GIS And Remote Sensing Integrated Environmental Impact Assessment of Irrigation Project In Finchaa Valley Area

Ahmed Amdihun
Addis Ababa University, Ethiopia
aamdihun@yahoo.com

Abstract

This research was conducted in order to assess the environmental impacts of Finchaa irrigation project using GIS and remote sensing techniques. Because of the limited resources only some environmental parameters were selected. These parameters are natural vegetation, soil/land, water quality, climate and health conditions.

The normalized vegetation index (NDVI) analysis was used to detect the spatial and temporal change of vegetation biomass in the study area. The result indicated that the natural vegetation biomass is declining. This is mainly due to the expansion of agricultural land and escalating human made structures in the area.

The water physico-chemical analysis demonstrated that the down stream water has more chemical substances and degraded physical properties than the up stream counterparts. The direct leakage of industrial liquid waste and the agro-chemicals from irrigation fields are supposed to contribute for this result. The GIS analysis of a 100 meter buffer around Major rivers and tributary streams is found to be a necessary action to mitigate the problem of pollution.

The soil chemical and physical property analysis in the irrigated and non irrigated fields reveals that the soil samples taken from irrigated fields contain higher phosphorous, Nitrogen and organic carbon compared to its counter parts. The use of agro-chemicals in the irrigation fields contribute for the result.

From the twenty two years rain fall, temperature and humidity data no abrupt inclining or declining trend is observed that could tell the possible impacts of the project.

The post irrigation development years witness that some water born diseases and malaria case records have increased. It is also found out that expansion of irrigation fields and the respective Malaria case records are positively correlated.

Generally, despite the significance of the Finchaa irrigation project, it has negative environmental repercussions. This is evident from vegetation cover distraction, water quality deterioration in the down stream area, alteration of soil physical and chemical components and increasing health threats. If the current condition continues the problems may out weight the benefits of the irrigation project. Thus in the project site and adjoining areas urgent environmental conservation is necessary. This helps to sustain the existing and revitalize the fading resources.

1. Introduction

1.1 Background Information

The expansion of irrigation scheme in Ethiopia lend a hand to achieve food self sufficiency and poverty reduction. Irrigation agriculture makes production more unwavering than the rain fed agriculture. Proper planning and management aided irrigation projects contribute for the growth of national GDP and GNP. It also creates job opportunities for several thousands of people directly or indirectly.

Despite their significances, however, irrigation practices have sometimes adverse impact on environmental conditions. It is known that Human activities have a profound effect up on the natural

environment and are becoming the main agent of environmental degradation.

Finchaa valley was one of the few areas in Ethiopia to preserve its natural conditions for years. The topographic set up made the area to be inaccessible. In 1975 the valley was selected as a suitable site by the state farm to produce food and commercial crops. After few years the area was again chosen to establish a sugar factory. Following these there were many activities carried out in the area. Some of these activities have an enormous positive contribution while some others have negative effect on the environment.

In Finchaa valley, following the establishment of the sugar factory more pronounced land degradation is observed. There is large scale land clearance (deforestation) by the factory for new irrigation field.

In addition there are many people in and outside the valley that earn their livelihood from forest and forest products.

The factory uses agrochemicals like fertilizers, pesticides and herbicides in irrigation fields and the wash away collected in ditches and then join the nearby tributary stream. On the other hand some Part of the liquid waste from the factory spillover the treatment plant and joins Finchaa River. The problems emanate from the little attention given for environmental conservation as the main objective is to maximize production and productivity. The cumulative effects of these all problems can result in environmental degradation.In Finchaa valley there exists a continuous disturbance on vegetation cover, soil, and water. If the trend goes on, there will be an extreme effect on the environment. Thus, it is indispensable to carry out environmental impact assessment (EIA) of the irrigation project in the area.

Environmental Impact Assessment has been recognized as an integral part of the early planning studies of irrigation projects in order to identify any expected negative impacts and to suggest the necessary actions to curb the problem. In addition, EIA can consider different designed alternatives for the project as an essential step for better decision making. The application of Geographic information system (GIS) and remote sensing can facilitate the study of environmental impact assessment of irrigation projects for a better outcome.

1.2. Objectives of the study

1.2.1. General Objectives

- To Asses the impact of the irrigation project on the natural environment of Finchaa valley Area.

1.2.2. Specific Objectives

- To see the impacts of Finchaa irrigation scheme on vegetation cover using satellite images of different years.
- To explore the extent of soil quality degradation as a result of the irrigation scheme.
- To asses the impact of the irrigation on water quality in the upstream and down steam water of Finchaa River.
- To see the climatic change (temperature and rain fall) over the past 22 years and interpret the results on sustainability of the irrigation project.
- To investigate some health threats following the irrigation project spatially and temporally.
- To propose some valuable measures to be taken to mitigate the negative impacts of the irrigation project on the environment in such away that assures sustainable development.

1.3 Research Methodology

In order to make out the positive and negative impacts of the irrigation project on the environment of Finchaa valley area more of primary and some secondary data are collected. Some of these data are integrated with GIS and remote sensing techniques in a way that manifests the impacts of the irrigation project on the environment.

To best investigate the positive as well as negative impacts some components of the

environment are preferred for investigation. These are vegetation cover, soil/land, water, climate and health cases records.

The first line consideration is given to the direct environmental impacts of the irrigation scheme. In light of this the indirect impacts are also inspected to the best of the researchers' knowledge and available resources.

Different years of satellite images are used for the vegetation cover change with the expansion of the irrigation in Finchaa valley. Under this the scope and extent of variation in land cover, land use, reflectance properties, Image differencing, erosion estimation and the NDVI analysis are explored and quantified.

To investigate the impacts of the irrigation on the soil the physical and chemical soil analysis has been made. The soil samples in different sites were collected. These sites are the irrigated fields, ploughed but not yet planted and non irrigated (vegetated) areas. The samples were taken in three layers and totally nine samples were analyzed. The result is believed to show the soil component anomalies in the irrigated and non irrigated areas and the possible causes. Visual presentation of the land with and without irrigation also gives some idea about the level of land degradation. Some GIS integrated slope analysis also provides slope differences and the intensity of erosion.

In order to investigate water quality problems water samples from upstream and down stream areas were taken and these samples are supposed to show the spatial water quality changes. This intern helps to examine the impacts of the project on water quality. Quantity wise the irrigation water use will be incorporated to asses the problems emanating from under and/or over utilization of water.

Long year's meteorological data are used in order to evaluate the micro climate of Finchaa valley area for temporal anomalies. In light of this panorama other environmental components are examined and possible solutions recommended. This again helps to foretell the sustainability of the irrigation scheme in relation to climatic favorability.

The unstructured interview to the concerned bodies and past research works furnish with valuable information with respect to the past-present natural and socio-economic setup of the area. These data are integrated with impact assessment and GIS/RS techniques in such a way that shows the kind and extent of changes that have been taking place.

2. Impacts of the Irrigation project on Vegetation and Soil

2.1. Impacts of the Irrigation project on vegetation cover

2.1.1. General Conditions of Natural Vegetation Cover

In developing countries the attention given for vegetation conservation is less compared to the need for development. In realizing their policies for food self sufficiency and agricultural productivity preeminent value is given for irrigation developments even some times at the expense of environmental considerations.

Depending on the management system irrigation projects can have both positive as well as negative impacts on vegetation cover. Undoubtedly the expansions of irrigation projects have many advantages. However, in most cases there happens change in the natural ecosystem following large scale irrigation developments. Obviously in order to under take large scale irrigation projects the vegetation cover in the area needs to be cleared and different construction activities should be carried out. Natural Vegetation as one of the eminent part of the ecosystem is negatively affected with such development activities. Large scale forest resource degradation can change the natural environment. This in turn puts the sustainability of irrigation projects in question. Conversely if appropriate consideration is given for vegetation conservation the forest area can be delineated and effective afforestation and reforestation can be carried out. For that matter vegetation resource can be keep hold around the hills, on vacant and marginally suitable lands. The conservation of natural vegetation can fix the problem of soil

erosion, micro climatic disturbances, biodiversity and it balances many of the environmental systems.

Well planned irrigation schemes have good natural vegetation conservation and management plans. Effective management and proper balancing of these seemingly conflicting issues should be treated wisely.

Finchaa valley in the pre 1975 years was virtually under natural vegetation cover. The tall savanna grasses mixed with short and medium trees predominate the elevation below 1600m.The steep escarpments and the far down stream areas experience dense vegetation growth. The gallery forests occupy the networks of major rivers and their tributaries. As it is evident from the MSS satellite image of 1972 there was no apparent human intrusion to the valley. From unstructured interview made with local elders there were some individuals who went to the area to collect wild honey from trees and hunters for valor.

The first intrusion to the valley was successfully made by the state farm in 1975. Since this time it is estimated that the state farm cleared about 3,500 hectors of land (vegetation) .The 1986 TM image reveals that some parts of the eastern and western banks of Finchaa River are occupied with some food and commercial crops. Even at this moment most part of the valley was under the natural vegetation cover.

The construction of the road dawn the escarpment made the forest resources accessible and vulnerable for human interference. This opened up a new episode for the forest resource exploitation. Still to the present Finchaa valley is considered as an ideal site for hard wood and bamboo forests used for fire wood and construction activities.The beginning of 1990s can be seen as the second turning point in the forest history of the area. In these years Finchaa valley was selected as the most suitable site for sugar cane plantation and industrial development. In the mean time the state farm abandoned the farm and handed over the area to Finchaa sugar Factory. In 1991 the Finchaa sugar project started extensive mechanized vegetation clearance. From the three major Companies that carried out the feasibility study any of them did not recommend for any single area buffering for natural vegetation conservation. Almost all attention was on sugar cane production and strategies for expansion. Accordingly the west bank of Finchaa River was considered more suitable and fertile and at present about 8,064.88 hector is under sugar cane plantation. (See fig 4.3)The factory neglected the east bank until the recent years. This year Vegetation clearance and land preparation has been taking place on the eastern bank. The total area of 7,108 hector is expected to be irrigated. Despite the fact that the expansion escalates the industrial productivity, it further aggravates the problem of deforestation in the valley.

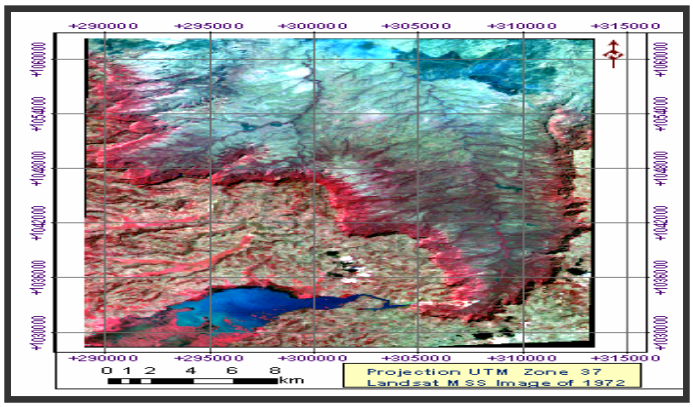


Figure 2.1. RGB/321 MSS satellite images of Valley Area 1972 with 30 meter resolution.

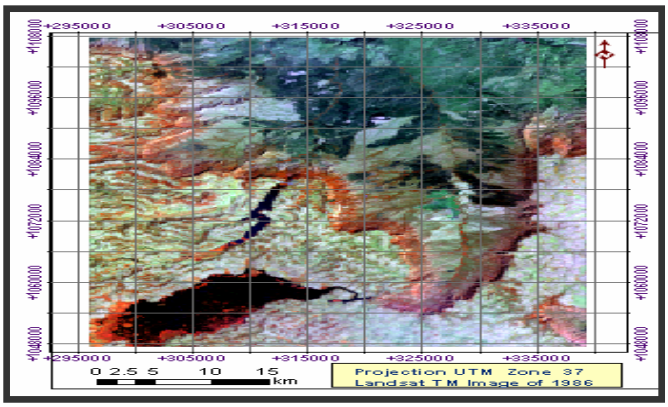
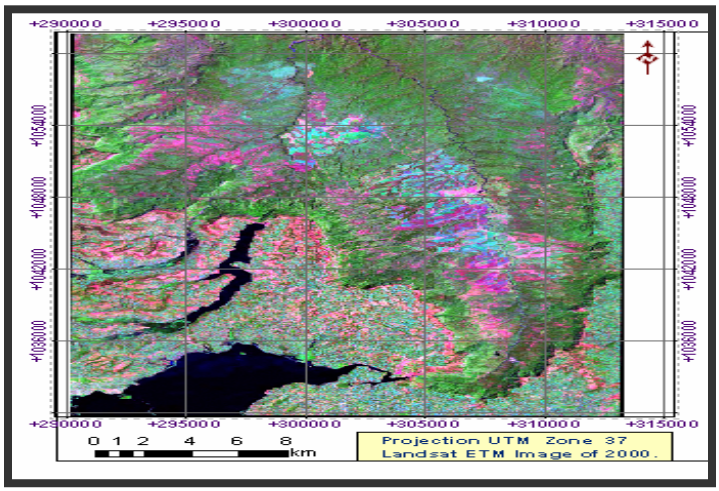


Figure 2.2. RGB/321 TM satellite Valley Area 1986 with 30 meter resolution.



From the visual image interpretation it is evident that there is land cover change. Some features like the vegetation biomass are diminishing while some others like Finchaa Lake are increased in size. Even though there is large scale vegetation clearance there are efforts made by the factory to plant trees on unused areas. To the present Finchaa sugar factory under forestry department planted 600 hectors of land in the afforestation program. One of the tree species preferred is eucalyptus tree .This was so for the accessibility of the tree.

Figure 4.1. RGB/321 ETM satellite images of Finchaa Valley Area 2000

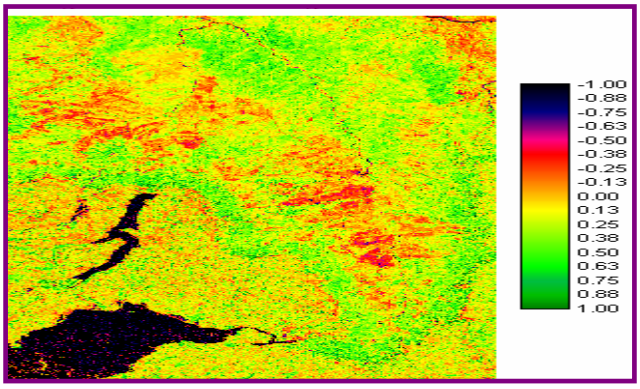
Currently the department has the plan to cover 2,200 hectors of land under the reforestation and afforestation programs.However, this amount is very less with respect to the vegetation clearance which has been taking place for long years in the area. In comparison to the vegetation that has been cleared the present afforestation program reclaim for not more than 7.5 percent of the land under irrigation. Even if the future goal of the department is attained it reclaims only for about 27.3 percent of the present land under irrigation. At the time 13,000 hectors of land is irrigated if only 2,200 hectors of land is under forest cover it means that less than 17 percent of the cleared land is revitalized.

The irrigated field has increased a lot. In 1997/98 about 932.27 hectors of land was harvested and after eight years that is in 2005/06 it increased by more than seven folds. By implication the vegetation cover is retreating with the same or even more rate.

Deforestation is the major problem in Finchaa valley area. The large scale vegetation clearances by the factory together with individuals earning a livelihood from forest products are devastating the vegetation resource. Forest fire is one of the critical causes for the vegetation degradation. In addition to the naturally instigated fire the factory and some individuals play a significant role in triggering the problem. The fire escaping from the frequent cane burning by the factory and irresponsible action by individuals who are looking for timber, charcoal, fire wood, Wild honey collection, construction wood and others exacerbate the obliteration.

2.1.2. The Normalized Difference Vegetation Index

Figure4.6. The Normalized vegetation Index results of Sept.2000 ETM image



Normalized difference vegetation index (NDVI) is a method used to analyze the vegetation cover of an area. NDVI is calculated from reflectance measured inthe visible and near infrared channels from satellite-based remote sensing. NDVI shows the temporal and spatial change of Vegetation cover. The difference between two images is calculated by finding the difference between each pixel in each image and

generating an image based on the result. The NDVI Analysis

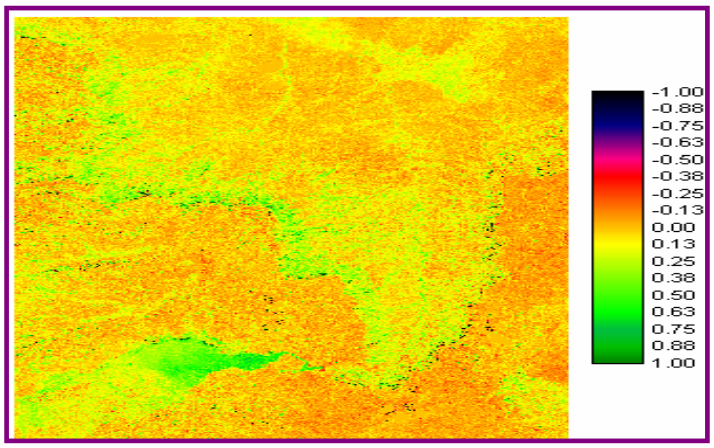


Figure4.6. The Normalized vegetation Index results of Dec.1972 TM image

of the 1972 Multi spectral scanner (MSS) image of Finchaa valley area reveals that there is more vegetation biomass in the study area (NDVI>0) compared to the later years.

The Normalized vegetation index of 2000 image shows lesser vegetation biomass compared to the 1972 image. The expansion of cultivated areas, bare lands and built up areas are apparent in the NDVI analysis. These areas appeared as deep red and NDVI < 0.0. This means that many areas that were formerly under vegetation cover are turned up into Human made features.

Table 4.1: The Normalized Vegetation index result of the 1972, 1986 and 2000 satellite images.

Year	Landsat MSS		Landsat TM		Landsat ETM	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
1972	87.3427	66.2614	-	-		
1986	-	-	80.4064	63.1612		
2000					68.2834	58.5612

Table 4.1 Reveals that the mean and standard deviation of the 1972, 1986 and 2000 images has been decreasing. This could indicate the rate of vegetation cover destruction.

Generally the Visual image interpretation and the Normalized vegetation index results confirm that the vegetation biomass of Finchaa valley area has been diminishing. There are three major factors that can explain this circumstance. These are the expansion of agricultural lands, growing settlement areas and large scale deforestation that has been taking place for many years. Still the present trend indicates that the deforestation will continue to the virgin lands. By taking the aspiration of the factory for expansion in to consideration large effort should be made in afforestation and reforestation projects. Strict measures should be taken to stop illegal forest resource exploitation and the frequent fire. Afforestation and reforestation activities should not be considered as a superfluous

activity. Beyond harmonizing many of the natural systems they can serve as a means to solve many problems like soil erosion, hot weather conditions, degradation of biodiversity, fire wood and wood product requirements and many others.

4.2. Impacts of the Irrigation project on Soil

Soil is one of the most decisive natural resources. It has been supporting the increasing number of life in our planet earth. Now a days the large number of population increased the demand for food, this in turn put forth full-size pressure on land /soil resource. Areas formerly considered as marginal are currently being cultivated. The demand for big yield created enthusiasm to look for alternative means. One of these is getting bigger yield through customary agricultural practices like irrigation systems, use of fertilizers, pesticides, herbicides and many other agricultural inputs.

Irrigation schemes beside their positive contributions have many shortcomings on the physical and chemical properties of soil in particular and the environment in general. The FAO repository document mentioned some of the adverse impacts of irrigation schemes on soils which include Salinization, Alkalization, Water logging, soil pollution and Soil acidification.There are two dominant soil types in the project area; these are the Luvisols and vertisols. Luvisols covers 75 percent of the irrigated land. These soils are partly made of alluvial and colluvial materials from the surrounding escarpments. Luvisols has limited fertility and agricultural suitability. Water logging is not a vital problem in the area as the factory is using over head sprinkler irrigation system. This consecutively evades the problem of salinization. In order to maximize production the Agro-chemicals have been used in the irrigation fields .The most common ones are fertilizers, pesticides and herbicides. The two commonly applied fertilizers are Urea and Dap. The brief summery of the total amount of agro-chemicals is presented in table 4.1. (See Appendix 4 for the details)

Table 4.2. Shows that the use of fertilizers, pesticides and herbicides has been increased in an alarming rate with the expansion of irrigation. The Use of large scale agro-chemicals alter the physical and chemical properties of the soil which can damage the soil quality and use full living organisms.

Year	Fertilizers (Qunt.)	Pesticides(Lts.)	Herbicides(Lts.)
1994/95	219.4	480	5
1995/96	5,224	20,074.5	8
1996/97	5,806	10,403	267
1997/98	4,003	311.8	20
1998/99	15,952.68	5,278	716
1999/00	17,264.9	10,914.56	216.51
2000/01	23,097.01	25,794.31	2,943
2001/02	19,444.25	17,585.9	2,330
2002/03	23,274.7	15,899.51	1,019
2003/04	25,760.3	14,370.63	2,368
2004/05	36,538.69	17,837	2,712
Total	**176,584.93**	**138,949.21**	12604.51

In order to see whether there is change in the soil physico-chemical properties of the dominant Luvisols in the irrigated fields samples are collected and analyzed. Luvisols are preferred for analysis because 75 percent of the irrigation is carried out in this soil. The samples are taken from three sites in three layers. The first site is the non irrigated field where there is no human interference. The second site is ploughed but not yet planted field. In this site none of the agricultural inputs are applied. The third site is the irrigated field where the agricultural inputs have been used. In each of the three sites soil samples from three spots are collected and mixed to form only one composite soil sample. The three layers are the top layer (0-30 cm), the middle layer (30-60) and the bottom layer (60-90cm).Totally nine samples were investigated and the result will be presented under 4.2.1 and 4.2.2. The three spots are believed to show the possible positive and/or negative impacts of irrigation scheme on the physical and chemical properties of the soil. In addition the comparative results of samples from cultivated but not planted and non irrigated spots can reveal weather the change is due to human intervention or natural causes. The soil sample from vegetation cover area is supposed to reveals the natural properties of the Luvisols in the area. Thus, the site selection for soil samples is intentional and made in such away that shows the impacts of irrigation on the physical and chemical properties of the soil.

2.2.1. Irrigation and Physical properties of the soil

The Luvisols and vertisols occupy more than 95 percent of the Finchaa valley area. Luvisols have reddish brown color and weakly developed structure. They have also shallow profile and limited fertility. Luvisols are composed of sand which decreases with increasing depth. This soil is the most exploited soil in the valley. About 75 percent of the irrigation is carried out on Luvisols. The vertisols on the other hand have black color

and shallow profile. Vertisols contains more clay materials with increasing depth.

Table 4.3.The physical properties of the Luvisols from irrigated, Ploughed but not planted, and vegetated area in three layers. (0-30, 30-60, 60-90)

LUVISOLS	FROM IRRIGATED FIELD			FROM PLOUGHED BUT NOT PLANTED			FROM VEGETATED AREA		
Depth(cm)	0-30	30-60	60-90	0-30	30-60	60-90	0-30	30-60	60-90
Total sand (percent)	63.55	57.33	53.34	51.16	41.87	41.78	51.56	35.78	41.35
Silt (percent)	4.17	2.08	7.26	7.60	4.39	4.39	12.37	25.27	11.52
Clay (percent)	32.28	40.59	39.40	41.25	53.74	53.83	36.07	38.95	47.13
Texture class	SCL	SC	SC	SC	C	C	SC	CL	C
Ph-H2o(1:2.5)	5.62	5.20	4.89	5.62	5.04	5.04	4.86	4.48	4.56
Ph-kcl(1:2.5)	5.16	4.79	4.76	5.08	4.57	4.58	4.42	4.00	3.87
Ec(ms/cm)(1:2.5)	0.03	0.04	0.02	0.03	0.01	0.01	0.06	0.02	0.01

Table 4.3 illustrates that the total sand content of Luvisols decreases with increasing soil depth in all sampled layers. The silt content of the soil from vegetated area is higher. This can be due to the lesser amount of erosion in vegetated areas compared to the cultivated areas. The clay content of the soil in ploughed and vegetated areas increases with the increasing depth. Unlike the non irrigated fields the clay content of the soil from irrigated site is higher in the 30-60 cm depth. This can be due to the excess water that dissolves soluble minerals and percolates down. On its way it accumulates the insoluble clay in this horizon. Generally the texture class of the Luvisols in all locations ranges from sand clay loam (SCL) to clay (C). Such soils are known to be suitable for irrigated cane plantation with cautious soil management. The soils in all the three spots of the three layers are found to be acidic. The PH is less than 5.6. It is investigated that there is perceptible PH difference between irrigated and non irrigated soil. The average PH value of the soil in the irrigated area is 5.3 where as in the vegetation area the value is 4.6. This shows that the soil in the vegetation cover site is more acidic than the soil in the irrigated field. Theoretically the fertilizers, pesticides and herbicides that have been applied to the cane fields seem to increase the PH of the soil. But the result shows that the soil in the irrigation field is less acidic than in the vegetation area. Three main reasons can explain this result. In the first place the surplus water use in the irrigated areas can wash the chemicals vertically and laterally. Secondly cultivation by itself can alter the inherent Ph of the soil by exposing the soil. Finally the respective composition of the soil forming parent material can be different in the sample sites.

2.2.2 Irrigation and Chemical properties of the soil

The Normal Soil chemical properties can be altered by natural and human made factors. Industrial toxic wastes, hazardous chemicals, Agricultural malpractices and inputs, and many others constitute the human factors. Alternatively due to some natural processes in the system there may be alteration of soil chemical properties. In this respect the

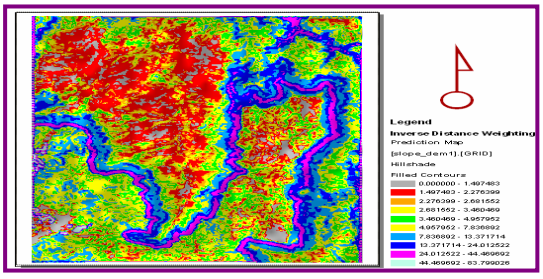
physico-climatic conditions play a key role to change the chemical properties of the soil.As it is illustrated in table 4.4 the average amount of chemical elements in the three sample areas are different. The amount of exchangeable bases (Exch. Na, K, Ca and Mg) varies with increasing depth. Generally speaking the amount of Potassium, Calcium and Magnesium decreases with increasing depth while sodium increases with depth.Exchangeable calcium and sodium is higher in the irrigation and cultivated but not planted fields than the vegetated areas. The total percentage of Nitrogen is higher in the irrigation field. The Available phosphorous is extremely high in the top layer of the irrigation fields. These higher amounts in the irrigation field are due to the fertilizers (Urea and DAP) that have been used in the irrigated areas. The organic carbon is found in higher quantity in the vegetated area. The soil sample from the vegetation area are found to be more acidic than the irrigation Fields. This is mainly due to high organic content in the vegetated areas. On the other hand the less acidic nature of the soil in the irrigated area is related to the exposure and excess water use in the irrigation fields.

Luvisols	**Irrigated field**			**Cultivated but not planted**			**Vegetated area**		
Depth in cm	0-30	30-60	60-90	0-30	30-60	60-90	0-30	30-60	60-90
Exch. Na(meq/100gm of soil	0.13	0.16	0.13	0.15	0.13	0.17	0.13	0.11	0.13
Exch. K(meq/100gm of soil)	0.20	0.15	0.16	0.27	0.20	0.21	0.48	0.18	0.16
Exch.Ca(meq/100gm of soil)	5.82	5.82	5.18	9.50	8.72	8.72	4.99	3.36	3.36
Exch. Mg (meq/100gm of soil	4.16	4.20	2.59	6.05	2.62	4.36	4.99	4.20	5.04
Sum of cations (meq/100gm of soil)	10.48	10.54	8.19	16.13	11.90	13.69	11.39	9.66	11.34
CEC(meq/100gm of soil)	14.02	14.48	14.56	23.95	25.12	26.54	24.87	21.46	15.52
Organic carbon (percent)	1.17	0.58	1.69	0.90	0.65	0.65	1.40	1.14	0.78
Nitrogen (percent)	0.14	0.10	0.14	0.13	0.09	0.09	0.09	0.07	0.05
Available P(mg p_2o5/kg soil)	29.20	5.10	4.00	7.80	2.80	2.80	2.60	2.70	2.70
Exchangeable Acidity	0.17	0.21	0.13	0.13	0.22	0.22	0.38	1.79	2.65

In addition the acidic nature of the soils in the vegetation areas shows that the soil in the area is naturally acidic and the human intervention minimizes the soil acidity.
Generally the analysis of the three soil samples indicates that there is alteration of some of the soil physical and chemical properties as a result of the irrigation scheme. The level of alteration hardly results in full-sized soil pollution at this level. However the cumulative impact could grow in to soil quality degradation. Thus there are signs of soil pollution in the Irrigated areas. There are several reasons that can explain this condition of which application of the agro-chemicals is one.

2.2.3. Soil Degradation

It is found out that one of the preeminent problems of soil in Finchaa valley area is erosion. There is active soil erosion in the surrounding areas and irrigated fields. The surrounding steep escarpments with average slope ranging from 5 to 65 percent create favorable condition for erosion. There is also high rain fall intensity (90-120mm/hr) which is highly erosive. Rain fall intensity greater than 50mm/hr is believed to be erosive. In Finchaa valley area human intervention exacerbates the problem of erosion, especially deforestation and road construction. The large scale deforestation exposed the soil for agents of erosion and contributes for high runoff. Due to terrain inconvenience the roads have been constructed by dissecting hills and uplands which facilitate the birth and intensification of sheet, rill and gully erosions. Road construction and the frequent maintenance also play a vital role in aggravating the problem.
The energetically operating sheet, rill and gully

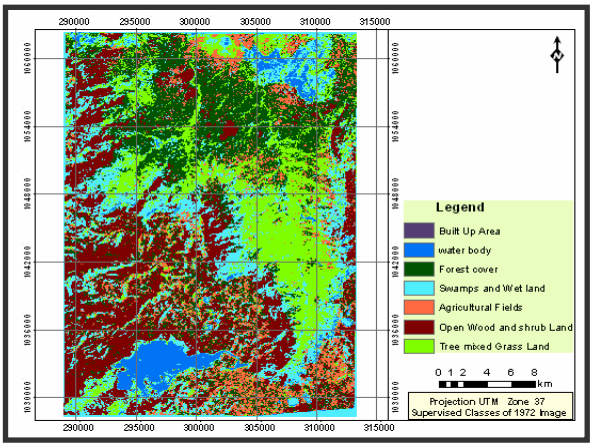


erosions around the escarpment donate the fertile top soil to the valley floor. This partly fed fertile soil to the irrigation fields. On the other hand however, the high runoff from elevated ridges accelerates the formation and intensification of gully and considerable deposition on the roads and cane fields. The active erosion and expansion of gully in the road side made road construction a year round activity. In addition beyond taking the fertile top soil erosion has been expanding active gullies and turns the potentially irrigable lands in to bad land.
Figure 4.9. Slope based Interpolation Map showing General Conditions of erosion

There is a general elevation decline from south to north and from the eastern and western edges to Finchaa River. This indicates that the general trend of erosion is to Finchaa River first and finally to the Abay gorge. The tributaries fed fertile soil to Finchaa River and the soil finally transported to Abay River.
The digital elevation model based run off estimate indicates that there is high runoff pattern in the areas that lies from the eastern and western escarpments to the banks of Finchaa River. This is due to the steep slope down the escarpment to the valley floor. Obviously the high runoff in these areas contributes for high rate of erosion. Thus the topographic set up and human activities make soil erosion to be a critical problem in the study area.
In a nutshell one of the critical problems of soil resource in the project area is erosion. The use of agro-chemicals in the irrigation fields has also its own share to degrade the soil quality. Soil pollution emanating from chemical pollutants is found to be moderate in the study area. This can be due to soluble nature of chemicals that have been applied and the quantity in proportion to the total sampled soils. But there is greater possibility of the agro-chemical use in the irrigation fields to alter the soil quality in the long run.
The Soil erosion mainly takes the fertile top soil and contributes for expansion of gullies and there by reduce the potentially irrigable lands. These two major soil problems needs proper follow up and management. If the present trend continues, in the long run the problem of soil/land degradation can put the sustainability of the project in question. Persistent and considerable efforts should be made to mitigate the impacts of erosion on the soil and potentially irrigable lands.

2.2.4. Land use and Land cover

Finchaa valley area have transformed from primary to secondary and tertiary economic activities; from traditional agriculture to industrial and commercial activities. There is land use land cover change in the area since 1975.



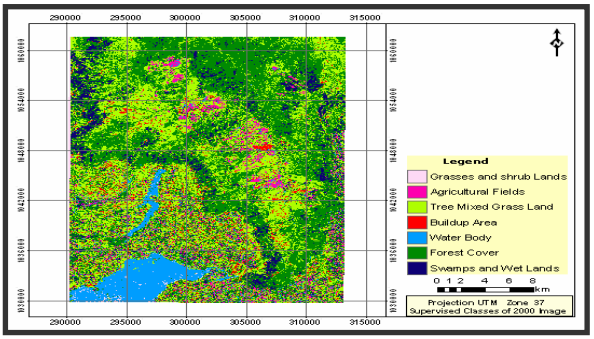
In the pre 1975 years there were no considerable land use classes in Finchaa valley area. Most of the areas were under the natural vegetation cover. From 1975-1991 the state farm used to produce some food and commercial crops on about 3,500 hectors of land in the valley floor. This incident attracted few people to the area to get jobs in the farm but still the number was not that much substantial. During this period there were no significant land use classes except for the state farm and few fragmented private holdings out side the valley. With the beginning of the sugar project in 1991 extensive land has been cleared and irrigated. Currently the irrigated land is about 8,064.88 hectors and the built up areas occupy approximately 200 hectors of land in the valley. The dominant land use classes are irrigation agriculture; Rain fed agriculture, built up areas, roads, artificial reservoir, lakes, and others.

The land cover of the study area can be categorized in to two classes. These are the natural and artificial land covers. The human made features in the area composed of towns, roads, drainage canals, ponds, agricultural and irrigated fields, and artificial lakes. Only a few artificial structures are observed near Finchaa dam in the MSS image of 1972 following the construction of the dam. (See figure 4.1) In these years approximately more than 95percent of the area was under natural environment.

In the TM image of 1986 some artificial developments have been observed (See Figure 4.2).This is mainly because of the introduction of the state farm to the valley and slight population growth in the surrounding high lands. From this time on wards agricultural lands have been expanding in the valley and the surrounding areas.

it is evident that many of the area were under Savanna grasses, open wood land and dense forest. There were no significant land use classes in this year. The present Amerti Lake was in its swamp stage. In the upper right corner the area that appeared as lake is incorrect .Rather it is spike involved during Satellite image acquisition. In the land use classification of 1972 the built up area category is very small and insignificant and therefore not represented in the unsupervised classification. In this year very few agricultural plots are observed.

In the ETM image of 2000, which is after 22 years, significant human made features are evident in and around Finchaa valley. The vast



irrigation fields and built up areas have increased. By implication the vegetation biomass in these areas has diminished. (See fig 4.3)

In the surrounding areas the rain fed agricultural plots have intensified. Some smaller towns and villages are observed including Finchaa town, Achane, Homi and Kombolcha villages. The size of Finchaa Lake is also increased compared to the pre 2000 years. However from the field observation it is perceptible that in recent years the size of the lake is diminishing. In the

Figure 4.12. Supervised Land use/ land cover Map Of 2000 image.

unsupervised classification map agricultural land, built up areas, bare lands and the size of the lake have increased in size. The Amerti swamps grow in to a perennial lake. Conversely the total share of dense forest,

open wood land, savanna grass lands have diminished.

Generally there have been land use and land cover changes in the study area. This is mainly due to favorable climate and environmental conditions which instigate agricultural and industrial development activities in the area. This phenomenon was in turn followed by population growth and intensification of agriculture and industrial developments. The development of the irrigation scheme in the project area facilitates the alteration of the natural ecosystem and brought changes in the land use land cover of the study area.

2.2 Irrigation project and water Quality and Health Conditions

2.2.1. Impacts of Irrigation project on Water Quality

2.2.2 General Conditions of water in Finchaa Valley Area

In the study area the Finchaa and Amerti-Nashe rivers form the main drainage system. They both join the Abay River in the far down stream area. The irrigation field and the Finchaa sugar factory lie with in the networks of Finchaa river system. They both relay on this river to meet their water requirement. Finchaa River is diverted to cane fields near the power house in the upstream area through concrete canals. At present the west bank canals run for about 44 kilometers. Water from the canal is pumped to irrigation fields and finally sprinklers shower the water to the growing cane. The extra water from cane fields flow to the near by ditches and join one of the nearest tributary streams.

On the other hand the industrial waste water is taken to the treatment plant which is situated to the east of the factory. The factory uses a rock filtration treatment method. However some of the instruments of the treatment are nonfunctional. The waste water coming from the factory over flows due to these broken parts and two stream-sized crude waste water flows to Finchaa River. These direct leakages together with the agro-chemicals from irrigation fields indisputably alter the physico-chemical properties of the water.

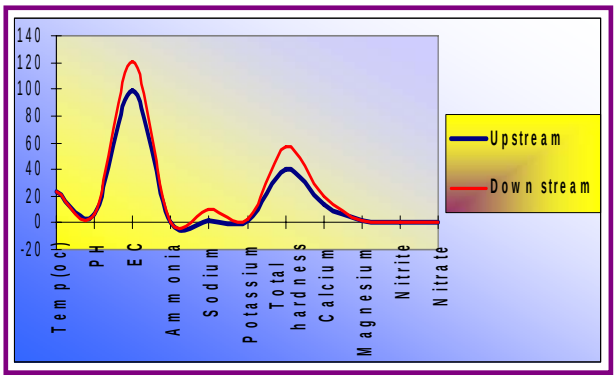
This phenomenon affects the living organisms in water in particular and the environment in general. Again Finchaa River as one of the tributaries of Abay River crosses the boundaries of Sudan and Egypt. Any water quality problem in this place arise dispute with these countries. Thus strict water quality control works should be carried out in and around the industrial and agricultural sites.

2.2.3. The Physico-Chemical Properties of the Up Stream and Down Stream Water

The physical and chemical properties of water characterize the water quality. These properties of water are susceptible for change. The addition of toxic wastes to the surface or sub surface water alters the normal composition. The PH for instance is sensitive and decisive factor for the survival of living organisms in water.On experimental lakes in North West Ontario Schindler (1988) find out that due to change of PH from 5.4 to 5.1 over all, the number of species in the lake at PH 5.1 was 30 percent lower than in the pre acidification years. In order to asses the impacts of the agro-chemicals and industrial wastes, water Samples from the up stream and down stream areas are taken and analyzed. (See Appendix 5)

The up stream area refers to the water near the power house where the water does not get in contact with water from irrigation and industrial wastes sites. The down stream comprises the water after it mixes up with water from streams in the irrigated and industrial waste sites. (See Figure 5.2 for sample sites)

In order to increase the accuracy of the results water sample was not taken from the irrigation ditches and direct industrial waste water. Rather the Mixed down stream water was preferred so as to avoid inaccuracies and exaggerated results.The physical properties of water like pH, EC, Odor and color are found to be different in the upstream and down stream areas. The PH and EC are lower in the upstream water compared to the down stream water. This could be due to difference in the chemical constituents in these two sites. The color differences are also discernable.



The results of the water chemical analysis also indicate that some elements are found in a higher quantity in the down stream than the upstream water. (See appendix 5)

As it is evident from Figure 5.3 almost all of the inspected elements are found to be higher in the down stream water. This could be due to two major reasons. In the first place the extra water washed the agro-chemicals from irrigated

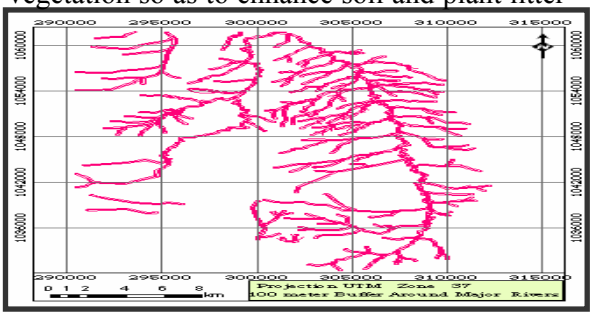
Figure 5.3. The physical and chemical properties of upstream

and down Stream Water from Finchaa River. fields and joins the river.

The Second main reason is the liquid waste from the industry and the urban areas that directly or indirectly drains to surface or subsurface water. These two cases comprise the point and non point source for the pollution. The industrial waste water escaping from the treatment plant forms the point source pollution while the agro-chemicals from irrigation field cover the non point source for the pollution.

In an effort to alleviate the problem of water pollution the point and non point sources should be given priority. As a point source the contribution of waste Water from the industry can be addressed by continuous follow up and maintenance of the treatment plant. It is again advisable to replace the treatment plant with modern and effective instruments and methods. And the problem of non point source can be mitigated by avoiding the direct contact of the excess water from irrigation ditches and metropolitan wastes with the river and tributary streams. This can be possible by creating a buffer around Finchaa and Amerti-Nashe Rivers and major tributaries. (See figure 5.4)

The buffered zone needs to be covered with vegetation so as to enhance soil and plant litter



filtration and purification. As an alternative approach the extra water from the irrigation field can be collected in an artificial reservoir and treated before it discharges to the main rivers.

Generally, the water samples from Finchaa River indicate that there is water quality difference between the upstream and down stream area. This shows that, to a greater or lesser extent, there is water pollution in the River. The discrepancy in the physico-chemical properties of water is supposed to be from the industrial wastes, agro-chemicals from irrigation fields and to a lesser extent metropolitan wastes forming the point and non point sources.

Figure 5.4. 100m Buffer around the Finchaa and Nashe rivers and their major tributaries.

2.2.4. Health Conditions in the Post Development Years Of the Irrigation project

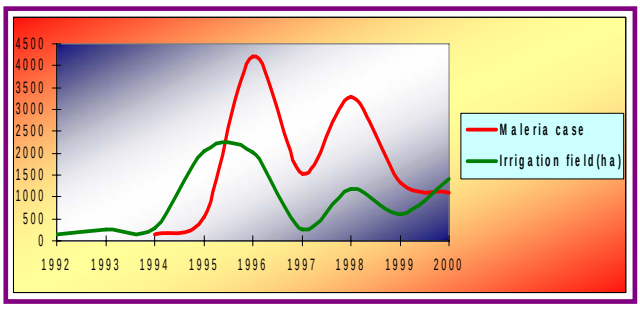
There is no recorded health status data before the establishment of Finchaa sugar factory as there was no settlement in the valley. However, from unstructured interview made with local inhabitants some people asserted that the area had been affected by epidemics even before the arrival of the state farm. The interviewee sited the problem as one of the impeding factor for permanent settlement not to take place inside the valley in the former years.

Booker international agriculture Ltd (1977) in the feasibility study for Finchaa sugar project affirmed that there exists Malaria and Tsetse fly in the valley. The company added that this could be a challenge for the project workers and residents of the valley. Currently there is one health center in the valley and some recorded case information is available. Accordingly the intestinal and malaria cases have been increased from 1992 on wards. From the informal interview made with the staff of the health center three possible rationales can explain this scenario. In the first place the water used for drinking is pumped from the canal with diminutive treatment. Secondly the expansion of irrigation can facilitate the spread of malaria and access to unclean water. Finally the population explosion in a short period of time may inflate

the proportion of patients compared to the early years.

Malaria is the top health problem in the last 12 years. The fluctuating Weather conditions together with the expansion of irrigated fields and ditches can be the factors behind the problem. The fluctuation in malaria case records arises from the inconsistent use of anti-malaria chemical sprays and expansion of irrigated lands. The Second and third top health threats are Guardia and Ascaries. These intestinal problems in most cases are water born disease which can be related with unhygienic water use for drinking. The haphazard increment of intestinal parasite and malaria case records can be due to natural or human made reasons. On one hand the natural set up of the valley and the climatic conditions can facilitate the birth and growth of pathogenic organisms in the area. On the other way round human interference have changed some of the existing natural systems. In other word the expansion of human made environments results in alteration and degradation of the natural ecosystem.

These environmental modifications create a fertile ground for some insects and pathogenic organisms which give birth to the spread of diseases. The classical example here is the



expansion of irrigation and increasing malaria case records.

Figure 5.9.Expansion of Irrigation fields Vs Malaria case records.

As it is evident from figure 5.10 Malaria cases are increasing with the expansion of irrigation fields. In the beginning few malaria cases were seen in the valley. For the 1992 and 1993 there were no recorded malaria cases data available in the health center. But for the consecutive two years fewer malaria cases were recorded. From 1995-1997 large number of malaria cases were observed. (See appendix 3) In these years extensive sugar cane plantation was carried out in the valley. The lag time between highest malaria case and the expansion of irrigation could be due to the time taken for reproduction and stages of development in human body.

In general there is no health data available on the pre irrigation development years of the valley. Since 1992 malaria and intestinal parasite case records have increased. Conversely the health facility given in the valley has improved a lot since 1992.It is found out that there is a positive relation ship between malaria cases and expansion of irrigation fields. The intestinal health threats are also interlinked with unclean drinking water. Well organized preventive and controlling measures should be implemented as the health cases are interrelated with workers productivity.

3. Conclusions

In order to see the possible environmental impacts of irrigation projects some parameters were selected. Some of the Geographic information system and remote sensing techniques were also used. Accordingly, it is observed that the natural environment in Finchaa valley has been modified due to agricultural and industrial developments since 1975. Following this modification the irrigation project have both positive as well as negative impacts on the environment.

From the positive contributions the project opened up large scale job opportunities for many thousands of people. It has also many socio-economic benefits for the valley and surrounding people. In addition Finchaa Sugar factory play a key role to address the current sugar demand in a local market. There are also many efforts to exploit the byproducts of the factory for other extra purposes like using ethanol for fuel. The project has also an important role for the growth of national GDP and GNP.

On the other hand the attention given for natural resource conservation is less and this has been devastating some of the environmental components. There has been large scale vegetation clearance taking place in the study area. The NDVI image analysis of the 1972 MSS and the 2000 ETM images shows that the vegetation biomass is diminishing. The intensification of agricultural and industrial developments together with population explosion has the coin share for the decrement. The large scale deforestation has

been devastating the vegetation and wild life resources in particular and the biodiversity in general. There are efforts made by Finchaa sugar factory to rehabilitate the forest resource. But the amount and rate of deforestation in one side and the reforestation and afforestation projects on the other side are incomparable in any measure.

In addition deforestation is facilitating the progress of runoff and accelerates erosion. Accordingly soil erosion is a critical problem in the project area. The active erosion, beyond taking the fertile top soil, is changing some of the potentially irrigable lands in to Bad Lands. In some areas there are gullies that extend for about 30 m. The topographic set up and Human induced factors are responsible for the active erosion in the area. The steep slope in the escarpments surrounding the valley promotes greater runoff. The Road construction and the frequent maintenance down the valley made the soil ready for erosion.

The physical and chemical analysis of the soil samples taken from irrigated field, cultivated but not yet planted and Vegetation cover area are found to be different. The total sand content of Luvisols decreases with increasing soil depth in all sampled layers. While the clay content increases with depth. The exchangeable bases are higher in the irrigated and cultivated area than the vegetation cover area. Relatively Organic carbon, Nitrogen and phosphorous are found in large quantities in the irrigation fields especially in the upper layer (0-30cm). The use of agro-chemicals in the irrigation fields are supposed to contributes for this result. In general some of the physical and chemical properties of the soil in the irrigated and non irrigated sites are found to be different. This shows that, to a lesser or greater extent, there is soil contamination that could lead to full-size soil pollution. The result of water samples from up stream and down stream areas indicates that the physico-chemical properties are different in these two areas. The down stream water contains more chemical substances than the up stream water. The point and non point sources contribute for the pollution. The point source comprises the industrial waste water that escapes from the treatment plant and join the river. The non point sources involve the use of agro-chemicals (fertilizers, pesticides and herbicides) and the metropolitan wastes that join the tributary streams. Thus, based on the water samples inspected there is water pollution emanating from poor industrial waste water treatment and the leftovers of the agro-chemicals used in the irrigation fields.In most cases climate is the reflection of the natural environment. Any system disturbance on the environment can affect the climatic conditions. The analysis of the 22 years rain fall, temperature and humidity data can not meaningfully imply any climatic change as a result of the irrigation project. This is due to the sluggish and unpredictable nature of climatic anomalies. It is reasonable however to say that there is imperceptible changes following the environmental degradation. Still it is open for further specific and detailed works to see the impacts of irrigation on the local climate. Case records of Malaria and some water born disease have been increasing following the opening of Finchaa irrigation scheme. There is a positive correlation between malaria case records and expansion of irrigation fields. Although the health care facility given has improved a lot, the number of patients boost up by a large number. This shows that big attention is given on disease control than prevention. The environmental modifications and the diminutive prevention measures contribute for the large number of malaria and water born diseases case records.Generally despite of its positive consequences, the irrigation project in Finchaa valley area has a negative impact on the environmental components. Especially on the vegetation cover, soil quality, water quality and partly on some health conditions. But this does not, in any way, mean that the problems out weight the benefit of the factory and that the problems are out of control. The degradation is in its early to moderate stage and even not difficult to address and alleviate them all. The possible solutions are much easier and cheaper in this moderate stage of the environmental degradation. But undoubtedly if the current trend keeps on the problem would get more complex and difficult to reclaim. Thus, urgent attention should be given for the environmental rehabilitation and conservation.

4. Recommendations

In line with the findings of this selective parameter based environmental impact

assessment the following recommendations are presented:

1. The environmental considerations should not be disregarded in any way and with any justification seeing that well organized environmental management positively contribute for better productivity and sustainability.

2. The rehabilitation of devastated vegetation biomass should be given first line attention as it helps to maintain the soil, water, climate and biodiversity of the area. Finchaa sugar factory should tackle the problem of frequent Forest fire and large scale deforestation that are observed inside the valley.

3. There should be well organized and effective afforestation and reforestation programs to reestablish the ecosystem. Some areas like the surrounding escarpments, river sides, agriculturally non suitable and marginal lands can be delineated and protected as the forest area.

4. There should be continuous follow ups and assessment of the physico-chemical properties of the soil in the irrigation fields. This helps to see the impacts of fertilizers, herbicides and pesticides on the soil quality and to take timely measures.

5. Strict physical and biological measures should be taken to impede the actively operating erosion and growing gully problem in the irrigation fields and the surrounding areas.

6. Finchaa sugar factory should establish a modern and efficient waste water treatment plant in order to stop the two stream-sized industrial waste water and irrigation field wash away leakages to the river. Further inspections should be carried out for the water quality problem in the down stream area and appropriate measures should be taken.

7. In addition to disease controlling strategies, research based preventive approaches should be adopted so as to mitigate the escalating malaria and water born disease case records and their far reaching impact on production and productivity.

References

African development fund. (2002). The Federal Democratic Republic of Ethiopia. Agricultural review. Rural development department, Onar.

Agrawal.M.L. and A.K. Dikshit (2002). Significance of Spatial Data and GIS for Environmental Impact Assessment of highway projects. India.

Ahmed A. (2002). A Geographical study on Finchaa sugar Factory. A senior essay .Haromaya University.

Alan Gilpin (1995).Environmental Impact Assessment. Cutting Edge for the Twenty-first century. Cambridge university press. London.

Anuctech private. Ltd (1994), Finchaa sugar project proposal for the Finchaa Valley Forestry project, Finchaa sugar project office,
Addis Ababa: 61pp.

Atesmachew B., Yasin G., Girma T, Don Peden. (2000). GIS Application for Analysis of Land suitability and Determination of grazing pressure in up land of the Awash river basin. ILRI, Addis Ababa

Bandaragoda.D.J. (1998).Need for Institutional Impact Assessment in planning Irrigation system Modernization. Delhi, India.

Barrow.C.J. (2000). Environmental Impact assessment of developments. Longman printing press. USA.

Birhanu.M. (2005). Remote Sensing and GIS techniques in land use/land cover mapping, change detection and evaluation of environmental degradation in the main Ethiopian rift (MER) between Koka and Ziway.

Booker Agricultural International Ltd. (1977).Finchaa valley Feasibility study main Report.vol.1.London.12-15pp.

Chris Parker. (1998).GIS and Environmental Management in the Sultanate of Oman. Turkey.

Darout Gum'a. (2004). The socio-economic Aspects of irrigation management. Addis Ababa University. Addis Ababa.

Dereje.A. (2005). Assessment of Socio-economic Impacts of Irrigation in Finchaa valley, Addis Ababa University, Addis Ababa.

Donalds Ahrens (2005). Microsoft Encarta Reference Library2005 .1993-2004.Microsoft Corporation.

FAO (2001). Environmental Impact Assessment report. Retrieved from http//www.

Gideon. A. (2005).Environmental degradation. Forum for social study. Addis Ababa.

Girma A. (2005). Evaluation of Irrigation Water Quality in Ethiopian sugar Estates. Research report. 23-34pp.

Girma.T. (1995).Finchaa Sugar Project Soil Survey/west Bank. Land Management unit Final report.Vol. I. Addis Ababa.

Glen Paleto (2003). Environmental Impact Assessment (EIA).Lecture Notes.

Haklay.M, Feitelson E. and Doytsher.Y. (1998). The Potential of a GIS based Scoping

System. An Israeli proposal and case study. Environmental Impact Assessment review.Israel.439-459pp.

Hartza Engineering Company (1965). Appraisal of Potential Agricultural Development of Finchaa project. Final report. Addis Ababa.
43-48pp.

Mintesinot B., Mohammed A., Atinkut M.and Mustafa Y. (2004). Community Based Irrigation Management in the Tekeze Basin: Impact Assessment. A case study on three small-scale irrigation schemes (micro dams) .Mekele University, ILRI, and EARO.

Morgan M.K. (1998).Environmental impact Assessment. A Methodological Perspective.Kluwer Academic publisher. Dordrecht.

Painnly J.P. (1994). Environmental impact Assessment: A case study on the irrigation project. Gujarat. India.37-39pp.

Paul Engelking (2005). Micro soft Encarta Reference Library 2005. 1993-2004. Microsoft Corporation.

Rosenqvst.I.T. (1978).Alternative sources of acidification of river water in Norway. The science of the total environment.Oslo.39-49pp.

Schiondler D.W. (1990).Effects of acid rain on fresh water ecosystem Ontario. Canada 25pp.

Shawinigan Company. (1981). Finchaa Sugar Project Design Report. Ethiopian Sugar Corporation. Addis Ababa.9-11pp.

Smajstrla.A.G, Zazueat.F.S.and Haman D.Z. (2002). Potential Impacts of Improper Irrigation system Design. Florida University. Florida.

Smol J.P. (2002). Pollution of lakes and rivers. A paleo environmental perspective. Arnold publishers. Network and Oxford University press. London 126pp.

Sophie N. Laurence S. and Kai Sorensen (2003).Adaptive, participatory and integrated assessment (APIA) of the impacts of irrigation on Fisheries. Evaluation of the approach in Sri Lanka.

Stockle.C.O. (2002). Environmental Impact of Irrigation: A review water Research Washington state university.Washington.121-129pp.

Vicharn A. and Sirirat S. (2001). GIS Application on the Strategy for Sustainable Development in Phitsanulok Province.Naresuan Unive4rsity. Phitsanulok. Thailand.

Worku B. (1995).Agro ecological conditions and background information on Finchaa sugar project/Factory site. Finchaa valley.6-18pp.

Zeleke K. (2005).GIS and remote sensing in Land use/Land cover change detection in Finchaa valley area. East wollega.Addis Ababa University. Addis Ababa.36-44p