Linum urtisssimum	Linaceae	Cultivated
14	Musa paradisiaca	Musaceae	Cultivated
15	Sesamum orietale	Pedaliaceae	Cultivated
16	Hordeum vulgare	Poaceae	Cultivated
17	Triticum aestivum	Poaceae	Cultivated
18	Sorghum bicolor	Poaceae	Cultivated
19	Eragrostis teff	Poaceae	Cultivated
20	Zea mays	Poaceae	Cultivated
21	Avena abyssinica	Poaceae	Cultivated
22	Solaum tuberosum	Poaceae	Cultivated
23	Lycopersicon esculentum	Solanaceae	Cultivated

Table 4.22 : Cultivated Species in the Core and Buffer Zones

There is no continuous vegetation cover on the plateau except some patches or isolated trees, which are planted for various purposes. The plateau was covered by dry evergreen montane forest before human settlement. The current vegetation in this area is mainly dominated by herbaceous genera including Pennisetum, Sporobolus, Eleusine, Chloris, Aristida, Phalaris, Commelina, Trifolium, Alchemilla and Cyperus. Most of these are

Fig. 4.29 : Barley farm on the plateau with eucalyptus trees in the background

highly valuable pasture species. Trees species on the plateau are restricted to churchyards and isolated patches around homesteads such as Euphorbia candelabrum, Juniperus procera, Acacia abyssinica, Hagenia abyssinica, Olea europaea ssp. Cuspidata, and Podocarpus falcatus. There are about 12 exotic species including Eucalyptus globulus, E. camaldulensis and Cupressus lusitianica plantation sites in the plateau **(Table 4.23).**

Species	Family	Use and Status
Agave americana	Agavaceae	Fiber, hedge, cultivated
Agave sisaliana	Agavaceae	Fiber, hedge, cultivated
Schinus molle	Anacardiaceae	Shade, construction
Casuarina equisetifolia	Casuarinaceae	Construction
Cupressus lusitianica	Cupressaceae	Construction
Acacia decurrens	Fabaceae	Nitrogen fixation, construction, fodder
Acacia melanoxylon	Fabaceae	Nitrogen fixation, construction, fodder
Sesbania sesban	Fabaceae	Nitrogen fixation, construction, fodder
Musa paradisiaca	Musaceae	Food
Bouganveillia sp.	Nyctaginaceae	Ornamental
Eucalyptus camaldulensis	Myrtaceae	Construction, fuelwood
Eucalyptus globulus	Myrtaceae	Construction, fuelwood
Grevellia robusta	Sapotaceae	Construction, fuelwood

Table 4.23 : Exotic Species Grown in the Study Area

4.14.1.3 The Valley and Inaccessible Hill Slopes

The steep slope of the valley precludes intensive agricultural activities except in some places where the slope is gentle. The vegetation cover is composed of dry evergreen thicket and shrubs and a few species of larger trees. This vegetation type is remnant of the degraded vegetation type found on the plateau.

Fig. 4.30 : Vegetation cover on the inaccessible hill-slope and farmlands on the more gentle slope of the Muger Valley

In the valleys and hill slopes, the vegetation is dominated by shrub lands and scrublands with an average canopy height of 1.5 m. In most places of the valley, the vegetation is highly exploited for charcoal production and fuel wood. The valleys are major suppliers of charcoal to the highlands and the neighboring towns including Addis Ababa. Agriculture has encroached into the valleys and hill-slopes and marginal lands that are not favorable for crop cultivation reducing the vegetation cover in the hillsides.

Fig. 4.31 : Charcoal Production in the Valley

The vegetation in the valley varies in composition and abundance depending on altitude. The top of the valley is covered mainly by herbaceous and scrubby species such as Carissa spinarum, Osyris lanceolata, Euclea racemosa, and Dodonaea angustifolia. At lower elevations, there is a decline in herbaceous cover and an increase in woody shrubs such as Rhus natalensis, Acacia spp., Balanites aegyptiaca; and succulents such as Opuntia-ficus indica and Euphorbia candelabrum. The detailed description of the vegetation along the altitudinal range is given below. The species composition and abundance in the plots sampled both on the plateau and the steep slopes of the Muger valley are shown in **Annex 4.7**. The map showing the altitudinal range is enclosed as **Fig. 4.32.**

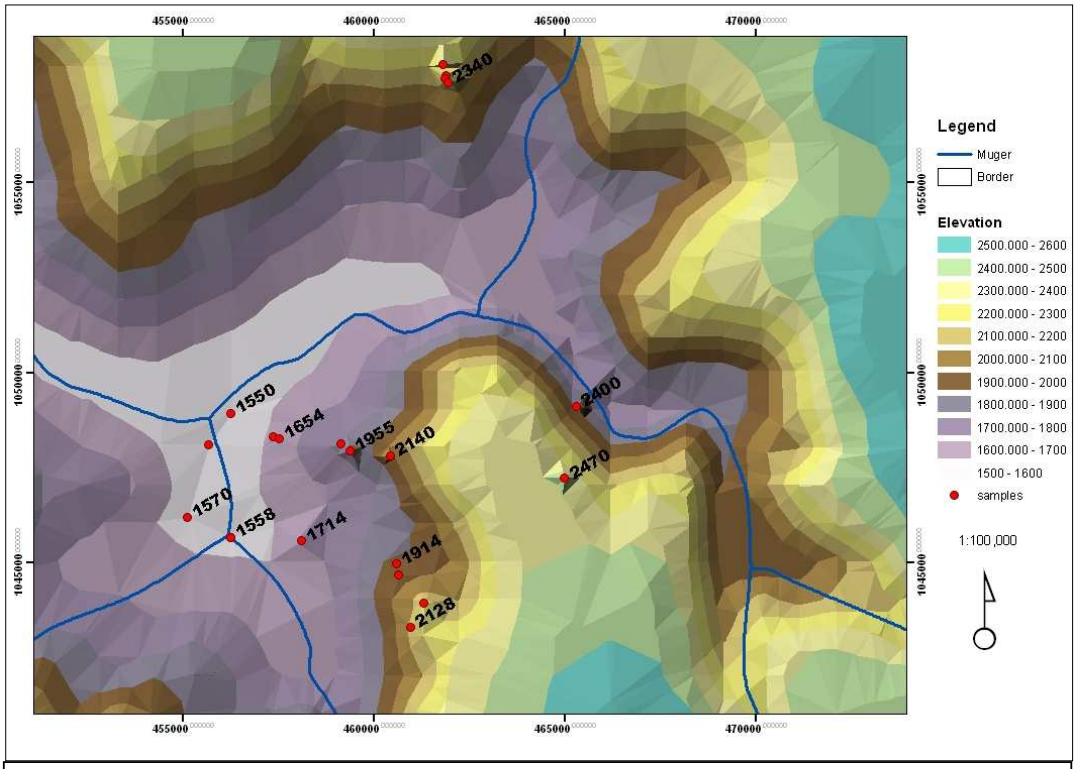

Fig. 4.32 : Altitudinal ranges and sample plots of the project area

1. 1500 - 1600 m altitudinal range - Average altitude for the plots is 1557 m.

   Acacia ehrenbergiana, Acacia gerrardi, Acacia tortilis, Acacia etbaica, Acokanthera schimperi, Balanites aegyptiaca, Cadaba farinosa, Calpurnia aurea, Clerodendrom myricoides, Combretum molle, Commicarpus grandiflorus, Commiphora schimperi, Euclea racemosa, Euphorbia candelabrum, Euphorbia tirucalii, Maerua triphylla, Maytenus arbutifoilia, Opuntia ficus indica, Plectranthus sp., Rhus natalensis and *Senna singuinea* were encountered in the plots.

   Dominant species in this altitudinal range are *Acacia gerrardi, A. tortilis, Opuntia ficus-indica* and *Acacia etbaica*.

   Ficus sur, Ficus vasta, Acacia lahai, Coccinia abyssinica, Ficus thonningi, Urtica simensis, Grewia velutina, Acacia lahai, Calpurnia aurea, Maytenus senegalensis, Croton macrostachyus, Dichrostachys cinerea, Opuntia ficus indica, Acalypha sp. , Euphorbia tirucalii, Achyranthes aspera, Albizia gummifera, Ficus thonningi, Grewia trichocarpa, Grewia flavescens, Commelina benghalensis, Grewia villosa, Commicarpus grandiflorus, Grewia ferruguinea, Ziziphus mauritania, Lannea rivae, Acacia nilotica, Stereospermum kunthianum, Grewia arborea, Cadaba farinosa, Dichrostachys cinerea, Oxygonum sinuatum, species of *Trifolium and Crotalaria*, *Abutilon sp., Euphorbia dumalis*, and *Justicia ladanoides* are also found around the plots in this range.

2. 1600-1700 m altitudinal range - Average altitude for the plots is 1647 m.

The species encountered in this range are *Acacia etbaica, Acacia gerrardi, Acokanthera schimperi, Asparagus africanus, Cadaba farinosa, Capparis tomentosa, Cissus rotundifolia, Combretum molle, Commiphora schimperi, Crorton macrostachyus, Dombeya torrida, Euphorbia candelabrum, Ficus sur*, *Grewia ferruginea, Hibiscus micranthus, Lannea sp., Maerua triphylla, Opuntia ficus indica, Senna singuinea* and *Trema guneensis*.

Dominant species in this altitudinal class are *Euphorbia candelabrum, Commiphora schimperi, Opuntia ficus indica, Acacia gerrardi,* and *Combretum molle*.

3. 1700-1800 m altitudinal range - Average altitude for the plots is 1714 m.

   Balanites aegyptiaca, Schrebera alata and *Senna singuinea* were found in this plot.

4. 1800-1900 m altitudinal range - Average altitude for the plots is 1840 m.

   The species encountered in this range are *Ficus vasta, Ocimum lamiifolium, Schrebera alata and Impatiens rothii. Agave sisaliana, Salix subserrata, Erythrina abyssinica, Cordia africana, Acacia tortilis* and *Euphorbia tirucalii* are found around settlement places.

5. 1900-2000 m altitudinal range - Average altitude for plots is 1951 m.

   The species encountered in this range are *Acacia gerrardi, Acacia etbaica, Calpurnia aurea, Calpurnia aurea, Capparis tomentosa, Clerodendrom myricoides, Combretum molle, Commiphora schimperi, Dodonaea angustifolia, Euclea racemosa, Ficus sur, Maytenus arbutifoilia, Osyris quadripartita, Pentas lanceolata, Premna resinosa, Rhus retinnorhea, Scheffleria abyssinica*, and *Ximenia Americana*.

   Acacia gerrardi, Acacia etbaica and *Maytenus arbutifoilia* have dominant cover in this altitudinal range. *Stephania abyssinica, Maytenus heteromorpha, Euphorbia tirucalii, Acacia tortilis, Cordia africana, Croton macrostachyus, Commiphora schimperi, Pilostigma thonningi* and *Erythrina abyssinica* are also found around the plots in this elevation range.

6. 2000- 2100 m altitudinal range - No plots were established in this altitudinal range.

7. 2100 - 2200 m altitudinal range

   The species encountered in this range are *Albizia gummifera, Alchemilla sp., Calpurnia aurea, Carissa spinarum, Clerodendrom myricoides, Clutia abyssinica, Dichrostachys cinerea, Helinus mystacinus, Hibiscus sp., Hypericum quartitianum, Phyllanthes sepialis, Rhus retinnorhea, Rhus glutinosa, Rumex nervosus, Senna singuinea*, and *Tagetes minuta*.

8. 2200-2300 m altitudinal range - Average altitude for the plots of this range is 2240 m.

   The species encountered in this range are *Aloe sp., Carissa spinarum, Combretum molle, Commiphora schimperi, Impatiens rothii, Kalanchoe sp., Lantana trifolia, Lippea adoensis, Ocimum gratissimum, Ocimum lamifolium, Olea europaea, Otostegia integrifolia, Rhocissus tridentate* and *Rumex nervosus*.

Impatiens rothii, Lantana trifolia, Lippea adoensis, Otostegia integrifolia, Rumex nervosus, Ocimum lamiifolium and *Ocimum gratissimum* are relatively dominant in this altitudinal range. *Oputia ficus-imdica, Euclea racemosa, Arthraxon species, Olea europaea, Ficus sur, Rhocissus tridentate, Schrebera alata* and *Abutilon sp.* are also found around the plots in this range.

9. 2300 -2400 m altitudinal range - Average altitude for the plots of this range is 2351 m.

   Acacia brevispica, Albizia gummifera, Calpurnia aurea, Carissa spinarum, Carissa spinarum, Epilobium hirusutum, Clerodendrom myricoides, Dodonaea angustifolia, Euclea racemosa, Heteromorpha trifoliata, Jasminum floribundum, Lantana trifolia, Maytenus addat, Maytenus arbutifoilia, Osyris quadripartite, Premna schimperi, Pterolobium stellatum, Rhus natalensis, Rhus glutinosa, Rosa abyssinica, Rumex nervosus, Senna singuinea, and *Steganotaenia araliaceae* are encountered in the plots. The species relatively dominating in this altitudinal range are *Albizia gummifera*, *Calpurnia aurea, Heteromorpha trifoliata, Dodonaea angustifolia*, and *Steganotaenia araliaceae.*

   Olea europaea, Solanum somalense, Solanum incanum, Verbascum sinauticum, Cordia africana, Scheffleria abyssinica, Ricinus communis, Hypericum quartitianum, Phoenix reclinata, Ficus sur, Croton macrostachyus, Clutia abyssinica, Salix subserrata, Otostegia abyssinica, Aloe sp., Asparagus sp., Bersama abyssinica, Podocarpus falcatus, Clematis sinensis, Clausenia anisata, Plantago lanceolata, Rosa abyssinica, Eucalyptus globulus, Eucalytus camaldulensis, Acacia melanoxylon, Sesbania sesban, Cupressus lusitianica, Acacia decurrens, Schinus molle, Croton dichrogamus, Leucaenia leocarpa, Ricinus communis, Bouganvellia sp., Solanum marginatum, Agave sisaliana, Pterolobium stellatum, Agave americana, Grevellia robusta, Hagenia abyssinica, Casuarina equisetifolia, Vernonia amygdalina, Vernonia abyssinica, Senna singuinea, Ficus sycomorus, Rhus glutinosa, Ekebergia capensis, Embellia schimperi and *Stephania abyssinica* are also observed in different spots.

9. 2400-2500 m altitudinal range - Average elevation of the plots established in this range is 2431 m.

   The species encountered in this range are *Acacia abyssinica, Asparagus sp., Carissa spinarum, Crorton macrostachyus, Dovyalis abyssinica, Euclea racemosa, Euphorbia candelabrum, Hibiscus micranthus, Impatiens rothii, Lannea sp., Lippea adoensis, Olea europaea, Osyris quadripartita, Plectranthus sp., Rhus retinnorhea, Rubus steudneri, Rumex nervosus, Salix subserrata and Scheffleria abyssinica. The species occurring with high dominance are Euclea racemosa, Rumex nervosus, Rhus retinnorhea, Acacia abyssinica, and Lippea adoensis. Other species observed around the plots in this range are Cupressus lusitianica, Eucalyptus camaldulensis, E. globulus, Salix subserrata, Arundo donax, and Eucalyptus globulus*.

4.14.1.4 Medicinal Plants

A total of 60 medicinal plants were recorded in the study area. **Table 4.24** gives a list of the medicinal plants found in the area.

Sn	Species	Family	Status
1	Justicia schimperiana	Acanthaceae	M
2	Otostegia integrifolia	Acanthaceae	M
3	Otostegia tomemtosa	Acanthaceae	M
4	Allium sativum	Alliaceae	M
5	Allium sepa	Alliaceae	M
6	Achyranthes aspera	Amaranthaceae	M
7	Agrocharis melanantha	Apiaceae	M
8	Ferula communis	Apiaceae	M
9	Acokanthera schimperi	Apocynaceae	M
10	Carissa spinarum	Apocynaceae	M
11	Artemisia abyssinica	Asteraceae	M
12	Vernonia abyssinica	Asteraceae	M
13	Vernonia amygdalina	Asteraceae	M
14	Vernonia leopoldii	Asteraceae	M
15	Balanites aegyptiaca	Balanitaceae	M
16	Impatiens rothii	Balsaminaceae	M
17	Stereospermum kunthianum	Bignoniacea	M
18	Cordia africana	Boraginaceae	M
19	Datura strumarium	Boraginaceae	M
20	Opuntia ficus-indica	Cactaceae	M
21	Maerua angolensis	Capparidaceae	M 2
22	Combretum molle	Combretaceae	M
23	Commelina benghalensis	Commelinaceae	M
24	Kalanchoe sp.	Crassulaceae	M
25	Coccinia abyssinica	Cucurbitaceae	M
26	Croton dichrogamus	Euphorbiaceae	M
27	Croton macrostachyus	Euphorbiaceae	M
28	Euphorbia candelabrum	Euphorbiaceae	M 1
29	Euphorbia dumalis	Euphorbiaceae	M1
30	Euphorbia tirucalii	Euphorbiaceae	M2
31	Calpurnia aurea	Fabaceae	M
32	Senna occidentalis	Fabaceae	M
33	Senna singuinea	Fabaceae	M
34	Trigonella foenicum-graecum	Fabaceae	M 2
35	Clerodendrum myricoides	Lamiaceae	M
36	Leucas martinicencis	Lamiaceae	M
37	Ocimum gratissimum	Lamiaceae	M
38	Ocimum lamiifolim	Lamiaceae	M

Sn	Species	Family	Status
39	Premna resinosa	Lamiaceae	M
40	Premna schimperi	Lamiaceae	M
41	Verbascum sinauticum	Lamiaceae	M
42	Bersama abyssinica	Melianthaceae	M
43	Stephania abyssinica	Menispermaceae	M
44	Myrica salicifolia	Myricaceae	M
45	Maesa lanceolata	Myrsinaceae	M
46	Ximenia americana	Olaccacaceae	M
47	Olea europaea	Oleaceae	M
48	Phytolacca dodocandera	Phytolaccaceae	M
49	Rumex abyssinicus	Polygonaceae	M
50	Hagenia abyssinica	Rosaceae	M
51	Rosa abyssinica	Rosaceae	M
52	Clausenia anisata	Rutaceae	M
53	Brucea antidysentrica	Simabouraceae	M
54	Solanum incanum	Solanaceae	M
55	Solanum marginatum	Solanaceae	M
56	Solanum nigrum	Solanaceae	M
57	Solanum somalense	Solanaceae	M
58	Lantana trifolia	Verbenaceae	M
59	Lippea adoensis	Verbenaceae	M
60	Rhocissus tridentata	Vitaceae	M

Note M: Medicinal, M1= Medicinal and widely distributed, M2= Medicinal in other places

Table 4.24 : Medicinal Plants in the Study Area

Fig. 4.33: Impetiens rothii, a widely distributed medicinal and cosmetic plant species found in the area

4.14.1.5. Endemic and Threatened Species in the Area

The plant species encountered in the buffer zone include 15 endemic species of which 5 are highly endangered and 10 are of least concern. **Table 4.25** gives a list of endemic species found in the area. The species are designated as threatened as per Ethiopian classification.

Endemic threatened	*Least concern endemics*
Crotalaria rosenni	*Dombeya aethiopica*
Hypericum gnidiifolium	*Echnomps longisetus*
Indigofera rothii	*Erythrina brucei*
Maytenus addat	*Euphorbia dumalis*
Satureja puncata	*Lippea adoensis*
	Milletia ferruguinea
	Rhus glutinosa
	Senecio myriocephalus
	Vepris dainellii
	Vernonia leopoldi

Table 4.25 : Endemic and Threatened Species in the Study Area

The Plant families and the number of species in the project area are given in **Table 4.26** the detailed list of flora species occurring in the area is enclosed as **Annex 4.8.**

Family	No. of species
Acanthaceae	6
Agavaceae	2
Alliaceae	2
Aloaceae	1
Amaranthaceae	1
Anacardiaceae	8
Apiaceae	6
Apocynaceae	2
Aquifoliaceae	1
Araceae	1
Arecaceae	1
Asparagaceae	1
Asphodelaceae	2
Asteraceae	20
Balanitaceae	1
Balsaminaceae	1
Bignoniacea	1
Boraginaceae	3
Burseraceae	1
Cactaceae	1
Capparidaceae	4
Caryophyllaceae	1
Casuarinaceae	1
Celasteraceae	3
Combretaceae	1
Commelinaceae	2
Convolvulaceae	2
Crassulaceae	1
Cucurbitaceae	1
Cupressaceae	2
Cyperaceae	2
Ebenaceae	1
Euphorbiaceae	10
Fabaceae	40
Flacourtiaceae	1
Hypericaceae	2
Iacinaceae	1
Lamiaceae	8
Lamiceae	1
Linaceae	1
Malvaceae	4
Meliaceae	1
Melianthaceae	1
Menispermaceae	1
Moraceae	4
Musaceae	1
Myricaceae	1
Myrsinaceae	2
Myrtaceae	4
Nyctaginaceae	2
Ochnaceae	1
Olaccacaceae	1
Oleaceae	3
Onagaraceae	1
Pedaliaceae	1
Phytolaccaceae	1
Pittosporaceae	1
Plantaginaceae	1
Poaceae	15
Podocarpaceae	1
Polygonaceae	3
Ranunculaceae	2
Rhamnaceae	2
Rosaceae	5
Rubiaceae	6
Rutaceae	1
Salicaceae	1
Santalaceae	1
Sapindaceae	5
Sapotaceae	1
Simabouraceae	1
Solanaceae	5
Sterculiaceae	1
Tiliaceae	7
Ulmaceae	1
Urticaceae	1
Verbenaceae	2
Vitaceae	2
Total	79

Table 4.26 : Plant Families and number of Species in the Study Area

4.14.1.6 Protected Areas

Ethiopia is making efforts to protect biodiversity and conserve resources through the creation of protected parks, wildlife resources, controlled hunting areas and Regional Priority Forest Areas. Based on the review of available national and regional conservation area maps issued by the Government and other competent authorities, it has been confirmed that the project area is neither contiguous with, nor in close proximity with any of these nationally protected areas.

There are many birds in the project area. However, according to Ethiopian Wildlife and Natural History Society (EWNHS, 1996), none of the 78 nationally designated Important Bird Areas are found anywhere near the project area.

4.14.1.7 Conclusions

The study area of 10 km radius around the plant and mining sites is rich in species composition though the abundance and distribution is highly influenced by anthropogenic factors such as crop cultivation, grazing, charcoal production and wood cutting for domestic use. A total of 241 species in 79 families have been recorded. Most of these species are indigenous while a few others are exotic or naturalized. A total of 23 cultivated plant species were recorded. A total of 60 medicinal plants were recorded. The plant species encountered include 15 endemic species of which 5 are highly endangered and 10 are of least concern.

4.14.2 FAUNA

A detailed faunal study has been carried out in the area by experts from the University of Addis Ababa. The general objective of the faunal study is to make a baseline survey of the fauna at the proposed DMC plant and mining site and:

- To inventorize and identify the faunal composition of wildlife, insects, birds, amphibians, reptiles, domestic animals and aquatic invertebrates at the proposed plant and quarry core and buffer zones of the project area
- To distinguish between the fauna found in the core zones (plant and quarry sites) and the buffer zones (around 10 km radius from the core centers)
- To determine the ecological status of the fauna according to the IUCN/ Ethiopian guidelines as endangered (critically), threatened, vulnerable, extinct, rare, etc

4.14.2.1 Methodology

On-site observations were made and recorded at the plant and quarry sites, in both the core and buffer zones.

- Birds - Birds were identified based on direct observation and calls on site. For species identification, the guide of Williams and Arlott (1980) was referred.
- Wildlife - Local informants were interviewed about the past and present status of wildlife in the buffer zones. The quarry core area is very small and inhabited by the workers of Mugher factory; so no wildlife exists there. The plant core site is close to Adero village and inhabitants of the village reported that the wildlife in the area was long ago decimated. The taxonomy of wildlife was checked with Kingdon (1997).
- Insects and butterflies - These were recorded from the valley and by the river banks and a few specimens were collected for verification. Cross checking was done with the

reference insect and butterfly collection of the Zoological Natural History Museum, Biology Department, Addis Ababa University.

- Reptiles - Informants were requested to describe the snakes they encounter as poisonous/ non-poisonous and using the local names, an educated guess was made about the scientific identity of the snakes. Lizards and turtles were rarely observed. Reference was made for further authentication to the draft paper prepared by Mohammed et al. (2001) on the terrestrial wild animals and protected areas in Ethiopia.
- Amphibians - Both on site observation and local information was used. Frog croaking was common in the Mugher River in the late afternoon.
- Fish - The rivers were in high flood at the time of the survey, so no fish was directly sampled. The local people confirmed that fish tend to hide in the riverbed or migrate elsewhere at this time. In the long dry season, however, local informants said that the rivers were full of fish. The scientific identity of the fish could easily be deduced from the fine description of the informants.
- People also claimed that they prepared different types of food from fish - dried and pound fish-soup, fillet, cooked, fried, but never ate raw fish as is commonly observed in the rift valley lakes.
- Other mammals - Besides wildlife, a lot of domestic animals were observed, including cattle, goats, sheep, chicken, donkeys, horses and dogs/cats.
- The ecological status of the fauna was determined according to the criteria recommended by IUCN using Internet resources and literature.
- Plankton samples - Algal samples were collected and preserved in Lugol's Iodine from backpools of some rivers, and ditches in Derba.

4.14.2.2 Fauna in Project Core Areas

Core Plant Site - Becho

Table 4.27 shows the faunal composition at the core area of the proposed plant site. Because of human incursion in the area, most of the wild fauna has disappeared. Intensive cultivation has removed most of the original forest and the natural habitat of birds, insects, and butterflies has almost disappeared, which explains the poor faunal diversity in this area in general. There is a small spring from which the village of Adero draws water. It had no amphibian, reptile or fish specimens.

The fauna existing in the core zone of plant is given in **Table 4.27.**

	Scientific Name	Common name	Status as per IUCN	Status as per Eth. Wildlife
Mammals	*Tragelaphus seriptus*	Bush diuker	R	R
	Geneta abyssinicus	Genet cat	R	R
	Theropitecus gelada	Anubis baboon,	C	C
		Gelada baboon	R	R
	Canis mesomelas	Vervet monkey	R	R
	Crococta crococta	Jackal	R	R
		Hyaena	C	C

	Scientific Name	Common name	Status as per IUCN	Status as per Eth. Wildlife
Aves (Birds)	*Francolinus clappertoni*	Francolin	R	R
	Corvus albus	Pied crow	R	R
	Accipiter rufiventris	Sparrow	C	C
	Vidua paradisea	Paradise whydah	R	R
	Placoeus baglafechi	Weaver	C	C
		Paradise flycatcher	R	R
		Guinea fowl	R	R
	Terpisiphone viridis	Tawny eagle	R	R
		Starling	C	C
		Yellow-billed Oxpecker	R	R
Pisces (Fish)		None in the Adero spring		
Amphibians		None observed		
Reptiles		Poisonous snakes		
Insects		Grasshoppers (Acrididae)	C	C
Butterflies		Family Lycaenidae Popillionidae Hesperidae Daniidae,	C	C
Plankton		Not sampled		

R = Rare; C = Common

Table 4.27 : Faunal Composition at the Core Plant Site

Core Zone of Quarry Site at Mugher Valley

Table 4.28 gives the faunal composition at the quarry core site in the Mugher valley. This excavation site is 1.4 km away from the old quarry site of the state-owned Mugher factory. The area is a sparsely populated farmland with the rivers flowing far below on the north-eastern side. The long history of human encroachment for farming and charcoal production has decimated the forest and wildlife. Birds and insects are rare because of the deforestation. The area can be described as already depauperate in fauna.

Core zone (Quarry)

	Scientific name	Common name	Status as per IUCN	Status as per Eth. Wildlife
Mammals		Vervet monkey	C	C
		Anubis baboon	C	C
		Jackal	R	R
		Leopard	R	R

	Scientific name	Common name	Status as per IUCN	Status as per Eth. Wildlife
Aves (Birds)	*Ploceus baglafechi* *Accipiter rufiventris*	Weaver Sparrow	R R	R R
Pisces (Fish)		None observed		
Amphibians		None		
Reptiles		None		
Insects Butterflies		Butterflies, beetles (scarabid) and meadow grasshoppers	C	C
Plankton		Not sampled		

R = Rare; C = Common

Table 4.28 : Faunal Composition at the Core Quarry site (Mugher valley)

River Floodplain

The five rivers in the Muger valley - Lebu, Bole, Duketu, Jemma, Sibilu and Muger - were at high flood season at the time of the survey. Therefore no plankton or macroinvertebrate collection was made, except for a few phytoplankton samples collected from backpools. Fish were not directly observed also; instead, the local people were interviewed about the status of fish during the long dry season.

The river floodplain is rich in both aquatic and terrestrial fauna. The presence of riparian vegetation and forest contribute to diverse insect and butterfly species. Fish and amphibians are common in the rivers. The Nile lizard (*Varanus niloticus*) is common in the Muger River, but the people say that crocodiles are absent, which explains why the local people frequently water their livestock, bath and even graze their cattle near the riverbanks. Some parts of the floodplain have even been converted into banana plantations and sorghum fields. Many farmers make charcoal by indiscriminately cutting the forest, thereby exposing the soil to erosion into the rivers and exacerbating habitat loss for birds and insects.

The bird diversity is high in the floodplain, and most of these birds migrate locally to the escarpment. The surrounding land is intensively farmed and attracts a lot of birds and monkeys. The heavy human encroachment may pose the most serious ecological challenge in the river floodplain than the operation of limestone quarries by the old and the new cement projects.

In general, this is a biodiversity-rich area, but already, this has been compromised by the intensive deforestation, wildlife hunting and other human activities, which have affected the natural resources in a very negative way.

Buffer zone (Mine/Quarry)

	Scientific name	Common name	Status as per IUCN	Status as per Eth. Wildlife
Mammals		Anubis monkey	C	C
	Theropithecus gelada	Gelada baboon	R	R
	Canis mesolamis	Jackal	R	R

	Scientific name	Common name	Status as per IUCN	Status as per Eth. Wildlife
	Potamochoerus porcus	Bush pig	R	R
	Panthera pardus	Leopard	R	R
		Porcupine	R	R
	Felis serval	Serval	R	R
		Goats, sheep, donkeys, horses, chicken and cats/dogs	C	C
Aves (Birds)	*Francolinus clappertoni*	Francoline	C	Same category as IUCN
	Numida meleagris	Guinea fowl	R	
	Euplects franchiscus	Red-headed bishop	R	
	Ploceus baglafechi	Weavers	R	
	Terpsiphone viridis	Paradise flycatcher	C	
	Streptopelia senegalensis	Dove	R	
	Vidua paradisea	Paradise whydah Swallows	C	
	Lagonosticta rufopicta	(Nesting) Finches	C	
	Serinus tristrianus	Seed-eaters	R	
	Uragenthis bengalus	Red-checked cordon blue	C	
		Starlings, etc		
Pisces (Fish)		4 species of *Labeo*, *Barbus*, *Oreochromis* and *Clarias* (catfish)	C	C
Amphibians		Frogs (Bufo sp.)		
Reptiles		(Family Boidae and Viperidae),	C	C
		Lizards (Agamidae)	C	C
		Crocodile in Muger downstream	R	R
Insects		Insects: Odonata (dragonflies and damselflies),	C C	C C
Butterflies		Beetles (Cuculionidae, Scarabidae, Elateridae), Crickets,	C R	C R
		Grasshoppers (Acrididae - *Acrida* and *Oxya* sp.)	C	C
		Praying mantis *Colotis* butterflies	C	C
		Millipedes		
		Burrowing beetles (Noteridae),	C C	C C

	Scientific name	Common name	Status as per IUCN	Status as per Eth. Wildlife
		Velvet ants (Mutilidae) etc		
Plankton		Algae in backpools Macroinvertebrates and plankton not sampled	C	C

Table 4.29 : Faunal Composition at the Buffer River Floodplain (Muger valley)

4.14.2.3 Habitat Integrity Rating of the Rivers

Rapid habitat integrity assessment was made of the five rivers using the criteria developed for the Rapid Bioassessment Protocol (RBP) of Barbour *et al*., (1999). A few criteria were modified to suit the local conditions, such as pollution by dung and human wastes. Weights are assigned to different in-stream and riparian characters of the river reaches such as flow modification, exotic macrophytes, solid waste disposal, bank erosion and vegetation cover. The ten most important habitat components are considered for analysis with each component having a score of 10 points, adding up to a total of 100%. A range of score points describe the habitat integrity status of the river. High scores describe pristine or unimpaired conditions and low percentages apply to impacted rivers.

Table 4.30 gives the criteria and the score of the habitat components considered for the ecological integrity assessment of the five rivers in the Muger valley. Rapid habitat assessment was done by visual scoring of both in-stream and channel features of each river and each component was assessed out of 10 points to make a total of 100 points. Category and interpretation was done according to Barbour *et al*., (1999).

Habitat component (instream and riparian)	Lebu River	Bole River	Duketu River	Jemma River	Muger River
Substrate quality and quantity	10	10	10	10	10
Sediment and sand deposition	9	8	8	9	7
Channel alteration (modification)	10	10	10	9	7
Bank stability (canopy and erosion)	8	8	8	8	8
Riparian vegetation zone width	9	8	8	8	7
Frequency of riffles/bends	10	10	10	10	9
Manure/dung wastes	9	9	8	8	6
Velocity/depth regime	10	10	10	10	10
Water quality (appearance)	10	10	10	10	10
Exotic plants and animals introduction	10	10	10	10	10
Total habitat score	95	93	96	92	84
Interpretation Largely pristine with few modifications. A small change in natural habitats and biota may have occurred, but the basic ecosystem functions are predominantly unchanged (80-99% score)	B	B	B	B	B

Table 4.30 : Habitat Integrity rating for the five rivers at the Muger Valley

The main reasons for the lowered score of the habitat integrity of some of these rivers (especially Muger) could be the following:

- Bank erosion and modification due to cultivation on the river banks
- Channel modification for excavation purposes
- High level of cattle dung due to the large livestock and their daily watering at different sites of the rivers
- Some human encroachment especially at Muger river
- Impact of the Muger old town at upstream site
- Removal of riparian vegetation for cultivation and charcoal making.

Adjoining Buffer Weredas

Wildlife data was collected from the local community and the Wereda offices of four adjoining buffer zone areas - Yayu Gulele, Adaberga, Wuchale and Sululta Weredas and shown in **Table 4.31.**

Common name	Scientific name	IUCN status	Ethiopian Statutes
Bush buck	*Tragelaphus seriptus*	*R*	*R*
Bush diuker	*Sylviacapra grimma*	*R*	*R*
Leopard	*Panthera pardus*	*R*	*R*
Civet	*Viverra civetta*	*R*	*R*
Vervet monkey		C	C
Gelada Baboon	*Therophitecus gelada*	R	R
Aardvark	*Orycteropus afer*	*R*	*R*
Serval	*Felis serval*	*R*	*R*
Warthog	*Phacochoerus aethipicus*	*R*	*R*
Colobus monkey	*Colobus abyssinicus*	*R*	*R*
Porcupine	*Hystrix cristata*	*C*	*C*
Jackal	*Canis mesomelas*	*R*	*R*
Hyaena	*Crococta crocota*	*C*	*C*
Genet cat	*Geneta abyssinica*	*R*	*R*
Hamadryas Baboon	*Papio hamadryas*	*C*	*C*
Bush pig	*Potamochoerus porcus*	*R*	*R*
Cheetah	*Acinomyx jubatus*	*R*	*R*
Rock hyrax		*R*	*R*
Abyssinian hare	*Lepus abyssinicus*	*R*	*R*

R = Rare; C = Common

Table 4.31 : Fauna in the Adjoining Buffer Weredas

Algal samples were recovered from rock pools and mud slicks. The major groups found in their order of dominance, were *filamentous green algae, especially Cladophora and Spirogyra sp. and* some diatom species. These are the only plankton samples collected during this time of the year. During the dry season, they could potentially form algal blooms in backpools and impounded waters (perhaps causing problems for livestock and wildlife watering). The tangled mass of such algae can be a nuisance in potable water filters and can clog pipes and plant installations.

4.14.2.4 Conclusions

Far fewer fauna were observed in the core zones as opposed to the buffer zones, even if the latter was already highly impacted by deforestation and wildlife hunting.

There are no faunal species recorded from the Muger valley area that can be categorized as endangered, threatened or vulnerable. The species encountered are common forms that are observed in other parts of Ethiopia. The adjacent Sululta plains on the other hand harbour the globally threatened white-winged flufftail and corncrake and the near-threatened Rouget's Rail, Pallid Harrier, Great Snipe and Abyssinian Long claw. The open plains are an important feeding area for blue-winged goose, spot-breasted plover, wattled ibis and red-chested swallows. The last were reported roosting in the Muger valley in addition to a few Egyptian geese in the Muger River. The Muger area could be a potential migration route (at least locally) for these threatened species from the Sululta plains. The endemic birds present in the Sululta plains (spot-breasted plover, Abyssinian longclaw and Abyssinian catbird) were not observed in the Muger valley.

People indicate that the forest cover and wildlife numbers were very high even as recently as three decades ago. The last few remaining forests on the escarpment should be supplemented with revegetation programs around the quarry and plant sites. This will help both to mitigate the impact of dust and noise emissions and enhance biodiversity level resulting in an improved situation from the baseline status.

4.15 CULTURAL, HISTORICAL & ARCHAEOLOGICAL FEATURES

A rapid archaeological survey was carried out in the project plant site and quarry area, and their environs from August 29 to September 1, 2007.

4.15.1 PRIMARY DATA

The archaeological survey was carried out using the following methodology:

- Site Survey was conducted to search archaeological materials on the surface of the project area and its environs.
- Site recording of the study area by GPS and existing topographic maps.
- Photographic recordings of the landscape, sites and identified materials.
- Tape measurements of identified sites, artifacts and ruined structures.
- Informal Interview with local elders and officials.

Secondary data was obtained from written historic sources, maps, previous archaeological works, reports, and archival materials particularly from ARCCH (Authority for Research and Conservation of Cultural Heritage, Ethiopia).

The gathered data was analyzed qualitatively with standard risk assessment and evaluating format of preventive archaeology.

4.15.2 BACKGROUND OF THE PROJECT AREA

Although a number of rivers are found in northwest of Addis Ababa in the environs of the study site, Sibilu and Gerbi Rivers, which converge and enter into Muger river, are the major ones. Muger River is one of the main tributaries of Abbay (Blue Nile) River. These rivers are located southwest of Debre Libanos Monastery of Abuna Teklehymanot. Abuna

Teklehymanot was a thirteenth century Saint of Ethiopian Orthodox Church, who carried out evangelical activities with his disciples in this part of the region.

The predominant population of the region is Oromo.

History of the Region

Ancient Period : 2800 BC – 1270 AD

During the ancient period (ca 2800 BC-1270 AD) the region was occupied by the ancient and medieval states, which were outside the occupation of the Aksumite Empire and the Zagwe dynasty. Though there are no available historic sources that mention that the region was under the two kingdoms during ancient time, other sources indicate that the region was partly the Shewa state and partly the anonymous state of Damot.

Medieval Period : 1270 AD – 1524 AD

Historical references to the position of the study area and the medieval district of Muger indicate that the region was at the strategic position of Shewa where the fertile districts of Waj, Enarea, Indagabatan, Warab, and Damot were found. Tradition and written documents mention that the treasury and wealth of the medieval Emperors of Ethiopia were deposited in this part of Shewa. References to the region were available in relation to the invasion of Ahmad Gran and the movement of the Oromo.

Historical written sources indicate that the western side of Debra Libanos and the whole region of Muger were highly dominated by pagan religious practices before the advent of Christianity to the region. Indagebtan, Warab, Tsegagen, Slalish, Waj and Damot were most probably pagan. Of these the most widely known pagan kingdom was Damot. The rulers of Damot, and Meteolomi had fought against the Christian king in this region near Sibilu River.

Christianity was introduced in the region by Aba Tekele Haymanot in the thirteenth century.

Medieval historical sources indicate that the region northwest of Addis Ababa has occupied an important place in the history of Ethiopia. The region of Showa became the very centre of the Christian kingdom. The fertile districts of Muger attracted Christian settlers from the north. The region became the seat of the king and the abbot. Therefore palaces, churches, monasteries and residential houses flourished in the region. Still there are ancient monasteries in the region. A good example of these is Debra Semona, northwest of Sibilu River in the district of Wizero.

The region of Derba and Muger was a seat of the medieval emperors. Yekuno Amlak (1270-1283 AD) and his successors established their royal courts and important towns in this part of the region. The mountainous region of the north, which is traversed by Muger River, holds the town of Baquellat and the venerated church of Tekle Hawaiat. In this part of the region the lost town of Zaraah, where the Egyptian and Syrian Christian merchants dwelled was also found.

To sum up, oral tradition and historic written sources testify that the fertile districts of northwest Showa such as Muger, Wagda, Dinbi, Waj, Warab, Indagabtan and others, were located between Muger River and Indagabtan. Indagabtan was stretched eastward from the source of Awash to Debra Berhan. These districts were the seat of church and state. Thus royal palaces, churches, monasteries, markets and residential houses were highly concentrated in the region during the medieval period.

The Oromo Movement

Since the sixteenth century, the Oromo tribes, Mecha and Tulema, have moved to and settled in the region of Derba and Muger. This movement has resulted in the assimilation and intermingling of the ancient settlers of the region with the Oromo.

4.15.3 PREVIOUS ARCHAEOLOGICAL RESEARCH IN THE AREA

Since the 16th century the map of the project area has changed dramatically. The ancient and medieval place names appear to be changed or distorted. The original inhabitants of the region might have been pushed further north, or assimilated into the present inhabitants of the area. Most inhabitants of the region neither remember nor claim the location and stories of the old monasteries, palaces and churches of the region. The only remnants that could testify the existence of the wealth and powerful states in this part of Ethiopia are archaeological materials, such as ruins of palaces, churches or monasteries, burial places and artifacts.

Based on these assumptions, experts from the ARCCH conducted archaeological survey and impact assessment in the environs of Chancho in connection with the Sibilu and Garbi dam sites reservoir and transmission lines. The study was conducted in 1996 based on the mutual agreement between AAWSA Stage III Water Supply Project and the Department of Archaeology and Anthropology of the CRCCH (now ARCCH).

The ARCCH survey team discovered largely two distinct cultural remains. These are megalithic and medieval cultures. Megalithic, which stretches back to the Neolithic, consists of standing stone (Stelae), tumulus and dolmen. Medieval structures consist of wall structures most probably constructed between the 10th to the 16th century. The team discovered traces of archaeological elements at Deneba, Gulele (probably Dinbi); Awaso-Daka, Fita, Didibe, Birbirtu (probably Barara), and Galiye Mana Abichu-Burka, Bodo and Boru.

The team finally concludes that they do not certainly know to whom these monuments belonged. They recommend proper investigation and excavation so as to trace their originator and reach to know their social, economic and political organizations, which in turn contribute a new knowledge to the history of Ethiopia.

In 2006, a team of Preventive Archaeology carried out field survey in two major archaeological areas: Dibdibe and Ochi Luncha, which are located in the environs of the project area. In Dibdibe the team found a total of ten archaeological areas. In Dibdibe the team discovered red and black potsherd, obsidians, tumuli and ruined structures. However, this site is nearly 40 km away from the DMC plant and mining sites.

Like Dibdibe the team also spent some days in Ochi Luncha area to carry out an archaeological ground survey. Six archaeological areas were found concentrated on farming and grazing areas with plain and slope land morphology. Five of these archaeological areas have potsherds and obsidians of different colour and thickness.

A tumuli and stelae have been found here. The standing basaltic rocks are found to the north of Dibdibe. It is the effect of natural phenomena. However, it seems that in the long past people were living on those basaltic rocks, managed part of the spaces and left some traces of archaeological elements on the surface; example, potsherd, obsidians. The stones were used by the people in the natural state. Here tumuli with standing stones were observed.

The locations of Dibdibe and Ochi archaeological sites are shown in **Fig. 4.34.**

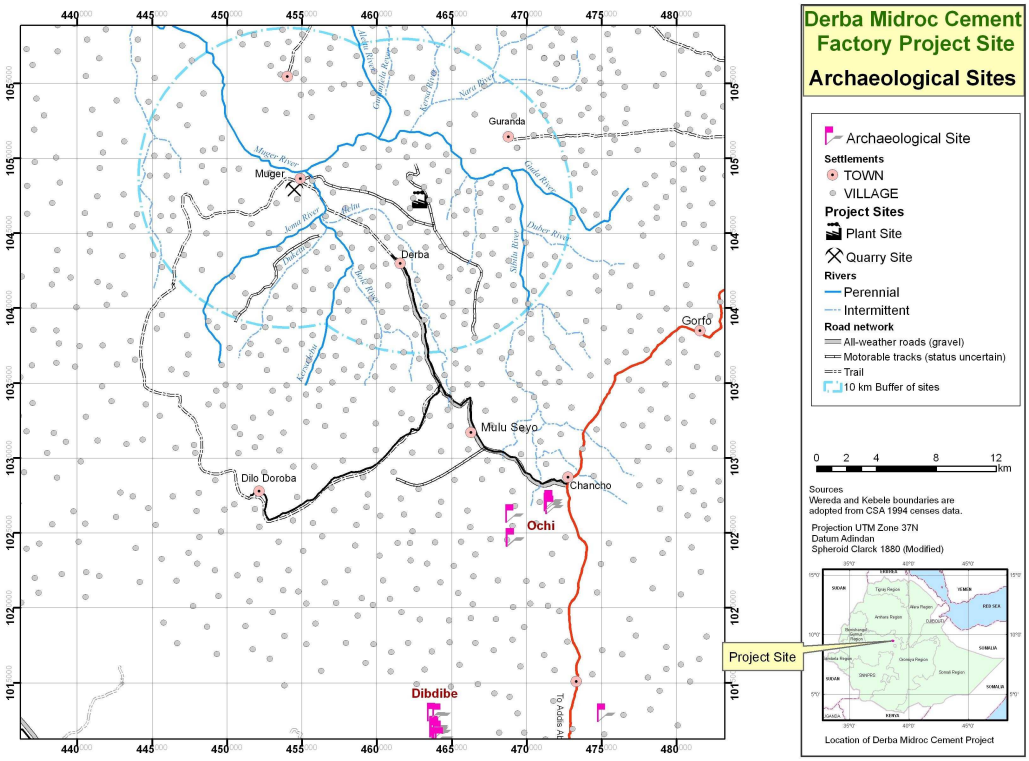

Fig. 4.34 : Archaeological Sites in the Area

4.15.4 ARCHAEOLOGICAL SURVEY RESULTS

4.15.4.1 Plant Area

The plant and camp sites were surveyed extensively on foot from south to north direction. The survey result revealed that there are no observable artifacts, features, and fossils in the plant site. Consultations with the project constructors and local farmers also justified that no observable ruined structure, standing stones, obsidian stone tools or ceramic fragments in the project area. Investigation was carrying out on the excavated materials, which were dug out for construction purposes. In some part of the plant site 2-4m deep trenches are observed. Excavated soils are also visible. Analysis on the excavated soils also confirmed no visible archaeological materials in the site.

Further survey was also conducted outside the plant site around the hills of Dibdibe. At a place called Gulbe, unknown age stone structure, which is similar to the ruined structure discovered by the preventive archaeology team in the other side of Dibdibe Mountain, is observed.

4.15.4.2 Mining Area

Archaeological survey and observation of the landscape were carried out over the 1km^2 × 2km^2 quarry site and its buffer zone. Investigations were also conducted in 11 boreholes, drilled in the mining area.

Church of Aba Tekle Haimanot *Foundation of the new church*

The excavated soils and sediments are thoroughly investigated. No stone artifacts, organic and inorganic archaeological materials are observed. No mega structures are also seen. Local informants also confirmed that there is no observable cultural remains in their region.

Although the Church of Aba Tekle Haimanot is located outside the quarry site, it is close to it. According to locals, the villages surrounding the church might be evacuated soon, which may isolate the church from the villagers. Since the church is placed close to the quarry site, the process of quarrying, transportation and other related activities would be affected directly or indirectly the church. Currently new construction is going on inside the church compound.

4.15.5 CONCLUSIONS

The results of methodical surface survey and evaluation in the actual plant and quarry sites of DMC demonstrate that no visible archaeological remains, which have scientific, cultural, public, economic, ethnic and historic significances, are discovered.

The construction of the plant as well as the excavations in the quarry site have no direct impact on the archaeological materials, which are placed particularly in the hills of Dibdibe, which are about 40 km away.

The risks value in both the plant and the quarry sites are very low, where no significant observable archaeological evidence is found. The sites have no archaeological importance. Thus, the preservation of the sites is not mandatory.

It may be advisable to consult with the authorities of Mugar Tekle Haymanot church about the future fate of the church and about the ongoing construction inside the church compound. It is recommended that the old church might be preserved as it is. But the site of the new church could be transferred to the nearby village.