PRODUCTIVE AND SUSTAINABLE USE OF WATER AMONG COMPETING SECTORS

A STUDY IN THE NAIVASHA CATCHMENT,
RIFT VALLEY PROVINCE, KENYA

BY:

AHMAD SALAH

BY THE NAME OF ALLAH THE MOST MERCIFUL, THE MOST COMPASSIONATE

PRODUCTIVE AND SUSTAINABLE USE OF WATER AMONG COMPETING SECTORS

A STUDY IN THE NAIVASHA CATCHMENT, RIFT VALLEY PROVINCE, KENYA

BY:

AHMAD SALAH

THESIS SUBMITTED TO THE INTERNATIONAL INSTITUTE FOR AEROSPACE SURVEY AND EARTH SCIENCES (ITC), ENSCHEDE, THE NETHERLANDS, IN PARTIALL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF SCIENCE DEGREE IN ENVIRONMENTAL SYSTEMS ANALYSIS AND MONITORING (ESM).

EXAMINATION BOARD:

CHAIRMAN	:	PROF.DR. A.M.J. MEIJERINK {ITC, WATER RESOURCES AND ENVIRONMENTAL STUDIES DIVISION, HEAD}
EXTERNAL EXAMINER	:	DR.IR. E.SEYHAN {VUA, VRIJE UNIVERSITEIT AMSTERDAM (FREE UNIVERSITY OF AMSTERDAM)}
SUPERVISOR	:	DR.IR. W.G.M. BASTIAANSSEN {ITC, WATER RESOURCES AND ENVIRONMENTAL STUDIES DIVISION.}
SUPERVISOR	:	DR.IR. C.M. MANNAERTS {ITC, ESM COURSE, DIRECTOR OF STUDIES}
SUPERVISOR	:	DR. A. SHARIFI {ITC, SOCIAL SCIENCE DIVIOSION.}

APRIL 1999.

By The Name of Allah,
the most Merciful, the Most Compassionate

ACKNOWLEDGMENT

I BELIEVE that God created the universe, he puts everybody in a situation that best suits him. As one of his servants, unchangeably excellent conditions were there for me. Two of which were the terrific educational guidance, and the relieving home-away social life, that I was gifted in the last 20 months. I BELIEVE that I do love God, Thanks God.

Plates

Annex

Introduction

Part 1: Current Water Use

Part 2: Current Water Quality

Part 4: Optimum Water Use

Part 5: Basin-Wide Planning.

Part 1: Current Water Use.

Part 2: Current Water Quality.

Part 3: Productivity.

Part 4: Optimum Water Use.

Part 5: Basin-Wide Planning.

ABSTRACT

Water scarcity is a vital issue allover the world. In some regions water is abundant and the water resources need only to be properly managed. Hence a proper management of the water resources needs to take place, and re-distribution of the resources is becoming a necessity.

Water accounting framework is carried out as a first step in evaluating the water status for the whole basin. Most of the constituents of the water budget are calculated on Geographic Information System (GIS) or Remote Sensing (RS) basis. Detailed calculations are carried out to unfold the concealed reality of the water consumption by various sectors/users. Sensitivity analysis is done also to check how wide is the range in which some values lie.

A descriptive water quality analysis is done to see how well is, the available water, suitable for the utilizations in hand.

As a third step, the productivity of each sector or sub-sector in terms of US$/m^3 (of water) is done resulting in a refined comparison.

Having the three last layers in hand, it was easier to analyze the whole system in both quantity and quality. A comparison between the ideal and current water use manifested the overuse of water in some sectors while others are under pressure. On the other hand, the pollution is pressing on the environment hardly in an endless deteriorating circle.

At the end, the results obtained are reformulated in a basin-wide planning scheme. Six scenarios are assumed in addition to the base scenario, of no action, and evaluated in a multi-criteria decision making process to come up with a set of Best Management Practices (BMP) that are thought to be of a great help to the sustainability of the basin.

INTRODUCTION

I.1 General

"Human beings are at the center of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature"; says the coordinator of United Nations Conference of Environment and Development at the opening ceremony. The existing imbalance between water supply and demand holds considerable potential for internal conflicts and competition among the water sectorial users allover the world. In general, the governing forces that could precipitate water conflicts in any region can be categorized as follows:

* Flow variation in time and space.
* Population trends.
* Inefficient Agricultural Practices.
* Variable precipitation.
* Decreasing groundwater Availability.
* Global warming.
* Environmental impacts of water use.

Demand of water for agriculture, household use, and industry continues to increase rapidly, while watersheds, the irrigated land base, and the quality of water delivered to the final user are deteriorating. Scarcity of water has led to demand for policy reform but many questions remain concerning the feasibility, costs, and likely effects of alternative water allocation policies in developing countries. Increasingly there will be competition between agriculturists, and the industry, urban areas, and wildlife conservation for water supplies, necessitating more use of less optimal land and reliance on less satisfactory water supplies. **[Barrow, 1995]**

On focus question is yet to be satisfyingly answered is how much water can be safely extracted without serious disturbance of the water balance. As water is reallocated away from agriculture to other uses it creates the most profound challenge facing agriculture today; how to produce more food with less water.

Nowadays, we readily talk about "integrated water resources management" instead of the usual sectoral approach to developing and managing water resources, integrated water resources management recognizes that river basins are complex systems in which the use of water for one purpose has important implications for other uses. Focusing attention on water basins, a term that includes the upper and lower areas of the basin together with the groundwater enables a systematic approach to managing water including the socio-technical, economic, and human aspects of water.

I.2 Water Accounting

Data on water supply tend to be poor, while information on demand is often based on gross estimates. This means that the construction and interpretation of, for instance, water supply and demand balances needs great care. With water resources under pressure, more effective demand management is essential to husband supplies, to promote conservation and to encourage reappraisal of current water uses. Water conservation opportunities feature strongly. Public understanding of the need for a shift from "on demand" to "needs only" water use will be essential to their cooperation.

A comprehensive water demand/supply framework needs to get developed for Lake Naivasha Basin in order to be able to analyze all the constituents of water sector effectively. Unlike the conventional water balance methods, water accounting can describe in details all the water users involved accompanied with their contribution to the "disturbance of the environment".

Water accounting is a procedure for analyzing the uses, depletion and productivity of water in a water basin context. It is a supporting methodology useful in assessing the performance of irrigated agriculture, and the allocation of water among users in the basin **[Molden, 1997]**. Doing water accounting in terms of quantity and quality will help pinpointing the gaps and/or shortages in economical, environmental and social aspects. Although the major water use activity is taking place around lake Naivasha in the riparian zone (area covered by the lake during the year of 1906), we are carrying out this exercise of water accounting in the whole catchment to get the complete picture.

The water accounting accompanied by its new terminology is needed to clearly describe the impact of any and all types of water use on actual physical losses of utilizable water from the affected hydrologic system. Unlike most efficiency terms, the proposed methodology and terms (a) are appropriate for evaluating water allocation, water use, and related management options, (b) are consistent and appropriate for all the water use, not only for irrigation and a narrow evaluation of evaluation of irrigation practices, and (c) can be clearly understood conceptually and in terms that can be correctly applied by people engaged in the water allocation/use/management debate. A change from using "efficiencies" to using "fractions" to describe water use would eliminate many misunderstandings **[Molden, 1997]**.

I.3 Site Description*

The Naivasha basin is bounded by the Aberdares Mountains to the East and the Mau escarpment to the west, The total area of the catchment is 3,292 km^2. Lake Naivasha is located in the eastern arm of the Rift valley, at 80 km south of the equator, at longitude and latitude 0 45′ S & 36 20′ E at mean altitude 1885m a.m.s.l. It is located within the boundaries of Naivasha division, part of Nakuru District, rift valley province, Kenya. The lake has four distinct components; (1) The Main Lake (130 Km^2) is of maximum depth 6-8 m, mean depth 4m,(2) Crescent island Bay that forms the deepest part of the lake is presently of maximum depth 15 m, mean depth 11 m, (2) Oloidien Bay (5.5 km^2) is of maximum depth 7 m and mean depth 6 m that at low water levels is a separate lake and has considerably high pH, And (4) Lake Sonachi (0.2 Km^2). A small crater lake, 3 Km from the main lake of maximum depth 4 m and mean depth 3 m. is also a part of lake Naivasha system. The main sub-divisions in the catchment are:

i- The Malewa River Basin, including the Turasha River Basin (1,579 km^2). Drainage into the Malewa starts among the steep forested eastern slopes from the Kinangop plateau (2,483m a.m.s.l.) and the Aberdares (3,960+m a.m.s.l.) where the average annual rainfall is 1087.5 mm. Initial flow takes place in a westerly direction via a number of steeply graded tributaries that, at the lower slopes of the range, develop into four main tributaries, the Mugutyu, Turasha, Kitiri, and Makngi.

ii- The Gilgil river basin (524 km^2). The Gilgil drains a long narrow basin (the Bahati Highlands to the north of the Elementeita-Nakuru basin) in the western part of the Naivasha catchment. It has few tributaries and rises at an altitude of approximately 2,772m a.m.s.l., in an area where the average rainfall is 1300 mm. The two important tributaries of it are Marundati and Little Gilgil rivers.

iii- The Karati Catchment; the lake itself; and the areas around the lake to the east, south and west (1,238 Km^2). Karati is the other river that flows occasionally into the lake, it drains about 134.7 (Km^2) and is normally dry for long periods. It rises at altitude 2,648m a.m.s.l. where annual rainfall is remarkably constant at about 775 mm, and well distributed throughout the year.

The lake itself receives 90% of its inflow from the perennial Malewa and Gilgil rivers, the remaining comes from seasonal streams, direct precipitation and ground water inflow.

The climate of the area is warm and semi arid. Air temperatures are moderate with monthly means varying between 5.9 and 18.5 °C. Only light breezes are common in the morning but stronger afternoon winds (11-15 km/h) are typical, and often produce violent storms on the lake. Winds usually come from the south with the importance of easterly and westerly components depend on season. The stronger afternoon winds in conjunction with night-time cooling usually cause complete mixing in the main lake almost every day and well oxygenated water (5 mg/l) is present from top to bottom. Semi-arid climate makes the average rainfall amounts to, only around the lake, 620 mm/yr, while annual evaporation is 1735 mm. So, evaporation exceeds precipitation throughout the year except at peak rainfall. Bimodal rainfall, having two peaks, one major in April/may; and a

* Source **[Ase, 1986]**.

minor one at October/November. As detailed later on, overall average rainfall of 860 mm is expected annually at a standard deviation of 25% amounting to 215 mm.

The lake has always been an important ecological site to Kenya, because of the diversity of flora and fauna in the range of vegetation-zones associated with the lake and the hinterland, which is greater than the rift valley lakes. Lake Naivasha is also a Ramsar site being a wetland of international importance with a rich biodiversity, including some endangered species, and support tourism and research activities.

Abstraction can not be always higher than replenishment, otherwise lake will disappear in few years. First of all a population of 350,000 was assumed based on the last census of 1989, and Kenyan highest growth rate (11%). On top of all, the imported labor into the catchment with the agricultural expansion **[Goldson, 1993]**. Major national income comes from tourism, agriculture, best represented by the tea and coffee. Privately owned land is approximated at 80% of the total area under study (Riparian Zone). East and northwest ground water is very good in quality, rather than the poor quality of the rest.

In recent years, there has been a rapid expansion of greenhouse mainly for flower cultivation around Lake Naivasha. Together with the expansion of greenhouse growing, new irrigation techniques have also been introduced in greenhouses, one of which is the drip irrigation. At the same time, tensiometers have been widely used for determining irrigation timing and/or requirements. Even though, the amount of water applied is, as illustrated later, far more than the theoretical needs. Nearly 85% of the flowers cultivated in Naivasha is indoors where they can not control the temperature very much. 50% decrease in the yield may arise just because of the cold weather. Farms around the lake differ in the technical way of cultivation. Ranging from pure experience-based techniques to very sophisticated techniques in which soil is being analyzed in terms of nutrients and other necessary elements. Based on that they know how much fertilizer they should implement.

I.4 Objectives

The overall goals of this research are to (1) Quantify the water used by every sector and its' sub-sectors, (2) Have a more in depth understanding of the water quality status and effect on the environment, (3) Assess the current economical situation in terms of $/m^3 of water and, ultimately (4) Understand the productivity, equity, and environmental impacts of alternative mechanisms and policies for inter-sectoral water allocation. The effect of land-use and land-use changes on the water resources and quality will be a research key. Increase the physical and economical productivity of water, in other words, produce more with less water.

I.5 This Thesis

This thesis is organized in a manner that can facilitate the process of finding a single information about the water use in the area, and how it was calculated/approximated. Interested readers can even go further to the annexes to look at some raw data that have been gathered during the field trip period, and detailed calculations are there as well. The first part is dedicated to the current situation of water use in terms of quantity. In the second part attention is drawn to the ever-important water quality (current Conditions). Part three discusses the productivity of every sector in the study area. The fourth part was aimed at investigating the relationships between the current and optimum or ideal water use. The fifth and last part of the puzzle is the wrapping up of the situation in a basin-wide planning scheme using multi-criteria decision making, which was targeted to propose a certain scenarios, or solutions of the water shortage problem based on the personal experience gained from the field trip. Finally, conclusions of the whole study are being summarized and reformulated in the form of recommendations. **[Fig. I-1]**

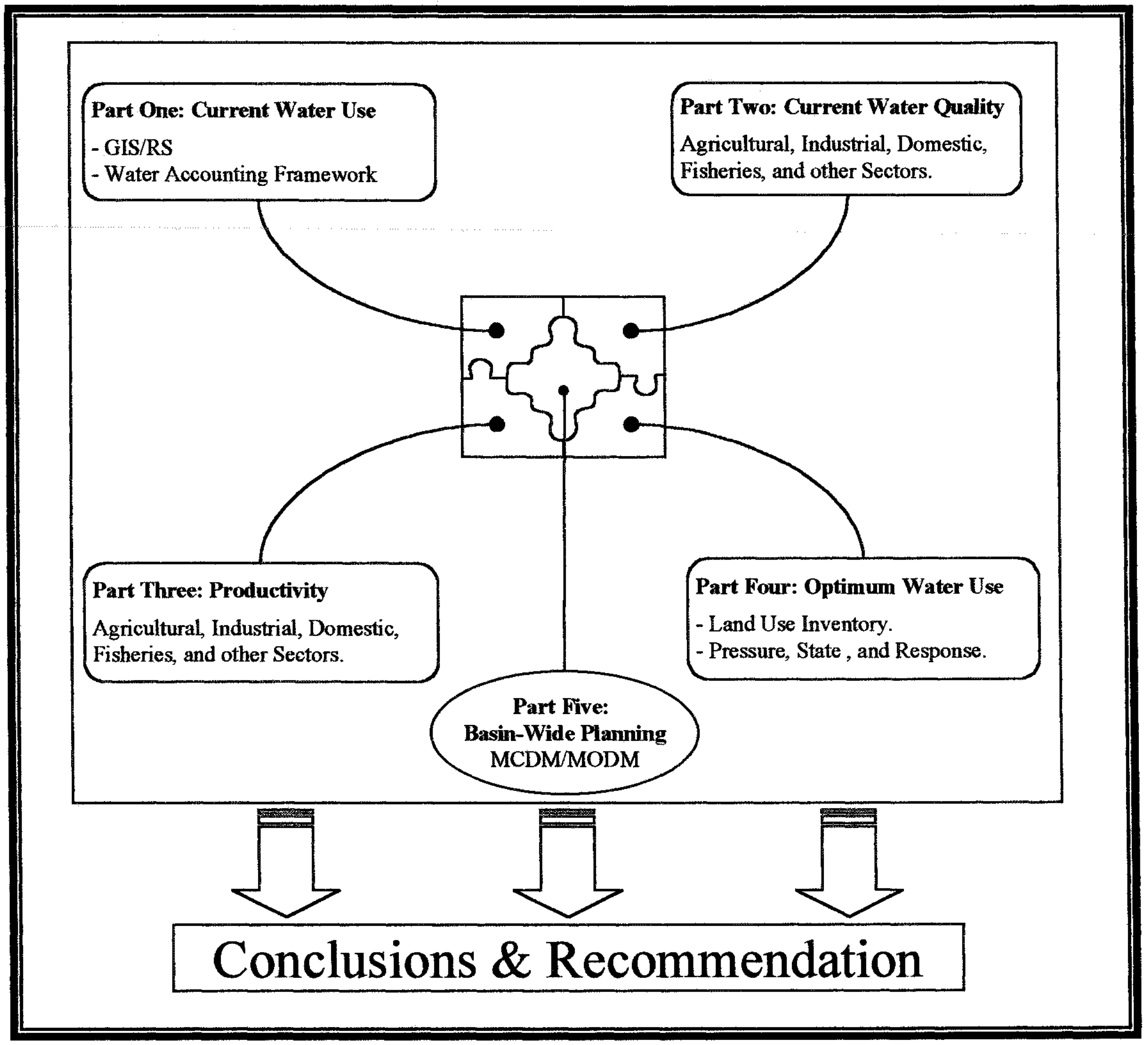


Figure I-1: General Structure of the Thesis.

Part One

Current Water Use

1.1 GIS/RS

Geographic Information System (GIS) and Remote Sensing (RS) were used as tools for facilitating the procedure of water accounting. The emerging technologies helped rigorously in spatial variability of the different parameters involved.

1.1.1 Land-Use

With the help of remotely sensed data, the catchment has been classified according to the following land-use classes:

- Forest.
- Irrigated agriculture.
- Lake
- Rain-fed Agriculture.
- Rangelands. (combination of soil and natural vegetation)
- Wetlands.

A Landsat Thematic Mapper (TM) scene of January 21st, 1995 was used for the classification. Results of the classification are indicated in **[Fig. 1-1]**. A supervised classification based on the ground truth taken from the field was the basis for the classification **[Plate 1-1]**. Maximum likelihood technique was used to analyze the sample set, representing the six different classes, which was required to run the spectral classification. The confusion matrix, accuracy checker, has shown a relatively good accuracy obtained **[Annex QN-3]**.

A comparison between the classification obtained and other land-use classifications was necessary to unchain the uncertainties involved in the random process of selecting sample sets [Huaccho, 1998], [Hussein et al, 1998], and [Hammouda, 1999]. Although different classes were used, all of the classifications can meet in some major classes, and the results of the comparison were judiciously satisfactory. **[Fig.1-2]**

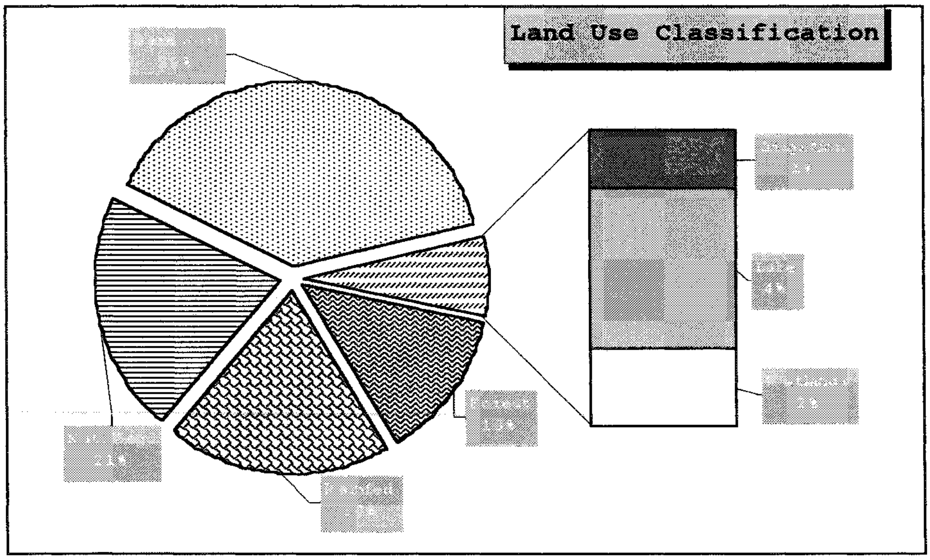
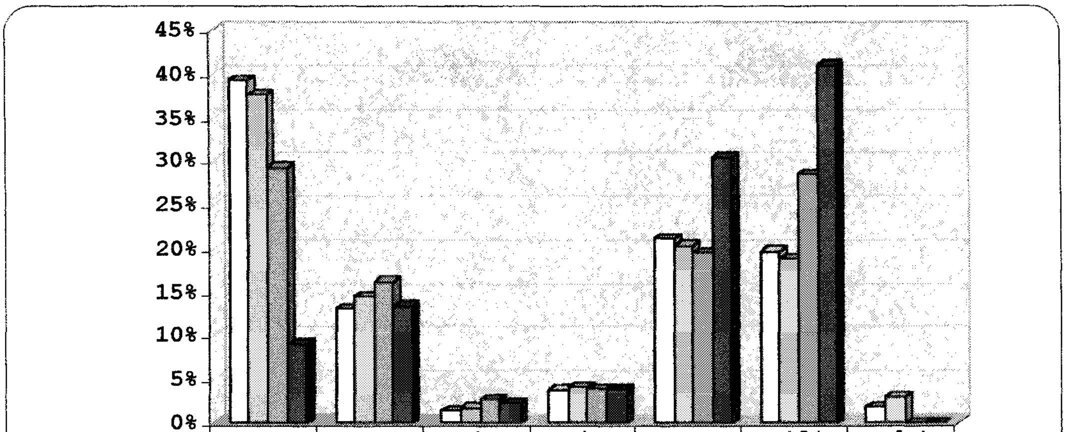


Figure 1-1: Land-use Classification Results.

The land-use classification was also verified against the fractional vegetative cover. Making Soil Adjusted Vegetation Index (SAVI) **[Bastiaanssen, 1998]**, using the same TM image, band 3 and 4, which take into account the reflectance from the soil, that will make it a better representation of the vegetative cover than NDVI. Crossing the obtained SAVI, after slicing, with land-use classification gave supporting results. Having sub-classes in irrigated lands for instance could be easily explained by the fact of different crop stages. **[Annex QN.3]**



	Bare	Forest	Irrig.	Lake	NatVeg.	Rainfed	Wetlands
Current	39.3%	13.1%	1.4%	3.7%	21.2%	19.6%	1.8%
Hussein	37.7%	14.5%	1.7%	4.1%	20.3%	18.9%	2.9%
Hammouda	29.2%	16.2%	2.7%	3.9%	19.5%	28.5%	0.0%
Huaccho	9.1%	13.5%	2.2%	3.8%	30.4%	41.0%	0.0%

Figure 1-2: Land-use Classification Comparisons.

A soil map, in the digital format, was available with textural classes, i.e. clay, silt, clay. It was found that the area weighted average clay content is 47%, silt content is 24%, and sand is 29%. Which in a way or another suggests that the dominant texture in the region is clay.

1.1.2 Digital Elevation Model (DEM)

Generating a DEM was necessary for the calculations of rainfall; hypsometric method, and also to cross check it with the land-use map for the location of some land-uses like forests, and even to cross check the interpolated map of rainfall.

In pursuit of attaining a reliable digital elevation model (DEM) of the study area, two DEMs were generated. One of them was obtained based on the original contour map of the area, refined contour lines around the lake, and the echo sounding survey done for the lake bed (done 1998). Another DEM was obtained from a worldwide data **[Hammouda, 1999]** on a pixel size of 1.0 km. Later this DEM was resampled to the pixel size of TM. The resampled DEM has been stretched to the actual values that are taking place in the study area in terms of min-max altitudes. Correlating that DEM with the previous DEM gave a very high overall correlation coefficient of 0.92 **[Hammouda, 1999]**.

The Digital Elevation Model (DEM) was visualized in three-dimensional view to have an effective view of the site detailing the catchment which helps in describing some of the phenomenon taking place; i.e. orographic effects. **[Plate 1-2]** views the catchment in a three-dimensional overlaid by the land-use map. That was in pursuit of checking the land-use classification obtained. The location of the different land-use classes in a three-dimensional view was very helpful. Drainage map on top of the DEM was also created to check the reliability of the DEM. **[Plate 1-3]**

One major thing was done also by means of GIS is the Level-Volume and Level-Area rating curves of the lake. Having the original digitized contour map of the area, and the refined contours around the lake, in addition to the very valuable lake echo sounding survey, was the basis of the calculations. Transferring those maps into point map and then interpolate them to have the whole thing in a raster format of lake bed level. Having the bed level on a raster format, it was easy to assign a certain water level to get back the volume and the surface area of the lake. Interpolation techniques did not make a big difference in this case as the lake echo soundings grid is relatively small (500 m), and the lake bed level is nearly flat.

1.2 Gross Inflow

Since there is no reliable piezometric indications on the ground water levels that will help pinpointing any ground water inflow, ground water inflow was neglected and the incoming sources to the catchment is only the rainfall.

Rainfall

Globally speaking, rain is the only source of incoming water, and in our particular case it is the main contributor to the water resources in the catchment. Having said that emphasis is put towards the calculations of the rain. Uncertainties in rainfall of only 1% is a figure of $28*10^6$ m^3 and that is approximately four times than the amount of domestic use (later on briefly explained). So, we must say that much more attention should be given to estimating the total rainfall. Dividing the catchment into area-governed polygons around each of the rainfall stations will not be a wise manner of calculating the total rainfall. Orographic effect-governed areas should be divided elevation wise.

First of all rainfall double mass curves were done to check the overall consistency of the data set. That check revealed no substantial measuring or location errors. Accordingly rainfall data could be used at a confidence level of "no better available". A three years moving average **[Annex QN.3]** of the rainfall data set was also done revealing some major errors in one of the stations in particular years. Those years were excluded from the analysis (average to be put incorporated in the GIS techniques).

Hypsometric method for areal estimation of precipitation is a good option in our case as it is deterministic, smoothing, and surface fitting method **[Dingman, 1994]**. Above all it is appropriate for regions in which orographic effects are important. Herewith the precipitation is a function of elevation. Constructing a relationship between the elevation and rainfall and using this equation in combination with the DEM of the area is a reasonable approximation. The first step in applying this approach is to plot the measured rainfall values against the corresponding elevation **[Annex QN.3]** establishing a relationship between rainfall and elevation **[Eq. 1-1]**. Taking the effect of windward/leeward sides of the mountain ranges is necessary in this approach. Knowing those high enough mountain ranges, are located along the east boundary of the catchment, and the west boundary is partially occupied by Eburu hills, this effect can be neglected for the sake of simplicity. That established equation of Rainfall as a function of elevation is being used for each pixel to calculate the rainfall for this pixel knowing its elevation.

$$\boxed{Rainfall = 0.6118 * Elev. - 409.81}$$

Eq. 1-1: Rainfall Elevation Relationship.

Where; **Rainfall** is the rainfall expected for a particular pixel in mm, and **Elev.** is the elevation of that particular pixel in m (a.m.s.l.)

Applying the same methodology for the min or max of all the stations simultaneously is not a wise calculation as a max of one station may correspond to a min in another station. Due to lack of data, rainfall of the year 1997 was assumed to be equal to the average year. Alternatively, it might be calculated through **[Eq. 1-2]**. Unfortunately, available data is not even sufficient for this way. On top of that a complete frequency analysis of the rainfall pattern in the area is beyond the scope of the study. To get rid of, at least partially, the climate change on the value taken in calculations, a certain threshold was put for this sake. The year 1960 was taken as a boundary of the calculations.

$$\text{Current Rainfall} = \text{Qualifier} \otimes \text{Average}$$

$$\text{Qualifier} = \left(\frac{\text{Stations Average in Current Year (mm)}}{\text{Stations Average for all Years (mm)}}\right)$$

Eq. 1-2: Rainfall Approximation.

To further complicate matters, one other method of estimating the total volume of rain coming to the catchment is to interpolate the available average data of different stations. Three techniques of interpolation were used moving surface, moving average, and trend surface.

The four values would always harmonize no matter the original input data of stations are. Results of the previous methods are shown in **[Table 1-1]**. A weighted average of the four techniques has been calculated in order to reach a compromise **[Plate 1-4]**. Weights have been assigned due to the appropriateness of the technique and the errors encountered. For instance Equation 1-1 was based on a low correlation of 0.5, that is why hypsometric method is given low weight. Error maps were created for both the trend surface and moving average to indicate how accurate every method is. The difference between the interpolated value and the original value of rainfall was the error, which was divided by the original rainfall value to obtain it as a percentage. Later on the percentages were involved in assigning the final weights. Finally, those weights have been incorporated in a GIS based calculations to get the annual weighted average rainfall which is $2792*10^6$ m^3. Rainfall for various covers is given in **[Table 1-1]** based on the average rainfall map obtained after making an aggregation by land-use for the target area.

Table 1-1 : Annual Rainfall Estimation for the Catchment and Various Covers.

Method	Value (10^6 m^3)	Error	Weight (-)	Weighted Average (10^6 m^3)
Hypsometric	3284	R^2=0.5	0.10	328
Moving Surface	2776	0.0 %	0.20	555
Moving Average	2714	1.0 %	0.50	1357
Trend Surface	2819	8.0 %	0.20	563
Total	--		1.00	**2803; (GIS: 2792)**
Average input to the catchment		**860 (mm)**		
Rainfall for irrigated Area		**655 (mm)**		
Rainfall for rain-fed area		**801 (mm)**		
Rainfall mountainous forests		**996 (mm)**		
Rainfall for rangelands		**871 (mm)**		

1.3 Change in Storage

As a temporary process, the change in storage taking place as a result of the whole process in a year can be divided to ground and surface water storage change. Ground water modeling [Trottman, 1998] helped in estimating the storage change in ground water revealing the following:

- ★ The significant storage change in the saturated zone takes place in a zone encountered by 3 km away from the lake level at year 1997(1886 a.m.s.l.).
- ★ No Significant storage change in the rest of the catchment. Simple calculations revealed that a specific yield of 0.001, and a G.W.L. change of 10 cm would result in $0.33*10^6$ for the whole catchment. A very negligible amount.
- ★ The change in storage is being calculated according to 3 different types of hydrological years; wet, average, and dry years. Values are $8.5*10^6$, $1.4*10^6$, $1.9*10^6$ respectively. The later is a decrease while the two formers are increase.

As we are taking the whole catchment, the change in storage is not a water source unless the overall annual change in storage has decreased in a certain year. Meaning that the people were abstracting from that source as another source of water. Here in this particular year storage is being replenished either surface or ground water. So, one way out of the water is being stored either in the ground water aquifer, or as increase in the lake water volume.

Ground water depths, interpolated from point map of well depths, **[Plate 1-5]** range from very few meters in the farms around the lake to 271.0 m, showing an overall average of 82.0 m. Hence, the unsaturated zone soil volume is determined in a GIS procedure after incorporating the available well depths for the whole catchment (26.6*10^6 m^3). The question now is how to quantify the change in storage that takes place in the unsaturated zone. A closer look on the two main rivers' hydrographs **[Annex QN.3]** during the last five years (1993-1997) can help a bit in approximating that figure. Discharge changes from year to year, for March, the driest month, during the year 96-97 was considerably high for both rivers, meaning that there was a significant storage change in the unsaturated zone. Having the change in storage in the unsaturated zone as a closing term of the whole water accounting framework, we obtained a value of 179*10^6 m^3/yr. that means an increase in the volumetric water content of the unsaturated zone of 6.7%.

For the same year 1997, a replenishment of 2.0*10^6 m^3 to the ground water and a change **[Fig. 1-3]** in lake storage of 30*10^6 m^3 has occurred indicating that this year was one of the surplus years.

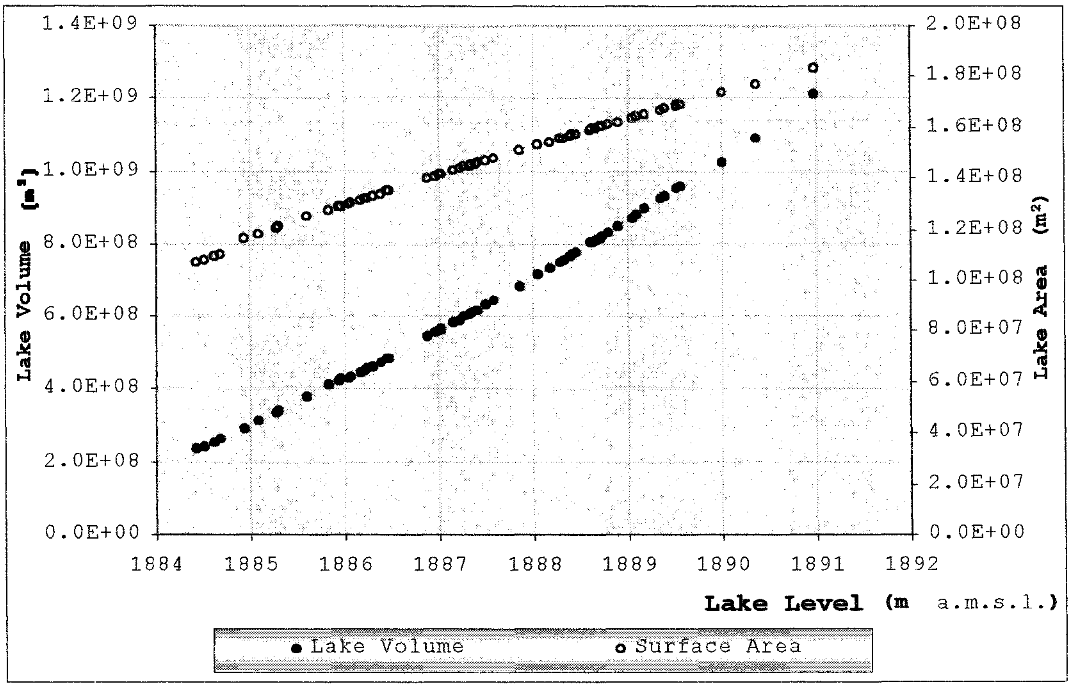


Figure 1-3: Level-Volume & Surface Area Rating Curves of Lake Naivasha.

Net inflow is the mathematical subtraction/addition of the last two terms; i.e. gross inflow and change in storage. In the sense that if the change in storage is positive; i.e. resources replenishment, net flow is the subtraction of change in storage from the gross inflow. In case the change in storage is negative; i.e. abstracted resource, then it should be added to the gross inflow.

Yet, there is another constituent of the storage change, which is the storage change in permanent plantations tissues. Carrying out the water balance on annual, not seasonal, basis has minimized the differences encapsulating the plant storage change. Moreover, it needs very sophisticated techniques to measure and quantify. Accordingly, this constituent is being neglected in this study.

1.4 Outflow

In the water accounting terminology **[Molden, 1997]**, outflow is the amount of water that is not depleted by any of the uses encountered. It can be further classified as committed and uncommitted outflows.

1.4.1 Committed outflow

It is that part of outflow that is committed to other uses, it's not necessarily to go out of the catchment. In our case there are two branches of the committed outflow:

- ★ Townships: This is the amount which is being abstracted from river Turasha for Nakuru, Kipipiri and Ol Kalau townships for domestic use, as the water sources are insufficient for those towns. The amount of 19,000, 6,100, 16,400 m^3/day respectively, totaling $15.16*10^6$ m^3/year, is currently abstracted **[Goldson, 1993]** on the maximum capacity of the pipeline, hence, no variability over time unless an extension of the pipeline system is planned. No doubts that any future expansion of the project depends on the discharge of the river, which is on average $0.3*10^6$ m^3/day.
- ★ Olkaria: the geothermal plant based in olkaria uses the water for two main reasons; (1) the steam used to drive turbines, (2) water used to condense the steam. The later was said to be direct from the lake. People at the Olkaria claim to use half of the irrigation water on the assumption of **[Goldson, 1993]**, that amounts to $15*10^6$ m^3/year while a realistic value may be imagined to be $30*10^6$ m^3/year, and that was the value used for the water accounting calculations. Future expansions of the plant will definitely affect the water use. Which means a monitoring program of the water use by the plant is needed.

1.4.2 Uncommitted Outflow

Uncommitted outflow is the water that is not depleted, nor committed, and is available thus for a use within the basin or for export to other basins. It flows out due to lack of storage or operational measures. Ground water outflow is the only constituent that represents the uncommitted outflow in our case, and obviously it flows outside of the catchment. The southern part of the lake is the window for the ground water out flow.

Detailed study of the aquifer system in the area [Ojiambo, 1996] revealed that the ground water outflow is ranging between $18\text{-}50*10^6$ m^3/year depending on the hydraulic conductivities in the region concerned. Previous researches have shown that the ground water outflow also lies within those figures. Based on the piezometric contours, Ojiambo illustrated that the ground water outflow is in the direction of south to southwest. Thus an average of $34*10^6$ m^3/year is being taken for the water accounting calculations. Another outlet of the groundwater is thought to be to the north direction of the catchment and is estimated to be $11*10^6$ m^3/year [Goldson, 1993]. So in total an approximation of $50*10^6$ m^3/year is being taken for the groundwater outflow.

1.5 Water Depletion

Is the use or removal of water from a water basin that renders it unavailable for further use **[Molden, 1997]**. Water depletion is a key concept for water accounting, as it is often the productivity and the derived benefits per unit of water depleted we are interested in. It is extremely important to distinguish water depletion from water diverted to a service or use, because not all the water diverted for a use is depleted. In water accounting framework **[Fig. 1-8]**, a separation is made between sink and return flow, which represents the difference between, diverted and depleted water. Two generic processes are responsible for water depletion: process depletion and non-process depletion. we will start by process depletion which is the amount of water diverted and depleted to produce an intended good. Again process depletion is further classified into our major sectors, agriculture, industry, and domestic.

1.5.1 Agricultural

Total irrigated area around the lake was declared in the water permits submitted to the ministry of water to be 3,246 ha. While this area was conducted from RS **[Hussein et al, 1998]** to be 4,600 ha. Sticking, only, to remote sensing cluster analysis, or declared agricultural area will not be a wise solution. The land-use classification done has indicated that the irrigated area is 4,568 ha and that was in a good comparison to the other classifications indicated before. Hence it was used for the sake of GIS calculation. On the other hand, the estimation of water consumption using water permits is not trustworthy. Current water use by the different crops is being conducted from the irrigation values declared by the farmers, which were cross-checked with the water permits data. Most crops have fallow period in which the soil is completely bare and is being neglected water-wise. Food and Agriculture Organization of the United Nations (FAO) tabulated information **[FAO, 1986]** about the growing period of each crop **[Annex QN.1]** was used in combination of the data declared by the farmers about cropping in turn. Evaporation from topsoil during the fallow period is being assumed to be of the normal bare soil evaporation. Actual vs current water consumption are shown **[Table 1-2]**.

Table 1-2: Applied Water Vs Theoretical Consumption & Return Flow.

Crop	Area (ha)[1]	Applied Irr. (mm/day)	Applied Irr. (mm/yr)	Rainfall (mm/yr)	ET_{act} (mm/day)	ET_{act} (mm/yr)	Surplus (m^3/yr)
Flowers	1,200	6.0	2557	0	2.1	751	16,064,685
Wheat	25	5.0	1826	655	3.2	874	401,870
French Beans	125	6.0	2192	655	3.2	1064	2,227,829
Baby Corn	100	5.5	2009	655	3.2	1064	1,599,638
Cabbages	75	5.5	2009	655	3.2	1064	1,199,729
Squash	75	5.5	2009	655	3.2	1064	1,199,729
Onion	75	5.5	2009	655	3.2	1064	1,199,729
Tomatoes	75	5.5	2009	655	3.2	1064	1,199,729
pea	75	5.5	2009	655	3.2	1064	1,199,729
Grass	800	3.5	1278	655	2.9	967	7,727,097
Fodder	1,943	3.5	1278	655	2.9	967	18,771,920
Rain-fed	64,559	.	.	801	3.3	820	-12,188,878
Natural Veg.	69,634	.	.	871	1.4	511	250,438,775
Bare	129,320	.	.	871	0.8	294	745,644,152
Forest	43,031	.	.	976	4.0	1,477	-215,844,892
				Total Return Flow from Agricultural Land			52,791,684
			Total Return Flow from Natural Vegetation, Bare and Forest				780,238,035
						Total (include sink)	**833,029,718**
						Total(exclude sink)	**785,517,202**

1. Acreage of various crops was obtained from the water permit cross-checked with the current values from farmers.

Apart from the regular irrigated area around the lake, there is rain-fed agriculture taking place allover the basin. The area under rain-fed was estimated, as illustrated before, by remote sensing means to be 64,559 ha, consuming some $517*10^6$ m^3/yr of rain water. Farmers are cultivating various types of crops, such as potatoes, maize.

1.5.2 Industrial

There are three main industries which are taking place in the catchment; agro-industries, better say diaries and milk production, geothermal plant, local beverages factory, and the telecommunication factory near Gilgil town. Agro-industries, taking water for irrigating fodder crops and for processing of milk. Based on certain acreage of fodder and grass according to **[Table 1-3]**.

Table 1-3: Industrial Water Consumption.

Fodder Acreage for diaries (ha)	700
Grass acreage left for grazing (ha)	400
Milk consumption (lt/capita/day)	1.0
Factory Water consumption (lt_{water}/lt_{milk})	12.0
Total Factory Water Consumption (m^3/year)	**1,534,050**

Delamere Estate				Other Factories		
Fodder	**Grass**	**Factory**		**Gilgil**	**Others**	**Others2**
13,076,397	8,035,500	1,534,050		5,000,000	7,085,850	.
		22,645,947	Totals	12,085,850		
			34,731,797			
			13,619,900	Water for factories only		

1.5.3 Domestic

Although a small 1% uncertainties in rainfall may result in $28*10^6$ m^3/year exceeds the peanuts of water consumed by domestic sector is worth mentioning for the sake of having the complete picture of the water users. Having the population of the whole catchment, the way the population is being distributed among the different classes of housing, the total number of tourists per year, and all the available public amenities number and capacities **[Annex QN.1]** will enable us to get a well structured calculations of the domestic water consumption of the study area. Ideal values for each sub-sector of the domestic sector were get from the "*Kenya Design Manual for Water Supply*". A certain requirement satisfaction percentages were assumed for, tourism, urban and rural sub-sectors based on the different interviews that were carried out during the field trip period. From those requirement satisfactions the current water supply was calculated showing a deficit increases from tourism to urban to rural. Requirement satisfactions were taken 95%,75%,45% for tourism urban rural respectively. Total of $7*10^6$ m^3/year is yet 25% of the mentioned rainfall uncertainties.

Non-process depletion occurs when diverted water is depleted, but not by the process it was intended for. Beneficial non-process depletion is the water that is not used for one of the economic processes that takes place in the region. However, some economic returns may emerge from these domains.

1.5.4 Wildlife Conservation

Water that is used by wild animals **[Table 1-4]** is obviously regarded as a beneficial non-process depletion. Being an indirect manner of capturing foreign currency does not have any thing to do with being non or even low beneficial water use. Tabulated values **[Annex PR.2]** are used for the estimation of water used for this domain. A Tropical Livestock Unit (TLU) is a nonphysical representation of a mature animal weighing 250 kg **[FAO & IIASA, 1991]**. This TLU is being used for any further calculations regarding the livestock/wildlife. Water for livestock is not only for drinking but also for watering. Major farmers claim to water animals twice daily. The difficulty of estimating the total wildlife population in the whole catchment was behind the lack of data necessary to approximate the water consumption. Instead, data on wildlife population around the lake was the basis for the rough estimation. A total of $1.96*10^6$ m^3/yr is obtained as a water usage by all the animals in the whole catchment. As we see it is not a sensitive parameter in our calculation as expected.

Table 1-4: Wildlife Water Consumption.

Unit	Equivalent TLU	Total No.[1]	Total TLU	Water Consumption (lt/day) Watering	Water Consumption (lt/day) Drinking	Water Consumption (m^3/yr) Lake	Water Consumption (m^3/yr) Catchment
Zebra	0.85	337	286	0.0	7,151	2,612	52235
Impala	0.10	206	21	0.0	515	188	3758
Elands	0.75	37	28	0.0	690	252	5040
Giraffe	1.10	8	9	0.0	223	81	1627
Water Buck	0.50	37	19	0.0	466	170	3406
Thomson Gazelle	0.20	64	13	0.0	322	117	2349
Cattle	1.00	35,000	35,000	2.0	1,250,000	493,088	1725806
Sheep	0.10	35,000	3,500	0.0	125,000	45,656	159797
Camel	0.50	0	0	2.0	0	0	0
Buffalo	1.50	100	150	0.0	3,750	1,370	6848
Elephant	9.10	0	0	0.0	0	0	0
A TLU consumes 25 lt/day						**Total**	**1,960,867**

1 Source: Kenya Wild Life Service, Naivasha Agricultural Office.

1.5.5 Economic Forest

The community in the basin is placing beneficial values on trees that consume some of the water. Economic forest is the forest that is being used for any economical activity **[Table 1-5]**. One further distinction between the economic and non-economic forest is the scale of use, few local persons in the upper catchment cutting some trees once in their lifetime for construction of their own houses is different than the continuous utilization around the lake.

Table 1-5: Different Uses of Forest.

Usage	Operator	% of Use
Power Posts	Kenya Power Company	5
Telephone Posts	Kenya Telephone Company	2
Char Coal	Private Farms	40
Domestic	Individual	23
Construction	Individual	10
Investors	Developers	20

Those utilized forests lie within a 3 kilometers offset from the current (year 1999) lake shore hence account for approximately 6% of the total forest.

Actual evaporation from forest is being calculated by remote sensing means **[Hussein et al, 1998]**. Three classes have been selected to represent coniferous forest amounting to 14.5% of the total area of the catchment. Weighted average of 4.1 mm/day is obtained as a result **[Table 1-9]**. The economically used trees will grow faster than non-economical trees, not for anything except that at the early stages of a tree, it grows faster than it does in a later stage of its life. Unfortunately that can not be directly translated to water consumption of the tree. However, for the same type of tree that grows for economic return and the one for non-economic return we can say that the overall evapotranspiration for economic forest is a bit higher than the one of non-economic. A percentage by which ET_{econ} exceeds $ET_{non-econ}$ is roughly estimated at 20%.

1.5.6 Natural Vegetation

Actual evaporation for rangelands (natural Vegetation) is being calculated **[Table 1-9]** and results are shown; 1.4 mm/day.

Evaporation from swamp area is being roughly estimated based on the fact that evaporation from papyrus swamps or any kind of weeds can never exceed the evaporation from the lake which is 4.61 mm/day. An arbitrary percentage of the lake evaporation amounting to 70% is being assigned to the evaporation from swamps and wetlands leading to a value of 3.2 mm/day.

1.5.7 Forest

With respect to the species endangered in the area, Acacia is the major type, a few types experiencing a smaller percentage **[Table 1-6]** are there as well. Moreover, these percentages are not very accurate, as it is logistically expensive and tedious exercise to carry out a study to know the total number of different species in the whole area.

Table 1-6: Tree Types in the Catchment with their Coverage and Theoretical Water Consumption.

Type	Coverage (%)	Theoretical Water Consumption (mm/d)	Remarks
Acacia	50	6.3	Can go up to 15 m height
Xantho Pholea	15	1.5	Smaller than Acacia
Eurphorbia	10	1.5	
Eucalyptus	10	4.0	
Non-Woody	15	1.0	

(Source: Naivasha Forestry Department & **[Calder, 1996]**.)

The verity of having faster growing properties of the acacia trees near the lake confirms that proposed deficits in the water needs by those trees which is based on previous investigations **[Calder, 1996]**. In other words, this faster growing can be attributed to the shallower ground water table from which the rooting system of that species can find a shorter and easier way of extracting the water necessary for the plant growth.

Forest is being divided, in the water accounting procedure, into two main parts, economic and non-economic forests. A great care should be expected for the economic forest rather than the non-economic, unfortunately, that is not the case in the study area. Those forests are being left to natural conditions, and later on they are cut based on broken (either by wild animals or nature), diseased, or dead, if not normal trees are cut. Robust trees are left for habitat. Different uses of forest are well indicated in **[Table 1-7]**. Fallen leaves that can shield the soil surface and act as water collector surface which will, no question about it, increase the amount of evaporation attributed to forest. That can be called the secondary interception. Apart from that utilized forestry people are just leaving the trees to grow naturally without any disturbance. Considering water consumption, they take the most of the water incoming to the catchment. To put the thing in the water accounting terminology, this item is regarded as a non-beneficial non-process depletion.

The average evaporation rates from wet trees tend to be much higher, say 2-5 times, than those from wet shorter vegetation **[Calder, 1996]**. Which might give a range of high evapotranspiration. Finally an evapotranspiration model **[Calder, 1978]** was used to estimate the evaporation from the forest. The meteorological data **[Mekonnen, 1999]** **[Annex QN.3]** revealed an evaporation of 4.0 mm/day which is in a good comparison to various studies done in similar conditions **[Calder, 1996]**, **[Chin, 1998]**.

Table 1-7: Different Uses of Tree Types.

Use	Acacia	Xantho Pholea	Eurphorbia	Eucalyptus	Non-Woody
Firewood	●	◉	○	◉	**O** (small scale)
Charcoal	●	**O**	**O**	◉	○
Construction	**O**	**O**	**O**	●	○
Wind Bracing	**O**	**O**	**O**	◉	●
aesthetic	**O**	○	**O**	●	◉
Wildlife Habitat	◉	○	**O**	○	●
Timber	○	○	○	**O**	○
Soil Conservation	◉	**O**	**O**	◉	◉
Fencing	◉	◉	◉	◉	◉

● Highly Utilized, ◉ Utilized, **O** Poorly Utilized, ○ Non Utilized.

A misleading term of "non-beneficial" points to pure economic non-value gaining processes. This term has nothing to do with the sustainability or other environmental valuing. Non-Beneficial includes all the water consumers that r not part of the intended processes, or the diverted water.

1.5.8 Interception

Although always forgotten or intentionally neglected, interception may constitute a large part of losses. Raindrops can be intercepted on plants' leaves and directly evaporated without even reaching the earth's surface. Interception losses is governed by many factors:

* Forest-related:
  * Density of the canopy
  * Leaves type
* Weather-related:
  * Rainfall intensity
  * Wind/humidity/temperature

The leaf interception storage capacity varies widely between tree species. Highest storage capacities have been reported for tropical rain forest trees, 2.2 to 8.3 mm **[Calder, 1996]**. Eucalyptus are likely to fall into the lower end of the range of tree storage capacities. Evaporative losses of intercepted water occur both during the rainfall event itself, and afterwards from water stored on the leaves, branches and trunks of trees, and are then constrained by the water storage capacity of the vegetation.

Well it is always better to assume a certain interception taking place rather than neglecting it all. Should we need to assume a certain percentage of interception losses, we still need to have a solid background to build our assumption upon. Obviously interception in the highlands is much different than around the lake, and by forest is different than by Lucerne. Highlands having higher rainfall, and forest intercepts the great, are our basic rationale to put along a certain percentage.

Table 1-8: Interception (Percentages) as a Function of SAVI and Rainfall.

SAVI Class (-)		Interception (%)	Rain Class (mm/yr)		Interception (%)
Min	Max[1]		Min	Max	
0.00	0.20	0.00	0	400	85.0
0.20	0.40	10.0	400	550	72.0
0.40	0.60	19.0	550	700	64.0
0.60	0.70	26.0	700	850	57.0
0.70	0.80	31.0	850	1000	50.0
0.80	0.90	36.0	1000	1150	42.0
0.90	1.00	46.0	1150	1500	30.0

1. Mathematically Speaking, SAVI values can be more than one but it was masked here.

The Soil Adjusted Vegetation Index (SAVI) is being used as an indicator of the density of the vegetative cover. Regarding rain intensity, we have no sufficient data to get it on a mm/hr basis, so we will assume that for each classified unit of the SAVI, rainfall intensity is fixed based on the rainfall of the nearest meteorological station.

Interception is being assumed subjectively twice in an interactive GIS process. An average rainfall map calculated from the four methods indicated above is being classified into number of classes assuming that the classes of rain represent to a certain degree the classes of intensity. The SAVI map is also being reclassified into no of classes represents the interception capacity of each land cover. Subjective percentages are being assigned to each class in the last two maps (interception as a percentage of rain) taking into consideration that irrigated lands and rain-fed agriculture are practically having no interception. Hence, masking the irrigated and rain-fed areas will give us the final interception map **[Plate 1-6]** in terms of, both, percentages and volumes of rain. This amount of interception is being evaporated directly as evaporation from water surfaces, and that is why it is separated from the forest evapotranspiration.

Calder has conducted the results of many interception studies carried out in different parts of the world under different climatic conditions [Calder et al, 1992]. Those values have been taken as a reference for the subjective interception percentages assigned **[Table 1-8]**. Once again those values were assumed on the basis of interception of 100% is of the surface which tend to be so flat to intercept the all the rain. Linear relationship was also assumed between the interception and the SAVI irrespective of the rainfall and intensity.

For interception as a function of rain, the following subjective percentages **[Table 1-8]** were used assuming that this will be the behavior of a flat surface of leaves regardless any other conditions, and irrespective of the canopy species. Linear relationship **[Annex QN.3]** was also assumed between the interception and the rainfall irrespective of the rainfall, and intensity. Last hurdle confronted the process was the uncertainties in those subjective assumptions and linear relationships and the spatial as well as temporal variations of land-uses classes. To come over temporal variations, the same procedure could be done for another TM image of different date(s), but for the sake of simplicity and data availability we can take this for granted. That was assumed Knowing that forest and natural vegetation does not vary too much from time to time, and for irrigation and rain-fed areas, interception was set to zero. Finally the total intercepted volume on anneal basis was declared to be $231*10^6$ m^3, and that is obviously a very considerable amount not to be neglected especially in this particular case. For this hydrological year, only four storms had intensities above 12 mm/hr **[Hamududu, 1998]** which suggest a stable rainfall. Tabulated values of different tree types [Todd, 1970] has shown that the assumed moderators were relatively good. Noting that the interception percentages include the stem flow. Interception varies on a seasonal basis, for instance interception, as a percentage of rainfall, in wet season is different than interception in dry season. Todd also manifested that interception could happen for other shorter crops that exist in the study area, such as alfalfa, and maize. Smaller percentages of interception are experienced by those crops, a fact that was incorporated in the analysis.

1.5.9 Lake Evaporation

Annual evaporation from the lake surface **[Ashfaque, 1999]** is estimated at 1684 mm (4.61 mm/d), knowing the surface area of the lake at the year 1997, we can calculate the total evaporation which amounts to $227*10^6$ m^3/year.

1.5.10 Bare Soil

Bare soil is being defined, as the soil in between trees, bushes, or shrubs that practically has not any kind of vegetative cover even partially. Bare soil is not the item to be forgotten here in this catchment, as we see from the flow chart in **[Fig. 1-8]**, it is the highest water consumer on annual basis. Having the lowest evapotranspiration in mm/day is not automatically leading to minimum water consumption in m^3/yr. As illustrated in **[Fig.1-4]**, the X-axis represents the daily evapotranspiration, and Y-axis represents the area of which this item is covering in the catchment, and the size of the ball represents how much it consumes of water. We can see that bare soil is having very low ET, but very high total area, leading to a very big amount of water consumption; i.e. the largest ball in the chart.

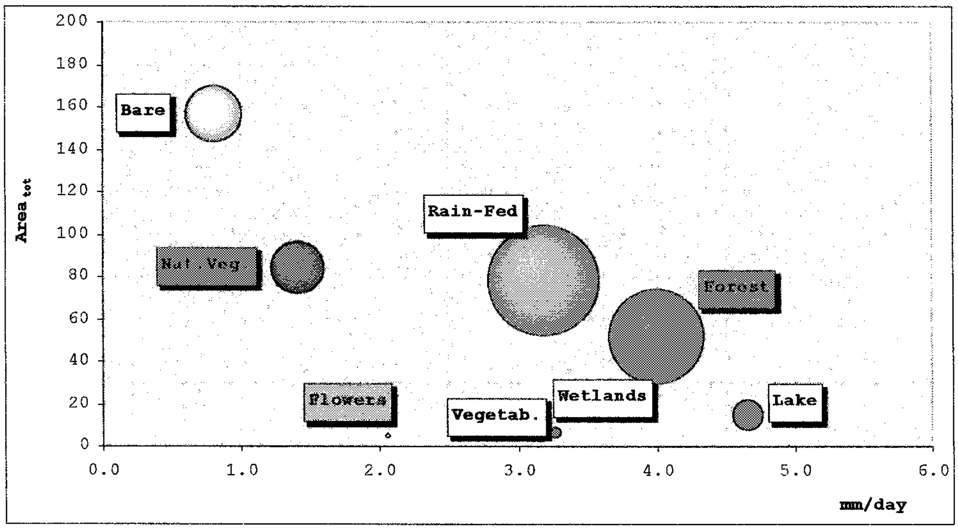


Figure 1-4: Water Consumers

Bare soil evaporation is being averaged along the whole year based on the fact that soil in wet conditions evaporate more than under dry conditions. Plotting the average annual rainfall on monthly basis simultaneously with the reference potential evapotranspiration [Mekonnen, 1999] is the first step. Then assuming that actual evaporation of the soil is a certain percentage of the potential at different moisture regimes, i.e. actual evaporation nearly equals the potential in the very wet season, and declines abruptly in drier conditions **[Fig. 1-5]**, **[Annex QN.3]**. Third step is to multiply this percentage by the potential evaporation for each month to get the actual soil evaporation on monthly basis, which can be further aggregated to an annual basis. The effect of spatial variability in soil texture is being neglected especially after the GIS procedure of soil map that revealed that the dominant texture is clay. Hence, no significant percolation unless after dry period. For the other parameters controlling the water status through the soil surface, could be neglected for the sake of not complicating matters.

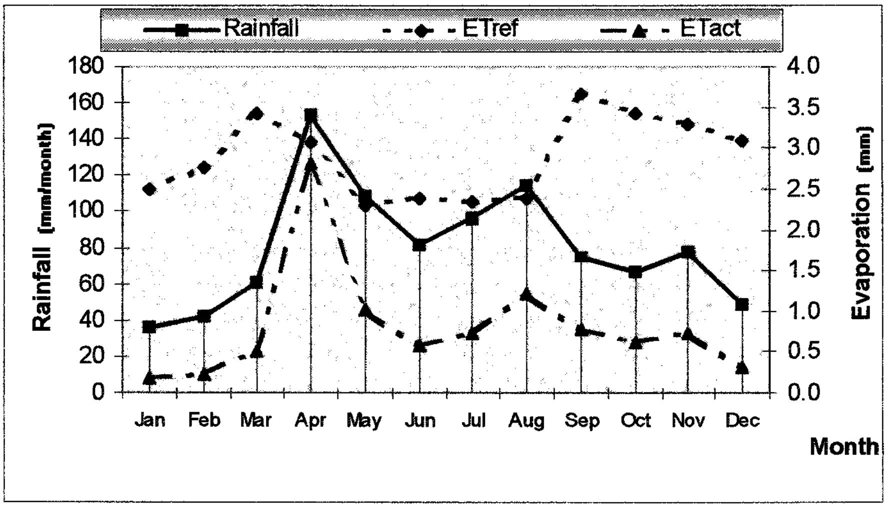


Figure 1-5: Soil Evaporation Vs Monthly Rainfall, Reference Crop ET.

Actual evaporation for bare soil, is being calculated by remote sensing means **[Hussein et al, 1998]** and results **[Table 1-9]** has shown an ET of 0.67 mm/day, which is comparable to the obtained value of 0.81 mm/day.

Table 1-9*: Actual Evaporation from Bare, Forest, and Natural Vegetation.

Cover	Class	Area (%)	ET_{act} (mm/d)
Bare Soil	1	19	1.70
	4	3	0.70
	5	32	0.50
	7	24	0.70
	14	22	0.00
	Average		**0.67**
Forest	6	54	3.80
	9	31	5.50
	15	15	2.80
	Average		**4.1**
Natural Vegetation	8	12	1.2
	10	20	1.6
	11	36	1.4
	12	13	1.6
	13	19	1.2
	Average		**1.4**

(* Source [Hussein, 1998])

Having problems relating everything to either beneficial or non-beneficial has paved the way to consolidate another term called the "Low beneficial Non-process Depletion". That includes the forest and natural vegetation as putting them in the non-beneficial domain will be severely opposed by manifold question marks from altered aspects like environment, social, and economics. On the other hand, those two domains are not sufficiently beneficial to be classified as pure beneficial domains.

1.6 Return Flow

Stressed vegetation is a consequence of a deficit in the water. On the other hand, if input water is more than what is needed, then a surplus results. This surplus gets, in away or another, its way back to the system, and gets incorporated in a manner best represented by the term **Return Flow [Fig. 1-6]**. It finds the way back through the ground water, so in a certain way, gets the contamination diluted. This contamination would be a consequence of any human activities as intensive agricultural practices resulting in a high content of chemicals in the drained water. Return flow is comprised of three different stages:

1. Diversion Return Flow: is the part that is abstracted and is not delivered to the plant.
2. Deliverance Return Flow: is the part that is diverted to the plant area but not delivered to the plant itself.
3. Application Return Flow: is that part which is diverted and delivered but not actually transpired or used for the plant growth.

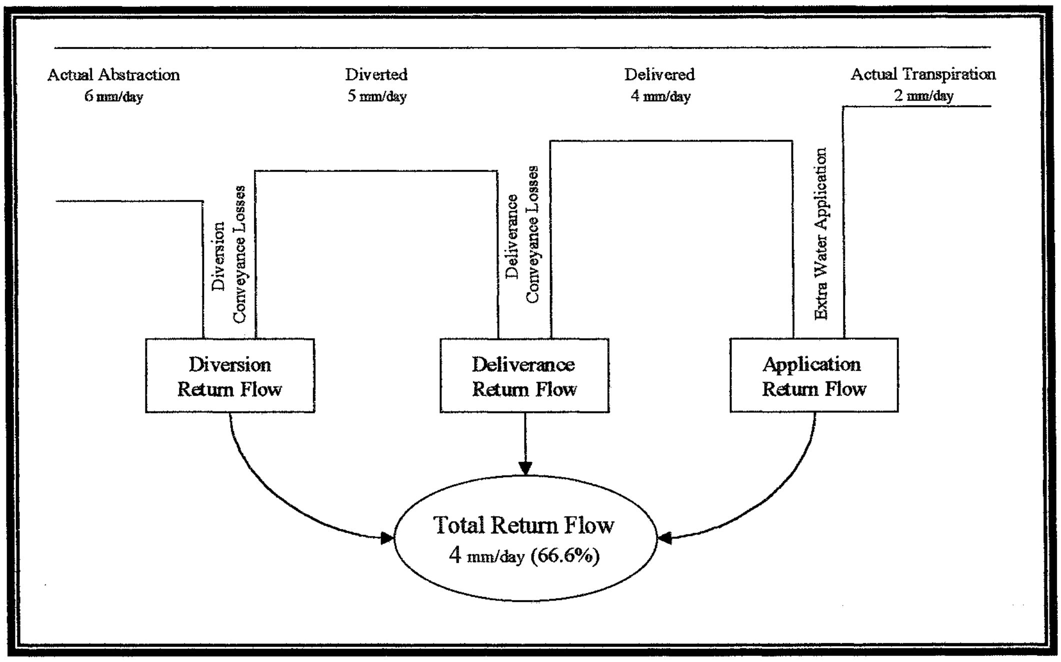


Figure 1-6: Different Constituents of Return Flow

Part of this return flow is being heavily polluted and referred to as sink and will be discussed in details in part two. Poor irrigation efficiencies, improper water distribution networks result in relatively high losses. Yet it is nothing compared to the big three; i.e. forest, natural vegetation, and bare soil. Evaporation from the lake and wetlands amounting to $275*10^6$ m^3 for the hydrological year 1997 are considered to be losses, and are regarded, in water accounting terminology, as non-beneficial non-process depletion. This amount of water could have been utilized in another way, that is the idea behind putting it under the utilizable water concept.

1.7 Performance Indicators

Water accounting performance indicators **[Molden, 1997]** are presented in the form of fractions.

Depleted Fraction: is that part of the inflow that is depleted by both process and non-process uses. It can be identified in terms of net, gross, and available water.

1. DF_{net} = Depletion/Net Inflow
2. DF_{gross} = Depletion/Gross Inflow
3. $DF_{available}$ = Depletion/Available Water

Process Fraction: relates process depletion to either total depletion or the amount of available water.

4. $PF_{depleted}$ = Process Depletion/Total Depletion
5. $PF_{available}$ = Process Depletion/Available Water

And the obtained values of the mentioned indicators are as follows:

1. DF_{gross} = 91.4%
2. DF_{net} = 97.2%
3. $DF_{available}$ = 98.5%

4. $PF_{depleted}$ = 19.1%
5. $PF_{available}$ = 18.8%

1.8 Sensitivity Analysis & Validation

The sensitivity analysis procedures has been done for most of the calculations revealing some unexpected behaviors of some of the parameters as well as some expected ones. To start off, unexpected behaviors.

- **Albedo:** Albedo for forest has a wide range of values of which selecting a single value for calculations is a troublesome. Choosing all the values in the range will not affect the average forest ET AT ALL.

- **Wildlife Population:** Increasing that figure in the whole catchment by **100%** will result in an increase in the water usage from $1.96*10^6$ m^3/yr to $2.1*10^6$ m^3/yr. Decreasing the total population in the whole catchment by 90% will result in a decrease in the wildlife water usage from $1.96*10^6$ m^3/yr to $1.89*10^6$ m^3/yr. Difference is yet an inconsiderable difference.

- **Livestock Population:** Increasing that figure in the whole catchment by **100%** will result in an increase in the water usage from $1.96*10^6$ m^3/yr to $3.87*10^6$ m^3/yr. Decreasing the total population in the whole catchment by 50% will result in a decrease in the wildlife water usage from $1.96*10^6$ m^3/yr to $0.85*10^6$ m^3/yr. Difference is yet a very negligible amount.

- **Cultivation Area:** Agricultural Sector water usage is being calculated based on many parameters, one of which is the area under various crops, assuming that the actual values of areas are slightly (20%) higher, or 30% lower, as two extremes, resulted in a range of ($81*10^6$ - $56*10^6$ m^3/yr). That was based on a fixed distribution of the different crops.

Finally, as a validation of the results obtained, simple calculations based on **[Eq. 1-3]**. Change in storage in the ground water was neglected, hence three terms only were included in this normal water balance equation; rainfall, runoff, and evapotranspiration. This validation **[Table 1-10]** is being done for the three sub-catchments in the region, Malewa, Gilgil, and Kartati.

$$\text{Rainfall} = \text{Evapotranspiration} + \text{Runoff}$$

Eq. 1-3: Validation Equation

Table 1-10: Water balance of the Three main Sub-Catchments as a Validation

Parameter	Units	Sub-Catchment		
		Malewa	Gilgil	Karati
Area	(km^2)	1579.5	524.2	149.9
Rainfall	($*10^6$ m^3)	1454.052	464.766	122.131
Evapotranspiration	($*10^6$ m^3)	1.839	0.642	0.111
Calculated Runoff	($*10^6$ m^3)	1452.213	464.124	122.020
Measured Runoff	($*10^6$ m^3)	2394.323	331.529	251.961
Error in Runoff	(%)	39.3	39.9	51.6
Weighted Average Error	(%)		**40.3**	

A large percentage of the error encountered might be attributed to the uncertainties in land-use classification, errors in measuring discharge, filling up of missing data. Having the two main sub-catchments' error near to each other may suggest that there is a consistent error. On top of all, the measured runoff was for the hydrological year March 1996-1997, while rainfall is done on average basis. Although year 1997 is considered as an average year, a difference of 20-40% added to a normal rainfall measuring error of 10% will make the error in runoff equal to 21%, 9% respectively. This error is primarily attributed to the rainfall estimation rather than evapotranspiration as the contribution of evapotranspirationis negligible. Rainfall is lower than runoff in two sub-catchments, Malewa & Karati, while the other way is taking place for Gilgil sub-catchment, that also suggests that a considerable contribution from the ground had happened in this year, an item which is not incorporated in the above mentioned equation **[Eq. 1-3]**.

All the above-calculated values are time independent unless for the change in storage and lake evaporation as they were based on the data for the hydrological year March 1996 - March 1997, while other data were not based particularly n that year.

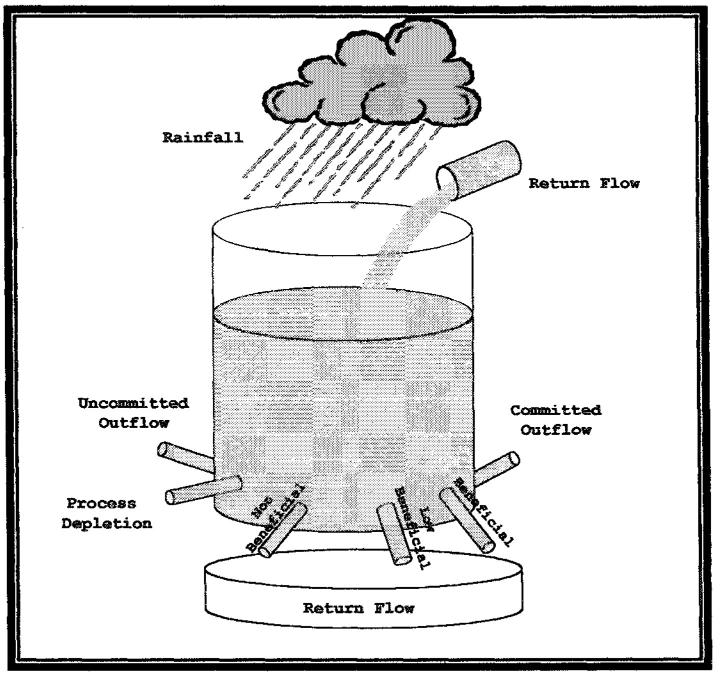
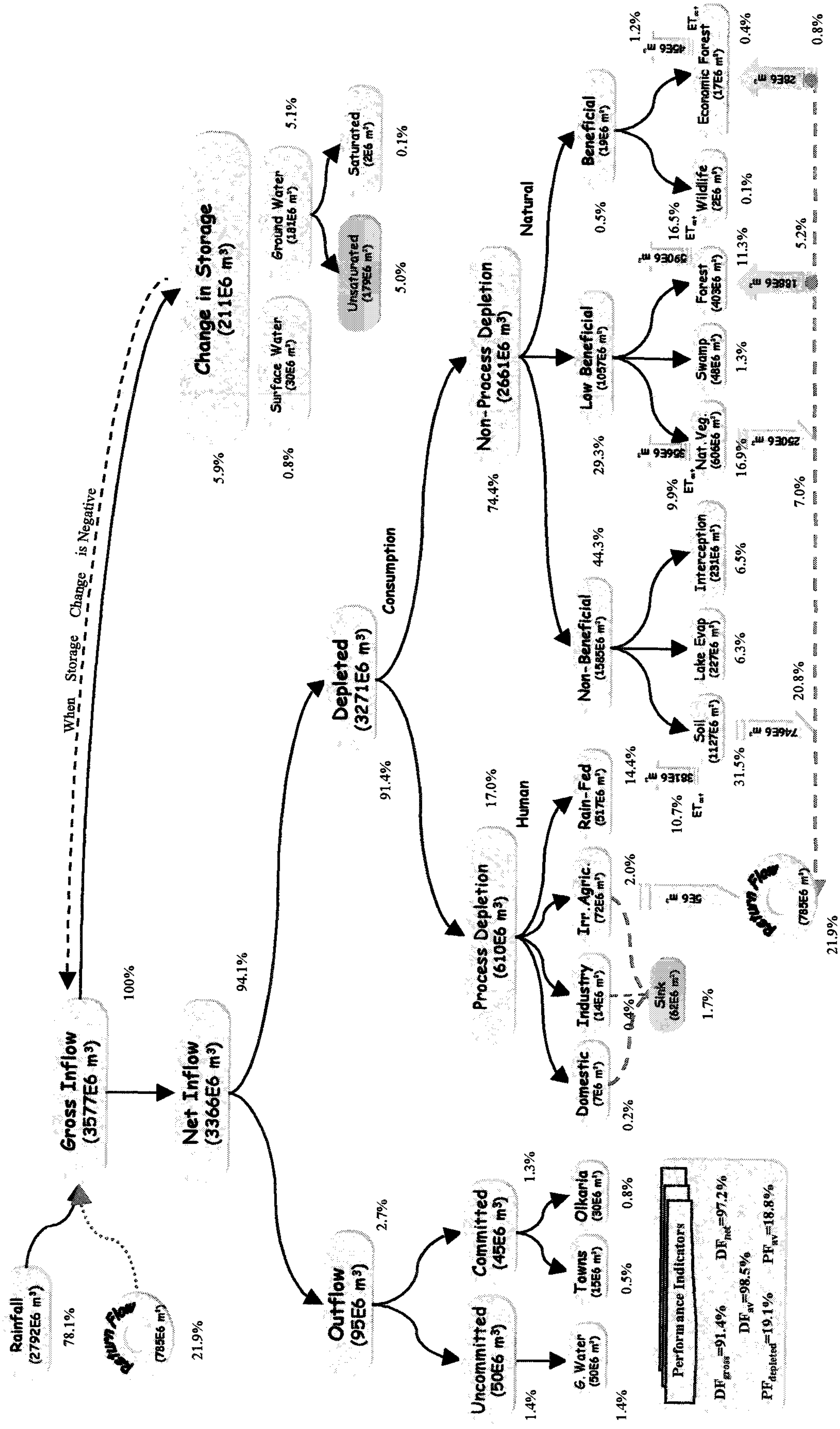


Figure 1-7: A Schematic Representation of the Water Status in Naivasha Catchment



These Calculations are for the hydrological Year March 1996-march 1997.

Fig. 1-8: Water Accounting Framework

PART TWO

CURRENT WATER QUALITY

Availability of water is not an issue if not escorted with the suitability to a given utilization. So water quality plays, at no small part, a large role in determining if the **available** water is **suitable** or not. Attention is drawn to the quality of the available water, is it suitable for various uses or not.

2.1 Agriculture

As a corner stone of concern, we will stress on this sector as a polluting activity. Most farmers have their own treatment system, by which they treat their water for both agricultural use, and the domestic use. Existing water quality of the lake, or even bore holes, is not very satisfactory for most of the farmers. Having higher electric conductivity (EC) or inappropriate pH value is as basic as easily adjustable through adding some chemicals. Furthermore, other water quality parameters require more sophisticated treatment, and often not done by small farms. Both will lead to a consecutive pollution of the water. Intensive agricultural activities are taking place in the vicinity of the lake leading to deterioration in the surface and ground water quality. Detailed leaching study of the different agrochemical and chemical analysis of waste water from agriculture is done [Tang, 1999] revealing that some samples may have concentrations of some parameters up to 17 times than the allowed by "*Kenyan guidelines for discharge into public water courses/sewers*".

As already divulged in the part one, too much amount of water is being used for irrigation with a certain percentage of chemicals that are required for a certain crop. Therefore, a portion of the applied irrigation, containing the necessary fertilizers and pesticides is only being used by the plant, and the rest goes to return flow with all the chemicals included. Once more this return flow is either going straight to the lake or to the ground water. Undoubtedly, an increase of usage of chemicals is corresponding to the deterioration of water quality. However, no profound increase in the chemicals used by the farmers in the last six years **[Fig. 2-1]**, or at least declared by them. Meticulous investigation may conclude that those amount declared by the farmers and even by the dealers are not the exact ones, moreover there is no point in running after those values because it is already clear enough that chemical use is in substantial increase. The point is how to mitigate those effects.

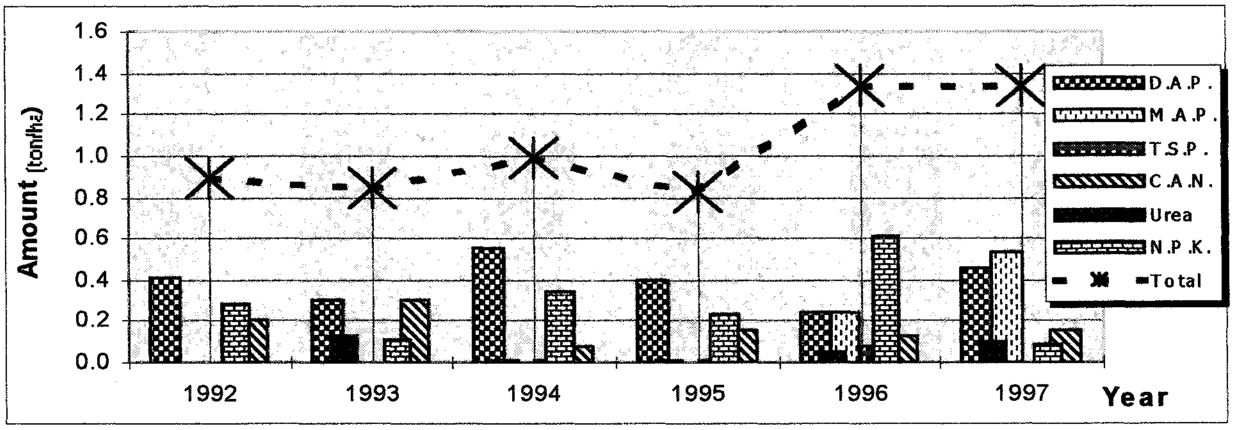


Figure 2-1: Fertilizers Usage in the Last Six Years (1992-1997)

One other point regarding the water quality is the productivity by unit area of the land. Logic reasoning will lead to a declining productivity over time, while actual situation is not approving this reasoning **[Fig. 2-2]**. Some particular crops are sensitive to water quality deterioration like carrots, leeks, strawberries, and grapes **[Annex QL.2]**, while others have no profound change in productivity per hectare unless even a slight increase.

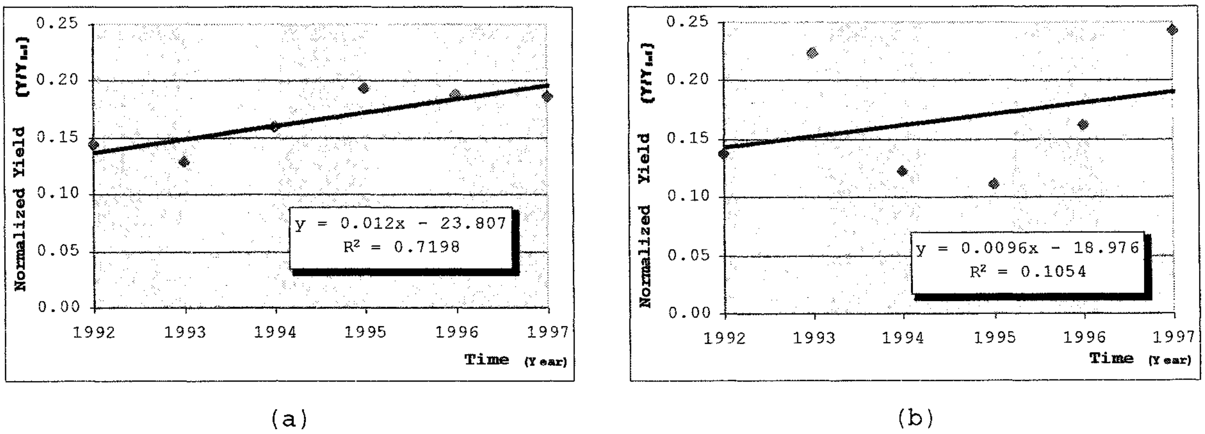


Figure 2-2: Change in Production for Cabbages (a) & Tomatoes (b) over the Last Six Years (1992-1997).

Stable crop productivity over time; i.e. the last 10 years, was a vague question mark arising based on the background of the site under study. The answer was very simple:

- ★ Farmers are cultivating in turns, meaning that if a piece of land is being cultivated for tomato, after harvesting, another crop will come over just to rejuvenate some soil minerals that have been exhausted by the previous crops. Then a continuous refreshing of the soil minerals is taking place, hence the soil is nearly always rich of minerals.
- ★ For instance, experience has shown that seeding tomato after harvesting Potatoes, or one week prior to planting French beans after harvesting cabbages is a good combination for one particular piece of land. That will keep the minerals available in the soil for many plants, and let the overused minerals to replenish during their rest period.
- ★ Farmers are increasing the amount of fertilizers used just for the sake of increasing productivity, even at the cost of long term sustainability as discussed earlier.
- ★ High soil fertility.

A more in depth study of the water quality effect on certain crops is being manifested in **[Table 2-1]**, and **[Table 2-2]**.

Table 2-1: Current Water Quality for Agriculture Vs Comparative International Standards.

Irrigation Problem, & Parameter		Unit	Degree of Restriction in Use[3]			Current situation	
			Slight	Moderate	Severe	Sample 1[4]	Sample 2[4]
Infiltration[1]							
	SAR						
	0-3 , **EC=**	µS/cm	700	200	< 200		
	3-6 , **EC=**	µS/cm	1200	300	< 300	**200**	
	6-12 , **EC=**	µS/cm	1900	500	< 500		**430**
	12-20 , **EC=**	µS/cm	2900	1300	< 1300		
	20-40 , **EC=**	µS/cm	5000	2900	< 2900		
Toxicity[2]							
SAR		(--)	3	9	> 9	**4.922**	**8.036**
Bicarbonate (HCO_3)		mg/l	91.5	518.7	> 518.7	< 1.2	< 2.2
Boron (B)		mg/l	0.7	3	> 3	0.374	0.407
Cadmium (Cd)				0.01		**0.027**	**0.029**
Chloride (Cl)		mg/l	141.8	354.5	> 354.5	89.29	41.14
Chromium (Cr)		mg/l		0.10		0.225	0.223
Cobalt (Co)		mg/l		0.05		0.027	0.018
Copper (Cu)		mg/l		0.20		0.078	0.059
Lead (Pb)		mg/l		5.00		0.090	0.052
Lithium (Li)		mg/l		2.50		0.021	0.000
Manganese (Mn)		mg/l		0.20		0.063	0.061
Nickel (Ni)		mg/l		0.20		0.161	0.085
Nitrogen (N)		mg/l	5	30	> 30	**5.719**	**10.09**
Titanium (Ti)		mg/l	Effectively Excluded by Plants			0.080	0.095
Zinc (Zn)		mg/l			2.00	0.292	0.187

1. Affects infiltration rate of water into soil.
2. Affects sensitive crops.
3. Source **[FAO,1985]**.
4. Sample 1 is from Delamere estates, and sample 2 is from Brixia Farm. (Point Samples, October 1999)

Table 2-2: Crop Tolerance and Yield Potential of Selected Crops Vs Current Status.

Crop	EC (µS/cm) for different Yield Potentials*				Tolerance Rating[1]	Current Status
	100%	90%	75%	50%		
Wheat	4,000	4,900	6,300	8,700	M. Tolerant	1100[#1]
Beans	700	1,000	1,500	2,400	M. Sensitive	**700**[#2]
Squash	2,100	2,600	3,200	4,200	M. Tolerant	700
Tomato	1,700	2,300	3,400	5,000	M. Sensitive	700
Cabbage	1,200	1,900	2,900	4,600	M. Sensitive	700
Potato	1,100	1,700	2,500	3,900	M. Sensitive	650[#3]
Maize	1,100	1,700	2,500	3,900	M. Sensitive	650
Onion	800	1,200	1,800	2,900	Sensitive	**700**
Grass	5,000	6,000	7,400	9,800	Tolerant	1500[#4]
Barley	4,000	4,900	6,400	8,700	Tolerant	1500
Alfalfa	1,300	2,200	3,600	5,900	M. Sensitive	1500
Peas	3,300	3,800	4,700	6,000	M. Tolerant	700

* Source [FAO, 1985]

Sample 1: Average irrigated Wheat and Rain-fed Wheat. Sample 2: Average Vegetable Farms. Sample 3: Average Rain-fed Cultivation. Sample 4: Average Irrigated Fodder Cultivation. (Point Samples October 1998 **[Morgan, 1998]**)

As seen, there are few parameters that lie under the restricted use zone, although the effect is not very profound. The same situation is found regarding the salinity tolerance table. The mineral content of the soil is being managed by the farmers themselves either by sophisticated technology or by self experience of cultivating in turn. As an end, farmers are modifying the quality themselves.

2.2 Industry

For the diaries, they, at Delamere Estates, have a nice practice of recycling the water under use. They use the diary factory waste water, which is very fertile, hence can abate the use of fertilizers considerably, for irrigating the fodder crops, Although high EC and other components might be eminent, most fodder crops, if not all, are salinity tolerant. And that is a nice way of minimizing the water use, reducing electricity bills and reducing the threat of dumping polluted water into the lake. As shown in **[Table 2-3]**, most of the water quality parameters lay well below the threshold concentration except the fluoride which is still in between the threshold and the limiting concentrations **[Todd, 1970]**, a situation might be interpreted as safe, for the time being, with regard to the livestock.

Table 2-3: Current Water Quality for Livestock Vs Comparative International Drinking Water Guidelines.

Parameter[3]	Unit	Concentration		Current situation	
		Threshold [1]	Limiting[2]	Sample 1[4]	Sample 2[4]
Aluminum (Al)	mg/l	5.00	--	0.240	0.257
Bicarbonate (HCO_3^-)	mg/l	500.0	500.0	Low	Low
Boron (B)	mg/l	5.00	--	0.338	0.374
Cadmium (Cd)	mg/l	5.000	0.050	0.025	0.027
Calcium (Ca)	mg/l	500.0	1000	11.80	52.50
Chloride (Cl^-)	mg/l	1500	3000	11.16	89.29
Chromium (Cr)	mg/l	1.00	--	0.231	0.225
Cobalt (Co)	mg/l	1.00	--	0.024	0.027
Copper (Cu)	mg/l	0.50	--	0.063	0.078
Fluoride (F^-)	mg/l	1.000	6.00	**1.296**	**1.173**
Lead (Pb)	mg/l	0.050	0.10	**0.099**	**0.090**
Magnesium (Mg)	mg/l	250.0	500.0	1.230	5.910
Nitrates (NO_3^-)	mg/l	200.0	400.0	2.122	5.719
pH	(--)	6.0-8.5	5.6-9.0	7.2	6.9
Sodium (Na)	mg/l	1000	2000	30.00	26.60
Sulfate(SO_4^{2-})	mg/l	500.0	1000	4.984	53.23
Zinc (Zn)	mg/l	24.0	--	0.274	0.292

1. Threshold values represent concentrations at which poultry or sensitive animals might show slight effect from prolonged use of such water. Lower concentrations are of little or no concern.
2. Limiting Concentrations are based on interim criteria, South Africa. Animals in lactation or production might show definite reactions.
3. Source **[Todd, 1970]**, **[FAO, 1985]**
4. Samples are taken from Delamere estates.

Regarding the electric conductivity (EC) ratings, FAO has also classified the water used for livestock and poultry **[FAO, 1985]**. With respect to the water used for both in around the lake the EC ranges under the 1500 µS/cm limit of an excellent rating which could declare a water usable for all classes of livestock and poultry. Even if the EC goes up to 5000 µS/cm, it is still categorized as very satisfactory, although it may cause temporary diarrhea in livestock not accustomed to such water. For any organoleptic factors; i.e. odor, taste, they can be readily detectable by animals and are of little consequence to health or productivity unless water consumption is affected dramatically. For Olkaria geothermal plant, effluent **[Table 2-4]** and gases may impact on the environment. Moreover it is not yet known how the drilling affects the underground in and outflow of the lake water or the interrelationship of the aquifers.

Table 2-4: Water Quality Characteristics of the Effluent from Olkaria Geothermal Plant. (EC at 20 °C=2000 µS/cm)

Sample	Al	B	Cd	Co	Cr	Cu	Fe	Mg	Mn	Pb	Ti	Zn	F	Cl	SO_4
1	0.5	1.6	0.07	0.06	0.6	0.2	2.6	0.5	0.2	0.2	0.09	0.8	**104**	**342**	**37**
2	0.6	1.1	0.07	0.05	0.6	0.2	2.6	0.7	0.2	0.2	0.15	0.8	**110**	**367**	**27**

2.3 Domestic

Inappropriate sewage treatment is the main problem in that site allover the time. Few years after the establishment of the Naivasha Municipal Sewage Treatment Plant, it went down and the wastewater is being deliberately directed towards the lake through a directed channel. Obviously that will form a harsh point and non-point source at the same time. A point source at the junction it gets dropped into the lake and non-point source pollution through all the way from the bypassing junction of the treatment plant until it reaches the lake. To be discussed in part four. The other side of this coin, water quality, is the precautions that are taken by the households to safeguard drinking water. Most of the people are boiling the water before drinking, and very few people are using those high quality filters to filter out other types of contamination as well as the biological contamination which is partially removed by boiling. Other chemical aspects of the drinking water are dealt with in **[Table 2-5]**.

Table 2-5: Current Domestic Water Quality Status Vs Comparative International Drinking Water Guidelines.

Parameter	Unit	WHO[1]	EEC[2]	Current situation	
				Sample 1[4]	Sample 2[5]
Aluminum (Al)	mg/l	0.200	0.200	0.204	0.249
Ammonium (NH_4^+)	mg/l	1.500	0.500	Low	Low
Boron (B)	mg/l	0.300	NS[3]	0.256	**0.356**
Cadmium (Cd)	mg/l	0.003	0.005	**0.026**	**0.026**
Chloride (Cl^-)	mg/l	250.0	25.00	39.61	50.225
Copper (Cu)	mg/l	1.0-2.0	NS[3]	0.011	0.071
Cyanide (CN)	mg/l	0.070	0.050	Low	Low
Fluoride (F^-)	mg/l	1.500	0.7-1.5	**4.083**	1.235
Iron (Fe)	mg/l	0.300	0.200	**0.974**	**0.980**
Lead (Pb)	mg/l	0.010	0.050	**0.061**	**0.095**
Nitrates (NO_3^-)	mg/l	50.00	50.00	2.095	3.921
Nitrite (NO_2^-)	mg/l	3.000	0.100	Low	Low
PH	(---)	6.5-8.5	6.2-8.5	7.2	7.4
Potassium (K)	mg/l		12.00	**16.10**	8.925
Sodium (Na)	mg/l	200.0	75-150	39.00	28.30
Sulfate(SO_4^{2-})	mg/l	250.0	NS[3]	11.10	29.10

1 World Health Organization.
2 European Economic Committee, those limits were established by the European Committee for Environmental Legislation.
3 No Standards.
4 Sample 1 from Brixia Farm, sample 2 from Delamere estates. Average of the two samples. (9point Samples, October, 1999)

As clear enough from the table, there are some values, which lies far behind the certified limits. A situation supports the complains of the local people about the quality of the water. Values are 150% and even 600% higher than the recommended values **[Fig. 2-3]**.

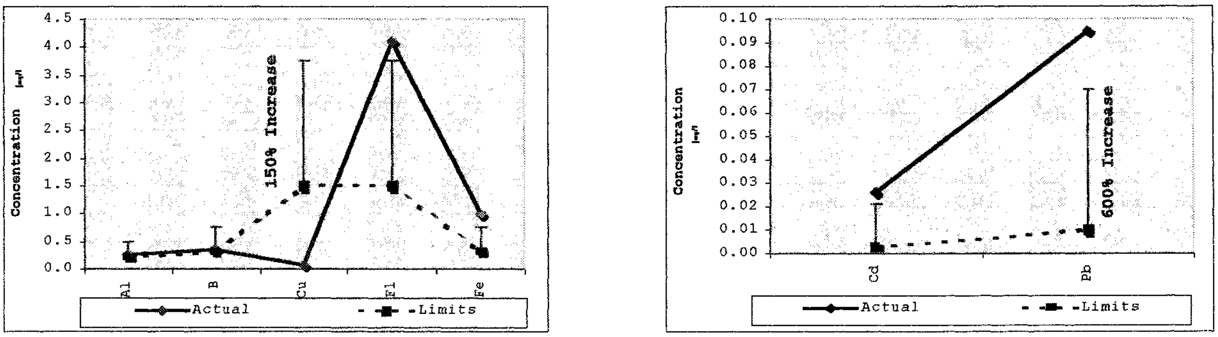


Figure 2-3: Selected Water Quality Parameters Concentrations Vs Guidelines for Drinking Water.

For the tourism sub-sector, most of the touristic firms carry out a regular water quality check on their sources of water. All of those firms claimed not to have a substantial change in ground water either in quality or quantity in the last decade. Yet the quality of the lake water is satisfactory for recreational activities. A comparison between the current state of the lake **[Samir, 1998]** and a recommendatory values for either water-contact, or boating and aesthetic activities **[Todd, 1970]** has shown that the current state is well below these standards. For instance, pH it is in the order of 7.2-7.9 and surface temperature has no evidence of exceeding the 50 °C.

2.4 Fisheries

The fish catch at the lake is well below the theoretical maximum sustainable yield [Harper, 1996], even though there might be unrecorded fish catches, i.e. illegal fishing, which might equal to the licensed catch. The three commercial species existed in approximately equal proportions in 1996, but there are substantial annual fluctuations in species' fortunes due to changes in lake level, shallow water plant community and temperature as illustrated later on.

The quality of the lake water is a vital issue for quantity, quality, and variety of the fish. Some species disappeared **[Table 2-6] [Abiya, 1997]**, that was primarily attributed to poorer surviving conditions. Increasing human activities around the lake; i.e. tourism, population, agricultural practices, have led to the deterioration of the lake water quality. Significant changes in the tourism sector, intensifying farming activities, and very rapid population growth, i.e. very high growth rates **[Annex QN.3]**, coincided with the disappearance of some of the species in the late sixties and early seventies. **[Fig. 2-4]** illustrates the starting time of earliest farms accompanied with the total area.

Table 2-6: Fish Species Introduction and Extinction.

Species	Introduced	Disappeared
Aplocheilichthys antnorii	?	1962
Oreochromis spirulus niger	1925	1971
Micropterus salmoides	1929	Present
Tilapia zillii	1956	Present
Oreochromis leucostictus	1956	Present
Oreochromis niloticus	1967	1971
Lebistes reticulata	?	Present
Oncorhyncus mykiss	?	Present
Barbus amphigramma	?	Present

Fish catch was plotted with the lake water level **[Fig. 2-5 (a)]** and to a certain degree the lake level corresponded to the fish catch. That was attributed to the size of fish breeding area. The wetlands at the moment (1998) is of a gentle slope in comparison to the lake bed itself, so a slight increase in lake level will result in a very large area under water, which is apparently shallow, and that is the conditions for breeding zones. So increase in lake level will be accompanied by a corresponding increase in fish breading zones, consequently, a healthier environment for fish leading to an increase in fish population. As a result lower effort is needed to catch the same amount of fish, or higher amount is caught by the same effort.

Fluctuations in lake level influence fish numbers through effects on food, breeding grounds, and predator-prey relationships. A study **[Muchiri et al, 1990]** has shown that food is not a limiting factor to fish in Lake Naivasha. A more probable effect of fluctuations in Lake levels is the breeding behavior. Predation by pscivorous fish and birds and over-fishing are also factors contributing to declining fish catches. Fish catches are also linked to the availability of submerged Macrophytes. Macrophytes provide breeding and nursery grounds, food and cover for fish. Same study indicated above has shown that even when the lake level was low, but there was an increase in submerged and swamp macrophytes, fish catches increased.

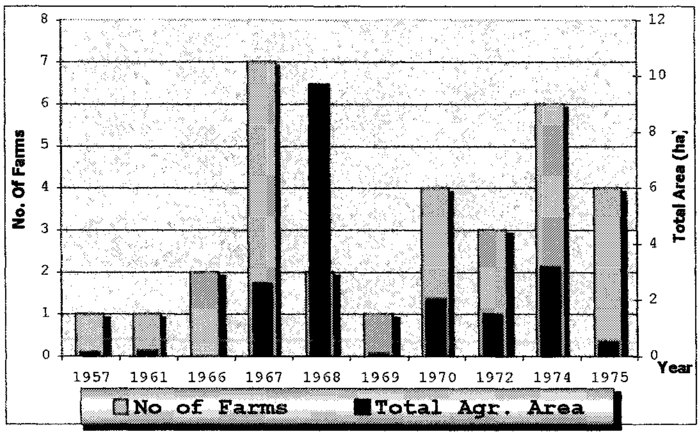
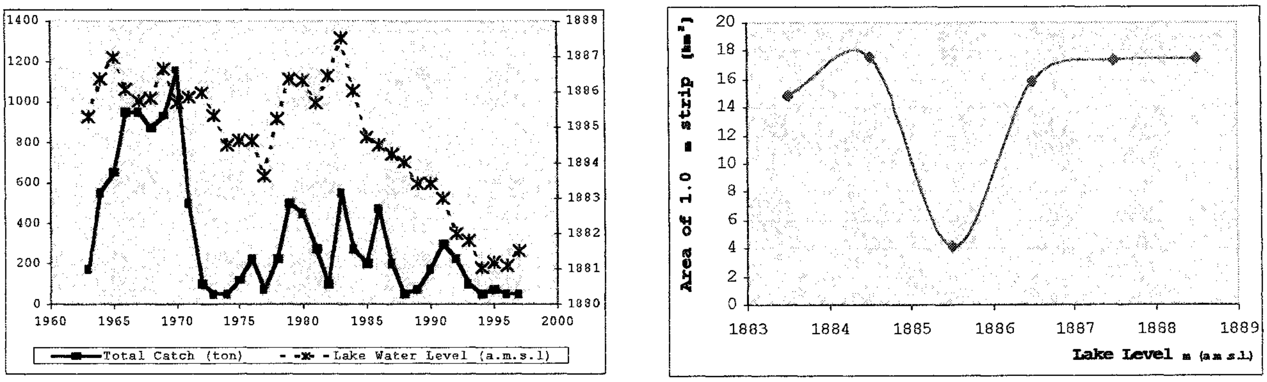


Figure 2-4: Starting Time of Farming Activities.

In our particular case any water level will provide the required breeding depth. The shape of the lakebed has proven to be as flat as to provide this depth no matter the water level is, unless water level is reaching the very bed level that is practically an environmental disaster. The issue is how wide is that part that is largely influenced by the slope of the land. Fixing a certain water level change of 1.0 m, and checking the corresponding width of the area covered by this threshold will be an appropriate check upon the fish breeding zone **[Fig. 2-5 (b)]**. An evidence of the effect of breeding zone is allover showing place in the historical fish catch, even that can go back as far as the fifties and sixties where some types of fish disappeared on the occasion of continuously decreasing water level. **[Abiya, 1997]**



(a) (b)

Figure 2-5: Lake Level Variations Vs Fish Catch (a) and Area of 1.0 Meter Strip (b).

Regarding the lake water quality, detailed study of the lake chemical status **[Samir, 1998]** revealed that there is high turbidity, that was mainly attributed to the shallowness of the lake (mean depth=4.0 m), suspended algae, and the eddies generated by the wind.

Some of the fish species migrate from the lake to Malewa to breed. As seen earlier, the low water level adversely affect the breeding areas. Some of the species, like Tilapia Zillii, prefer warm conditions; i.e. (23 °C-28 °C), as low temperatures will affect its appetite and hence humbled quality of the fish. In this sense temperature variation is another factor affecting production of fish. An evidence of better quality Tilapia Zillii is found in Lake Victoria where worm conditions are directly related to the better quality. Overall comparison on the sizes and/or quality of fish in lake Victoria **[Abiya, 1997]** has unfurled the fact of temperature effect on the fish. Other species which were originally introduced from Canada, Black Bass, has a wide range of temperature tolerance (14 °C-30 °C). Quantity of fish may change notably after heavy rains, to be manifested by the dilution effects of the rain and the increase in lake level, and the breeding area accordingly. At the end, we must say that heavy metals input from agricultural activities around the lake is accumulating in the lake, and that will further accumulate in the flesh of the fish. As a result, some heavy metal related diseases are likely to spread allover the fish eaters.

2.5 Sink

Physically speaking there is no sink prominent at that site. However, sink is being defined non-physically as the water, which has a quality that renders it unavailable by all means for other uses. Although no clear distinct water quality values are lying behind this definition, sensible status of the water can clearly identify its pertinence to sinks. In this sense several sources can be imputed to sink. Leached water, drainage, industrial effluents, and of course sewage are the major elements that can be regarded as sources of sink. As seen in part one the process depletion, or human consumption of water, is the only blamable section for contributing to this point/non-point source of pollution.

Having no, or better say diminutive, possibility for dilution effects, these point/non-point sources of pollution is seriously affecting the environment and threatening biodiversity as well as the sustainable development of the region. By inference the papyrus swamp that is surrounding the lake has its purifying effects, so it acts as a natural filter. Surface discharges make the most out of the purifying effect unlike the ground water that may get diluted only near the interface to the lake. The fact that water quality of the groundwater is of poorer than the surface **[Morgan, 1998]** can be in support of the previous rational, and also can be easily conceived through the phenomenon of leaching **[Tang, 1999]**. Having no filter, aquifers are highly prone to human induced pollution, which is likely to be in the vicinity of any human activity, especially for places where ground water levels are shallow, and have its extended effects further down to the lake. People are soliciting ground water with better quality as they largely depend on it especially for remote areas.

For agriculture, a percentage of heavily polluted water in the return flow is approximated at 90% giving a total of $47.5*10^6$ m^3/yr contribution to Sink. For industry, the pollution percentage is estimated to be 70% giving a contribution of $9.5*10^6$ m^3/yr. The return percentage of municipal water is said **[Todd, 1970]** to be 75% giving a contribution of $5.2*10^6$ m^3/yr. Total amount of water that is regarded as sink is $62.2*10^6$ m^3/yr.

Regarding wastewater from industry, a question arises, what if there is any kind of bacterial infection in the milk. The answer is as simple as biological contamination of water resources. Yet, the contaminated resources can be naturally alleviated knowing that the mammals, human, cattle, etc., bacteria take few days to die off at the range of temperature of 15-25 °C, which is the range of temperature in the study area.

PART THREE

PRODUCTIVITY

The fundamental engineering definition of efficiency is an output divided by input, both of the same character. Implicit to this definition is that any difference between the output and input constitutes a "loss" to the process in both a physical and economic sense. However, use of term efficiency in irrigation evaluations ignores the true disposition of the water, which is, that any water not consumed by the crop or by a salt sink remains in the hydrologic system.

The value of productive users of water like Agriculture, industry, fishery, tourism, wildlife, and others can be calculated based on the following formula (adapted after **[Bakker, 1998]**):

$$\omega = \frac{\sum_{i=1}^{n} R_i . O_i - \sum_{j=1}^{m} C_j . I_j}{V_W}$$

While;

ω : Productivity Factor.
R_i : Return of Output. (In US$)
O_i : Quantity of Output.
C_j : Cost of Input. (In US$)
I_j : Quantity of inputs needed to produce (n) Outputs
n : Number of Outputs.
m : Number of Inputs.
V_w : Volume of Water needed for (n) Outputs. (In m^3)

All of the productivity calculations are based on US$ to ease the process of quick comparisons. Exchange rate at the year 1997 was 1.0 US$=61.0 Ksh. This way of calculating productivity could be used on different scale; farm, national, global scale. In our particular case a catchment scale is needed to have completed the picture of the catchment.

Productivity is being calculated for the whole catchment for an average condition of water, while the effect of two extreme dry and wet years is discussed. We will not consider particular year here, for the sake of time delay of many processes especially for lake level; i.e. volume and surface area, and ground water recharge. So it is in away a generic representation irrespective of years.

3.1 Agriculture

All farmers agreed upon one single property of the soil in the vicinity of the lake, and that it is fertile. Moreover, the soil structure is being replenished all the year round by all ploughing activities or cultivating different crops in turns. There was a supporting evidence of having increased the agrochemical used by the farmers in the vicinity of the lake. For the flowers, stems will persist for approximately 5-6 years without any significant change in production or quality of flowers. After these years a change in there type of flower is necessary for the reason indicated above. The yield of a certain crop is not sufficient for measuring the productivity, yet the marketable yield is the issue.

Inside the greenhouses, farmers can not fully control temperature like what is done in the developed countries. Up to 50% decrease in yield may arise because of cold weather. The year 1997 was worse in comparison to the year 1996 in terms of crop production. The yields were very low due to prolonged draught, the area was also very low. That was attributed to the delayed rainfalls causing most of the seedling and early-planted crops to die off.

Flowers:

Something should be considered here is that flowers consume a very small amount of the water in comparison to natural vegetation, but the economic return out of the flowers is something considerable, on the very far contrary of natural vegetation. Relevantly, 60% of the Kenya flower export in produced in Naivasha.

Production of flowers was averaged over the different farms to be 200 stems/m^2.yr at an average cost of 2.19 US$/$m^2$. A relevant comparison is to be portrayed here, should we want to produce the same kinds of flowers in Holland, we have got to pay 150 US$/$m^2$. The average market price of flowers is 0.16 US$/stem. which leaves behind a net return of approximately 60,000 US$/ha.yr. Use of water is averaged at 6, 4, and 2 mm/day for diverted, delivered, and actual respectively. Those values are converted to 2.19, 1.46, 0.73 m^3/m^2.yr.

Vegetables:

Different Vegetables' prices were commenced during the field trip. Market prices were used for both getting the total benefit and to be able to compare between all categories. Most of the vegetables are for local market, hence a trivial net return is expected out of it. French Beans is being cultivated there for export, that is why it is given higher concern in the region in addition to the flower industry. Most of the rain-fed crops are used for local market. Exported crops are being manipulated in the vicinity of the lake where great care is concentrated.

Production of Vegetables was averaged over the different farms to be 3.4 ton/ha.crop accompanied with nearly 4 crops per year equal to 13.6 ton/ha.yr. An average cost of 820 US$/ha.crop was revealed. A rough exaggeration coefficient is assumed = 1.5, accordingly, the costs turned to be 550 US$/ha.crop amounting to 2,186 US$/ha.yr. Average market prices of the vegetables was 1.55 US$/kg, a return coefficient is assumed to be 0.5 leaving behind a net return of 8,387 US$/ha.yr. Use of water is averaged at 8, 5, and 3.2 mm/day for diverted, delivered, and actual respectively. Those values are converted to 2.92, 1.83, 1.17 m^3/m^2.yr.

Fodder Crops:

During the dry seasons, there is a broad business, taking place in the whole country, what is known as Hay business. Agricultural residue manipulation of the wheat straws is taking efficient place in this activity. In addition to the wheat straws, grass or Lucerne is being used to obtain that Hay bales that is used later for feeding the cattle. In this sense farmers are recycling the secondary product and further reaching from it a tertiary product. And that is following the concept of recycling to minimize the solid waste dilemma.

Production of Fodder was dealt with differently. Costs of fodder were estimated at 22 US$/ha. The return out of the fodder is estimated as a percentage (75%) of the return of meat. That leaves behind a net return of 117 US$/ha.yr. Use of water is averaged at 3.5, 3.0, and 2.9 mm/day for diverted, delivered, and actual respectively. Those values are converted to 1.28, 1.10, 1.06 m^3/m^2.yr.

3.2 Industry

Diaries:

Prices of meat and diaries products are listed in **[Annex QN.3]**. Water use by cattle for drinking is accounted for in consumptive fraction of the water. Not forgotten, the water used in the factory has been considered partially in the consumptive fraction as part of it runs back to the system as a return flow.

Production of Diaries was declared to be 25,000 lt/day ($9.1*10^6$ lt/yr). A net return of 24,949 US$/yr is expected. Fodder use of water is averaged at 3.5, 3.0, and 2.9 mm/day for diverted, delivered, and actual respectively. Those values are converted to $15.4*10^6$, $13.2*10^6$, $12.8*10^6$ m^3/yr. Factory use of water is approximated to be $1.2*10^6$ m^3/yr for diverted, delivered, and actual. Accordingly, total use of water is $16.6*10^6$, $14.4*10^6$, $14.0*10^6$ m^3/yr.

Non-Diaries Industries:

For other industries taking place in the area, there were no sufficient data to carry out the same procedure. Hence, this contributor is being neglected especially after considering it is only for local market. Moreover, some of these small-scale factories are using the water for a non-industrial related purposes, so, it is not directly related to the production like the telecommunication factory based near Gilgil town.

3.3 Domestic

Natives:

For some cases, it is really harsh to estimate an economic net return out of it, as they may encounter, directly, non-productive sector. Water that is being delivered to the local people is not of a straight economic benefit, although it may experience secondary benefits coming out of the social welfare. Unlike other sectors, no direct benefit could be anticipated. However, a rough estimate could be established for the sake of completing the picture.

In this sense water supplied for natives are likely to be spending sector rather than being an earning sector. An average of 50 lt/day.capita is taken for the 350,000 population at an average price of water of 0.20 US$/$m^3$. And after adding the share of electricity bills, or any other energy provider, it might come to 0.30 US$/$m^3$. So the net return is a monetary deficit of $1.257*10^6$ US$/yr for the whole catchment; i.e. some 5.0 US$/ha.yr (only Five). Use of water is approximated to be $6.28*10^6$ m^3/yr for diverted, delivered, and actual.

Tourism:

Kenya is one of the countries heavily reliant on natural tourism for hard-currency earnings. Most of the touristic firms depend on their own sources of water; i.e. boreholes. Few cases that depend partially on the Naivasha municipal council for water delivery. In that case the price of water is as mentioned 0.20 US$/$m^3$. Seasons are likely to affect the consumption. High season touristic months; i.e. July and August are months of higher water requirements. Being indirect money earning sector, it was difficult to set up a net return value for that sector. Again a rough estimate is to be set for the picture completion.

The cost of supplying water for tourist is as calculated for natives. However, an average water use of tourists was approximated to be 250 lt/day.capita for the 40,000 tourists, spending 2-3 nights, expected to visit the area annually. More costs are involved like hotel, restaurant, and clubs' costs. As tourism is one of the main sectors for foreign currency earning for the country, a return of $7.56*10^6$ US$/yr. is estimated for the national parks entry, accommodation, food, and other facilities. So a net return of $6.57*10^6$ US$/yr for the whole catchment; i.e. some 30.0 US$/ha.yr. Use of water is approximated to be $0.72*10^6$ m^3/yr for diverted, delivered, and actual.

3.4 Fisheries

Fish play a key role in human food supply and aquatic ecosystems. Indicators for fish production can be expressed as amount per capita. Such indicator can give an insight into quantitative aspects of fish resources. Records available at the Naivasha fisheries department indicate that lake Naivasha has five species of fish three of them are commercially exploited. The fishery of the lake is also quite unstable and a link has been established over time between fish production and water levels **[Annex QN.3]**. Since there are no scheduled diversions of water into the fisheries sector, which is another productive use of water, there is no direct way of calculating the productivity factor for fish. However, a distinction between the production for dry and wet conditions can still be made based on the different interviews made in the site.

Production of fisheries during 1997 was declared to be 45092 kg, a return of 53,273 US$ was reported. Costs involved include the salary of the fishermen and the costs for operating the 182 boats an average of 3 men per boat was taken rounding the costs to 5,000 ksh/boat, that will result in total annual costs of 14,918 US$/yr. The water surface area during the same year was 13,331 ha. At the end an index is estimated for the fisheries to be 3.32 US$/ha.

3.5 Wildlife

Clearly enough, wildlife is closely related to the tourism sector. As a water consumer, values can be established for the amount of water consumed and for the net return. The design manual for water supply in Kenya is being used for the estimation of water used by different animals **[Annex QN.2]**.

Wildlife was assumed to have a 20% share of the total income from tourists. On the other hand, there are no clear direct running costs involved in this sector except the very start-up cost of introducing national parks, and maintaining it, which can be deducted directly from the entrance fees of the parks themselves. So a net return of $1.315*10^6$ US$/yr; i.e. some 4.0 US$/ha.yr. Use of water is approximated to be $1.98*10^6$ m^3/yr for diverted, delivered, and actual.

3.6 Environment

Having consumed most of the water incoming to the catchment, a suspicious conclusion could be made regarding natural vegetation, forest, and bare soil which reveals that they should attain most of the return. However, a direct relationship can not be established between the amount of water consumed and the economic return. In this context, it is rational to compare those two sectors, flowers and natural environment in money basis. Flowers consume a trifling amount of water but puts along a relatively giant net benefit, on the other hand natural environment consume most of the water 80% giving almost trivial economical benefits.

There is an interrelationship between the environment and both touristic and wildlife in the sense that tourists come for the sake of wildlife and environment, whilst wildlife sensibly survive in a healthy environment. A 60% of total income from touristic sub-sector is attributed to the environment; i.e. $3.945*10^6$ US$/yr; i.e. some 12.0 US$/ha.yr. Use of water is taken from the low beneficial values (part one), $1056*10^6$ m^3/yr for diverted, delivered, and actual.

At the end a summery has to be made to compile all the information obtained from the previous economical analysis, but not a cost benefit analysis, in the following table **[Table 3-1]**.

Table 3-1: Productivity Factors for Different Sectors. **[Annex PR.4]**

Activity		Productivity Factor for Average Conditions (US$/$m^3$)			Effect of Conditions on Productivity Factor	
		Diverted	Delivered	Actual	Dry Year	Wet Year
Agriculture	Flowers	2.74	4.11	8.23	NE[1]	NE[1]
	Vegetables	0.29	0.46	0.72	Slight	Moderate
	Fodder Crops	0.01	0.01	0.01	NE	NE
Industry	Diaries	0.15	0.17	0.18	Slight	NE
	Non-Diaries	--	--	--	--	--
Domestic	Natives	-0.20	-0.20	-0.20	Severe	Slight
	Tourism	9.17	9.17	9.17	Slight	Slight
Fisheries (only US$/ha)		3.32	3.32	3.32	Slight	Slight
Wildlife		0.66	0.66	0.66	Moderate	Moderate
Environment		0.004	0.004	0.004	Moderate	Moderate

1. No effect

Noting that all values are based on interviews as first estimates and should be seen as a first indication rather than absolute values. A distinction is made in the form of three values for both conditions; diverted, delivered, and actual. That was the net benefit divided by the diverted, delivered, and actual use of water respectively. Productivity factor for Actual is always bigger than delivered and the last is always higher than the diverted as always the actual use of water is less than the delivered, which is in turn less than diverted water. The water volume used for wildlife for instance will be returned to the system as a return flow.

Here it bears mentioning that the actual productivity factor for the flower industry, is approximately 3 times the diverted one, meaning that we can produce the same amount with three times less water.

Also, the productivity factor for the wildlife is much higher than for environment, that is because of the huge water consumed by the environment in comparison to the minute amount of water consumed by wildlife.

For the effect of dry/wet years, flowers productivity are assumed to have no effect as it is one of the indoor industries and it has the very first priority in the region, on the other hand prices of water is not affected by the type of the year. For vegetables, farmers can still get water in a dry year but at a higher cost (pumping costs). On the other hand very wet conditions can affect the yield dramatically. Diaries are not getting any effect in wet years, although on a dry year it might get some effect. Of course the domestic are the victims of any water shortage in the region, while tourists are not affected as severe as natives. However in a wet year, touristic sites for camping might get affected. Effect of dry/wet years on both environment and wildlife is assumed to be moderate.

PART FOUR

OPTIMUM WATER USE

Ideality is never achieved anywhere in any aspect, and absolute ideal conditions exist nowhere. Having a tendency towards the ideality is the aim of any sustainability-seeking plan. Hence it is necessary for any decision making process to identify the ahead-wanted goals, in other words, ideal conditions. Therefore, reaching a stage where our ideal conditions are relatively near is, no doubt, the very ambitious end of the process.

Herein in this part we represent the water requirements under optimum conditions that will satisfy sustainability, as "first of all" objective, in a prudent point of view.

An inventory of the whole area, in terms of water and land-use is necessary for the identification of different steps to be taken towards ideal conditions.

4.1 Land-Use Inventory

Filling up a table **[Table 4-1]** with all the values obtained in part one for every land-use, or sector, and sub-sectors was the main aim of this part. Optimum conditions were provoked for every sub-sector in case of relevance.

A. **Agriculture:** Optimum water consumption of the agricultural sector was based on the actual evapotranspiration rates calculated for the study area for every crop. **[Mekonnen, 1999]**

B. **Industrial:** Optimum water consumption of the industrial sector was divided into two main parts: diary industries and non-diary industries. For diary industries, water was optimally needed for fodder crops, and that was previously referred to in the agricultural sector, and water was also needed for the industry itself. Ideal values were taken from worldwide standards **[Todd, 1970]** for diaries industries. And was compared with the actual water use. Similarly, for non-diaries industries, ideal values for the industry were taken from worldwide standards for each industry taking place in the study area.

C. **Domestic:** Optimum water use for domestic sector is being taken from the "*Kenya Design Manual for Water Supply*" **[Annex QN.2]**. Here it bears mentioning that the liters per capita per day water share was found to be 21839, 4872, 90, 55 for the rainfall, process depletion, ideal domestic supply and current domestic supply respectively. From which we can conclude that the water reaching the consumer is a negligible amount of his proposed share.

D. **Fisheries:** Another assumption was made here for the ideality. And that was the amount of water that is contained in the lake at maximum fish catch which was reported in the year 1970. Volume of the lake at the year 1970 was taken as a reference of the ideal conditions of the fisheries. Ultimately, the fish catch quality, quantity, and variety largely depend on the water quality, hence, in a way or another the lake volume/level mainly due to the dilution effect of various pollutants.

E. **Wildlife/Livestock:** The actual water consumption per head for each type of wildlife/livestock was obtained from a survey done by the Kenya Wildlife Service. The survey conducted also the estimated total number of every species in the vicinity of the lake. Assumptions had to be made regarding the very total number of the wildlife in the whole catchment. Sensitivity analysis done earlier in part one, revealed that wildlife water consumption is not a sensitive issue in the water budget calculations. Therefore, these rough assumptions were accepted for the sake of having the calculations in a complete picture. In conditions that are not very harsh, in terms of water, wildlife can survive as they can find their own ways to watering.

F. **Lake & wetlands:** evaporation from lake and wetlands is dealt with differently as ideality in this context is distinctly assessed. As a function of the water level, optimum evaporation is something to be simulated through various models **[Mmbui, 1999]** to get the best sustainable abstractions on a long-term basis.

G. **Others:** groundwater outflow was calculated **[Ojiambo, 1996]**, as referred to in part one. Optimum and current situations of that constituent are identical.

A 1993 survey **[Goldson, 1993]** estimated the agricultural abstractions solely based on pumps and electricity bills revealing 30.4 $*10^6$ m^3/year excluding diesel pump units which supply a significant amount of water. The water bailiff abstractions are 32.7 $*10^6$ m^3/year at 1993 which shows a good comparable values. At the end of the day, taking expansions, which continuously takes place in the catchment **[Annex QN.3]**, into consideration will result in a comparable value to the value we got from part one (71.6$*10^6$ m^3/year). Theoretical calculations manifested the huge surplus indicated in **[Table 4-1]**.

By checking values in this table, we can see that the only sector that is consuming more water than it actually needs is the agricultural sector, particularly, the flower sub-sector is using water nearly two times more than needed. Other sub-sectors are not using as much, in terms of percentage. Elsewhere, there is always water deficit. That can be described by the fact that floriculture industry is very important to both farmers and the government.

Table 4-1: Ideal Vs. Current Water Use for different Sectors. {$*10^6$ m^3}

Sector	Land-Use	Water Use		Status		Coverage	
		Ideal	Current	Deficit	Surplus	Area (ha)	%
	Flowers	9.0	26.3	-	16.0 (178%)	1,200	0.36
	Vegetables	6.7	11.8	-	5.1 (76%)	625	0.18
	Grass	8.4	10.2	-	1.8 (21%)	800	0.24
	Fodder	19.3	23.3	-	4.0 (21%)	1,943	0.59
Agriculture	**Total**	**43.4**	**71.6**	**-**	**28.2 (65%)**	**4568**	**1.37**
	Rain-Fed	517.1	517.1	-	-	64,559	19.61
	Nat. Veg.	356.1	356.1	-	-	69,634	21.15
	Bare Soil	380.7	380.7	-	-	129,320	39.28
	Forest	635.6	635.6	-	-	43,799	13.30
	Total	**1889.5**	**1889.5**	**-**	**-**	**307,313**	**93.33**
Industry	Diaries[1]	2.0	1.5	0.50 (25%)	-	0.0	0.00
	Non-Diaries	15.0	12.1	2.90 (19%)	-	0.0	0.00
	Total	**17.0**	**13.6**	**3.4 (20%)**	**-**	**0.0**	**0.00**
Domestic	Tourism	0.02	0.02	0.00 (0.0)	-	0.0	0.00
	Urban	5.70	4.23	1.47 (26%)	-	0.0	0.00
	Rural	5.70	2.54	3.16 (55%)	-	0.0	0.00
	Facilities	0.23	0.17	0.06 (26%)	-	0.0	0.00
	Total	**16.45**	**9.99**	**4.7 (28.5)**	**-**	**0.0**	**0.00**
Fisheries[4]	Lake volume	[806]	[561]	[245]	-	--	0.00
Wildlife/Livestock		1.98	1.98	-	-	--	0.00
Lake & wetlands		274.2	274.2	-	-	17,330	5.30
Others[2]		50	50	-	-	--	0.00
	Total[3]	**2292.5**	**2310.9**	**-**	**18.4(0.8%)**	**329,211**	**100.0**

1 This values are for the factory only. Grass and fodder are included in the agricultural sector.
2 Groundwater outflow.
3 Without the lake volume.
4 Maximum sustainable Yield of fish was approximated **[Muchiri et al, 1990]** as 418.8 ton/yr, while average actual is 134 ton/yr over the last 10 years. (legal catch)

One of the irrigation efficiency indices is to divide the theoretical water requirements by the actual water use **[Menenti, 1990]** for the irrigated agriculture, it was obtained as 60.6%, to be seen as an over irrigation 1.65 times more than theoretically needed.

There is no particular rule that is valid to identify the water quality standards applicable regardless the relation to the use; in other words, water use determines the water quality standards. Water Quality, a complex concept with many aspects; i.e. physical, chemical, biological, microbial, can be defined in terms of a water body's suitability for various uses. It is affected by water abstractions, pollution loads from human activities, and climate.

Regarding the physical criteria of water quality assessment **[Mannaerts, 1998]**, temperature, color, taste, odor are yet satisfactory for the domestic sector including tourism as discussed in part two. And with respect to transparency, turbidity **[Samir, 1998]** there is no problem for agricultural or industrial sector as the farmers tend to collect the pumped lake water into tanks to let the sediments settle down before they take it for irrigation or drinking purposes. Fisheries and other habitat may get affected in the lake regions that experience excessive amounts of algae.

Inorganic chemical criteria in relation to the utilization encountered are extensively covered in part two. And the pressure from those parameters onto the environment will be discussed later on in this part. Chemical Oxygen Demand (COD) is defined as the Oxygen (O_2) used in the chemical oxidation of the organic carbon **[Mannaerts, 1998]**. It was selected to represent the organic chemical criteria. Nutrients are discussed also for their severe impact on the eutrophication status of the water sources. No microbial water quality criteria are discussed in this study.

4.2 System Analysis

The threat of pollution from various activities around the lake is pushing along a daunting effect of continuously deteriorating quality.

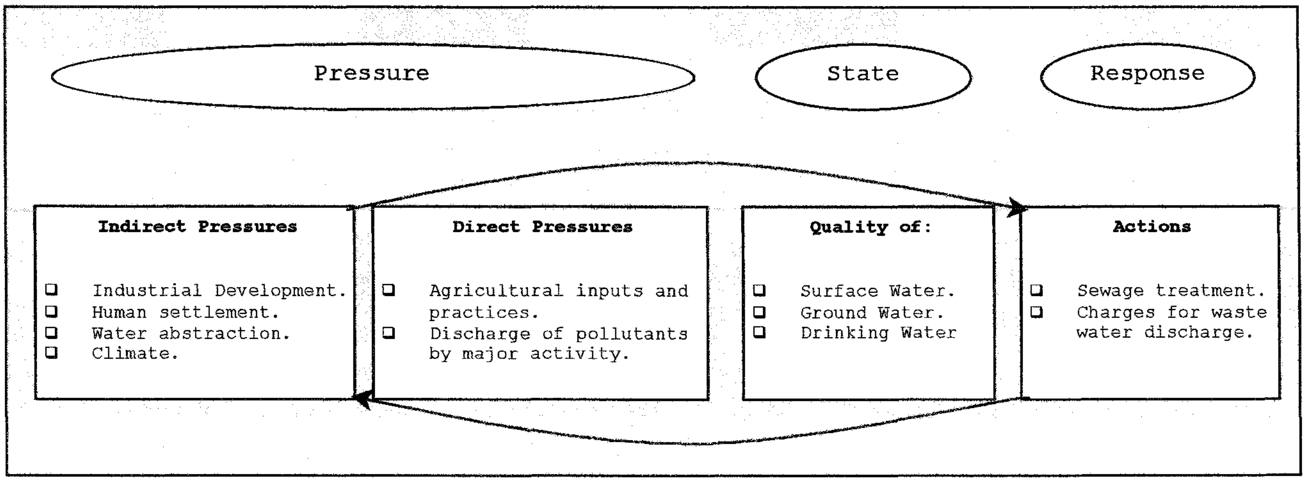


Figure 4-1: Water Quality System Analysis of Lake Naivasha Basin.

Various human induced outcomes are experienced in the vicinity of the lake, and in the whole catchment as well. Unlike the nature induced, human induced outcomes are hard to harmonize or to self mitigate themselves. Accordingly, greater attention must be given to human activities and its adverse effects on the nature.

4.2.1 Pressure

Many pressures are encountered, some of them are direct, while others are indirect. To start off, we start by the indirect pressures, one of which is the industrial development.

Wastewater from different factories **[Samir, 1998]** have been analyzed showing a serious water quality deterioration. High concentrations of different quality parameters **[Table 4-2]** can be regarded as substantial pressures on the environment. Mass inputs **[Table 4-3]** of the different parameters will Show a huge input to the system; the lake itself, or groundwater, through direct or indirect pathways. Any future development without regarding wastewater treatment is an extra pressure on the environment.

Other indirect pressures include increased population, water abstraction and climate; i.e. extreme events, etc. The former may impose crucial pressure on the environment as this area endures the highest growth rate in Kenya, a case clearly understood as a serious threat to the environment if no proper sewage treatment takes efficient place. Analysis of a domestic wastewater sample **[Table 4-2]** is shown to describe the level of pollution. Water abstraction is contributing to the pressure scheme in the form of concentration, less abstraction means giving place and chance for dilution effects to take place. On the other hand climate is double-edged sword, it can impose negative effects, positive effect is expected as well. For instance one of the advantages of high rainfall is the diluting ability it donates to surface or ground water reservoirs. The normal direct sources of pollution include the previously mentioned agriculture industrial, and domestic pollution.

Table 4-2: Concentrations of Selected Quality Parameters in Wastewater.

Contributor & Parameter	Observed Value	Guidelines	Unit
Non-Diaries (Beverages)			
Sulfate (SO_4^{2-})	475*	500	mg/l
Chloride (Cl^-)	250*	1000	mg/l
Ammonium (NH_4^+-N)	**26***	20	mg/l
Diaries			
Sulfate (SO_4^{2-})	High*	500	mg/l
Chloride (Cl^-)	High*	1000	mg/l
Ammonium (NH_4^+-N)	High*	20	mg/l
Nitrate (NO_3^--N)	High*	20	mg/l
Agriculture			
Sulfate (SO_4^{2-})	26*	500	mg/l
Chloride (Cl^-)	86*	1000	mg/l
Ammonium (NH_4^+-N)	5*	20	mg/l
Nitrate (NO_3^--N)	1-**76**#	20	mg/l
COD	**49**#	50	mg/l
Total-P	0.1-**53.8**#	30	mg/l
Domestic			
Sulfate (SO_4^{2-})	135	500	mg/l
Chloride (Cl^-)	180	1000	mg/l
Nitrate (NO_3^--N)	**160**#	20	mg/l
Phosphate (PO_4^{3-})	**570**#	30	mg/l
EC (at 21.3 °C)	2880#	(-)	µS/cm
COD	**520**#	50	mg/l

* Average point sampling done October 1998 [Samir, 1998].
# Average point sampling done October 1999 [Tang, 1999].

Having the papyrus swamp in place is a great advantage (of their purifying effect) menaced by those illegal fishermen who burn that papyrus, as they are afraid of hiding hippos and buffaloes. Some farmers still clear to plough or graze right down to the water edge which constitutes another pressure to the environment while some landowners control this by leaving a lakeside buffer strip.

4.2.2 State

Studies of water chemistry confirmed that the two perennial rivers are the water richest in plant nutrients **[Harper, 1996]**. Studies offshore from major potential point sources of nutrients, the Naivasha town sewage works and horticulture enterprises did not show conclusively that high levels of nutrients enter the lake from these sources. High levels were found at the lake edges, but these can also occur through re-mobilization of nutrients from the mud following disturbance by hippos or cattle. Further details about the state of the quality are illustrated before in part two. Rainfall is, of course, the purist as it is nearly man-untouched source of water.

Boreholes in the lake basin contain water with different chemical characteristics from lake water, and probably reflect several different streams of subterranean water flow. There is reasonable evidence that the borehole waters in the vicinity of the Malewa river, the main river, are dilute, reflecting the river characteristics **[Harper, 1996]**. After passing through this over exploited area, ground water flows out in a southerly direction polluted with the agro-chemical being used in the intensive agricultural area in the vicinity of the lake. EC of the groundwater outflow was obtained from water samples from wells in the south, as reported, that is the direction of ground water outflow. EC of 725 is the average for the ground water outflow.

For most of the domains involved in the non-process depletion, or the natural water consumption, this section, it is not a crucial issue to consider the water quality of the input unless for the sake of regarding other inter-related issues. For example, it is not very important to consider the water input to the soil which is later evaporated from the surface, but what is really important is the quality of the water that is leached down to the ground water aquifers. Interception and lake evaporation are the domains that can be considered of minimum deterioration. Natural vegetation has no evidence of being affected by the water quality. That is manifested by the endurance and durability of that natural vegetation to pure environmental conditions. And on the other hand it is not of too much economic importance to the natives, only aesthetic and/or environmental purposes.

As illustrated in part one, the return flow water is very poor in quality and is referred to as sink as discussed in part two. Part of this return flow has better quality, that is obtained from farms in the fallow period where no application of agro-chemical is taking place, and may be when the amount of water is large enough to dilute the pollutants contained. Agricultural non-polluted return flow is approximated as 10% giving $5.3*10^6$ m^3/yr and 30% of industry giving $4.0*10^6$ m^3/yr.

In the agricultural sector, farmers are manipulating the quality of the water by adding some chemicals to adjust different water quality parameters to satisfy their particular requirements. For instance flower farming needs a specific water quality standards for a better crop, quantity and quality. It was found during the field trip period that no farmer is affected by the water quality deterioration. Should any farm found itself confronted with water quality beyond its desires and/or requirements, they inject a certain amount of chemicals; i.e. acids, to adjust their specific requirements (i.e. EC, pH, etc.).

Considering the different water users as black boxes and tracing the water quality conditions before and after getting into those boxes **[Fig. 4-2]** was the way used to pinpoint the sector that most disturb the environment for different water quality paramters, in other words that contribute most to the pollution of the system. I_{Ag} & O_{Ag} are the input and output water conditions to and from the agricultural sector. Similarly, I_{In} & O_{In}, I_{Do} & O_{Do}, I_{Ec} & O_{Ec} are the equivalent for industry, domestic and ecology respectively. In a long-term basis, that will end in a cycle of continuously adding chemicals to mitigate water pollution.

I_{Ag} is being taken as area weighted average **[Table 4-3]** from different farms as the lake water quality is not the same allover. That was for those farms that use surface water as a major source. For other farms, location, as well, plays a large role in the quality of the water abstracted from boreholes. I_{In} is being taken from Delamere estates, where they pump up ground water for use in irrigation and for factory purposes. I_{Do} is being taken from self-measurements during the field trip period in number of samples from households, and a ground water chemistry survey **[Morgan, 1998]**. Rainfall is considered as the input to the ecology I_{Ec}. No considerable change in the output from ecology is assumed. Accordingly the contribution of the ecology is set to minimal figures unless in case of any polluted rain the contribution of the ecology might be the highest. This contribution must not be attributed to the ecology, but the output from any other activity that created this polluted rain.

After passing through these black boxes the quality of the output must have been deteriorated by the activities involved in these sectors, then the resultant is water of a deteriorated quality. These outputs in a way or another get incorporated into the environment, which will help to alleviate the mass inputs by either space or time. This alleviation ability depends on the saturation level of the environment, meaning that this will continue to happen until the environment can no longer support this action. Then we should consider the artificial treatments done by humans to mitigate the pollution before it gets into the system.

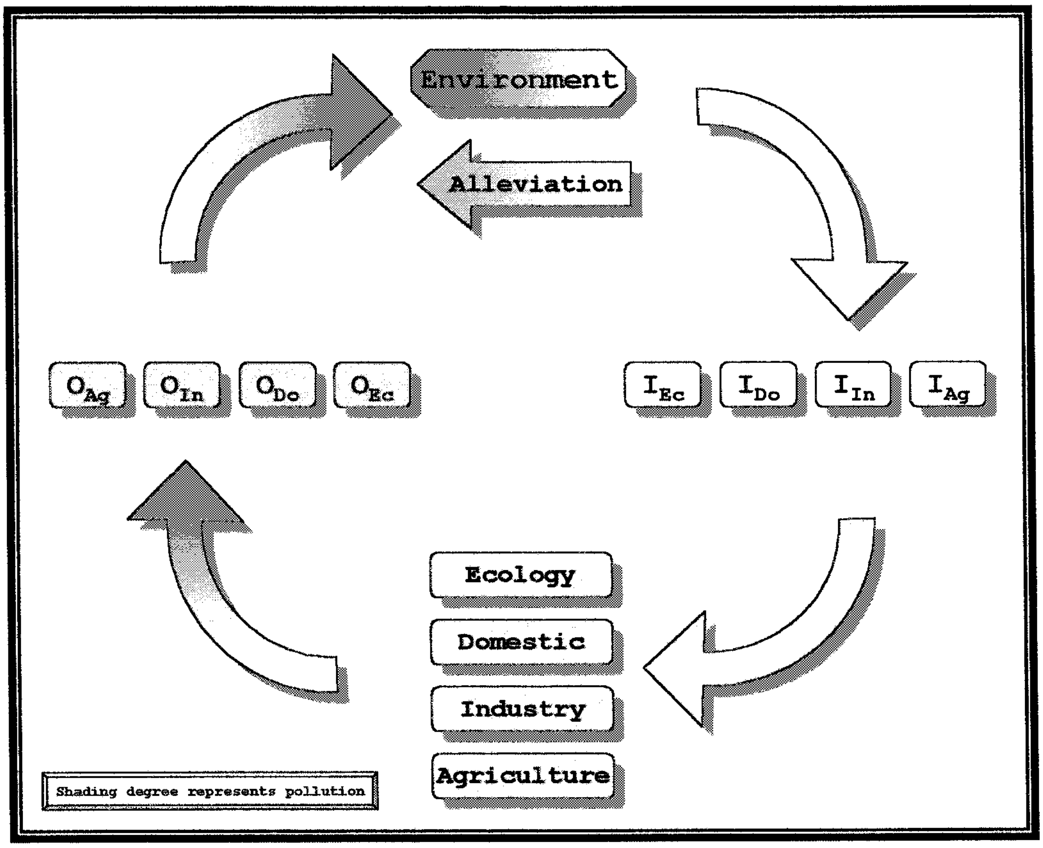


Figure 4-2: Schematic Representation of the Pollution Cycle in Naivasha Basin.

Exact segregated values regarding the amounts of effluents discharged from the different sub-sectors especially the industrial sector was needed to accurately generate a mass balance of the different quality parameters. As no fluxes were available, inevitably we would trace the pollutants by the aggregated values of the sectors **[Table 4-3]**. Now, there is still an issue of how much is the area being irrigated by surface water versus ground water. 85% of the agricultural uses around the lake is from surface water and hence a weighted average of 600 can be a good approximation of the electrical conductivity of the water being used for agricultural sector.

Although relatively small amount of polluted return flow (effluent) from industrial sector **[Table 4-3]**, the Sulfate (SO_4^{2-}) contribution into the mass balance is the highest among the four sectors. Obviously, that is because the highest concentration in the output. For Chloride (Cl^-), the agricultural sector is the highest. On the other scale, the highest contribution expected and seen from the domestic sector is the organic matter represented by the COD. The concept of Inhabitant Equivalent (I.E.) **[Verstraete, 1984]** could be included for domestic sector, one I.E. is equal to 100 g of COD, 10 g of Nitrogen, and 1.5 g of Phosphorus.

Table 4-3 : Selected Pollutants Input and Output to & from Various Sectors.

Parameter	Agriculture[5]		Industry		Domestic[1]		Ecology[2]	
	Qlty	Qnty	Qlty	Qnty	Qlty	Qnty	Qlty	Qnty
pH								
Input	6.7		6.8		7.5		7.0	
Output	8.0	47.5	NM[6]	9.5	NM	5.2	7.0	700[3]
Difference(%)	**19**						**0.0**	
Electric Conductivity (EC)								
Input	600		680		500		Low	
Output	1700	47.5	NM	9.5	2880	5.2	Low	700[3]
Difference(%)	**183**				**476**		**0**	
Sulfate (SO_4)								
Input	1.5		20		4.0		Low	
Output	26	47.5	475	9.5	135	5.2	Low	700[3]
Difference(%)	**1633**	**1235[4]**	**2275**	**4512[4]**	**3275**	**702[4]**	**0.0**	
Chloride (Cl)								
Input	15		10		13		Low	
Output	86	47.5	250	9.5	180	5.2	Low	700[3]
Difference(%)	**473**	**4082[4]**	**2400**	**2375[4]**	**1284**	**936[4]**	**0.0**	
Chemical Oxygen Demand (COD)								
Input	43		NM		43		Low	
Output	49	47.5	NM	9.5	520	5.2	Low	700[3]
Difference(%)	**14**	**2328[4]**			**1109**	**2704[4]**	**0.0**	

1. Average value taken from municipal water supply wells, elsamere.
2. Input is simply the rainfall.
3. Return flow excluding the other sectors.
4. Contribution (Qlty*Qnty).
5. Detailed output from agriculture is being analyzed [Tang, 1999].
6. Not Measured.

4.2.3 Response

Proper management of the pollution needs to take efficient place. As the sources of pollution, sources of alleviating the pollution could be natural or artificial. For some of the pollutants, they can get alleviated spatially or temporally, meaning a treatment facility, for the pollution sources, should be considered if the alleviating power of the environment is not sufficient. On the other hand charges for the wastewater discharge into public water courses or sewers should be deployed on the basis of a pollution unit. The concept of Inhabitant Equivalent (I.E) could be used as a unit of pollution. Detailed data is required to generalize this concept for all the activities in the basin. Water analysis of the effluents and the I.E. **[Table 4-4]** should base the charging scheme.

Table 4-4: A Unit of Inhabitant Equivelant (I.E.). {all values are in Grams}

Parameter	**COD**	**BOD_5**	**Total N**	**Total P**	**Total Solids**	**Suspended Solids**	**Grease , Oils**	**Alkalinity ($CaCO_3$)**	**Mineral Salts**
Value	100	54	10	1.5	200	100	20	25	10

Where; BOD_5 is the Biological Oxygen Demand over a 5-days period at 20 °C, and it is defined as the amount of Oxygen used by micro-organisms (bacteria, etc.) to eliminate (oxidize or metabolize) bio-degradable organic substances **[Mannaerts, 1998]**.

PART FIVE

BASIN-WIDE PLANNING

5.1 Introduction

The increasing role by community groups in a catchment scale decision making on sustainable resource use and management requires more comprehensive tools for managing ecosystems on temporal and spatial scales. Integrated catchment management is necessary as a strategic framework where individuals, groups, and government agencies with a vested interest in the catchment outcomes can make group decisions on regional and strategic development and management strategies for sustainable resource use **[Cairns, 1991]**.

Many interviews were commenced during the field trip with the farmers, local people, and government officials imparting the distinct truth of having severe water shortage. Results shown in the previous parts declared that there is no water shortage at all. However mismanagement of the catchment has led to inappropriate distribution of the water among the different sectors. In short the major **problem** encountered in the area is, as usual, the shortage of water for the various activities taking place around the lake. On the other hand the natural water consumption, i.e. water consumed by various environmental assets is approximately 75% of the resources. Thinking of resource allocation for the stressed 2.6% water use by humans around the lake is not a wise manner of solving the problem. Instead re-allocation of the water among the various users, especially the 75% may be a proper way of solving it.

A number of scenarios were proposed for implementation and further evaluated to seize out the best alternative. Scenarios were based on the detailed study of the area, and the gained field experience. Hereafter, the scenarios are represented to be evaluated and a final best management practice is proposed in conclusion.

5.2 Scenario Development

To develop a scenario is to propose a certain set of management actions to be implemented. **The overall objective** of these scenarios is to identify land-use, which will unchain the water shortage problem in the vicinity of the lake and to maximize the net return out of the whole catchment, and not on an individual farmer basis in a sustainable context. An understanding of the productivity, equity, and environmental impacts of alternative mechanisms and policies for intersectoral water allocation was necessary to get a better picture of the whole process. To effectively create "new" water in a regional context, a conservation program must in some way reduce evaporation or ET or improve return flow quality, and not simply reduce diversions.

5.2.1 Scenario I: No Action (No Go)

Current situation is being left to check on its applicability in a sustainable context. That was regarded as the base scenario.

5.2.2 Scenario II: Deforestation

"If you need water, cut forest!" one of the very major sayings in the water resources management. Unfortunately it is not always as easy as that, and even if it is the case, further complications might occur which were not accounted for in the primal plan, i.e. environmental, and socioeconomic consequences. If done, that should be on a small area based on usage and other environmental considerations. As shown earlier, forests consume too much water by the two major processes, transpiration and interception. One of the first options that came to my mind was to remove those economically unwanted commodities. Now the question is how much should we cut? Few further question marks appeared at once: how accessible, how applicable, costs involved, environmental consequences; i.e. (water logging, soil salinization), subsequent use of the area, ease of simulation of following situations. Those question marks may participate in constructing our multi-criteria basis for the evaluation. An area of application is assumed to be 10%, meaning 10% of the current forest are to be removed.

5.2.3 Scenario III: Mulching

The big guy, Bare Soil, is exhausting the catchment by the intense water usage, as referred to in the bare soil calculations in part 1. One of the first bright ideas was to, somehow, attenuate this resource-dissipating scheme. Keeping the soil dry or not evaporating even in the wet seasons will peculiarly reduce the bare soil evaporation on annual basis. A first estimation of the amount of water to be saved if we always keep the soil dry, is $300*10^6$ m^3/year. And that is quite enough for optimum non-stressed domestic use for 20 complete years or for non-stressed agriculture use for 4 years. Maintaining water tables at or below an optimal depth is required for avoiding water logging and soil salinization problems. Covering soil by any type of agricultural residues will reduce the evaporation from the soil dramatically. An area of application is assumed to be 30%, meaning 30% of the current bare soil area is to be covered. That could be of higher applicability as farmers can cover their adjacent land with the agricultural residues they got.

5.2.4 Scenario IV: Increasing Rain-Fed Area

At a first glance, Rain-fed agriculture is an economically sensible and environmentally sustainable solution. Increasing the rain-fed areas was one of the suggested management options as it satisfies the objectives of best management practices in the region. It increases the net return, utilizes the rainwater, at least partially, has no profound performance losses, creates lots of job opportunities, and has minimal pollution potential. Unlike the pros, cons of this scenario are not many but may be very potent, For instance, applicability of this scenario is very poor. An extra rain-fed agriculture area of 50,000 ha is assumed.

5.2.5 Scenario V: Night Irrigation

Some farmers are already implementing this scenario on the experience, and scientific fact, that irrigation during night minimizes the daytime losses. An extension of this scenario has to be seriously considered to reduce the different losses. In this sense, by some time, farmers will realize that they should not abstract so much water to irrigate their crops, hence a double effect of saving the water will take place. In this scenario abstracted water by farmers is reduced by 1.0 mm/day.

5.2.6 Scenario VI: New Reservoir

That scenario is assumed to stretch away some of the concern from being centralized around the lake, let the dilution effect take place, create more job opportunities, increase income, reduce rangelands cover, hence reduce the bare soil evaporation. If we assume that only 5% of the water used by the bare soil is being collected by a reservoir, a total of $50*10^6$ m^3 will be collected annually for various activities. Sedimentation problems might occur, hence a clear and well structured monitoring program should be embraced in the plan. A negative effect on the fertility of the soil near the lake might occur as, a proportion of the sediments is redirected into another coarse. A hasty, but detailed-enough study of the new reservoir is done **[Annex PR.1]** revealing that the new reservoir would not reduce the available amount of water in the lake itself, although it will result in a lower lake level. Lower lake level is not necessarily seen as a reduction in the available water. Lower lake level means less evaporation losses. So, let us consider the saved water from evaporation is being redirected towards that new reservoir, and in case of any serious water shortage downstream in the lake, gates of the dam could be opened to release some water to feed the ailing lake.

5.3 Scenario Evaluation

All of the scenarios need long term monitoring schemes to keep up with the changes taking place after implementation. For instance in the soil replacement scheme, we should monitor the ground water table for any considerable changes over time to that water table. Regarding any of the sub-criteria, they are given the equal internal weight, meaning that all sub-criteria involved in any criteria they are equally weighted.

5.3.1 Criteria

Different criterions have to be considered while testing each of the previously developed alternatives. All the criterions and their sub-criterions score generations and standardization are listed in the annex. **[Annex PR.3]**

Environmental Considerations

A score representing the effect of each Scenario is chosen based on several environmental considerations. Scores have been assigned based on three sub-criterions; (1) The Agro-chemical input, (2) Erosion, and (3) Natural vegetation loss. Agro-chemical score is being calculated based on the average input for each area.

$$\text{Agro-Chemical Score} = \sum \text{Crop\_Area}_i * \text{Crop\_Chem}_i$$

Any change in land-use will result in a corresponding sediment increase or decrease. Average sediment yield was considered **[Hamududu, 1998]**, on the other hand, the sediment yield of different uses was assumed. Erosion index is being calculated based on the following equation:

$$\text{Erosion Score} = \sum \text{Area} * \text{Sediment Yield}$$

In addition, for some scenarios further calculations are involved, for instance in deforestation, the deforested area is assumed to yield the same amount of sediments as averagly assumed earlier. And in mulching or soil replacement the reduction in total sediments is expressed in terms of average sediment yield multiplied by area under mulching or replacement.

Regarding natural vegetation, any areal change in land-use is assumed to inversely affect the natural vegetation. Hence, a corresponding natural vegetation loss is expected with an additional percentage that accompany the land-use changes. At the end of the day a weighted average of the three last indices is taken for each scenario.

Social Aspects

Social aspects are divided into three main sub criterions: (1) Per Capita Water Share; which was generated from running the water accounting framework with the different settings of each scenario, (2) Land Control; which was based on the control over the areas generated by different scenarios, and (3) Relative preferences, which was based solely on subjective weights. To come over any daze from the subjectivity, different opinions were chosen.

Costs

Costs are divided into three main parts: (1) Set-Up costs, (2) Management costs, and (3) Maintenance costs. Based on some values obtained from the field, costs involved in the different scenarios are being calculated. Set-up costs are the costs involved in setting up the whole project. Scenario six set-up costs are excluded. Management costs are the ones needed to run the project efficiently. Maintenance costs are speaking for themselves. We had this distinction between management and maintenance, as for this particular area there might be some process which can be categorized as management and not maintenance.

Applicability

Applicability of a certain scenario is being assessed according to the local economical and ecological conditions. Breaking it down, it came to three interrelated sub-criterions: (1) Accessibility, (2) Feasibility, (3) Sustainability. The first one represents the effect of accessibility on different scenarios. Feasibility reflects the overall possibility of the project, could it be applied, aside from the opinion of the farmers and any other decision-makers. Sustainability takes the role of reflecting the applicability of the scenarios on the time dimension, and how effective each one behaves after a certain period of time.

Ground Water Recharge

Ease of simulation of what will happen and subsequent use of the area after implementing that particular scenario is subjectively assigned. All of the scenarios will affect the ground water tables, either by rise or decline. That was, of course, of primer importance to the basin in the sense that an extreme rise of the ground water level may cause some problems (salinization, water logging, etc.) while an extreme decline will make the ground water pumping costs rise dramatically.

Employment

Two sub-criterions were splitted out of this criterion. (1) Start-Up Labor; which is the labor needed for the start-up of the project, (2) Running labor; which is the labor needed for the running itself of the project. Additional labor-requiring fields may arise parallel to the project itself even temporarily.

Income

Income criterion reflects what could be obtained as a net economic return. Based on the productivity obtained earlier, an index of each sector could be attained in terms of US$ per hectare. A multiplication of that index times the area of every sector, we can get easily the score of each scenario. Effect of soil erosion on the crop yield is being considered previously in the environmental criterion. Production of each scenario is being assessed through combined production expected from agriculture, fisheries, tourism, and whatever involved. Also include fish production in the new reservoir scenario. Include tourism income when applicable. The new reservoir (scenario VI) will definitely increase the production and may have higher productivities leading to a market competition, hence, prices will go down for crops.

Management

This criterion was broken down to another two sub-criterions: (1) On-Site Management; which includes any managerial aspect that takes care of on-site effects of the project, (2) Off-Site management; which is on the contrary of the previous one. Ease of management is represented here, hence the higher the score, the better it is.

On a priority matrix, **[Table 5-1]** different weights have to be assigned for every criterion based on diversified interests of various groups. Equal weights will not be considered in the priority matrix as this will be a kind of blending the different diversified opinions together, and that ends in a very close final weighted average of the different criterions which is not representing the case.

Table 5-1: Priority Matrix; different opinions of the involved groups.

Criteria	Involved Groups				
	Farmer[1]	Government[2]	Public[3]	Scientist	Foreign Scientists
Environment[4]	2	8	3	7	7
Social	3	9	10	1	7
Costs	7	6	2	3	5
Applicability	9	5	4	9	7
Simulation	2	2	1	1	5
Employment	3	8	10	8	6
Income	8	4	10	8	6
Management	6	7	6	9	5

1. Different farmers' opinion was taken during the field trip and generalized to one opinion. High weight is assigned for this group, as they are likely to affect decisions taken in the area.
2. Government officials were interviewed as well. Low weight is assigned to government, as the main controlling party in this region is the white skinned non-Kenyans.
3. Public were met as well, and one opinion was averaged out of all. Medium weight is assigned there.
4. Weights are assigned on the scale of 1 to 10, 10 being highest priority.

Finally an evaluation matrix, **[Table 5-2]** known as effect table in DEFINITE package, has to be set up to indicate how does each scenario behave in different perspectives. All the criteria and sub-criteria scores are listed in the evaluation matrix. Unlike others, scores for environment and cost criterions are based on the higher are less preferable.

Table 5-2: The Evaluation Matrix; different scores of scenarios among various criterions.

Criteria		Scenario					
		1	2	3	4	5	6
		No Go	Defor.	Mulch.	Rain-Fed	Night Irr.	N. Reserv.
Environment	Agro-Chem	76,806	76,806	76,806	132,668	76,806	83,808
	Erosion	31807	32323	27,151	27,807	31807	31,064
	Nat.Veg.	0	0	0	55,000	0	6,900
Social	Water Share	55	797	939	55	103	256
	Land Cntrl.	6913	11,015	10773	47,651	6,913	37,714
	Rel. Pref.	10	20	40	70	20	90
Costs	Set-up	0	21,515	19,301	100,000	9137	0
	Mngmnt	0	0	3,860	5,000	83,432	500,000
	Maint.	0	0	1930	2,500	83432	1000000
	Total	**0**	**21,515**	**25,091**	**107,500**	**176,001**	**1500,000**
Applicability	Access.	100	80	60	70	100	60
	Feasib.	70	60	50	70	30	40
	Sustain.	60	40	20	10	70	90
GW Recharge	GW Recharge	70	80	75	60	90	40
Employment	Start-up	0	33,659	303,466	391103	0	66469
	Running	607,63	607637	607,637	998,740	607,637	666,284
Income	Income*	98,153	98,156	98183	98192	98153	107969
Management	On-Site.	90	100	60	20	40	30
	Off-Site.	90	20	40	30	90	70

* Values in thousands

5.3.2 Standardization

For every scenario scores of every sub-criterion is put in a score matrix. Standardization is made **[Annex PR.3]** to all of the sub-criterion individually. Then a final score is being generated for every scenario as an average of the different sub-criterions and that is taken to be the representative of the scenario in the effect table. Two standardization techniques were used. Maximum standardization and the internal scale transformation **[Voogd, 1983]**. The former was used when the difference between minimum and maximum scores of a certain criterion is vast. The later is used when difference between minimum and maximum is relatively too small because of its' ability of exaggerating differences when scores are comparable.

5.3.3 Results

Three evaluation techniques were used to get the final ranking of all the alternatives in different points of view. The weighted summation, ELECTRE II, and the expected value **[Voogd, 1983]**.

DEFINITE Package **[Janssen, 1994]** was used for the flexibility it gives to evaluate the whole process by different evaluation techniques. Final assessment was done four times changing the weights of the criterions:

1- Using farmers-based priorities.
2- Using government-based priorities.
3- Using scientific-based priorities.
4- Using the public-based priorities.

Ranking of the alternatives was obtained from running DEFINITE for this evaluation matrix and for the previous different sets of priorities by the weighted summation method **[Table 5-3]**, ELECTRE II **[Table 5-4]**, and expected value method **[Table 5-5]** is shown.

Table 5-3: Ranked Alternatives for Different Groups by Weighted Summation.

Group		Farmers	Government	Scientists	Public
Priorities	1st	No GO	Mulching	No GO	**Reservoir**
	2nd	**Reservoir**	**Reservoir**	**Reservoir**	Rain-fed
	3rd	Night Irrig.	Rain-fed	Night Irrig.	Mulching
	4th	Deforest.	Deforest.	Deforest.	Deforest.
	5th	Rain-fed	No Go	Mulching	No Go
	6th	Mulching	Night Irrig.	Rain-fed	Night Irrig.

Table 5-4: Ranked Alternatives for Different Groups by ELECTRE II.

Group		Farmers	Government	Scientists	Public
Priorities	1st	No GO	Mulching	No GO	Mulching
	2nd	Night Irrig.	Rain-fed	Night Irrig.	Rain-fed
	3rd	Deforest.	Deforest.	Deforest.	Deforest.
	4th	Rain-fed	No Go	Rain-fed	Night Irrig.
	5th	Mulching	Night Irrig.	Mulching	No Go
	6th	**Reservoir**	**Reservoir**	**Reservoir**	**Reservoir**

Table 5-5: Ranked Alternatives for Different Groups by Expected Value.

Group		Farmers	Government	Scientists	Public
Priorities	1st	No GO	Mulching	No GO	**Reservoir**
	2nd	**Reservoir**	**Reservoir**	**Reservoir**	Rain-fed
	3rd	Night Irrig.	Rain-fed	Night Irrig.	Mulching
	4th	Deforest.	Deforest.	Deforest.	Deforest.
	5th	Rain-fed	No Go	Mulching	No Go
	6th	Mulching	Night Irrig.	Rain-fed	Night Irrig.

5.4 Sensitivity Analysis

Uncertainty is always an element in planning process. It arises because the values of many factors that affect the performance of water resource systems can not be known with certainty when a system is planned and constructed. The success and performance of a project depend on future aspects and conditions, which influence and determine future costs, benefits environmental impacts and social acceptability.

Criteria Weights

Four sets of priorities were used for different involved group points of view, farmers, government, scientists, and the public. Estimating the same percentage as an error for the entire criterion will result in a ranking same as the current. As DEFINTE does not take all the probabilities inside this region. Two ways were used here to overcome the uncertainties. First a 100% error is estimated separately for every criterion. The other way is to assume a simultaneous 25% error **[Voogd, 1983]** for the three most important criterions involved **[Table 5-6]**. We will choose the farmers ranking and the weighted summation to do our analysis at, as the farmers are likely to affect the decisions taken in the region, and the weighted summation represents in a way the final ranking as seen from tables **[5-3]**, **[5-4]**, **[5-5]**. The three most important criterions in this case are applicability, income, and costs.

Table 5-6: Simultaneous 25% and Separate 100% Error in Selected Priorities of the Farmers Opinion and Their Effect on the Ranking; weights sensitivity analysis.

	Scenario					
	1	2	3	4	5	6
	No Go	Deforestation	Mulching	Rain-Fed	Night Irrig.	Reservoir
Current	**1**	**4**	**6**	**5**	**3**	**2**
25 %	1	4	6	5	3	2
Environment	1	4	6	5	3	2
Social	1	4	6	5	3	2
Costs	1	4	6	5	3	2
Applicability	1	4	6	5	3	2
GW Recharge	1	4	6	5	3	2
Employment	1	4	6	5	3	2
Income	1	4	6	5	3	2
Management	1	4	6	5	3	2

Unexpected effect of changing the weights even up to 100 % was obtained. Instead of having a sensible effect on the last ranking, sensitivity analysis of criteria weights has revealed that no change occurs except for the governmental ranking of the 2nd and 3rd alternatives were interchanged. That could be interpreted as insensitive weights as well as clear choice ranking.

Scenarios Scores

The same technique was used in assessing the sensitivity of scores obtained for the different scenarios. Uncertainty in approximating the scores is a great issue in some scorings and that is why it was given a large importance in the analysis. The same simultaneous 25% is assumed. But for the separate error percentage, trial and error has revealed that 100% error in one of the criterions and 50% in all others will give sensible changes in the final ranking. But as seen **[Table 5-7]** those changes are quite supporting to the current final ranking obtained before. Meaning that scores even having a severe error, that will not affect the final ranking.

Table 5-7: Simultaneous 25% and Separate 100% Error in Selected Priorities of the Farmers Opinion and Their Effect on the Ranking; scores Sensitivity analysis.

	Scenario					
	1	2	3	4	5	6
	No Go	Deforestation	Mulching	Rain-Fed	Night Irrig.	Reservoir
Current	**1**	**4**	**6**	**5**	**3**	**2**
25 %	1	2	6	5	2	2
Environment	1	2	6	5	2	2
Social	1	2	6	5	2	2
Costs	1	2	6	5	2	2
Applicability	1	2	6	5	2	2
GW Recharge	1	2	6	5	2	2
Employment	1	3	6	5	2	3
Income	1	2	6	5	2	2
Management	1	2	6	5	2	4

Evaluation Technique

Three evaluation methods were used, the weighted summation, ELECTRE-II, and expected value. Results can be seen in tables **[5-3]**, **[5-4]**, **[5-5]** and easily seen in **[Fig. 5-1]**. Again farmers point of view is selected to get a representation. For the same reason indicated above.

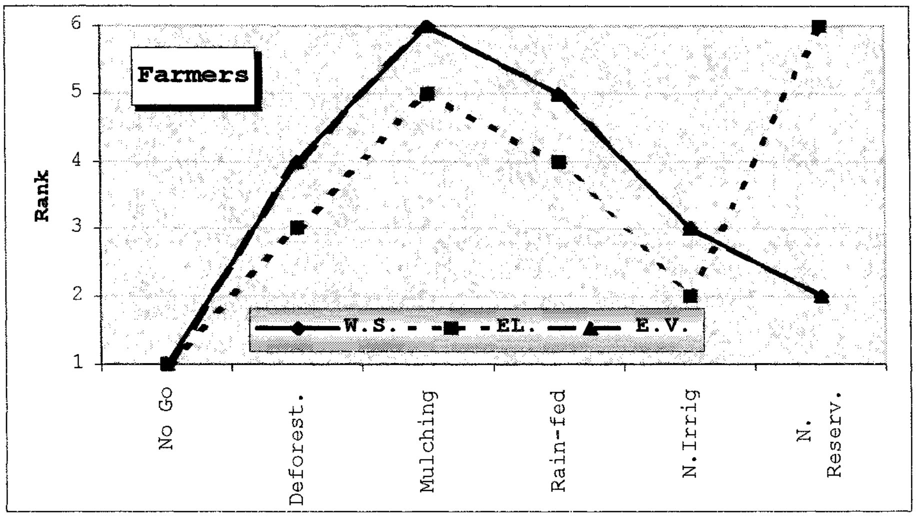


Figure 5-1: Effect of Evaluation Technique on the Final Ranking for Farmers.

Both weighted summation and expected value evaluation techniques gave, as seen , the same ranking, and the trend is even the same for the ELECTRE II but the new reservoir scenario is changed.

Weighting Method

Different weighting methods were used to check upon the consistency for the ranking using them. The three methods used are expected value, direct assessment, and random. No changes happened, meaning that the weighting method is insensitive parameter in the evaluation process. As seen **[Table 5-8]** weighting methods have trivial effect on the final ranking obtained.

Table 5-8: Effect of Changing the Weighting Method on the Ranking.

			Scenarios					
			No Go	Deforest	Mulching	Rain-fed	N.Irrig	Reservoir
Farmers	W.S.	Ex. Value	1	4	5	5	3	2
		Direct Ass.	1	3	5	6	3	2
		Random	1	4	6	5	3	2
	EL.	Ex. Value	1	3	5	3	2	.
		Direct Ass.	1	3	5	3	2	.
		Random	1	3	4	5	2	6
	E.V.	Ex. Value	1	4	5	5	3	2
		Direct Ass.	1	3	5	6	3	2
		Random	1	4	6	5	3	2
Government	W.S.	Ex. Value	5	4	1	3	6	2
		Direct Ass.	2	4	1	5	5	2
		Random	6	4	1	3	5	2
	EL.	Ex. Value	4	3	1	2	5	.
		Direct Ass.	2	5	1	4	2	.
		Random	5	3	1	2	4	6
	E.V.	Ex. Value	5	4	1	3	6	2
		Direct Ass.	2	4	1	5	5	2
		Random	6	4	1	3	5	2
Scientist	W.S.	Ex. Value	1	4	5	6	3	2
		Direct Ass.	1	4	4	6	3	2
		Random	1	4	5	6	3	2
	EL.	Ex. Value	1	3	5	3	2	.
		Direct Ass.	1	3	5	4	2	.
		Random	1	3	5	4	2	6
	E.V.	Ex. Value	1	4	5	6	3	2
		Direct Ass.	1	4	4	6	3	2
		Random	1	4	5	6	3	2
Public	W.S.	Ex. Value	5	4	3	2	6	1
		Direct Ass.	5	4	3	2	6	1
		Random	5	4	3	2	6	1
	EL.	Ex. Value	4	3	1	1	4	.
		Direct Ass.	4	3	1	1	4	.
		Random	5	3	1	2	4	6
	E.V.	Ex. Value	5	4	3	2	6	1
		Direct Ass.	5	4	3	2	6	1
		Random	5	4	3	2	6	1

Weight Interval

Changing the weights of the criteria for every point of view; i.e. farmers, government, public and scientist, on a scale from one to ten, and observing the changes that will happen to the final ranking is a way of checking the sensitivity of the weights **[Fig. 5-2]**.

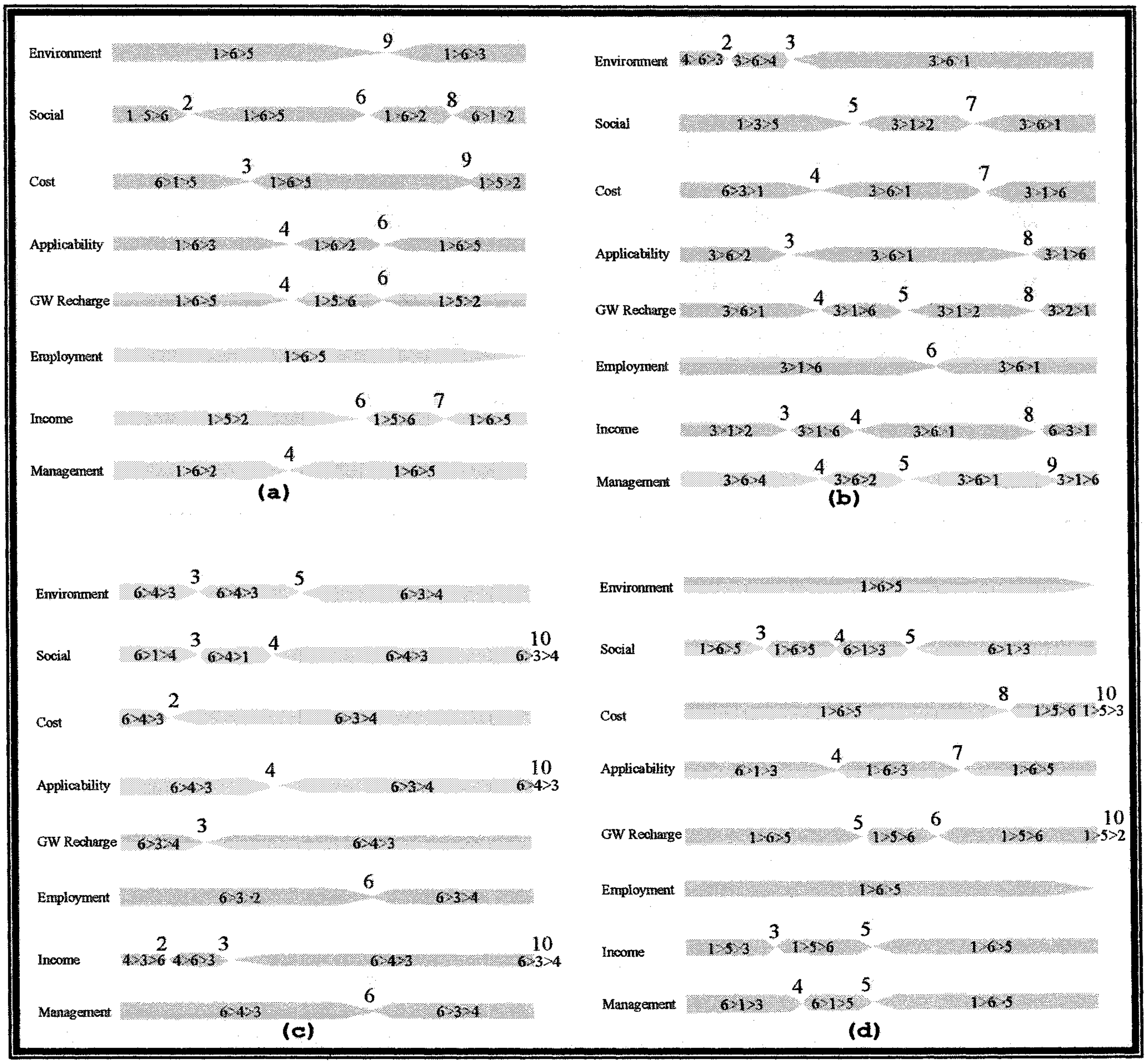


Figure 5-2: Weight Interval Sensitivity for Farmers (a), Government (b), Public (c), and Scientists (d).(numbers are scenarios)

5.5 Discussion

Achievement of every scenario in terms of water share, liters per capita per day and scores of income and cost are plotted **[Fig. 5-1]**. Scenario 3, the mulching, gives the highest water share while the lowest is attributed to the current situation and the rain-fed scenario, which suggests that the current situation has to be changed in case of a willingness to improve the domestic water conditions. On the other hand increasing the rain-fed area will utilize the rainwater, accordingly less water is available for the uses. The income score obtained for the new reservoir is the highest, however, the costs involved are the highest as well, so a difference is noticed instead of looking at one of them separately. Cost benefit analysis is needed for the complete analysis of the new scenario but it is beyond this study.

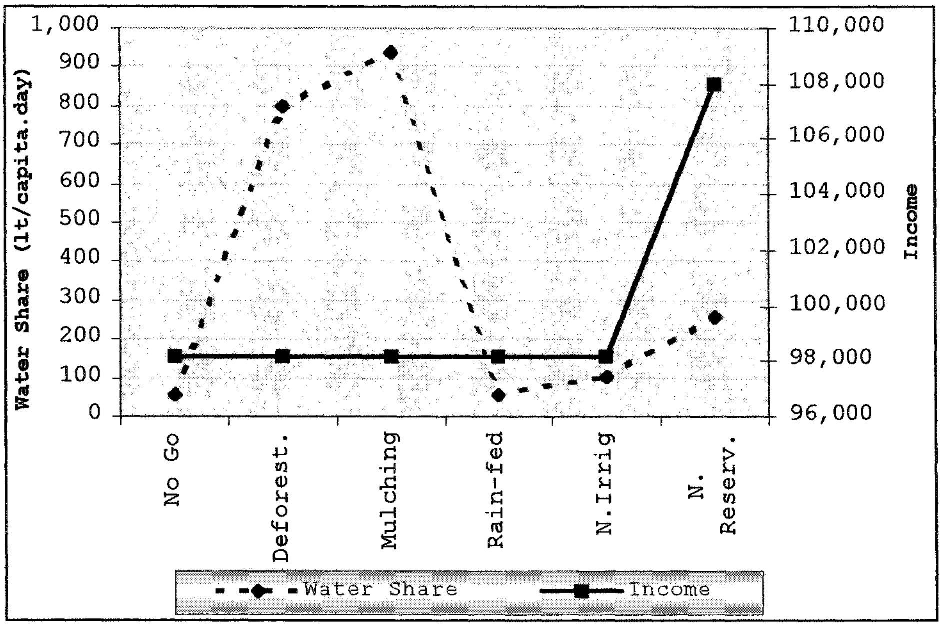


Figure 5-3: Achievments of Scenarios in Terms of Water Share and Income.

From the previous obtained tables, **[Table 5-3]**, **[Table 5-4]**, **[Table 5-5]** we can see clearly that the three alternatives "No Go", "Reservoir", and "Mulching" are taking higher positions in the ranking. Alternative "No Go" is the first option for farmers and that is clearly understandable as they tend not to modify the current situation and keep up with the situation that satisfies their monetary will irrespective of what will happen to the land. The second ranking of the new reservoir gives it a higher possibility of consideration. On the other hand we can clearly see that all the alternatives fluctuate in intermediate position in an interactive way that best suggests that a combination set of all of them; i.e. increasing rain-fed, deforestation, mulching, and night irrigation might be the best management practice (BMP) to be implemented, as one particular alternative may not fully satisfy the objectives.

Finally, the role of the Decision Support System is only to SUPPORT the decision-makers in taking critical decision in a regional basis and not to decide. Hence, a recommendatory outline is the best obtained from this chapter. Decisions are left to the personnel in charge.

CONCLUSIONS & RECOMMENDATIONS

C.1 Conclusions

Results shown in this research declared that there is no water shortage at all. However mismanagement of the catchment has led to inappropriate distribution of the water among the different sectors.

Far behind the expectations of anybody, the amount of water consumed by the presumed large guy, agriculture, is a peanut of the gross inflow. Pilfering only 2% of the gross inflow is inconsiderable amount in comparison to the gigantic ubiquitous bare soil, natural vegetation, and forest use of water. As seen earlier in part one, the natural water consumption (Non-Process Depletion) is 74.4% of the available resources, while humans consume only 17% including all the activities even rain-fed (14.4%).

Abstraction can not be always higher than replenishment, otherwise lake will disappear in few years.

Initially the main objective of this study was to reallocate the water in the vicinity of the lake. Field gained experience has shown that any kind of resource allocation is entirely impossible. Resource allocation by means of linear programming has shown minimal applicability in the area for two reasons (a) In such a colonized environment we can not reallocate water as white skinned owners will take their sufficient water no matter the consequences. (b) Most of the water is being unintentionally reserved by natural consumers (i.e. forest, natural vegetation, and bare soil).

Non-consumed non-evaporated water is not dissipated to a non-recoverable or non-usable form by irrigation. Therefore the non-consumed component of applied irrigation water is not a "loss" to the total resource, but may, to a varying degree, be reusable. As far as the water is concerned, the actual evapotranspiration is much less than the amount of water abstracted. Accordingly a giant, poor quality, return flow is taking the way back to the system deteriorating the water quality of either ground water aquifers or surface water.

Sustainable exploitation of living aquatic resources adds to the value of water resources and inland fisheries. Extensive aqua-culture is non-consumptive sector of water. Inland fisheries and aqua-culture needs good quality water in good quantity. The announced legal fish catch is 32% of the maximum sustainable catch.

The pollution Cycle, done in part four, has to be done on a series of consecutive years with monthly chemical analysis of the inputs and outputs to and from the sectors indicated. The reason is to be able to simulate the concentrations in the raw water after a period of time knowing the capacities of the various activities.

As importing water into the basin is practically impossible, development of the basin water status could be accomplished by reallocation among uses, not users, decrease the non-process depletion, and decrease the non-beneficial depletion. Naivasha basin could be considered as a fully committed water basin as the amount of outflow is negligible.

At the end the three overlaid pictures, i.e. Quantity, Quality, and Productivity, of the study area have introduced the final conclusions:

1- The environmental assets, such as forest, natural vegetation is the largest consumer of water.
2- Both agricultural and industrial sectors are pushing on a serious pressure onto the environment. Although clear segregated values about the sub-sectors and their contribution are not involved in this study, the aggregation is in favor of slightly overweighing the agricultural pressure over the industrial one in some parameters and the vice cersa in others. Domestic pressures will partly disapear if a proper sewage treatment facility is in place.
3- The most money earning sector is the tourism sector and then the flower industry which in a way or another launches a double swarded effect, most economic, but most polluting. On the other hand, the largest water consumer is not contributing to the economic return directly. In fact, they are economically contributing by their existence so they support a certain wildlife for which the tourists visit the area.

C.2 Recommendations

A comprehensive water allocation policy should be settled based on the long-term balance of the lake. To husband sustainability with economic development should be the first priority on which water permits are granted. And farmers should be one of the involved parties to set up that water allocation scheme. The water accounting framework needs to be done on a long time period basis, one year, and preferably to be carried out on a serious of consecutive years.

A better land-use classification would be achieved in case precise information about the land-use is ready for use. A comprehensive coordinate-based land-use, will facilitate the process of selecting sample set necessary for the classification. Hence minimizing the uncertainities in proportions of different land-uses.

More attention must be paid to the measurement and verification of rainfall as it is the only, until clear ground water inflow research appears, incoming water source to the catchment. As discussed earlier in part 1, Uncertainties in rainfall measurements is a vital issue for the water budget calculations. So, as a conclusion we must say that every endeavor should be made to accurately measure rainfall.

Because of the size and longevity of many investments in the water sector, it is essential to take a long view of trends in the sector. Forecasting future requirements would normally mean taking 25 to 50 years scenarios of supply and demand. Extrapolating current and recent trends in demand is pointless if these are unsustainable. Hence demand projects need to be **iterative**: if the first few demand and supply scenarios are clearly unworkable, scenarios including demand management should be introduced.

Water and chemicals uses for agriculture should be reduced gradually until it reaches approximately the theoretical water needs of the plants, hence reduce the surplus. That will not affect the production if not increasing it. Agriculture activities must be banned or at least controlled for minimum polluting effects. Some Non-Governmental Organization (NGO's); i.e. LNRA, should be involved in the process of analysis and decision-making. That will help in environmental protection and to stretch some of the governmental responsibilities. Exact volumes of effluents from different pollutant sources are necessary in husbanding the water quality analysis to come up with an extensive mass balance of different pollutants. Moreover, the industrial effluents must be treated properly before getting dumped into the system.

A detailed study about the water use of the trees is highly recommended to accurately attain the actual transpiration and interception losses from those trees as this constitutes a considerable volume of the water balance. In the absence of results from specific site studies, the hydrological impact of different tree species can only be made using generalizations obtained from studies already carried out elsewhere.

As some of the chemical constituents are found at a higher concentration than allowable, a monitoring scheme should be deployed to trace these concentrations in row water and check if it is human induced through the various human interventions or through any natural process. Also a detailed scheme of water quality analysis of different human activities is needed. Ground water subterranean pathways are recommended to check the flow of the pollution.

In view of the economic and environmental importance of the Lake Naivasha, a body or authority should be established to manage and co-ordinate the lake basin water resources including water allocations, resource monitoring and research programs. This body has to have the great virtue of being flexible, and to take great care of the ecological, environmental, and the aesthetic aspects as well as the economic values. The supply schedule should be directed towards minimizing water deficits during the most sensitive periods.

Best management practices for the whole catchment could be thought of, ONLY, if the involved personnel are imposing a sustainable development of the area. A mixture of deforestation, mulching, increasing rain-fed area and even night irrigation is to be implemented for the sake of capturing water in effective uses and minimizing the diversified loss schemes. In parallel, a new reservoir should be constructed to stretch out the concern from the surroundings of the lake and weaken the different adverse effects on the environment. Certain percentages of deforestation, mulching and increasing rain-fed are left for the decision-makers.

Abiya, I.O. 1997 *Towards Sustainable Utilization of Lake Naivasha, Kenya.*

Ahmed, A. 1999 *Estimating Lake Evaporation Using Meteo-Data & Remote Sensing. A Case Study of Lake Naivasha, central Rift Valley, Kenya.* ITC MSc Thesis.

Ase, L.E. 1986 *Studies of Lake Naivasha, Kenya, and Its Drainage Area.*

Bakker, M. 1998 *Valuing the Multiple Uses of Water.* Irrigation Water Management and the Bundala National Park. Proceedings of the Workshop on water Quality of the Bundala Lagoons, Colombo, Sri Lanka.

Barrow, C.J. 1995 *Developing the Environment; Problems and Management.*

Bastiaanssen, W. 1998 *Remote Sensing in Water Resources Management: The State of the Art.*

Cairns, J., Crawford, T.V. **1991.** *Integrated Environmental Management.*

Calder, I.R. 1996 *Water Use by Forest at the Plot and Catchment Scale. Commonwealth Forestry Review 75(1).*

Calder I.R., Hall R.L., Adlard P.G. **1992** *Growth and Water Use of Forest Plantation.*

Calder, I.R. 1978 *Transpiration Observations from a Spruce Forest and Comparisons with Predictions from an Evaporation Model. Journal of Hydrology, 38 (1978.*

Carter, B.G.F, 1994 *Geographic Information Systems for Geoscientists. Modeling with GIS.*

Chin, D. 1998 *Evaporation of Melaleuca Forest in South Florida*, Journal of Hydrologic Engineering, vol.3, no.2, 1998.

Dingman, S.L. 1994 *Physical Hydrology.* Printice-Hall, Inc. New Jersy.

Janssen, R., Herwijnen M.V. **1994** *DEFINITE: A System to Support Decisions on a FINITE Set of Alternatives.*

Dingman, S.L. 1994 *Physical Hydrology*

FAO & IIASA 1991 *Agro-Ecological Land Resources Assessment for Agricultural Development Planning, A Case Study of Kenya, Livestock Productivity*, World Soil Resources Reports, 71/5.

FAO, 1986 *Yield Response to Water*, FAO Irrigation and Drainage Paper 33.

FAO, 1985 *Water Quality for Agriculture*, FAO Irrigation and Drainage Paper 29.

Goldson, J. 1993 *A Three Phase Environmental Impact Study of Recent Develpoments around Lake Naivasha.* Phase I.

Hamdy, A., Abu Zeid M.,**1995** — *Agricultural Water Demand Management: A Must for Water Saving. Water International, Vol 20 (issue 4).*

Hammouda, F.1999 — *Time Series Analysis of NOAA-AVHRR Composite Images of Lake Naivasha Catchment.* ITC's MSc Thesis.

Hamududu, B.H. 1998 — *Erosion Assessment for Large Basins using Remote Sensing and GIS: a Case Study of Lake Naivasha Basin, Kenya.* ITC's MSc Thesis.

Harper, D. 1996 — *The Ecology of the Lake Naivasha and Hell's Gate National Park, Kenya.* A Collaborative Research Project Between the University of Leicester, the University of Niarobi, Zoology Department, and National Mueseums of Kenya. Field Report.

Huaccho, L.D. 1998 — *Water Availability Assessment using Multi-Objective Decision Support Systems (MODSS).* ITC's MSc Thesis.

Hussein, O.F. Bastiaanssen, W. **1998** — *Spatial Variations of Surface Parameters and Evaporation in the Lake Naivasha Basin Estimated from remote Sensing Measurements without Ground Data.*

Lillesand, T.M., Kiefer R.W., **1994** — *Remote Sensing and Image Interpretation*

Mannaerts, C. 1998 — *Water Quality Surveys.* ITC Lecture Notes.

Menenti, M. 1990 — *Remote Sensing in Evaluation and Management of irrigation.*

Mekonnen, G.W. 1999 — *Determination of Regional Scale Crop Coefficients for Crop Water requirement Calculations: A Remote Sensing Perspective. A Case Study of the Lake Naivash Basin, Kenya).* ITC's MSc Thesis.

Mmbui, S.G. 1999 — *Long Term water Balance of Lake Naivasha, Kenya.* ITC's MSc Thesis.

Molden, D. 1997 — *Accounting for Water Use and Productivity.* SWIM Paper 1.

Morgan, N.E.1998 — *Groundwater Chemistry and Quality Assessment of the lake Naivasha Area, Kenya.* ITC's MSc Thesis.

Muchiri, S.M., Hickley, P. **1990** — The Fishery of Lake Naivasha, Kenya. In Catch-Effort Sampling Techniques and Their Application in Fresh Water Fisheries, Management paper presented at an international Symposium and Workshop, Humberside Int. Fish Inst. And EIEAC.

Ojiambo, B.S. 1996 — *Characterization of subsurface outflow from a closed-basin freshwater tropical Lake, Rift Valley, Kenya.* Ph.D. Dissertation.

Samir, N. 1998 — *Integration of GIS and Computer Modeling to Study the Water Quality of Lake Naivasha, Central Rift Valley, Kenya.* ITC's MSc Thesis.

Tang, Z. X. 1999 — *Water Quality Assessment and Pesticide Fate Modeling, A Case Study for Lake Naivasha, Kenya.* ITC's MSc Thesis.

Todd D.K. 1970 — *The Water Encyclopedia.*

Trottman, D. 1998 — *Modeling Ground water Storage Change in response to Fluctuating Levels of Lake Naivasha.* ITC's MSc Thesis.

Verstraete, W. 1984 — *Biotechnological Processes in Environmental Technology.* Internal Lecture Note. Lab General & Applied Microbial Ecology, State University of Ghent, Belgium.

Voogd, D. 1983 — *Multi-criteria Evaluation for Urban and Regional Planning*

PLATES

Plate 1-1: Land-Use Classification Map.

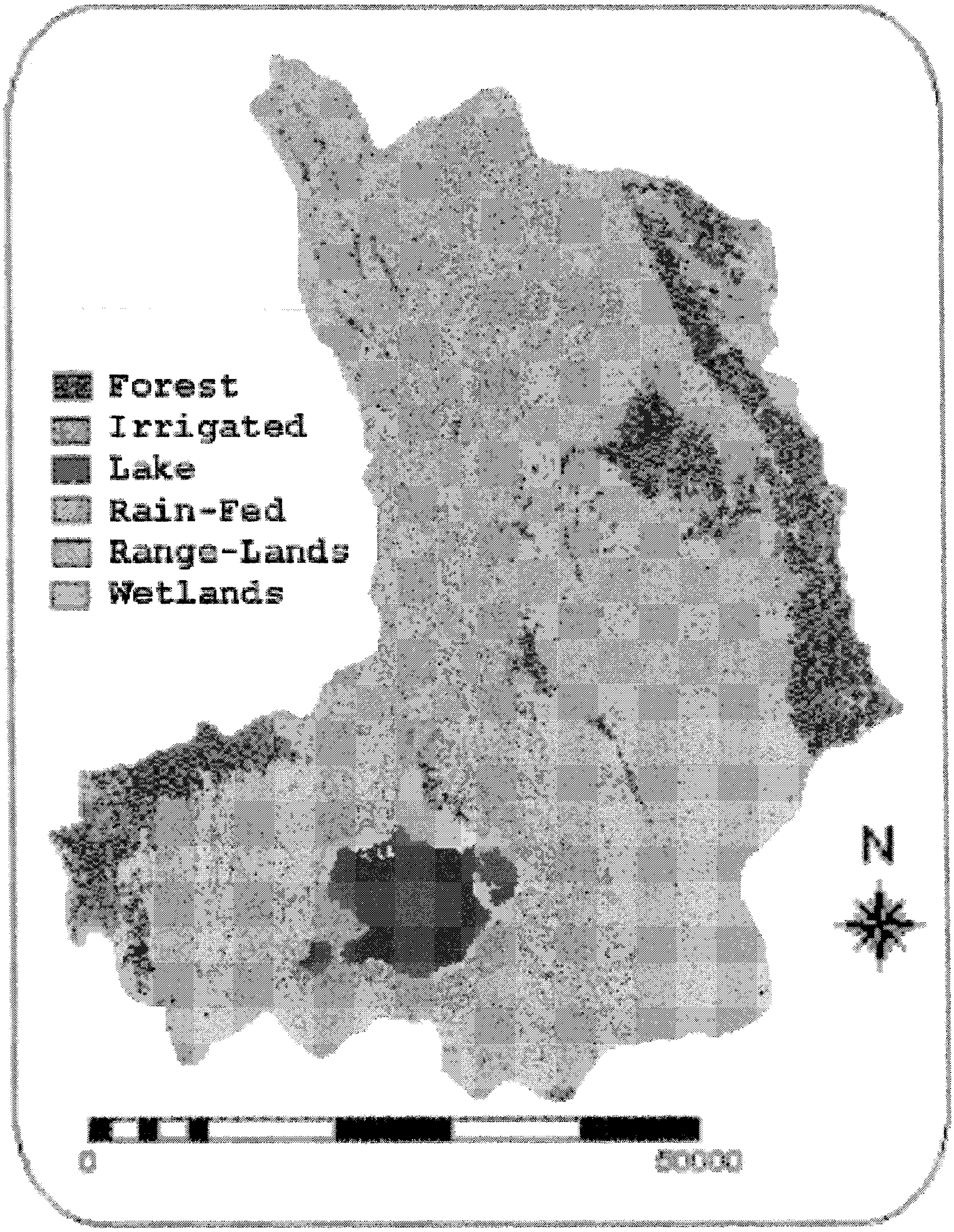


Plate 1-2: Three-dimensional View of the Catchmnet overlaid by the Land-Use.

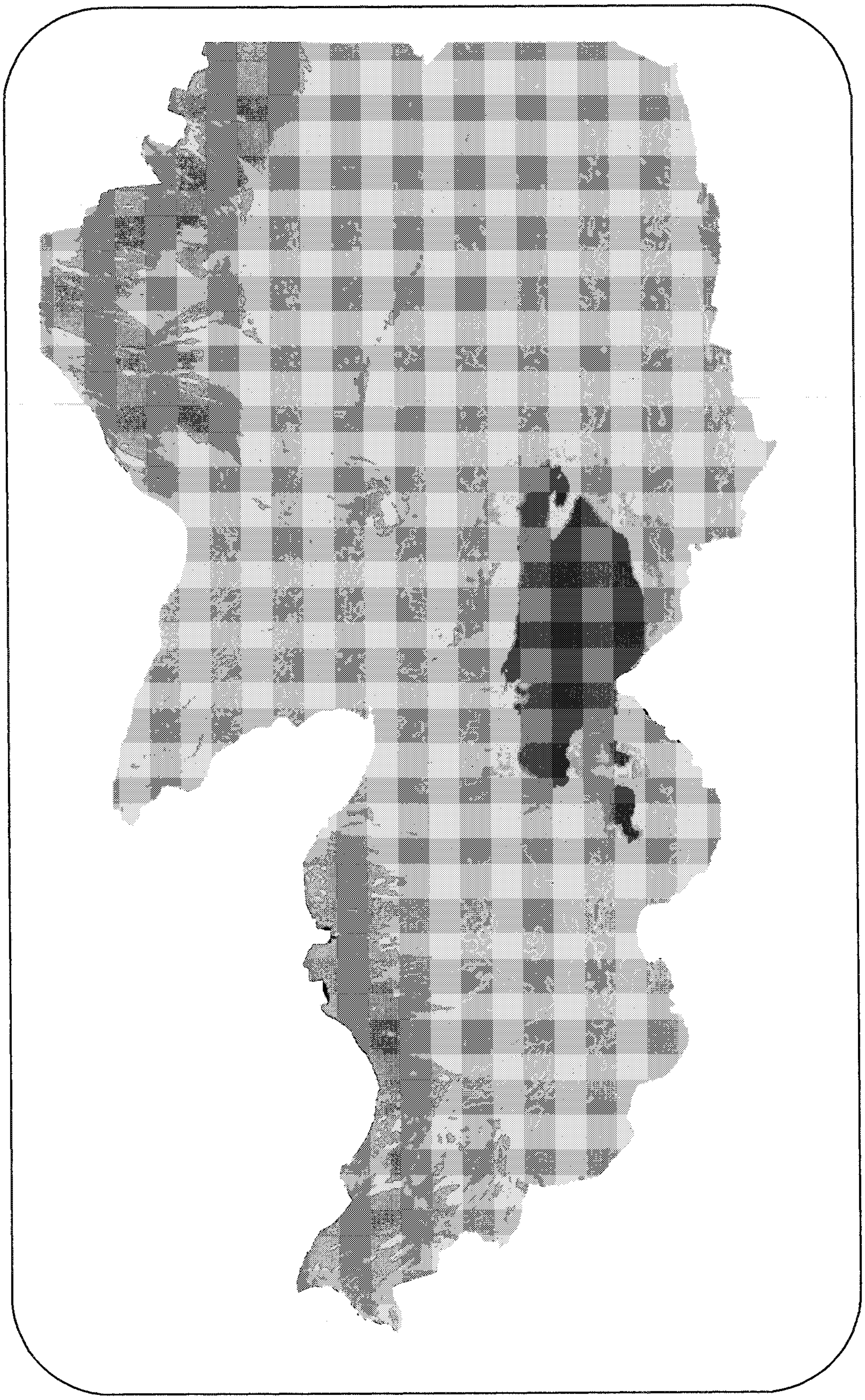


Plate 1-3: Three-dimensional View of the Catchmnet overlaid by Drainage Map.

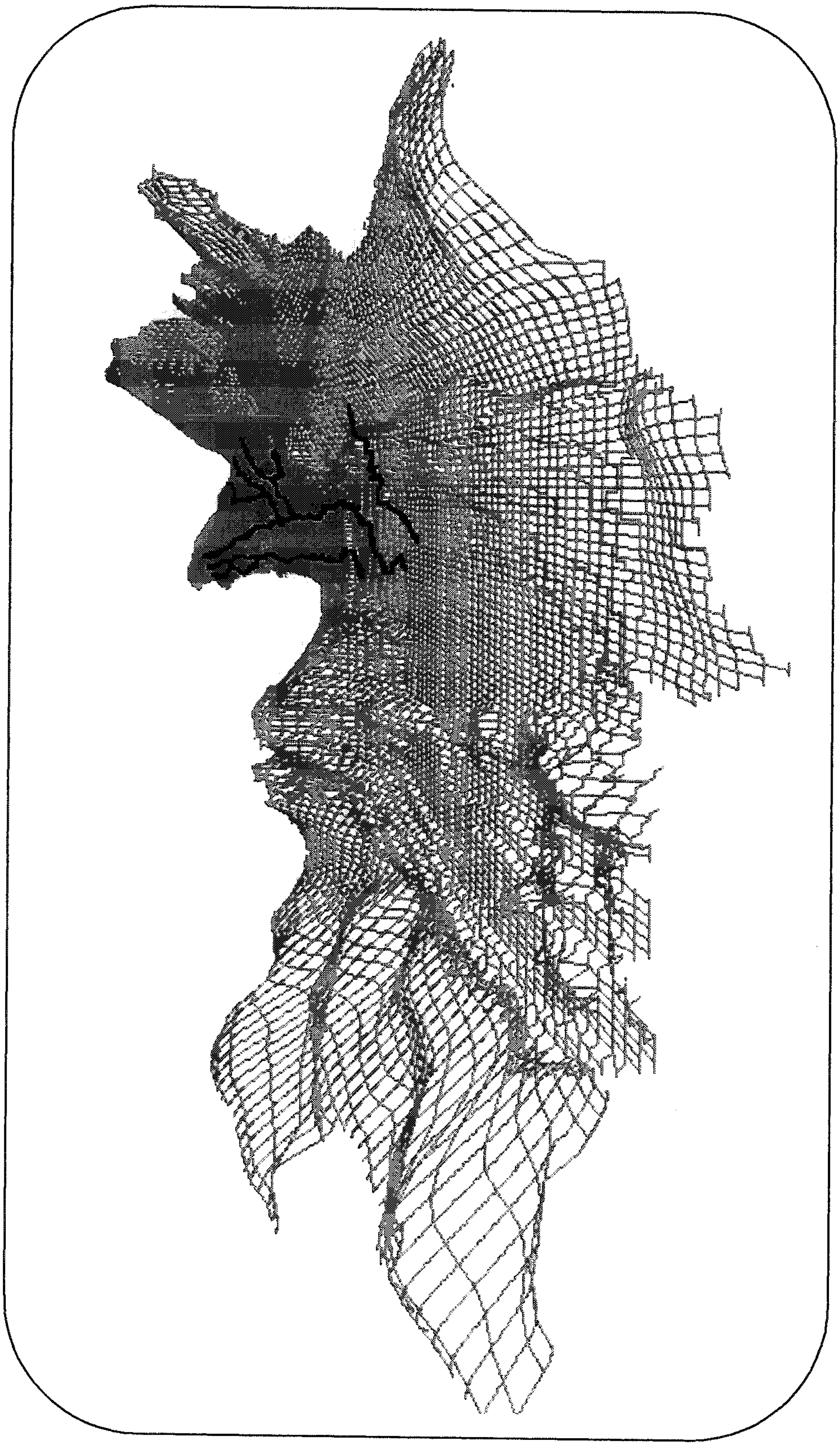


Plate 1-4: Rainfall Average Map.

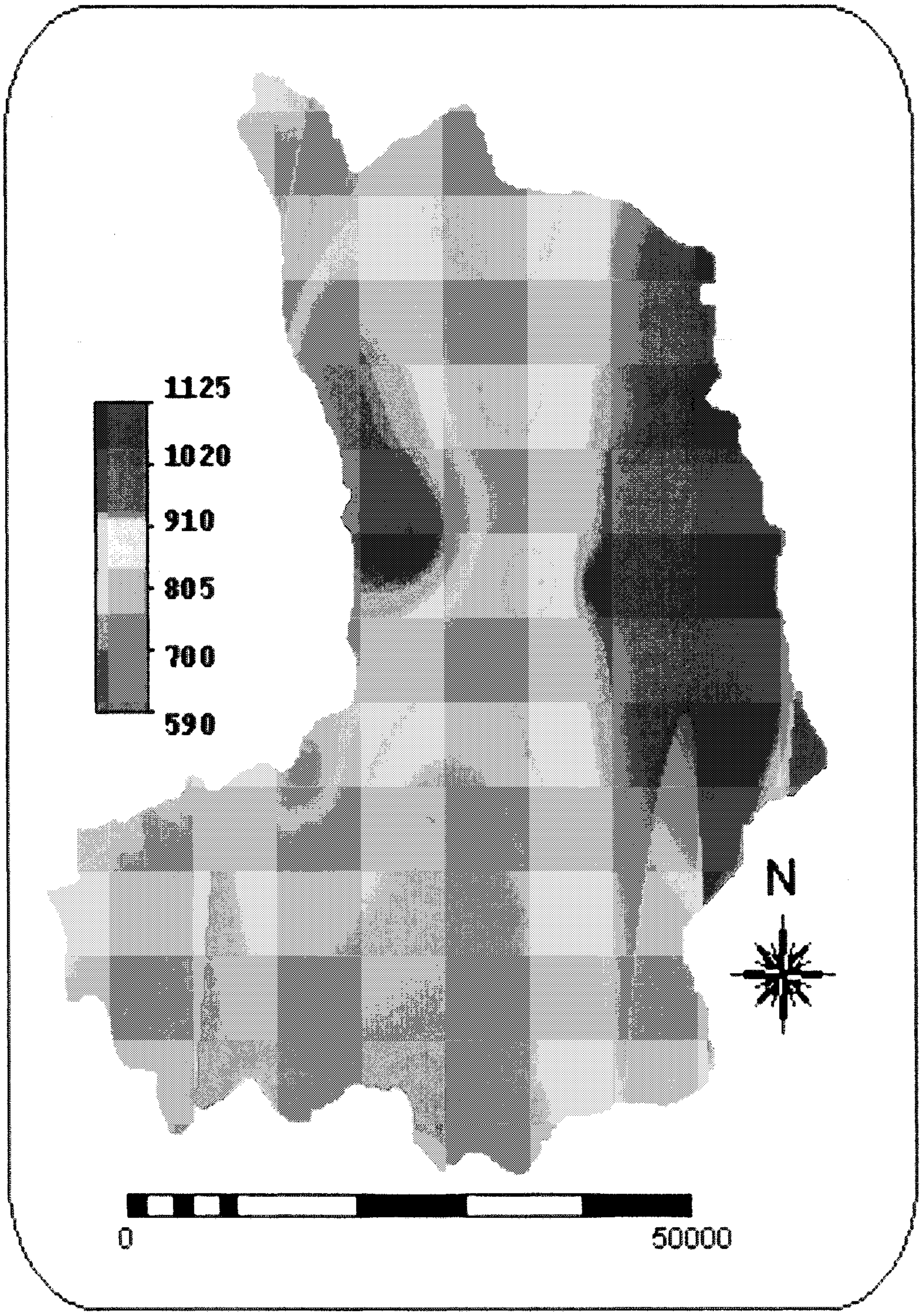


Plate 1-5: Ground Water Depth Map

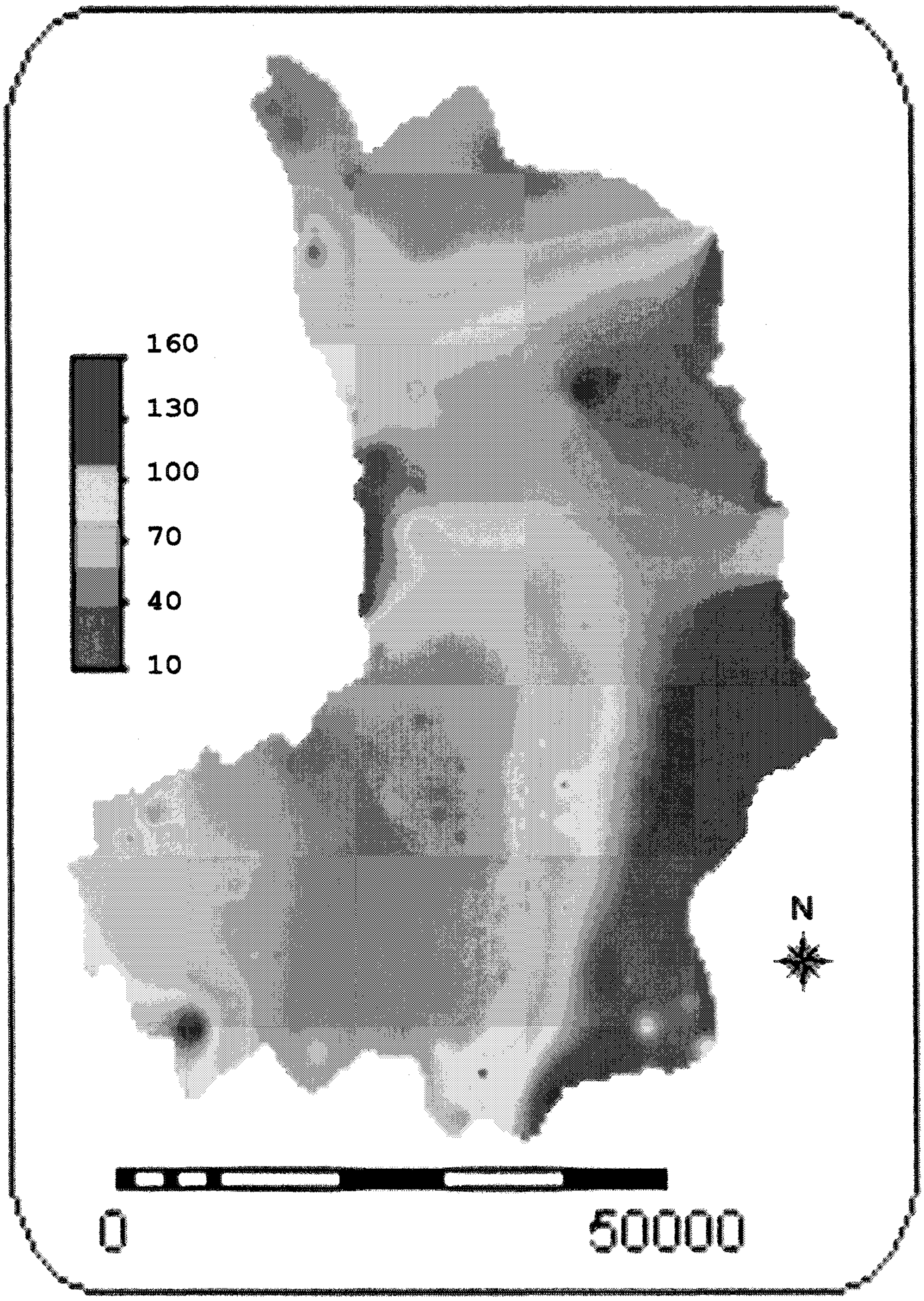


Plate 1-6: Interception Map

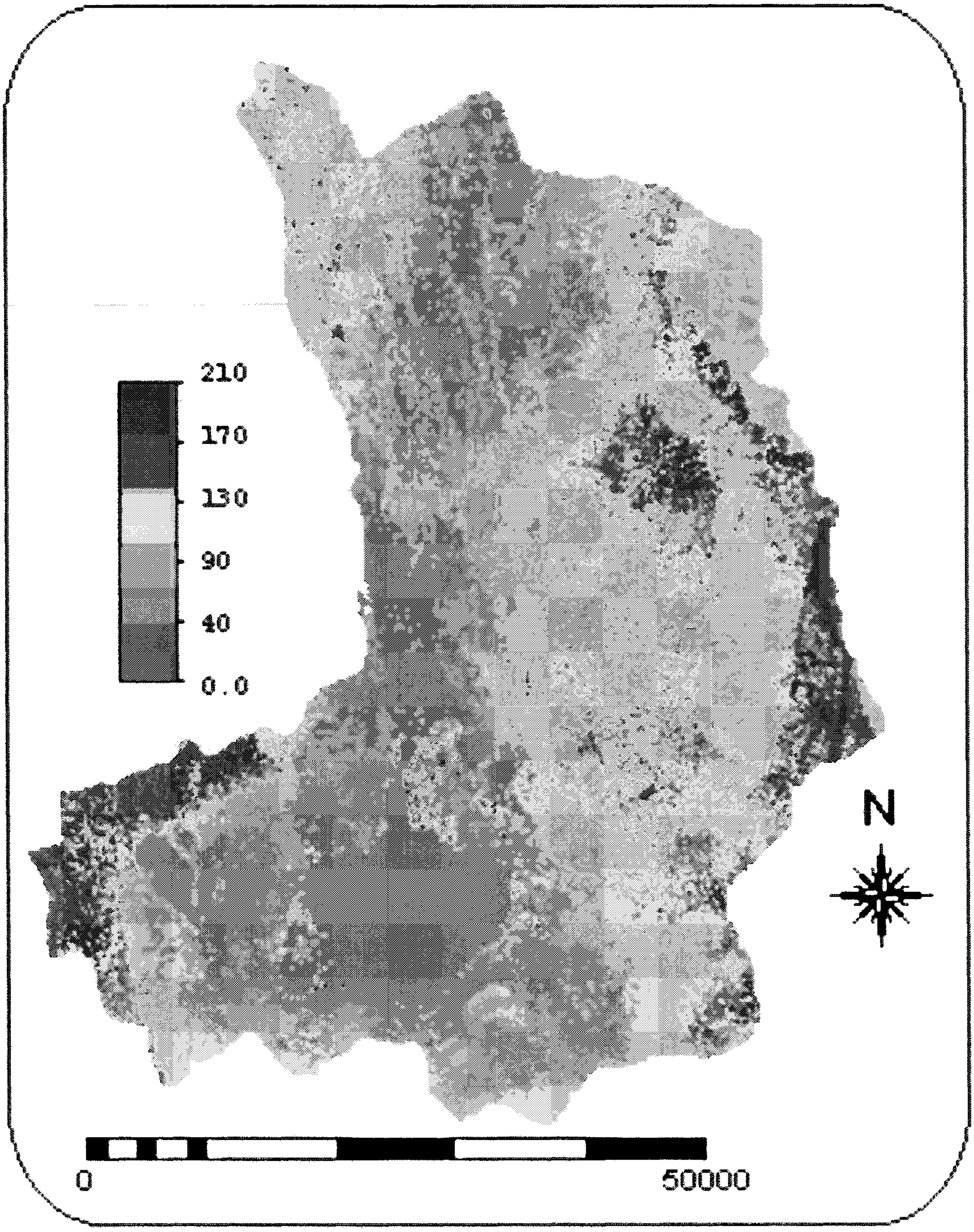
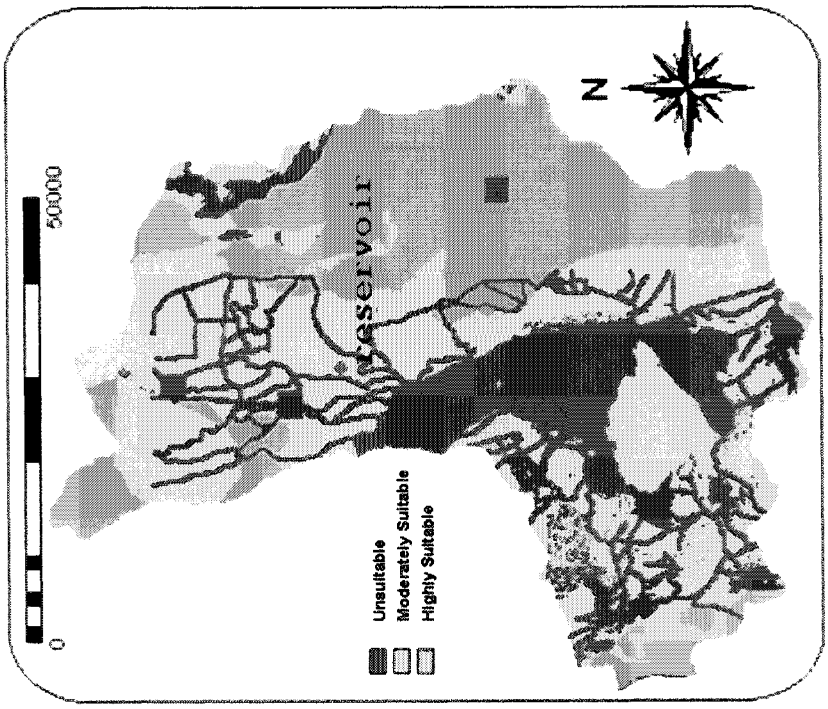
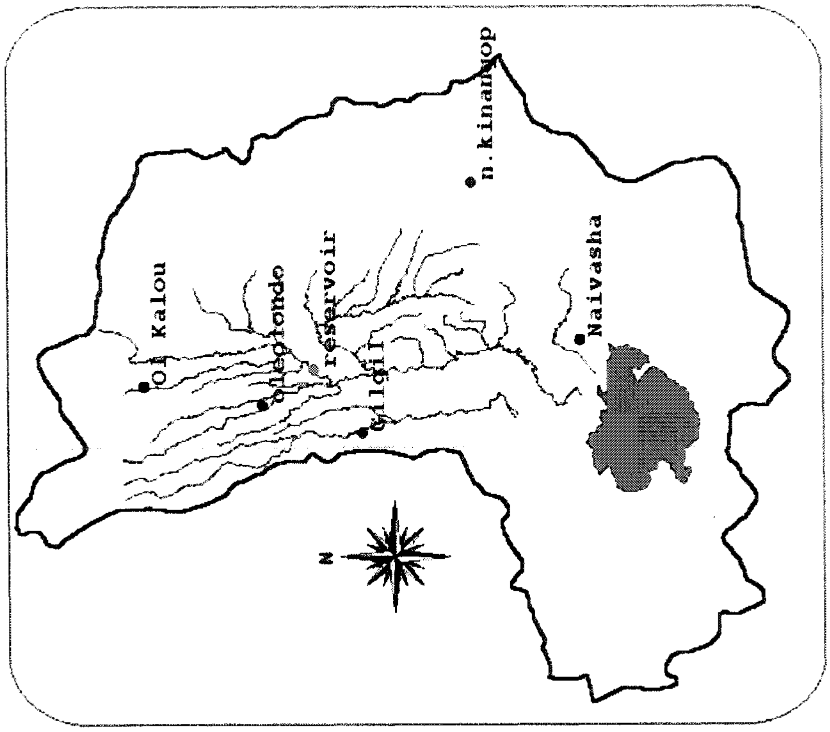


Plate 5-1: New Reservoir and Dam Location and Suitability Maps



(a)



(b)

New Reservoir Suitability Map with Location of the dam (a), Location among Cities and Rivers (b).

ANNEX QN.1

Water Accounting Framework

Water Accounting.....

Year: 1997

All volume figures are in m^3

Beginning Of Calculations

Wetlands/Water Area	
Land-Use	Used Here
47%	30%

Defined as soil of water content enough to potentially

Land Area Under Study (km^2)	3,119
Water Area Under Study (km^2)	133
Wetlands Area Under Study (km^2)	40
Total Area Under Study (km^2)	3,292

Ahmad Catchment

Inputs

Rainfall (mm/year) 860

Average for the stations within the catchment. (source, Ilwis,

Inflow

River Inflow is 0.0

Malewa	Gilgil	Karati		Rain Fall	Ground Water Inflow
No river Discharge for the whole catchment				2,791,844,307	0
		0	Totals	2,791,844,307	
			2,791,844,307		

Runoff

Minimal Surface runoff

SCS Curve number		others	
.	.	.	
		0	Totals
			0

Change in Storage

source: 1882echo.xls

Surface Water

Lake Volumes	
Previous Yr	Current Yr
434,439,523	464,834,726

Increase	Decrease
30,395,203	0
	30,395,203

Ground Water

Saturated Zone	
Increase	Decrease
2,000,000	0

Unsaturated Zone	
Increase	Decrease
180,996,183	
182,996,183	

Closing Term of the Process

Totals 213,391,386

Gross Inflow

Totals of the last level

G.W.Inflow	Rainfall	Runoff	Return Flow	
0	2,791,844,307	0	785,517,202	
		2,791,844,307	Totals	2,578,452,921
		3,577,361,509		3,363,970,123

Net Inflow

Gross Inflow & change in storage

Surface	Ground	Net Inflow
30,395,203	182,996,183	2,578,452,921

Water Accounting Framework

Year: 1997

All volume figures are in m³

Outflow

Committed

from Turasha

	Nakuru	Ol Kalau	Kipipiri	
Abstraction	19,000	16,400	6,100	m³/day

no data about variability over

Abstraction to Nakuru	Other Committed outflows		
Value	Ol Kalau	Kipipiri	Olkaria
6,939,750	5,990,100	2,228,025	30,000,000

6,939,750 Totals 38,218,125
45,157,875

Uncommitted

(50+18)/2=34, and that's what have been calculated in a PhD study. + 11 towards the north. [Ojiambo,1996]

Ground Water Outflow	Other Uncommitted outflows		
Value	uncom'td 1	uncom'td 2	uncom'td 3
50,000,000	.	.	.

50,000,000 Totals 0
50,000,000

Depleted

Non-Process Depletion

Beneficial

Economic Forest	Other Beneficial Depletion		
Value	Wildlife	NPD-B2	NPD-B3
16,911,140	1,981,413	.	.

16,911,140 Totals 1,981,413
18,892,553

Non-Beneficial

Ashfaque, 1999

Lake Evaporation (mm/year) 1,700 4.7 (mm/day)

Interception Losses	Bare Soil	Lake Evaporation
Value	Value	Value
230,966,033	1,126,380,109	226,627,128

230,966,033 Totals 1,353,007,237
1,583,973,270

Evaporation figure is only from the Lake

being used on 0.7of lake evaporation (3.5 mm/day) that was in correspondance to the

Low-Beneficial

Natural Vegetation	Swamp	Non-economic Forest
Value	Value	Value
606,512,366	47,591,697	402,872,405

606,512,366 Totals 450,464,101
1,056,976,468

Water Accounting Framework

Year: 1997

All volume figures are in m^3

Losses

Irrigation Efficiency 40%
Industrial Efficiency 30%
Domestic Delivery Efficiency 30%

Losses: Irrigation	Losses: Industry	Losses: Domestic		Other Losses: Interception	Other Losses: Losses 2	Other Losses: Losses 3
34,838,960	18,766,641	4,884,676		230,966,033	.	.
		58,490,277	Totals	230,966,033		
			289,456,310			

Wildlife Conservation

Tropical Livestock Unit Water Use (lt/d) 25
WildLife: Around lake/catchment (%) 5%
Livestock: Around lake/catchment (%) 20%

Unit	Equivalent TLU	Total No.	Total TLU	Water Consumption (lt/day) Watering	Water Consumption (lt/day) Drinking	Water Consumption (m^3/yr) Lake	Water Consumption (m^3/yr) Catchment
Zebra	0.85	337	286	0.0	7,151	2,612	52,235
Impala	0.10	206	21	0.0	515	188	3,758
Elands	0.75	37	28	0.0	690	252	5,040
Giraffe	1.10	8	9	0.0	223	81	1,627
Water Buck	0.50	37	19	0.0	466	170	3,406
Thomson Gaelle	0.20	64	13	0.0	322	117	2,349
Cattle	1.00	35,000	35,000	2.0	875,000	345,161	1,725,806
Sheep	0.10	35,000	3,500	0.0	87,500	31,959	159,797
Camel	0.50	0	0	2.0	0	0	0
Buffalo	1.50	100	150	0.0	3,750	1,370	27,394
Elephant	9.10	0	0	0.0	0	0	0
		70,789	Totals	1,981,413			
			1,981,413				

Process Depletion

Industrial

Including all diaries products.

Fodder Acreage for diaries (ha) 700
Grass acreage left for grazing (ha) 400
Milk consumption (lt/capita/day) 0.8
Factory Water consumption (lt_{water}/lt_{milk}) 12.0
Total Factory Water Consumption (m^3/year) 1,227,240

max
based on data from Delamere while world tabulated values for Belgium says it is only 7.0.

Delamere Estate: Fodder	Delamere Estate: Grass	Delamere Estate: Factory		Other Factories: Gilgil	Other Factories: Others	Other Factories: Others2
8,382,897	5,113,500	1,227,240		5,000,000	7,085,850	.
		14,723,637	Totals	12,085,850		
			26,809,487			
			13,313,090	Water for factories only		

An electric factory based in

Water Accounting Framework

Year: 1997

All volume figures are in m^3

Domestic

Population of Gilgil town, is incorporated here.

Tourists	40,000		Average nights		2
Population	350,000			Urban/Low	30%
				Urban/Med.	68%
Classification	Urban	50%		Urban/High	2%
	Rural	50%		Rural/low	25%
				Rural/Med.	50%
				Rural/High	25%
Requirement Satisfaction	Tourist	95%			
	Urban	75%			
	Rural	45%			

Residents Consumption m^3/day	Residents Consumption m^3/year		Tourist Consumption m^3/day	Tourist Consumption m^3/year
30,975	11,313,619	Ideal	55	20,000
18,585	6,788,171	Current	52	19,000

Public Services	Count	No of Persons/ Facility	Water Consumption m^3/day	Water Consumption m^3/year	
Boarding Schools	5	500	125	45,656	
Day Schools	10	500	125	45,656	
Hospitals	3	100	120	43,830	
Dispensaries	8	..	40	14,610	
Clinics	26	10	104	37,986	
Mortuaries	2	4000 body/year	40	14,610	
Slaughter Houses	5	..	50	18,263	
Bars & Clubs	20	..	10	3,653	
Clinics	100	..	10	3,653	
	6,807,171	Totals 170,937		227,916	Ideal
		6,978,108		170,937	Current

Agriculture

FAO Water Requirement

Source FAO 33

Crop	Growing period (days) min	Growing period (days) max	Water requirements (mm) min	Water requirements (mm) max	ETav min	ETav max	ETav avg
Bean	60	120	300	500	2.50	8.33	5.4
Cabbages	80	120	380	500	3.17	6.25	4.7
Maize	90	150	500	800	3.33	8.89	6.1
Onion	100	150	350	550	2.33	5.50	3.9
Pea	90	130	350	500	2.69	5.56	4.1
Potato	120	150	500	700	3.33	5.83	4.6
Sunflower	110	140	600	1000	4.29	9.09	6.7
Tomato	90	120	400	600	3.33	6.67	5.0
Wheat	120	155	450	650	2.90	5.42	4.2
Rainfed Percentage of avg ET			70%	3.5		avg	5.0

Rainfed Agriculture

Crop	Area (ha)	Area %	Rainfall (mm/yr)	Rainfall (mm/day)	Consumption; (Rainfall) (m^3/yr)
Wheat	10,000	3.04%	801	2.2	80,100,000
Maize	25,000	7.59%	801	2.2	200,250,000
Potatoes	20,000	6.08%	801	2.2	160,200,000
Other Horticulture	9,559	2.90%	801	2.2	76,567,430
Area	64,559	Totals	517,117,430		
		517,117,430			

Water Accounting Framework

Year: 1997

All volume figures are in m³

Forest

From GIS; around the lake!

That's the amount they're getting from rainfall only, the rest of the value listed in agriculture section is obtained from Gwater through deep roots.

Forest Area (ha)	43,031
Economic Forest (% of total Forest)	6
Non-Economic Forest	94

Crop	Area (ha)	Area %	Rainfall (mm/yr)	Rainfall (mm/day)	Consumption; (Rainfall) (m³/yr)
Economic Forest	2,582	0.8%	655	1.8	**16,911,140**
Non-Economic Forest	40,449	12.3%	996	2.7	**402,872,405**
Area	43,031	Totals	**419,783,544**		
		419,783,544			

Range Lands

Range Lands Area (ha)	**198,954**
Nat. Veg./Range Lands (%)	**35%**
Bare Soil/Range Lands (%)	**65%**

Crop	Area (ha)	Area %	Rainfall (mm/yr)	Rainfall (mm/day)	Consumption; (Rainfall) (m³/yr)
Natural Veg.	69,634	21.2%	871	2.4	**606,512,366**
Bare	129,320	39.3%	871	2.4	**1,126,380,109**
Area	198,954	Totals	**1,732,892,476**		
		1,732,892,476			
Non-Econ. Forest & Natural Veg. * Bare		**2,135,764,880**			

Agriculture (cont'd)

from Ilwis;Excel also "Landuse7" and

from Ilwis;Excel also "Landuse7" and

Total Catchment Area (ha)	**329,211**	
Land Area (ha)	**311,881**	
Fallow Period (Wheat)	**90**	days
Fallow Period (Flowers)	**0**	days
Fallow Period (Other Crops)	**30**	days
Fallow Period (Rainfed)	**120**	days
Irrigated Land (ha)	**4,568**	
Rainfed Area (ha)	**64,559**	
Forest Area (ha)	**43,031**	
Range Lands Area (ha)	**198,954**	
Nat. Veg./Range Lands (%)	**35%**	
Bare Soil/Range Lands (%)	**65%**	

based on 2 crops/year, Jun-Oct. and Dec.-Apr. having a fellow land for 3 months

Crop	Area (ha)	Area %	Current Water Consumption mm/day	m³/day	m³/year	
Flowers	1,200	0.36%	6.0	72,000	**26,298,000**	
Wheat	25	0.01%	5.0	1,250	**344,063**	
French Beans	125	0.04%	6.0	7,500	**2,544,602**	
Baby Corn	100	0.03%	5.5	5,500	**1,868,057**	
Cabbages	75	0.02%	5.5	4,125	**1,401,043**	
Squash	75	0.02%	5.5	4,125	**1,401,043**	**71,561,330**
Onion	75	0.02%	5.5	4,125	**1,401,043**	
Tomatoes	75	0.02%	5.5	4,125	**1,401,043**	
Pea	75	0.02%	5.5	4,125	**1,401,043**	
Grass	800	0.24%	3.5	28,000	**10,227,000**	
Fodder	1,943	0.59%	3.5	68,022	**23,274,396**	
Rainfed Agriculture	64,559	19.61%	2.2	1,415,790	**517,117,430**	**517,117,430**
Natural Vegetation	69,634	21.15%	1.4	974,876	**356,073,592**	
Bare	129,320	39.28%	**0.8**	1,042,398	**380,735,957**	**1,364,900,890**
Forest	43,031	13.07%	**4.0**	1,719,620	**628,091,341**	
Area	311,113	Totals	**1,953,579,650**			
Ag.Area	4,568	**1,953,579,650**				
		94.50%	The rest -of area!- is lake and wetlands!!			

Only 500 in

Water Accounting Framework

Year: 1997

All volume figures are in m^3

Irrigated Agriculture

Crop	Area (ha)	Area %	Currently Applied Water mm/day	Currently Applied Water m^3/day	Currently Applied Water m^3/year
Flowers	1,200	0.36%	6.0	72,000	**26,298,000**
Wheat	25	0.01%	5.0	1,250	**344,063**
French Beans	125	0.04%	6.0	7,500	**2,544,602**
Baby Corn	100	0.03%	5.5	5,500	**1,868,057**
Cabbages	75	0.02%	5.5	4,125	**1,401,043**
Squash	75	0.02%	5.5	4,125	**1,401,043**
Onion	75	0.02%	5.5	4,125	**1,401,043**
Tomatoes	75	0.02%	5.5	4,125	**1,401,043**
Pea	75	0.02%	5.5	4,125	**1,401,043**
Grass	800	0.24%	3.5	28,000	**10,227,000**
Fodder	1,943	0.59%	3.5	68,022	**23,274,396**
Area	4,568	Totals	71,561,330		
		58,064,933			
		1.39%			

Total - fodder & grass values taken for

Theoretical Consumption

Crop	Area (ha)	Area %	Theoretical Water Consumption mm/day	Theoretical Water Consumption m^3/day	Theoretical Water Consumption m^3/year
Flowers	1,200	0.36%	2.1	24,660	**9,007,065**
Wheat	25	0.01%	3.2	794	**218,442**
French Beans	125	0.04%	3.2	3,968	**1,360,523**
Baby Corn	100	0.03%	3.2	3,174	**1,088,418**
Cabbages	75	0.02%	3.2	2,381	**816,314**
Squash	75	0.02%	3.2	2,381	**816,314**
Onion	75	0.02%	3.2	2,381	**816,314**
Tomatoes	75	0.02%	3.2	2,381	**816,314**
Pea	75	0.02%	3.2	2,381	**816,314**
Grass	800	0.24%	2.9	23,087	**8,432,512**
Fodder	1,943	0.59%	2.9	56,087	**19,273,000**
Area	4,568	Totals	43,461,529		
		43,461,529			

Return Flow

Irrigated Agriculture

Indoor Flowers (% of total Flower) **85**
Outdoor Flowers 15

Crop	Area (ha)	Applied Irr. (mm/day)	Applied Irr. (mm/yr)	Rainfall (mm/yr)	ET_{act} (mm/day)	ET_{act} (mm/yr)	Surplus (m^3/yr)
Indoor flowers	1,020	5.0	1826	0	1.8	657	**11,921,760**
Outdoor Flower	180	8.0	2922	658	3.5	1,278	**4,142,925**
Wheat	25	5.0	1826	655	3.2	874	**401,870**
French Beans	125	6.0	2192	655	3.2	1,064	**2,227,829**
Baby Corn	100	5.5	2009	655	3.2	1,064	**1,599,638**
Cabbages	75	5.5	2009	655	3.2	1,064	**1,199,729**
Squash	75	5.5	2009	655	3.2	1,064	**1,199,729**
Onion	75	5.5	2009	655	3.2	1,064	**1,199,729**
Tomatoes	75	5.5	2009	655	3.2	1,064	**1,199,729**
Pea	75	5.5	2009	655	3.2	1,064	**1,199,729**
Grass	800	3.5	1278	655	2.9	967	**7,727,097**
Fodder	1,943	3.5	1278	655	2.9	967	**18,771,920**
Total	4,568						52,791,684
				Non-heavily Polluted Return Flow			5,279,168

Water Accounting Framework

Year: 1997

All volume figures are in m^3

Return Flow (cnt'd)

Rainfed Agriculture

Take the min of FAO as being stressed.

Crop	Area (ha)	Applied Irr. (mm/day)	Applied Irr. (mm/yr)	Rainfall (mm/yr)	ETact (mm/day)	ET_{act} (mm/yr)	Surplus (m^3/yr)
Wheat	10,000	0.0	0	801	2.9	799	**188,710**
Maize	25,000	0.0	0	801	3.3	818	**-4,125,000**
Potatoes	20,000	0.0	0	801	3.3	818	**-3,300,000**
Others	9,559	0.0	0	801	3.5	853	**-4,952,587**
	Area (ha)	64,559	Totals -12,188,878	-12,188,878			

Forest

% Increase of Economic Forest ET over Non-economic **20%**

Crop	Area (ha)	Applied Irr. (mm/day)	Applied Irr. (mm/yr)	Rainfall (mm/yr)	ET_{act} (mm/day)	ET_{act} (mm/yr)	Surplus (m^3/yr)
Econ. Forest	2,582	.	.	655	4.8	1,752	**-28,311,437**
Forest	40,449	.	.	996	4.0	1,460	**-187,533,456**
Total	**43,031**						**-215,844,892**

Range Lands

Crop	Area (ha)	Applied Irr. (mm/day)	Applied Irr. (mm/yr)	Rainfall (mm/yr)	ET_{act} (mm/day)	ET_{act} (mm/yr)	Surplus (m^3/yr)
Natural Veg.	69,634	.	.	871	1.4	511	**250,438,775**
Bare	129,320	.	.	871	0.8	294	**745,644,152**
Total	**198,954**						**996,082,926**

Brief Summary

Total Catchment Area (ha) **329,211**
Land Area (ha) **311,881**

Rainfall varies spatially

weighted average of the ET_{act} (indoor, and outdoor)

Crop	Area (ha)	Applied Irr. (mm/day)	Applied Irr. (mm/yr)	Rainfall (mm/yr)	ET_{act} (mm/day)	ET_{act} (mm/yr)	Surplus (m^3/yr)
Flowers	1,200	6.0	2192	0	2.1	751	**16,064,685**
Wheat	25	5.0	1826	655	3.2	874	**401,870**
French Beans	125	6.0	2192	655	3.2	1,064	**2,227,829**
Baby Corn	100	5.5	2009	655	3.2	1,064	**1,599,638**
Cabbages	75	5.5	2009	655	3.2	1,064	**1,199,729**
Squash	75	5.5	2009	655	3.2	1,064	**1,199,729**
Onion	75	5.5	2009	655	3.2	1,064	**1,199,729**
Tomatoes	75	5.5	2009	655	3.2	1,064	**1,199,729**
pea	75	5.5	2009	655	3.2	1,064	**1,199,729**
Grass	800	3.5	1278	655	**2.9**	967	**7,727,097**
Fodder	1,943	3.5	1278	655	**2.9**	967	**18,771,920**
Rainfed	64,559	.	.	801	3.3	820	**-12,188,878**
Natural Veg.	69,634	.	.	871	1.4	511	**250,438,775**
Bare	129,320	.	.	871	0.8	294	**745,644,152**
Forest	43,031	.	.	976	4.0	1,477	**-215,844,892**
	Big Three!!	**780,238,034**	Totals 833,029,718	**52,791,684**	**Agriculture**		

include the sink water

weighted average, forest and economic forest

Water Accounting Framework

Year: 1997

All volume figures are in m³

Sinks

Percentage of Heavily polluted Water in Agriculture	90%	
Percentage of Heavily polluted Water in Industry	70%	Todd, 1970: Domestic
Municipal Waste Water Return out of domestic input	75%	

Polluted Irrigation Water Value	Industrial Wast Water Value	Municipal Waste Water Value
47,512,515	9,319,163	5,233,581

	Totals	
47,512,515	62,065,260	5,233,581

Mathematical Balance

Outflow	Beneficial	Low Beneficial
95,157,875	18,892,553	1,056,976,468

Irrigated Agriculture		Industry
71,561,330		13,313,090

Rain-Fed		Domestic
517,117,430		6,978,108

Lake Evaporation	Interception	Soil Evaporation
226,627,128	230,966,033	1,126,380,109

Per Capita Water Share

Rainfall (lt/day.capita)	Pr. Depletion (lt/day.capita)	Domestic (lt/day.capita) Current	Ideal
21,839	4,869	55	90

Soil Evaporation	Rain Index (lt/day.capita)
1,618,562,810	55

Performance Indicators

Net Inflow	Gross Inflow	Available	Depletion	Process Depletion	Productivity
3,363,970,123	3,577,361,509	3,318,812,248	3,268,812,248	622,466,356	.

Depleted Fraction (DF)

Gross (DF_{gross})	Net (DF_{net})	Available (DF_{av})
91.4%	97.2%	98.5%

Process Fraction (PF)

Depleted ($PF_{depleted}$)	Available ($PF_{available}$)
19.0%	18.8%

End Of Calculations

Input Parameters

Jei moet enter:

Entry	**Description**
Year	
Water area under study	
Wetlands/water area (%)	
Total Area under Study	
Average rainfall for the whole catchment	
Rainfall in volume for the whole catchment (GIS based)	
Ground water inflow	
Surface runoff from outside the catchment	
Previous year surface water volume	
current year surface water volume	
increase or decrease in ground water storage	
Abstraction to committed outflow	
Fisheries commitment	
Other Committed outflow "2"	
Other Committed outflow "3"	
ground water outflow	
Other uncommitted outflow "1"	
Other uncommitted outflow "2"	
Other uncommitted outflow "3"	
evaporation from surface water/wetlands	
Interception Losses	
Irrigation Efficiency	
Industrial Efficiency	
Domestic Delivery Efficiency	
Total no. of tourists per year	
Average nights per tourist	
Population in the whole catchment	
classification of population	
Requirement Satisfaction for tourists	
Requirement Satisfaction for urban	
Requirement Satisfaction for rural	
different domestic amenities	
Fodder acreage for diaries (ha)	
Grass acreage left for Grazing (ha)	
Milk Consumption (lt/day.Capita)	
Factory Water Consumption (ltwater/ltmilk)	
Other Factory water Consumption "1"	
Other Factory water Consumption "2"	
Other Factory water Consumption "3"	
Fallow period for Wheat (days)	
Fallow period for flowers (days)	
Fallow period for other crops (days)	
Fallow period for rain-fed (days)	
Irrigated Land (ha)	
Rain-fed Area (ha)	
Forest Area (ha)	
Range lands area (ha)	
Natural Vegetation/ Range lands in percentage	
acreage (ha) of each crop	
applied irrigation water for each crop	
actual Evapotranspiration from natural vegetation (mm)	
actual Evaporation from bare soil (mm)	
Actual Evapotranspiration from Forest (mm)	
Acreage of each crop in the rain-fed area (ha)	
% of economic forest out of total forest area	
Rainfall for range lands (mm)	
rainfall relevant to each crop	
actual Evapotranspiration of each crop	
% of indoor flowers out of total flowers area	
Growing period of each crop	
water requirements of each crop	
Percentage increase in Economic forest ET over non-economic	
Percentage of heavily polluted water after agriculture	
Municipal waste water return out of domestic input	

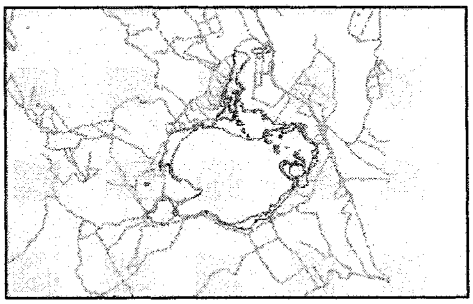
File Name:accounting Page: 1/1 Date: 4/15/99

ANNEX QN.2

Site No. ____________

SUPPLY MEASUREMENT NO. __971010/1__

__*Sulmac* **Flowers**__Farm near/at___**South Lake Road**_______



X: ______________ y: ______________ Alt.: ______________

Map reference : ________________________ Date : _**10th Oct**

Party : ____**Zhen Xu**________________________

Person : ____**Jack Juma**______ Tel. : ____________

Field Data:

Measured By : Current Meter/Float/Slope Area/Others; specify ____________________

Abstracted by: __**Pump ⇒ Tank, 4 of 700 m^3 =2800 m^3**__________________ No: ______________

Year	**The first 2 years gives high yields as the soil structure always drops in the yield.**
Yield	**Crop rotation/6 yr otherwise, accumulation of toxic matters.**

Abstraction from Naivasha to elsewhere: ______________________________ Amount: ________

Cows for : Beef/Milk/Others; specify ____________________ No.: ________

Water Quality Needs: Crops/Cattle/Domestic ____**Lake water pH goes up to 8.0**________________

Water temperature: ______ °C, EC: ______ µS/cm, pH: ___**6.0-7.5**_______

Turbidity: ________ NTU, DO: _______ mg/l, Na: ________ mg/l, Ca: _______ mg/l, Mg: _______ mg/l

STAGE READINGS				
On average water consumption				**5 mm/day**
	Measurement began			
Crop	**Area** ha	**Water supply**	**Fertil.**	**Yield**
Carnation	**27**	**4-6 mm/day**		**200 stem/m^2/yr**
Roses	**29**	**4-6 mm/day**		
Gipsofill a	**4**	**4-6 mm/day**		
Fr.Beans	**10**	**4-8 mm/day**		
Every week, they cultivate 2 ha to reach 200 ha of irrigated lands, then 600 ha.				
Chilis	**50% frensh beans, 25%Peas ,25% others**	**3 months crops**		
Peas				
Baby corn				
Carrot				
Squash				
	Measurement ended			
		Only Agr.	**All Uses**	**All expanded**
Mean/Total	**2000**	**7E6 l/day**	**10E6 l/day**	**12E6 l/day**

Computed Data:

SAR:

$$SAR = [Na^+] \Big/ \sqrt{\frac{[Ca^{2+}]+[Mg^{2+}]}{2}}$$

% flower: _______**80%**_______________

Remarks: __**1300 ha of the farm is in the riparian area. 80% of 2000 personnel; i.e. 10,000 (5000 b4 CDC)**_

__________**Remove crops of non-profit making. Reduce employees from 5000 to 2000 then 3000 af. expansion**

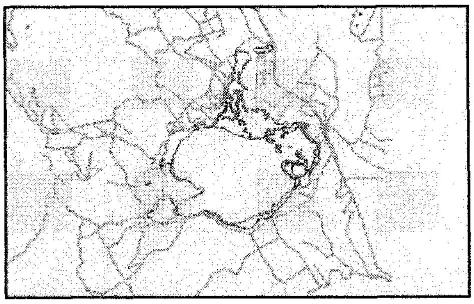
__________**Drip irrigation, overhead irrigation after seeding for vegetab. Only.**________________

__________**1.0-1.3E6 stems/week (from Oct. Till May) and 0.6-0.8E6 stems/week (from Jun. Till Sep.)**____

__________**Roses: 0.8E6, Carnation: 0.3E6, Gipsofilla: 0.3E6**________________________

Site No. ________

SUPPLY MEASUREMENT NO. __971012/1__



Delamere, Manera Farm near/at **North lake road**________

X: 212520________ y: **9923670**_______ Utm: **37M**__________

Map reference: ________________________ Date : **12th Oct.**

Party : **Alone** ________________________

Person : **Daniel/Hassan Ali**_Tel. : _(0311)20675/6_

Field Data:

Flat area, no erosion problem, LNRA precautions. They recycle waste water from factory (very fertile water) to irrigate vegetab. In addition to the borehole water______________

Abstracted by: __**bore Holes**_____ Amount abstracted:__**1,000,000 l/day**___ No: ___**7*70 hp**____

Year	**They buy additional 3000 l/day to be added to their daily production of 5000 l/day**
Yield	**8000 l/day of milk of which 70% goes to fresh milk, and 30% for butter and yogurt**

Cows for : Beef/**Milk**/Others; specify__**1500 cows, only 250 r for milk**___

Water Quality Needs: Crops/Cattle/Domestic _______ **Actual Water Quality**______________________

Water temperature: _____ °C, EC: _**0.49-0.87**__ µS/cm, pH: _**6.5-7.5**__ , Taste/Dissolved/**Clear**

Turbidity: _______ NTU, DO: ______ mg/l, Na: _______ mg/l, Ca: ______ mg/l, Mg: ______ mg/l

STAGE READINGS				
Time (sec)	Recorder	Distance	Flow base	Flow Peak

Product	Price (KSc)	Unit	Fertilizers	Net Return
Fresh Milk	**40**	**Lt.**	**Fertilizer information are in the hard copy sheet**	
Whole Milk	**44**	**Lt.**		
Skimmed Milk	**43**	**Lt.**		
Cream	**50**	**Lt.**		
Butter	**260**	**Kg**		
Yogurt	**90**	**Lt.**		

Crop	Area		Crop	Area
Potatoes	**14 ha, in turns**		**Fodder**	**500 ha**
Cabbages			**Nat.Veget.**	**700 ha**
Brocley			**That's left 4 grazing, in riparian zone.**	
	Measurement ended			
Total Area	**1200 ha**			

Computed Data:

Discharge : ______________ m^3/sec

Stage Ht. Change: nil/______________ m

SAR:__________ $SAR = [Na^+] / \sqrt{\frac{[Ca^{2+}]+[Mg^{2+}]}{2}}$

Irrigated Area: ____________________ m^2

Width: ______________________________ m

Max. Depth: _________________________ m

Max. Surface Velocity: __________ m/sec

Mean Velocity: _________________ m/sec

Wetted perimeter: ___________________ m

Hydraulic Radius: ___________________ m

Slope: ______________________________

Manning: ____________________________

Remarks: __**Fluorine is very high, the nearer u go to the lake the more saline u get**______________

__________**The extra milk they get from small farms around the lake**__________________________

__________**The water is for cattle and domestic use, and its quality is satisfying**__________

__________**They house 70% of their employees, 350 employees with their families (6persons/family)**_______

__________**When there's rain, less water for irrigation & Cattle**______________________________

Site No. ________

SUPPLY MEASUREMENT NO. _971014/1_

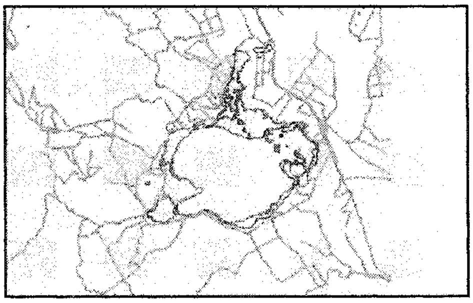
__Sher Agency__ Farm near/at __South lake road__

X: ________ y: ________ Alt.: ________

Map reference: ________ Date: _14th Oct_

Party : _Zhen Xu_

Person : _Marco Van Dijk_ Tel. : _30544/21058_



Field Data:

Measured By : Current Meter/Float/Slope Area/Others; specify________

Abstracted by: ________ Horse power : ________ No: ________

Indoor	**3000-5000 m^2/week**	**450 stems/m^2/yr**	**Quality of flowers in Kenya is better than Holland**	**Outdoor flowers is nicer**
Outdoor	**1 ha/week**	**100 stems/m^2/yr**		

Abstraction from Naivasha to elsewhere: ________ Amount: ________

Cows for : Beef/Milk/Others; specify________ No.: ________

Water Quality Needs: Crops/Cattle/Domestic __**Lake EC is 300 get it up to 1700**__

Water temperature: ____ °C, EC: ____ µS/cm, pH: _**6.5 by H_2PO_3 it reaches 6.3-6.8**_

Turbidity: ____ NTU, DO: ____ mg/l, Na: ____ mg/l, Ca: ____ mg/l, Mg: ____ mg/l

STAGE READINGS				
Time	Recorder	Distance	Flow: Mean	Flow: Peak
	Measurement began			
Crop	Area (ha)	Water supply		Net Return
Roses (out)	**120**	**7 l/d/m^2**		
Roses (in)	**30**	**10 l/d/m^2**		
Summer Flo.	**40**	**10 l/d/m^2**		**80 stem/m^2/yr**
Overhead irrigation 80%				
7 m^3/d/ha irrigation, without rain				
7/1.5=net area				
Fertilizer's data is in the hard copy.				
	Measurement ended			
Mean/Total	230	1400m^3/d		

Computed Data:

Discharges : ________ m^3/sec

Share of Storage: ________ m

SAR: ________

$$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^{2+}]+[Mg^{2+}]}{2}}}$$

Area: ________ m^2

Width: ________ m

Max. Depth: ________ m

Max. Surface Velocity: ________ m/sec

Drip for flowers - sprinkler for Vegetab

Outdoors are known for color distinction

Outdoor is difficult in decease control

Costs in Kenya: __200 Ksh/m^2__

Costs in Holland: __9000 Ksh/m^2__

Remarks: __**Took over another dutch person; new chairman is dutch.**__

__**Equador gives good quality flowers to sell it in east europe, but now, they've gone to west**__

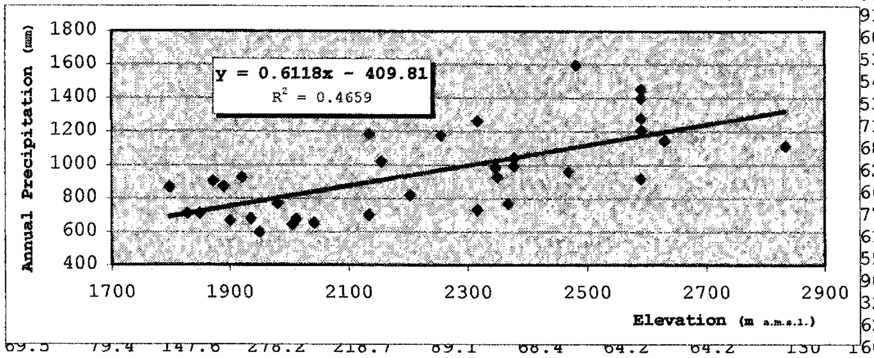
__**500-600 stems/m2. when weather is bad, they spend more money.**__

__**Recycling of drained water. 60% of kenya flower export is from Naivasha**__

__**Soil is good up to 11 years without any effect on yield, then u're having old fashion roses**__

ANNEX QN.3

Hypsometric Method (Rain -Elevation Relationship)

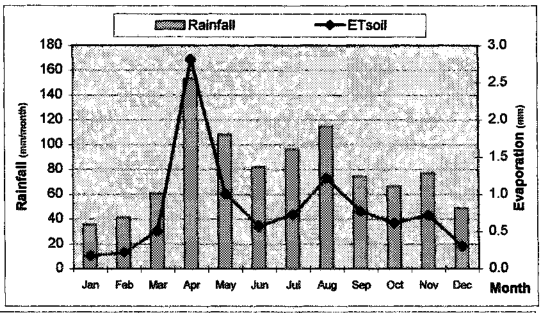


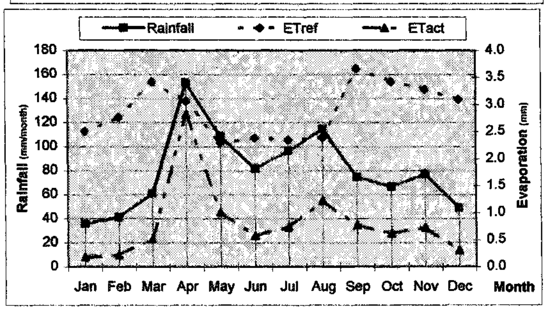
elev	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	totyr	no_yrs
1900.4	25.4	35.7	57.8	112.9	83.8	81.7	34.4	44.6	43	48.7	60.7	39.8	669	77
2630.4	43.1	50.9	86.9	174	154.4	107.1	75	94.3	102.6	98.9	98.4	59.1	1145	72
2347	29.8	30.1	61	148.9	124.9	88	98.4	116.8	74.6	77.4	88.2	46.8	985	68
2316.5											91.6	38.3	1265	59
2005.9											60.3	42.3	646	51
2367.1											53.3	20.3	768	50
2011.7											54.2	57.6	676	23
1950.7											53.3	38.2	598	57
1920.2											71.2	36.7	927	66
1828.8											68.2	45.5	711	54
2042.2											62.3	44.2	655	50
2377.4											66.7	57.6	993	44
2377.4											77.3	49.3	1041	39
1848.9											61.5	44	712	54
2133.6											59.1	39.3	701	59
2133.6											90.8	57.4	1186	32
2590.8											32.6	106	1279	38
2202.8											62.2	63.7	818	34
2590.8	69.5	79.4	147.6	278.2	218.7	89.1	68.4	64.2	64.2	130	160.4	84.5	1454	35
2481.1	79.2	81.2	149	309.8	266.9	97.4	66.2	69.1	66.4	139.8	179.1	94.1	1598	40
1798.3	29.8	34.4	53.2	144.9	102.3	66.3	69.3	97.8	61.2	52.6	105.3		865	33
1889.8	30.3	36.9	53.4	116.1	102.2	71.6	73.1	91.9	75.3	86.2	93	41.4	871	29
2590.8	41.1	45.2	75.1	168.2	168.5	109.9	106.4	116.6	125.2	105.5	91.3	54.9	1208	32
2255.5	29.1	28.7	64.8	164.9	160.9	120.7	122.4	131.8	106.3	104.7	104.7	39.1	1178	30
2590.8	70.6	66.6	112.8	302.5	234.5	70.1	49.5	46.6	56.7	125.2	171.6	92.6	1399	32
2154.9	40.2	37.4	65.2	148.3	129.6	81.7	90.5	111.4	98.5	83.3	96.7	37	1020	29
2350	27.5	50.5	44	169.6	111.8	67.9	54.8	85.8	52.8	63.5	118.2	82.6	929	22
2590.8	54.4	59.5	88.6	201.3	136.9	42.1	32.5	29.1	35.5	66.9	109.8	61.5	918	25
1871.8	28.2	43.1	66.7	140.9	127.8	75.7	91.6	112.4	39.1	67	72	38.4	903	27
1981.2	30.8	46.5	57.4	124.3	79.8	51.4	44.7	59.7	98.3	60.6	71.1	45.1	770	26
1935.5	39	43.8	60.3	116.3	79.2	51.3	36.8	44.9	43.5	56.4	61.9	47.6	681	21
2468.9	35.6	31.6	47	122.7	119.4	93.6	94.2	129.8	91.4	77.5	78	39.5	960	19
2316.5	30.2	26	49.8	110.6	107.4	77	64.3	86.1	63.3	53.4	48.4	16.1	732	14
2834.6	35.2	33.5	62.6	145.2	123.1	104.2	111.5	164.6	84.8	69.1	97.9	82.5	1114	11

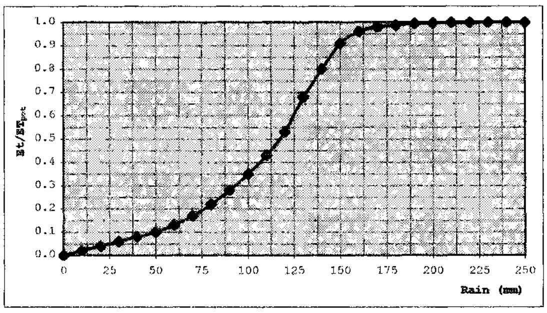
File Name: elev_rain Page:1/1 Date: 4/6/99

Bare Soil Evaporation Calculations

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1993	109.8	108.6	22.7	56.0	106.4	105.2	63.6	50.2	44.2	39.9	66.0	43.4	**816.0**
1992	11.5	14.3	28.4	154.6	85.1	102.6	89.5	94.4	75.9	85.9	75.0	92.0	**909.2**
1991	43.8	5.9	72.4	132.6	73.7	103.7	110.8	147.2	76.5	64.7	57.2	32.1	**920.3**
1990	64.1	71.2	189.0	161.1	97.7	52.6	69.6	75.4	47.9	94.3	49.5	60.5	**1033.0**
1989	41.7	84.0	66.3	164.4	77.9	36.3	101.7	87.8	92.8	98.8	108.9	118.8	**1079.5**
1988	58.7	10.2	50.2	248.1	164.9	104.4	117.4	146.2	92.7	83.6	55.6	50.3	**1182.4**
1987	11.6	22.1	36.9	98.3	124.8	153.2	32.7	68.4	37.2	31.3	134.5	10.1	**761.1**
1986	2.6	4.4	31.0	158.5	86.9	119.0	121.6	95.4	99.8	42.0	49.1	43.0	**853.3**
1985	15.8	44.0	85.9	207.9	103.6	112.2	88.0	79.1	40.0	27.8	72.7	17.2	**894.1**
1984	14.1	9.3	24.1	103.4	23.0	35.9	74.2	72.1	49.3	71.1	93.0	59.1	**628.6**
1983	14.1	42.1	9.7	120.2	86.8	88.7	73.3	147.4	113.5	104.2	76.7	93.8	**970.4**
1982	11.0	15.7	4.8	250.4	170.9	42.7	48.6	174.0	48.7	119.4	137.3	83.6	**1107.1**
1981	1.6	23.8	131.2	158.6	124.8	62.0	142.7	131.3	89.6	55.7	39.0	40.9	**1001.1**
1980	36.1	7.9	51.0	128.1	218.4	93.4	28.3	55.7	26.2	41.5	110.1	7.3	**803.8**
1979	97.9	161.0	90.7	161.5	96.6	86.1	83.4	83.1	39.5	26.5	67.2	28.8	**1022.2**
1978	89.1	121.9	200.0	189.9	70.2	69.7	129.6	142.1	113.6	95.9	48.8	77.6	**1348.4**
1977	55.9	28.7	30.8	283.2	165.5	63.7	140.9	85.3	54.5	66.7	179.4	69.7	**1224.2**
1976	3.1	25.1	18.6	89.7	87.1	62.6	165.3	159.4	81.7	24.8	46.6	59.0	**823.0**
1975	7.6	13.2	20.2	131.5	135.0	113.1	122.1	193.5	102.7	127.4	41.4	19.3	**1026.9**
1974	7.5	12.9	110.3	155.2	62.5	70.0	134.3	180.0	104.5	59.9	52.9	13.9	**963.8**
1973	51.8	42.8	2.7	61.1	111.8	43.2	85.2	138.2	134.5	40.6	58.5	7.1	**777.6**
Average	**35.7**	**41.4**	**60.8**	**153.1**	**108.3**	**81.9**	**96.3**	**114.6**	**74.5**	**66.7**	**77.1**	**48.9**	**959.3**
ET_{ref}	2.50	2.76	3.42	3.06	2.29	2.38	2.35	2.39	3.66	3.43	3.28	3.10	2.89
Suggested Kc	0.07	0.08	0.15	0.92	0.44	0.24	0.31	0.51	0.21	0.18	0.22	0.10	
Another Suggested Kc	0.08	0.09	0.13	0.92	0.43	0.22	0.32	0.50	0.18	0.15	0.19	0.10	
k_c	0.07	0.08	0.15	0.92	0.44	0.24	0.31	0.51	0.21	0.18	0.22	0.10	
ET_{soil}	0.17	0.22	0.51	2.82	1.01	0.57	0.73	1.22	0.77	0.62	0.72	0.31	0.81







File Name: Soil

Page: 1/1

Sheet: Summary
Date: 4/12/99

Forest Evapotranspiration (sample data)

Ndabibi14 may-14 tot oct'98

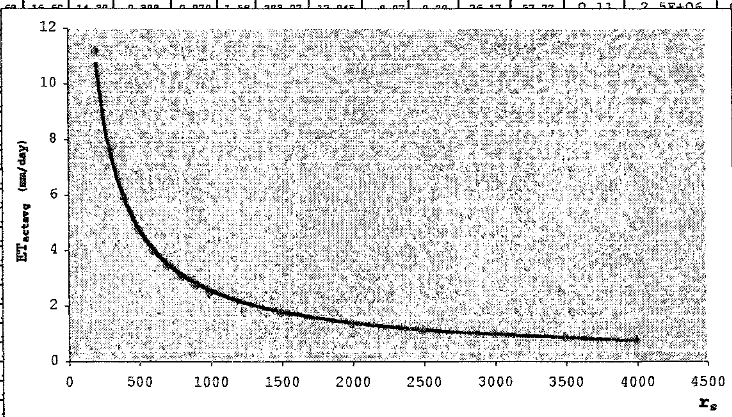
Coordinates of the point

x	203940	Latitude in radians	0.014
y	9912516	Longitude in radians	0.634

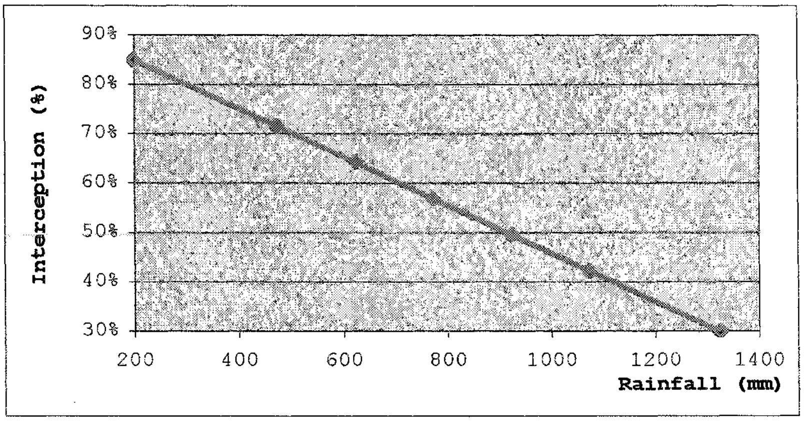
Albedo of Forest	0.25	R_s Maximum Value	600
Air Specific Heat	1004	r_a (taken from Calder)	3.5

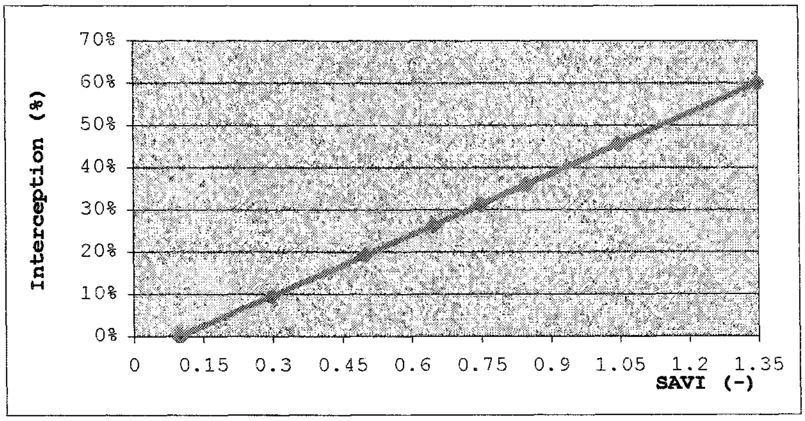
Avg. ET_{act} mm/day
4.0

Date	Day Number of the year	Incoming solar rad	Temp at 2m	Humidity at 2m	sat vap. Pre. e_{sat}	act vap. Pre. e_{act}	Solar declination	Solar distance	Solar hour angle	Extra-terrestrial shortwave	Maximum possible sunshine hours	n/N	actual sunshine hour, n	Net longwave rad.	24 hr.Net Rad, R_n 24hour	Delta	Lamda	Gamma	Pa	Rho	r_s	ET_{act}
[-]	[-]	[W/m²]	[°C]	%	[mbar]	[mbar]	(rad)	(-)	(rad)	[W/m²]	(hours)	[-]	[hour]	[W/m²]	[W/m²]	[Kpa/°C]	[J/Kg]	[Kpa/°C]	[KPa]	[kg/m³]	[s/m]	[mm/day]
05/14/98	134	98.37	15.62	90.30	17.75	16.03	0.324	0.978	1.58	412.63	12.036	0.00	-0.03	19.67	54.11	0.11	2.5E+06	0.05	79.52	0.96	325.3	3.33
05/15/98	135	109.88	17.26	86.29	19.71	17.01	0.328	0.977	1.58	411.88	12.037	0.05	0.55	25.17	57.24	0.12	2.5E+06	0.05	79.63	0.96	600	2.85
05/16/98	136	145.84	17.86	83.90	20.47	17.18	0.332	0.977	1.58	411.13	12.037	0.19	2.34	40.96	68.42	0.13	2.5E+06	0.05	79.67	0.95	600	3.47
05/17/98	137	100.42	17.22	86.31	19.66	16.97	0.337	0.977	1.58	410.40	12.036	0.01	0.10	21.27	54.04	0.12	2.5E+06	0.05	79.63	0.96	600	2.84
05/18/98	138	155.05	17.64	83.89	20.18	16.93	0.340	0.976	1.58	409.67	12.038	0.23	2.83	44.99	71.30	0.13	2.5E+06	0.05	79.66	0.95	600	3.43
05/19/98	139	181.63	17.86	81.17	20.46	16.61	0.344	0.976	1.58	408.96	12.039	0.35	4.17	56.68	79.54	0.13	2.5E+06	0.05	79.67	0.95	600	4.05
05/20/98	140	186.33	18.20	79.08	20.90	16.53	0.348	0.975	1.58	408.26	12.039	0.37	4.42	59.11	80.63	0.13	2.5E+06	0.05	79.69	0.95	600	4.59
05/21/98	141	180.62	17.37	82.30	19.84	16.33	0.352	0.975	1.58	407.57	12.040	0.34	4.15	56.06	79.39	0.13	2.5E+06	0.05	79.64	0.96	600	3.71
05/22/98	142	181.04	17.71	82.97	20.27	16.82	0.355	0.975	1.58	406.90	12.040	0.35	4.18	56.75	79.03	0.13	2.5E+06	0.05	79.66	0.95	600	3.64
05/23/98	143	144.17	17.53	86.89	20.04	17.42	0.359	0.974	1.58	406.24	12.040	0.19	2.34	40.83	67.29	0.13	2.5E+06	0.05	79.65	0.96	600	2.78
05/24/98	144	166.16	18.41	83.53	21.18	17.69	0.362	0.974	1.58	405.60	12.041	0.29	3.46	51.15	73.46	0.13	2.5E+06	0.05	79.71	0.95	600	3.67
05/25/98	145	146.33	17.62	84.93	20.16	17.12	0.365	0.974	1.58	404.97	12.041	0.21	2.46	41.98	67.76	0.13	2.5E+06	0.05	79.65	0.95	600	3.20
05/26/98	146	124.16	17.74	85.99	20.31	17.47	0.368	0.973	1.58	404.35	12.042	0.11	1.37	32.49	60.62	0.13	2.5E+06	0.05	79.66	0.95	600	3.00
05/27/98	147	100.61	16.92	89.67	19.28	17.29	0.371	0.973	1.58	403.76	12.042	0.02	0.19	21.99	53.46	0.12	2.5E+06	0.05	79.61	0.96	661.8	1.92
05/28/98	148	91.44	17.54	87.98	20.06	17.65	0.374	0.973	1.58	403.18	12.042	0.00	0.00	20.59	47.99	0.13	2.5E+06	0.05	79.65	0.96	600	2.54
05/29/98	149	102.34	17.73	87.74	20.30	17.82	0.377	0.972	1.58	402.62	12.043	0.02	0.29	23.16	53.59	0.13	2.5E+06	0.05	79.66	0.95	600	2.62
05/30/98	150	155.27	17.39	82.92	19.86	16.47	0.380	0.972	1.58	402.07	12.043	0.25	2.98	46.12	70.33	0.13	2.5E+06	0.05	79.64	0.96	600	3.58
05/31/98	151	181.54	16.55	81.62	18.83	15.37	0.382	0.972	1.58	401.55	12.043	0.36	4.33	56.80	79.35	0.12	2.5E+06	0.05	79.58	0.96	600	3.66
06/01/98	152	162.01	16.80	82.86	19.14	15.86	0.385	0.971	1.58	401.04	12.044	0.28	3.35	48.74	72.77	0.12	2.5E+06	0.05	79.60	0.96	600	3.47
06/02/98	153	130.22	17.73	83.36	20.29	16.92	0.387	0.971	1.58	400.55	12.044	0.14	1.74	35.62	62.05	0.13	2.5E+06	0.05	79.66	0.95	600	3.55
06/03/98	154	156.75	17.75	82.78	20.32	16.83	0.389	0.971	1.58	400.09	12.044	0.26	3.10	47.40	70.16	0.13	2.5E+06	0.05	79.66	0.95	600	3.68
06/04/98	155	158.56	17.72	83.32	20.28	16.90	0.391	0.971	1.58	399.64	12.044	0.27	3.20	48.26	70.66	0.13	2.5E+06	0.05	79.66	0.95	600	3.56
06/05/98	156	160.48	17.17	84.53	19.60	16.56	0.393	0.970	1.58	399.21	12.045	0.27	3.31	48.77	71.59	0.12	2.5E+06	0.05	79.62	0.96	600	3.20
06/06/98	157	83.50	16.88	86.01	19.23	16.54	0.395	0.970	1.58	398.81	12.045	0.00	0.00	20.33	42.30	0.12	2.5E+06	0.05	79.60	0.96	600	2.84
06/07/98	158	154.42	16.57	83.68	18.87	15.79	0.397	0.970	1.58	398.43	12.045	0.25	3.01	45.74	70.08	0.12	2.5E+06	0.05	79.58	0.96	600	3.26
06/08/98	159	111.18	14.58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.11	2.5E+06	0.05	79.45	0.96	279.1	3.86
06/09/98	160	94.45	15.68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.52	0.96	719	1.80
06/10/98	161	77.35	15.54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.51	0.96	4089	0.35
06/11/98	162	140.07	16.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.55	0.96	600	2.78
06/12/98	163	81.58	14.97	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.47	0.96	201.1	4.70
06/13/98	164	160.31	17.36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.64	0.96	600	3.78
06/14/98	165	157.05	16.48	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.58	0.96	600	3.29
06/15/98	166	131.81	15.77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.53	0.96	600	2.75
06/16/98	167	118.88	14.90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.47	0.96	600	2.38
06/17/98	168	187.13	17.65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.66	0.95	600	4.83
06/18/98	169	103.33	15.63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.52	0.96	600	2.51
06/19/98	170	157.33	16.16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.56	0.96	600	2.82
06/20/98	171	237.34	15.74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.53	0.96	600	3.62
06/21/98	172	283.54	14.69	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.45	0.96	600	3.33
06/22/98	173	284.41	15.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.48	0.96	600	3.87
06/23/98	174	236.48	16.12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.55	0.96	600	3.32
06/24/98	175	230.82	15.14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.49	0.96	600	3.14
06/25/98	176	228.58	17.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.61	0.96	600	3.63
06/26/98	177	103.69	14.76	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.46	0.96	392.4	3.06
06/27/98	178	207.71	15.21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.49	0.96	600	2.90
06/28/98	179	197.80	15.21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.49	0.96	600	3.24
06/29/98	180	120.69	14.07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	79.41	0.96	600	2.52
06/30/98	181	96.38	12.64	87.76	14.63	12.84	0.404	0.967	1.58	396.03	12.046	0.01	0.07	19.42	52.87	0.10	2.5E+06	0.05	79.31	0.97	296.8	3.83
07/01/98	182	181.45	14.56	84.26	16.58	13.97	0.403	0.967	1.58	396.22	12.046	0.37	4.45	55.92	80.16	0.11	2.5E+06	0.05	79.45	0.96	600	2.79
07/02/98	183	158.69	16.01	82.15	18.20	14.96	0.402	0.967	1.58	396.42	12.046	0.27	3.27	47.43	71.60	0.12	2.5E+06	0.05	79.55	0.96	600	3.45
07/03/98	184	190.10	16.27	82.06	18.51	15.19	0.401	0.967	1.58	396.65	12.046	0.41	4.88	61.22	81.35	0.12	2.5E+06	0.05	79.56	0.96	600	3.52
07/04/98	185	78.76	14.45	90.29	16.46	14.86	0.399	0.967	1.58	396.90	12.045	0.00	0.00	19.53	39.54	0.11	2.5E+06	0.05	79.44	0.96	201.5	4.91
07/05/98	186	128.61	15.62	85.31	17.75	15.14	0.397	0.967	1.58	397.17	12.045	0.14	1.71	34.16	62.30	0.11	2.5E+06	0.05	79.52	0.96	600	2.77
07/06/98	187	81.19	14.68	86.19	16.71	14.40	0.396	0.967	1.58	397.47	12.045	0.00	0.00	19.56	41.34	0.11	2.5E+06	0.05	79.45	0.96	600	2.46
07/07/98	188	152.42	15.85	82.79	18.01	14.91	0.394	0.967	1.58	397.78	12.045	0.24	2.92	44.38	69.94	0.12	2.5E+06	0.05	79.53	0.96	600	3.29
07/08/98	189	198.23	16.18	82.43	18.40	15.17	0.392	0.967	1.58	398.12	12.044	0.44	5.27	64.34	84.33	0.12	2.5E+06	0.05	79.56	0.96	600	3.43
07/09/98	190	202.49	14.40	82.68	16.41	13.57	0.390	0.967	1.58	398.48	12.044	0.45	5.47	64.05	87.82	0.11	2.5E+06	0.05	79.43	0.96	600	3.04
07/10/98	191	182.88	14.45	80.55	16.47	13.26	0.388	0.967	1.58	398.86	12.044	0.37	4.46	55.75	81.41	0.11	2.5E+06	0.05	79.44	0.96	600	3.42
07/11/98	192	214.49	16.42	76.24	18.69	14.25	0.385	0.967	1.58	399.26	12.044	0.50	6.07	71.07	89.80	0.12	2.5E+06	0.05	79.57	0.96	600	4.70
07/12/98	193	174.70	16.11	81.89	18.31	15.00	0.383	0.968	1.58	399.68	12.043	0.33	4.02	53.68	77.22	0.12	2.5E+06	0.05	79.55	0.96	600	3.52
07/13/98	194	166.43	15.83	84.97	18.00	15.29	0.380	0.968	1.58	400.12	12.043	0.30	3.59	50.04	74.78	0.12	2.5E+06	0.05	79.53	0.96	600	2.88
07/14/98	195	94.45	15.28	85.05	17.37	14.91	0.378	0.968	1.58	400.58	12.043	0.00	0.00	19.76	51.08	0.11	2.5E+06	0.05	79.50	0.96	600	2.61
07/15/98	196	100.82	15.48	85.09	17.60	14.97	0.375	0.968	1.58	401.06	12.042	0.02	0.23	21.76	53.85	0.11	2.5E+06	0.05	79.51	0.96	600	2.79
07/16/98	197	115.33	14.93	88.23	16.98	14.98	0.372	0.968	1.58	401.55	12.042	0.08	0.96	27.64	58.86	0.11	2.5E+06	0.05	79.47	0.96	538.2	2.37
07/17/98	198	82.24	14.94	87.08	16.99	14.79	0.369	0.968	1.58	402.07	12.042	0.00	0.00	19.66	42.02	0.11	2.5E+06	0.05	79.47	0.96	4335	0.33
07/18/98	199	87.42	15.23	87.13	17.31	15.09	0.366	0.968	1.58	402.60	12.041	0.00	0.00	19.76	45.80	0.11	2.5E+06	0.05	79.49	0.96	600	2.37
07/19/98	200	125.91	15.71	85.57	17.85	15.27	0.363	0.968	1.58	403.14	12.041	0.12	1.48	32.26	62.18	0.11	2.5E+06	0.05	79.52	0.96	600	2.74
07/20/98	201	165.65	16.09	84.56	18.29	15.47	0.360	0.969	1.58	403.70	12.041	0.29	3.48	49.28	74.95	0.12	2.5E+06	0.05	79.55	0.96	600	3.00
07/21/98	202	172.99	15.26	85.71	17.34	14.86	0.356	0.969	1.58	404.28	12.040	0.32	3.83	51.58	78.16	0.11	2.5E+06	0.05	79.49	0.96	600	2.65



Interception as Percentage of the Rainfall as a Fuction of Rainfall and SAVI





File Name: interception Page: 1/1 Date: 4/6/99

Farm Inventory

Farm Name	Total Area (ha)	Permit Validity		Water Consumption (M^3/Day)				Area Under Agriculture		Population	Total No. of Cattle	Remarks
		From	To	Irrig.	Domestic	Livestock	Others	Crop	Area (ha)			
Sulmac Flowers	2538	1998	2003	11704	4545	------	5474	Flowers Maize Vegetab.	445 50 20	20000	--	Pest Spray and environmental protection.
Samuel Mbugua	32	1974	1975	605	2.5	40	30	Vegetab. Grass	16 16	--	70	40 cattle and 30 sheep
Cutuni	6	--	--	27	--	--	--	Vegetab.	1.2	--	--	
Gilka Brothers	1107	--	--	454	4.54	--	--	Beans Flowers	20 30	100	--	
HansRudolf	4	--	--	605	1.4	4	--	Vegetab.	1.2	15	4	
Ruth Mumbi Muira	4.5	--	--	45	9	20	--	Beans Vegetab. Chilis Fodder	0.8 0.2 0.2 0.4	--	20	
Joka Kanguru	21.4	--	--	450	--	--	--	Beans Onions Cabbages	8 8 4	--	--	
African	8.1	--	--	36	--	--	--	Vegetab.	1.6			
Homegrown	80	--	--	1800	--	--	--	Flowers	80	--	--	
Barton Bernard	220	--	--	167	--	--	--	Grass Oranges	8.1 8.1	--	--	
David Njuguna	5.4	--	--	145	5.6	--	--	Beans Cabbages Potatoes	2.4 2 1	20	40	20 cows, and 20 sheeps
Elivd	?	--	--	18.2	45.5	1000	4.5	Vegetab.	0.8	--	1000	4.5 for cleaning tools.
Ministry of Energy	--	--	--	--	--	--	2600	--	--	--	--	Geothermal Drilling
Francis	3.4	--	--	90	--	--	--	Vegetab.	4	--	--	
Joice Nganga	4.4	--	--	36	--	--	--	Beans Vegetab. Maize	0.9 0.45 0.45	--	--	
Jan Mielsen	8	--	--	181	0.9	--	--	Flowers	8	10	--	
Joseph Kanani	11	--	--	90	--	--	--	Cabbages Maize Potatoes Beans	2 3 2 3	--	--	
W.S. Calder	8	1981	1998	20	--	--	--	--	--	--	--	
Campell	8.1	1976	1998	130	1.5	--	--	Fodder	6	--	--	
Junita	4.5	1967	1998	95	--	--	--	Lucerne	3.6	--	--	
Kijabe Hill Ltd.	10	1989	1998	227	3.2	25	--	Lucerne Maize Potatoes	3.2 3.2 3.2	6	25	
PiusHgugi	24.3	--	--	540	--	--	--	Various	24	--	--	
Sundance	20	1989	1992	363	--	--	--	Vines	16.2	--	--	
Kimema Ltd.	81	--	--	1800	--	--	--	Flowers	81	--	--	
Wefam Investment	11	--	--	72	5.6	30	500	Grass Vegetab.	2.4 0.8	46	30	500 chicken. Poultry were agreed to consume at the rate of
Kipabungi Ltd.	21.3	1993	1995	45.5	4.5	2000	500	--	--	35	2500	2000 cows, and 500 sheeps
Kiboko Ltd.	9.3	--	--	182	12	70	--	Citrus Vegetab.	6 2	112	70	
Longonot Horticultur	121	--	--	273	11.4	--	--	Vegetab. Flowers	80 40	207	--	
Maua Horticultur	93	--	--	727	--	--	--	Vegetab. Flowers	20.2 12.1	--	--	
Mwai Thogo	18.6	--	--	348	--	--	--	Vegetab. Melons Oranges Potatoes	4.9 4.9 4.9 4	--	--	
Moses Kioi Muturi	4.5	--	--	100	1.6	30	20	Maize Lucerne	2.4 2	--	50	20 sheeps
Mbugua Kugu	38	--	--	90	--	--	--	Maize Beans Potatoes Cabbages	2 2 3 3	--	--	
Mania Wanja	4	--	--	45	--	--	--	Vegetab.	2	--	--	
Mutati Transpoted	32	--	--	720	22.7	150	200	Fodder Vegetab.	8.1 24.3	200	350	200 Sheeps
Ngati F.C.S. Ltd.	1401	--	--	--	38	1000	--	--	--	--	1000	
Nguru Matiru	7.5	--	--	90	1.35	8	15	Beans Cabbages Onion Potatoes	2 1.5 0.4 0.1	--	23	15 sheeps
Safariland	4.5	--	--	17	--	--	--	Vegetab.	7.7	--	--	
Harison	5.6	--	--	18	--	--	--	Vegetab.	0.8	--	--	
Peter Edward	10	--	--	--	2.7	6	--	--	--	24	6	
Sam Erasto	8	--	--	18	--	--	--	Vegetab.	0.8	--	--	
Starley	4	--	--	18	--	--	--	Vegetab.	0.8	--	--	
T.P.K.	8.1	--	--	90	--	--	--	Fodder	2	--	--	
Horclam	12.1	--	--	272	--	--	--	Flowers	12	--	--	
KWS, TI	70	--	--	--	--	--	2400	--	--	--	--	Fish Farming
Updown Ltd.	20.8	--	--	15.1	2.3	30	--	Grass Vegetab. Flowers	0.8	20	30	
J.M.Kangari	809	1974	1978	677	--	--	--	Lucerne	30.4	--	--	
E.A.P.L.C.		1975	1998		4.5	--	2610	--	--	--	--	Power Generation
Loldia Ltd	?	1986	1990	2727	--	--	--	Lucerne Maize Beans Vegetab.	30.3 30.3 30.3 30.3	300	--	

Sheet: Unique Data
4/6/99

File Name: Water

Farm Inventory

Korongo Ltd	70	1974	1998	681.5	--	--	--	Gerranium	10.5	--	--	
					--	--	--	Grass	19	--	--	
Loldia Ltd	2278	1974	1983	113	--	--	--	Maize	3	--	--	
					--	--	--	Lucerne	3	--	--	
					--	--	--	Sorghum	3	--	--	
					--	--	--	Cagicum	3	--	--	
Edward John	148	1978	1998	1086	20.8	--	--	Vegetab.	20.2	125	--	
						--	--	Flowers	364		--	
Reymond Mareenward	35.6	1978	1998	9.1	1.36	--	--	--	--	15	--	Minor irrigation, less than 2 (two) acres
Gold Smith	13	1979	1998	800	4.5	0.5	--	Grn. Pepper	11.8	3	11 horses	0.5*people & 0.5*Cattle
							--	Vegetab.	1.2			
Il Njoro	30	1979	1998	68	4.6	2.6 people & 2.0 cattle	--	--	--	50	45	only cattle
							--	--	--			
Nderit Estat Ltd	1.6	1979	1998	68	--	--	--	Beans	0.8	--	--	
					--	--	--	Vegetab.	0.8	--	--	
Stephan Henry	1.6			34	--	--	--	Beans	0.8	--	--	
					--	--	--	Vegetab.	0.8	--	--	
Eraskine Enterprises Ltd.	326	1980	1998	7415	--	--	--	Vegetab.	80.1	--	--	
					--	--	--	Grass	168	--	--	
					--	--	--	Potatoes	40.5	--	--	
					--	--	--	Sun Flower	40.5	--	--	
Graylag Farm	93	1975	1998	1030	--	--	--	Vegetab.	50	--	--	
Loldia Ltd	2278	1996	1998	115	--	--	--	Lucerne	8.1	--	--	
					--	--	--	Wheat		--	--	
					--	--	--	Vegetab.		--	--	
Homegrown (Flaminco)	80	1993	1998	1800	--	--	--	Strawberry	14.6	--	--	Asparagus is a fooder crop for selling as they don't have cattle
					--	--	--	Melons	1.5	--	--	
					--	--	--	Vegetab.	6	--	--	
					--	--	--	Asparagus	7	--	--	
					--	--	--	Agroforestry	15	--	--	
Tirisha Muthoni	4	1987	1998	45.4	--	--	--	Vegetab.	2	--	--	
A.K.Karenju	4	1978	1998	54.5	--	--	--	Vegetab.	2.4	--	--	
Aberdare Estates Ltd	392	1987	1998	200	2.1	--	--	Beans	10.1	--	--	
						--	--	Fodder	30.3	--	--	
Gienbag Ltd	92	1980	1998	1481	18.7	15	--	--	--	71	400	
Homegrown (Pelican)	111	1998	2000	2592	37.8	--	32	--		520	--	
											--	
Mundui	458	1983	1999	11.35	--	--	--	Cabbages	0.6	--	--	
Michael	1590	1980	1998	45.5	--	--	--	Vegetab.	2	--	--	
Nini Ltd.	40	1989	1998	818	31	45.5	--	Vegetab.	12.1	20	120 cows & 1000	
							--	Lucerne	8.1			
							--	Fodder	16.2			
Otterhead	24	1967	1998	10	4.5	--	--	Vegetab.	0.4	--	--	
Kamuta Ltd	93.2	1983	1987	2454	7.2	2.7	--	Lucerne	56	128	60	
Akberali	6	1986	1998	91	--	--	--	Vegetab.	4	--	--	
Samuel Mwaura	8.9	1987	1998	91	--	--	--	Vegetab.	4	--	--	
John Charles	7.7	1987	1998	91	3.9	--	--	Tomato	2	10	15 cows & 10 Sheep & 15	
						--	--	Aikchako	0.4			
						--	--	Asparagus	0.8			
						--	--	Vegetab.	1.2			
						--	--	fruits				
Major Erelya Wood	23	1970	1998		1	--	--	--	--	--	--	
Walter Kitchener	20	1980	1998	91	--	--	--	Horticulture	4	--	--	
Oserian	2023	1974	1978	10862	--	--	--	Flowers	485			
Brixia Ltd.	405	1972	1998	510	22	--	--	Vegetab.	20	8	150 cows & 300	other area is hilly area. People get 50 % of the water, and the rest goes to cattle
Geoffrey & partners	4	1968	1998	105	--	--	--	Vegetab.	3.6	--	--	
								Lucerne	0.4			
Longonot Farm	9710	1968	1998	180	--	--	--	Flowers	7	--	--	
								Vegetab.	1			
								Fruit	1			
								Potatoes	21			
								Others				
Richard Donald	16.6	1977	1993	271	--	--	--	Lucerne	2	--	--	
								Potatoes	0.8			
								Vegetab.	1.2			
Richard	16.6	1993	1998	271	15	--	--	Flowers	12	300	--	
Safariland Club	42.4	1980	1983	10	--	--	--	Vegetab.	0.4	--	--	
								Flowers				
Mohamad Hussein	8.5	1980	1998	91	9	--	--	Vegetab.	1.6	30	10 cows & 600	
								Fruits	1.2			
								Flowers	1.2			
Korongo	138	1957	1998	1810	--	--	--	Lucerne	80	--	--	
Charles	9	1966	1998	450	--	--	--	Potatoes	20	--	--	
Mohamad Islam	8	1966	1998	115	4.5	--	--	Tomatoes	5	40	10 cows & 500 Chicke	80% of the domestic water use goes to people,, and the rest goes to cattle.
								Potatoes				
								Lettuce				
								others				
John Burch	20	1967	1998	180	--	--	27	Peas	2	--	--	
								Potatoes	2			
								Lucerne	4			
Diector Vertenery	210	1961	1985	1130	--	--	--	Lucerne	20	--	--	
Osirua Ltd	28	1992	1998	830	--	--	--	Lucerne	20	--	--	
								Flowers	4			
								Maize	2			
								Potatoes	2			

Sheet: Unique Data
4/6/99

File Name: Water

Farm Inventory

Diector Vertenery	210	1961	1985	1130	--	--	--	Lucerne	20	--	--	
W.S. Calder	8	1981	1998	20	--	--	--	--	--	--	--	
Junita	4.5	1967	1998	95	--	--	--	Lucerne	3.6	--	--	
Campell	8.1	1976	1998	130	1.5	--	--	Fodder	6	--	--	
Osirua Ltd	28	1992	1998	830	--	--	--	Lucerne Flowers Maize Potatoes	20 4 2 2	--	--	
Mundai	463	1975	1978	9		--	--	Vegetab.	0.5	--	--	
Calvilo Ltd	16187	1975	1980	2.3	2.3	--	--	Vegtab.	0.4	--	--	
La Pieve	5944	1976	1999	20	163			Cabbages	1			
Eric Stephenson	8			126	1.8	--	--	Harley Vegetab. Grass	0.8 0.8 4		20 Horses & 15 Sheeps	
M.D.Edwards	800	1990	1992	2270	2.7	3	--	Flowers Beans Cabbages Onions	16 6 6 12	--	--	
V.B.Jackman	16	1990	1991	40	--	--	--	Lucerne Potatoes Vegetab.	2 0.8 1.2	--	--	
A.G.B.V.Rocco	1100	1972	1996	900	--	--	--	Lucerne Vegetab.	20 20	--	--	
B.J. Barton	220	1989	1998	14	4.6	--	--	Fruit Vegetab.	0.6	34	50	50% of water goes to people.
Kinji Nurseries Ltd.	105	1969	1993	430	1.4	1	--	Roses Vegetab. Lucerne	2 4 12	5	--	
Lake Naivasha	21.2	1987	1998	40	--	--	--	Lucerne Flowers	5	--	--	
Naivasha Ushirika	--	--	--	--	265	--	--	--	--	--	--	Borehole/ Public Use
Corner Water	--	--	--	--	40	--	--	--	--	--	--	
Nyakairu Water	--	--	--	--	70	--	--	--	--	--	--	
Cesare Bellingeri	48.7	--	--	--	22.7	--	--	--	--	--	--	
Put Sarajevo General	--	--	--	--	--	--	300	--	--	--	--	Road Construction, from Malewa River, only for 5 months
IthIma Water Pr.	--	--	--	--	6.5	6.5	0.8	--	--	170	170 cows & 100	for sheeps only
Kiuself Help Water	--	--	--	--	57	--	--	--	--	--	--	Water for local Communities
Naivasha Girls Sec.	--	--	--	--	85	--	--	--	--	--	--	Borehole for Domestic
K.D.H. Sec. School	--	--	--	--	38	--	--	--	--	--	--	Borehole
Good Faith Water	--	--	--	6	12	--	--	--	--	--	--	Borehole
Milamuni Water	--		--	--	19	--	--	--	--	--	--	Borehole, Local Authority
Chepirelwe Ltd.	53	1982	1998	100	8.2	--	--	Lucerne Citrus Potatoes Onions Coffee	2 2 8 8 2	60	30 cows & 150 sheep	People use 4.6 m³/d
Naivasha Municipal Council	--	--	--	--	432	--	--	--	--	--	--	With lots of flouride causing health problems. That amount is considered very much low for
Farms change crop pattern a lot depending on the market. Big farms don't change so often.												
Catholic	--	--	--	--	192	--	--	--	--	--	--	
Naivasha Mixed Sec.	--	--	--	--	22	--	--	--	--	--	--	Borehole
Naivasha Municipal Council	--	--	--	--	800	--	--	--	--	--	--	Borehole/ puplic use
Naivasha Municipal Council	--	--	--	--	1590	--	--	--	--	--	--	another bore hole/ puplic use
Naivasha Municipal Council	--	--	--	--	500	--	--	--	--	--	--	another bore hole/ puplic use
Pan African Vegetable Produce	--	--	3800	--	--	--	--	--	--	--	--	Borehole
Total Water Consumed (m^3/yr)				24,138,753	5,835,183		5,974,093	**Total**	3,246			

Sheet: Unique Data
4/6/99

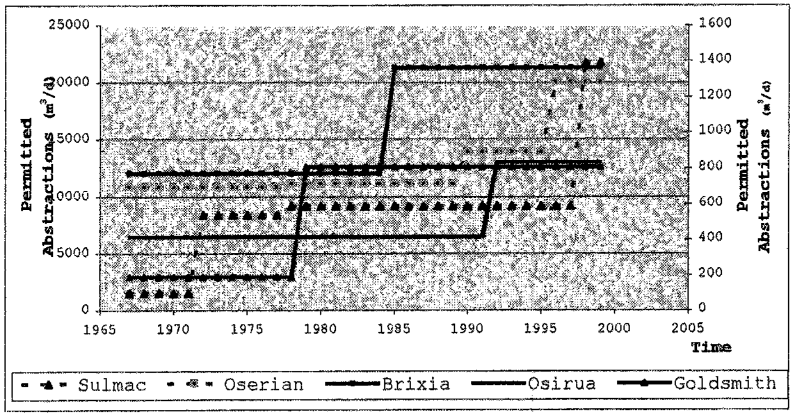
File Name: Water

Page 3/3

Farm Inventory

Farm Name	Permit Validity		Water Consumption				
Sulmac	1967	1972	1544	0	0	0	**1544**
	1972	1978	8328	4	76	0	**8408**
	1978	1989	9090	96	0	0	**9186**
	1989	1994	9090	96	0	0	**9186**
	1998	2003	11704	4545	0	5474	**21723**
Oserian	1974	1978	10862	--	--	--	**10862**
	1978	1983	11132	--	--	--	**11132**
	1990	1994	13859	--	--	--	**13859**
	1996	1998	14772	5274	--	--	**20046**
Brixia	1983	1985	770	0			**770**
	1988	1988	1363				**1363**
	1967	1992	415	0			**415**
	1992	1998	830				**830**
Gold Smith	1970	1979	189	0	0		**189**
	1979	1980	800	4.5	0.5		**805**

Date	Sulmac	Oserian	Brixia	Osirua	Goldsmith
1967	1544	10862	770	415	189
1968	1544	10862	770	415	189
1969	1544	10862	770	415	189
1970	1544	10862	770	415	189
1971	1544	10862	770	415	189
1972	8408	10862	770	415	189
1973	8408	10862	770	415	189
1974	8408	10862	770	415	189
1975	8408	10862	770	415	189
1976	8408	10862	770	415	189
1977	8408	10862	770	415	189
1978	9186	11132	770	415	189
1979	9186	11132	770	415	805
1980	9186	11132	770	415	805
1981	9186	11132	770	415	805
1982	9186	11132	770	415	805
1983	9186	11132	770	415	805
1984	9186	11132	770	415	805
1985	9186	11132	1363	415	805
1986	9186	11132	1363	415	805
1987	9186	11132	1363	415	805
1988	9186	11132	1363	415	805
1989	9186	11132	1363	415	805
1990	9186	13859	1363	415	805
1991	9186	13859	1363	415	805
1992	9186	13859	1363	830	805
1993	9186	13859	1363	830	805
1994	9186	13859	1363	830	805
1995	9186	13859	1363	830	805
1996	9186	20046	1363	830	805
1997	9186	20046	1363	830	805
1998	21723	20046	1363	830	805
1999	21723	20046	1363	830	805



Domestic Water Consumption

Consumer	Unit	Rates* HP	MP	LP	HC	MC	LC	Modification	total no
People with IC	l/p/day	60	**50**	40	250	150	75		
People without IC	l/p/day	20	15	10	0	0	20		
Livestock Unit	l/head/day	50						Preparatory Sch	77
Boarding School	l/p/day	50						Primary Sch	37
Day School	l/p/day	25		5				Secondary Sch	8
Hospitals	l/bed/day	400	200	100				Gov. Hospitals	11
Dispensaries	l/day	5000						Priv. Hosp.	33
Hotels	l/bed/day	600	300	50				..	19
Admin. Offices	l/p/day	25							
Bars	l/day	500						& restaurant	81
Shops	l/day	100						Eating Houses	250
Wild life unit	l/head/day	25							

* from design manual for water supply in Kenya

HP: High Potential = Rainfall>800 mm/yr
MP: Med. Potential = Rainfall:600-800 mm/yr
LP: Low Potential = Rainfall<600 mm/yr
IC: Individual connection, tap inside the house!
Livestock unit: 1 grade cow=3 indegenous cows=2.5 donkeys=2.08 camels=15 sheep/goat
Wild life unit: 0.11 elefant=0.69 buffaloes= 1.15 zebra= 2.09 waterbuck= 2.2 wild beast=5.63 warthog.
Wild life unit: 0.91 giraffs= 1.38elands=5 orix=5.63 heart beast=11.25 ostrich=15 gazelle=16 impalas.

The rates include 20% losses, and in some areas losses may increase.
Naivasha town: 30% Low potential, 70% medium potential, around 2% high potential
Poultry consume normally 0.5l/head/day, but for design purposes we take 2l/head/day

Naivasha town

Growth rate 79-89	89-99	Population in 1989	1979	Inflation rates 84	85	86	87	88	89	90	91	92	93
11%	8%	11491	34519	9%	11%	6%	7%	11%	13%	16%	20%	27%	46%

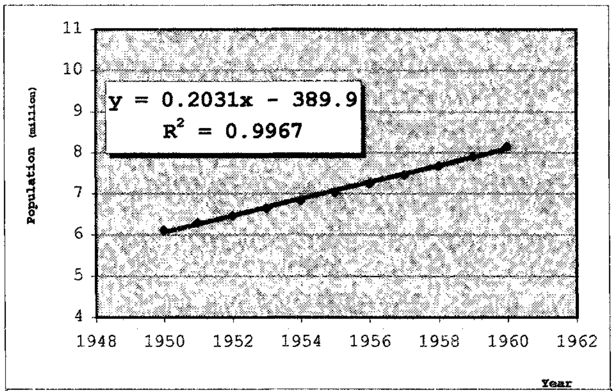
Linear Growth rate [illegible] Major Urban	Minor Urban	Rural	Growth Rate vest	heep
7.0%	4.5%	2.5%	2%	5%

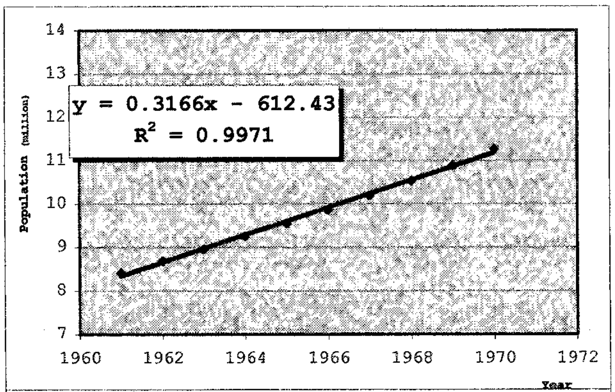
one of the highest gross rates in kenya, and the highest in Nakuru district.
Most of the developments don't have a good documentation of their projects, therefore, certain assumptions have to be made where important information was not available.
Future demands projected for 20 years planning horizon using the past trends.

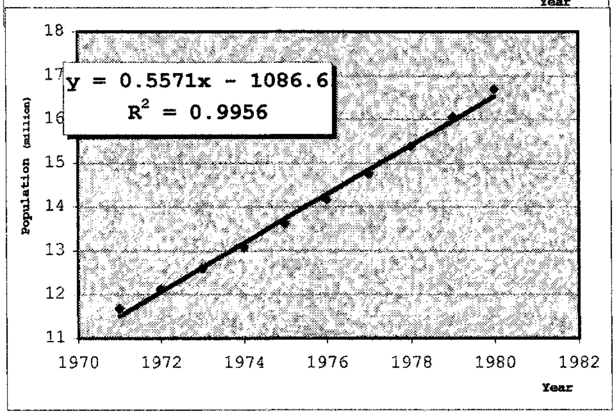
File Name: nakuru Page: 1/1 Date: 4/6/99

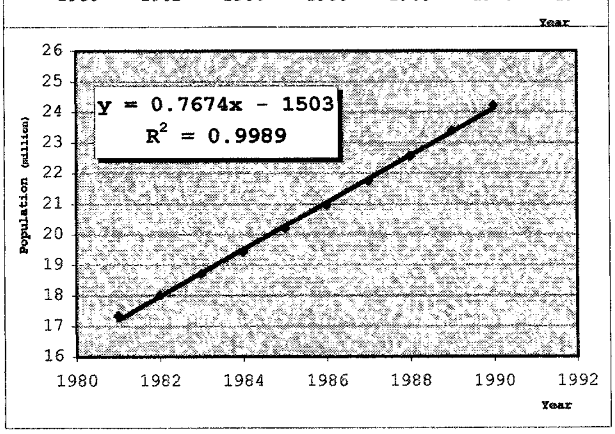
Population Growth Rate for Different Decades

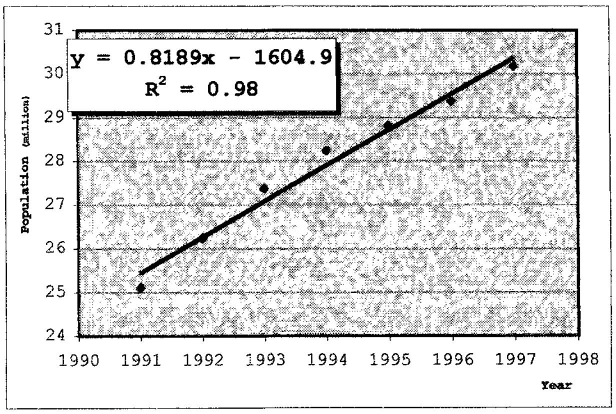
Population Growth Rates

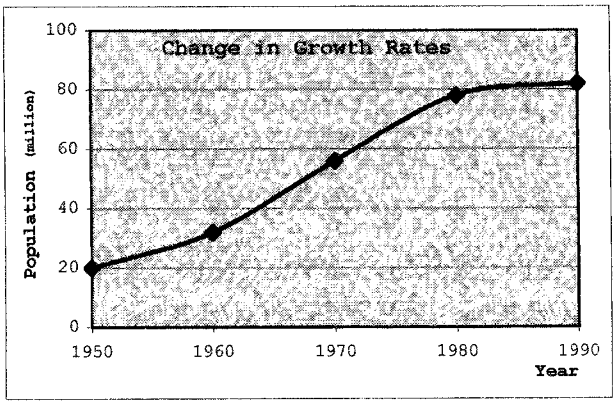












File Name: population Page: 1/1 Date: 4/6/99

Market Prices

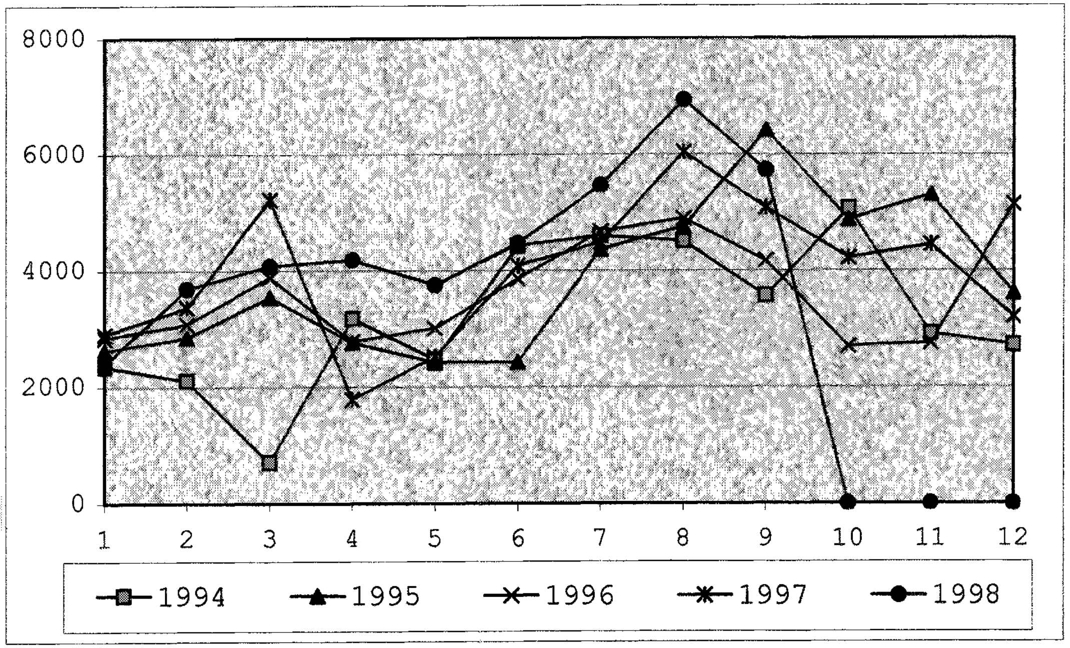
Category	Product	Price (Ksh/kg)	Vendor	Remarks
Protein				
	Fish	140		
	Meat	180	A big butchery in Naivasha	Silver side beef
	Fillet Steak	280	A big butchery in Naivasha	In rainy season meat prices increase
	Multon	170	A big butchery in Naivasha	Goat Meat
	Liver	180	A big butchery in Naivasha	
	Kidney	180	A big butchery in Naivasha	
	Avg	**188.333**		
	Chicken	160	Individual producer in Naivasha	
	Eggs	180	Individual producer in Naivasha	Per Tray
	Milk	18	Kenya Corporation Creameries (KCC)	Per Half Litre
vegetables				
	Carrots	30	Directly from a farm	
	Onions	70		
	Frensh Beans	70		
	Tomato	60		
	Potatoes	30		
	Ginger (fresh	300		
	Cabbages	30		
	Green Maize	10		Per Piece
	Green Peas	200		
	Sukuma	28		
	Spinach	25		
	Fresh Garlic	300		
	Cafsum	60		
	Avg	94.8462		
Fruits				
	Banana	40	Market	
	Raw Banana	7		
	Orange	40		
	Pineapple	25		
	Paw Paw	58		
Groceries				
	Rice	75-150	Naivasha Materesses LTD. (Supermarket)	
	Wheat Flower	40		
	Maize Flower	25		
	Coffee			
	Tea			
	Coke			

File Name: mrktprc Page1 of 1 Date: 4/6/99

Annual Visitors to Hells Gate Nationla Park

Month	Total Visitors					
	1993	1994	1995	1996	1997	1998
Jan	0	2346	2615	2838	2900	2386
Feb	0	2102	2844	3077	3361	3684
Mar	0	706	3541	3886	5218	4078
Apr	0	3176	2760	2778	1783	4185
May	0	2470	2416	3009	2518	3750
Jun	0	4422	2416	3858	4081	4463
Jul	0	4594	4361	4663	4475	5462
Aug	0	4505	4747	4890	6037	6931
Sep	0	3563	6412	4168	5076	5718
Oct	0	5061	4873	2694	4218	0
Nov	0	2909	5298	2749	4444	0
Dec	0	2717	3611	5134	3201	0
Total	**0**	**38571**	**45894**	**43744**	**47312**	**40657**

47312
43235.6



File Name: helsgate

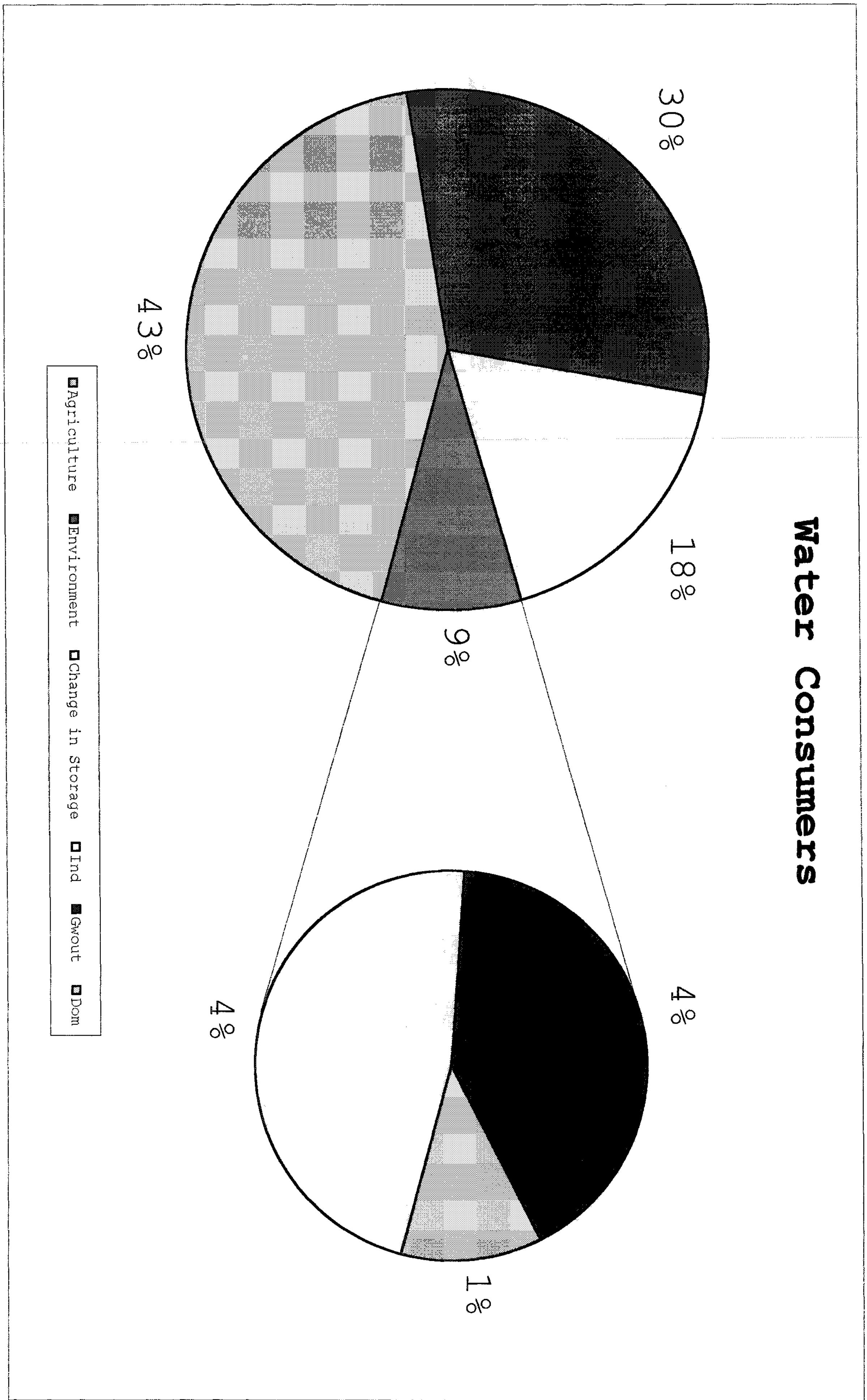
Page: 1/1

Date: 4/6/99

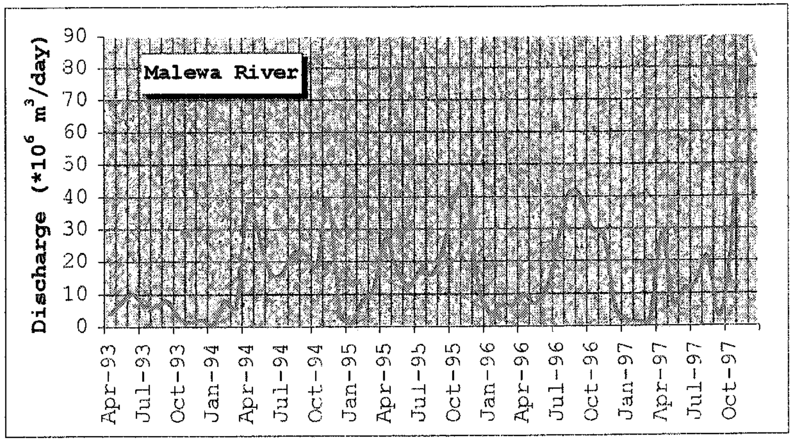
File Name: Consumers

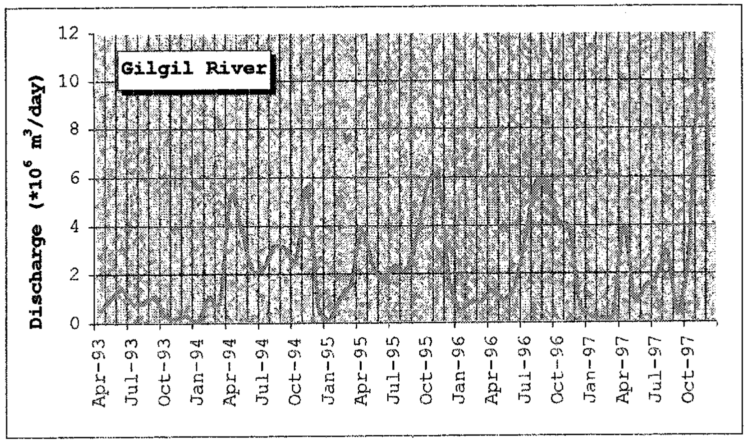
Page: 1/1

Date: 4/6/99

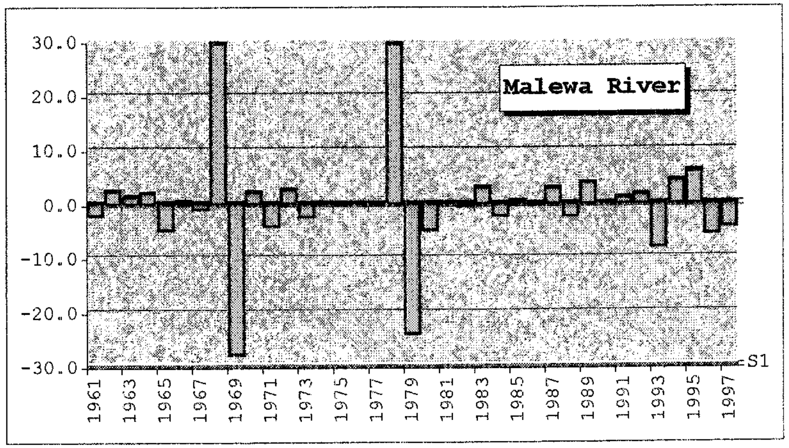


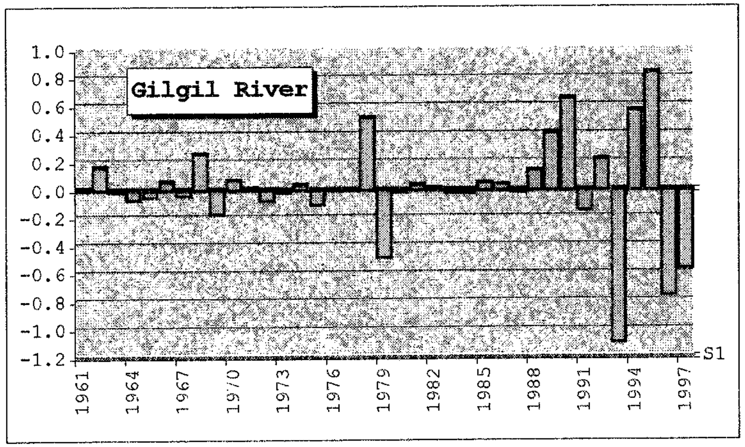
Malewa Gilgil rivers Hydrographs and Annual Change in Discharge





Annual Change in Discharge (*10^6 m^3/month)



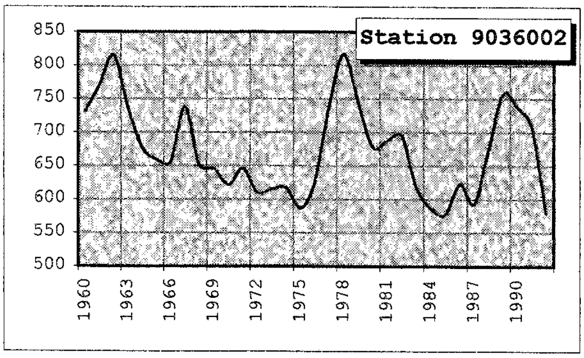


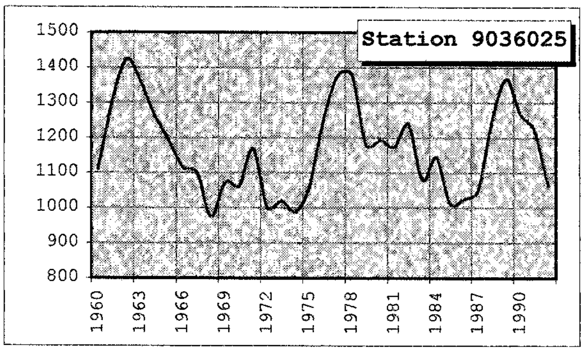
File Name: flowfile5new

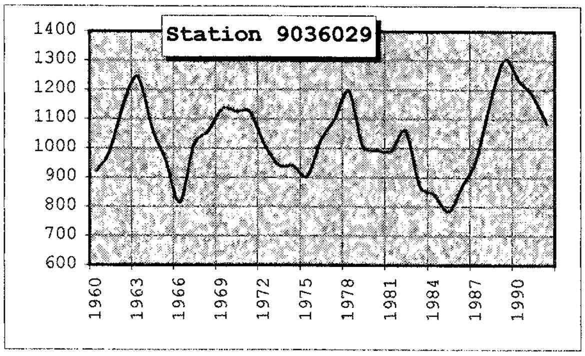
Page: 1/1

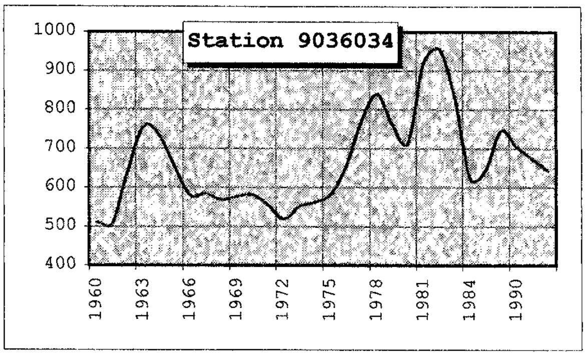
Date: 4/8/99

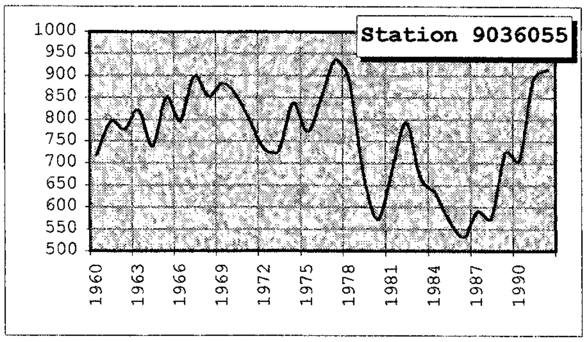
Three years Moving Average of Selected Rainfall Stations

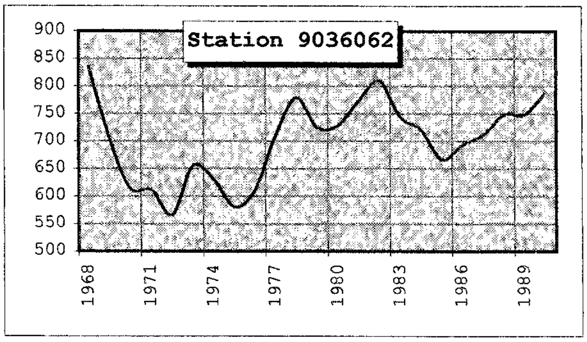


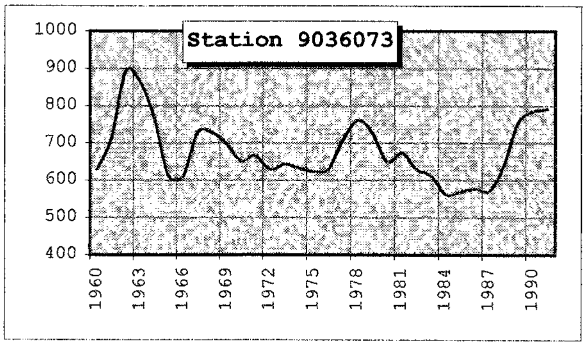


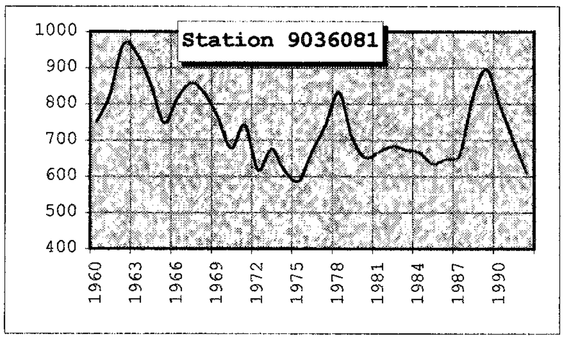






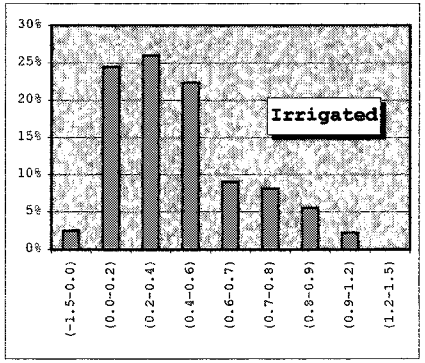


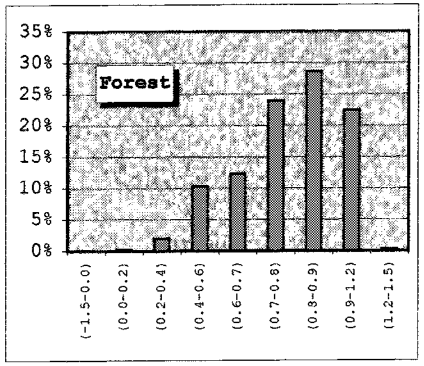


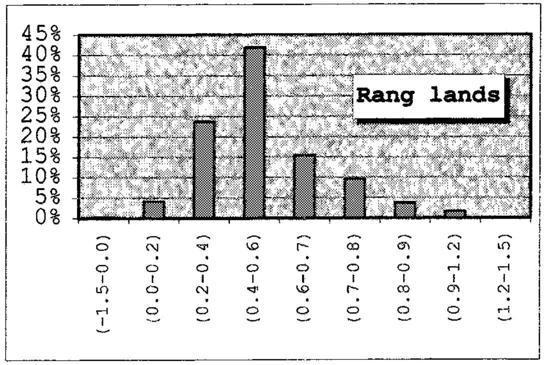


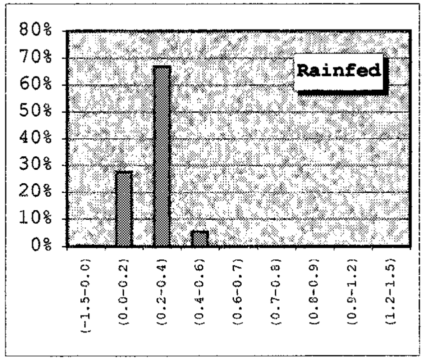
SAVI Clases for Different Covers

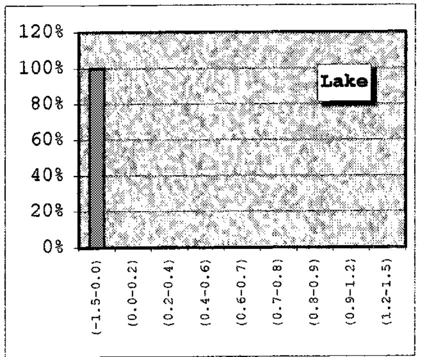
Sliced SAVI	Landuse7 Classes Irrigate(	Rainfed	Forest	ınge Lan(	Lake	Wetlands		Irrigate	Rainfed	Forest	ınge Lan	Lake	Wetlands
(-1.5-0.0)	2.45%	0.15%	0.05%	0.15%	99.88%	5.25%	####	9	0	0	0	100	18
(0.0-0.2)	24.45%	27.50%	0.23%	4.03%	0.06%	4.58%	####	94	41	1	10	0	16
(0.2-0.4)	25.94%	66.88%	1.98%	23.67%	0.40%	17.66%	####	100	100	7	57	0	60
(0.4-0.6)	22.30%	5.40%	10.23%	41.82%	0.02%	29.36%	####	86	8	36	100	0	100
(0.6-0.7)	9.03%	0.05%	12.26%	15.39%	0.01%	15.42%	####	35	0	43	37	0	53
(0.7-0.8)	8.11%	0.01%	23.93%	9.56%	0.00%	12.59%	####	31	0	84	23	0	43
(0.8-0.9)	5.52%	0.00%	28.63%	3.75%	0.00%	10.13%	####	21	0	100	9	0	35
(0.9-1.2)	2.21%	0.00%	22.44%	1.61%	0.00%	5.00%	####	9	0	78	4	0	17
(1.2-1.5)	0.00%	0.00%	0.26%	0.01%	0.00%	0.00%	####	0	0	1	0	0	0
Total	100%	100%	100%	100%	100%	100%	####						

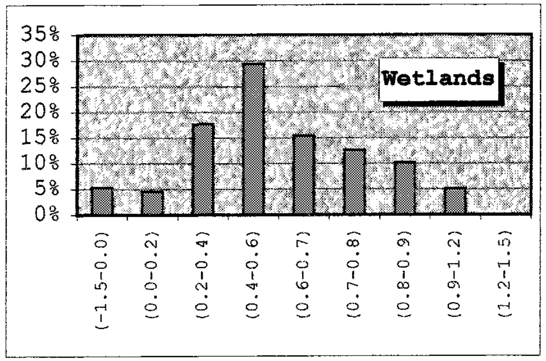












File Name: Landuse
Sheet: SAVI x Lanuse7

Page: 1/1

Date: 4/12/99

Table 1[1]: Error Matrix[2]; Comparison between the Obtained Land-Use and the Test Set.

		Land-use map						
		Irrigated Agriculture	Rain-fed Agriculture	Forest	Rangelands	Lake	Wetlands	Row Total
Test Set Map	Irrigated Agriculture	150	0	5	268	0	9	432
	Rain-fed Agriculture	0	1805	0	5	0	0	1810
	Forest	0	0	3257	41	0	0	3298
	Rangelands	0	172	4	3538	0	0	3714
	Lake	0	0	0	0	2520	0	2520
	Wetlands	0	0	0	0	0	498	498
	Column Total	150	1977	3266	3852	2520	507	**12272**

Average Accuracy = ((150/432)+(1805/1810)+(3257/3298)+(3538/3714)+(2520/2520)+(498/498))/6= **88.1**

Average Reliability = ((150/150)+(1805/1977)+(3257/3266)+(3538/3852)+(2520/2520)+(498/507))/6= **96.8**

Overall Accuracy = (150+1805+3257+3538+2520+498)/12272= **94.3**

1. Values are count of pixels.
2. **[Lillesand et al, 1994]**

ANNEX QL.1

FIELD TRIP

Questionnaire (Yes ☐ No ☐)

C.V.:

Firm Name		Activity	
Person name		Interview Date	
Position		Starting Time	
Place			
Others			

GENERAL

1- What is the main source of water supply?
Surface Water ☐ Ground Water ☐ Others ☐ (E.A.: 15% surface.)
Comments:

2- Are all the sources available for each user/sector?
Yes ☐ No ☐
Comments:

3- Are all the sources available for each user/sector suitable?
Yes ☐ No ☐
Comments:

4- What is the major water consumer?
Agriculture ☐ Industrial ☐ Others ☐ (E.A.: 85% Agriculture)
Comments:

5- What is the effect of water QUALITY upon different enterprises (past, presence, and future)?
Comments:

6- What have been the recent trends in the balance between the supply and demand of water?
Comments:

FIELD TRIP

Questionnaire

General: "Cnt'd"

7- What proportion of available supplies is already committed?
Comments:

8- How do projected trends in population, Food Self-sufficiency and economic growth affect the supply- demand balance in future?
Comments:

9- How feasible is to supplement the supply from elsewhere?
Comments:

10- Are existing farmers being seriously constrained by QUANTITY, QUALITY or reliability of water?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

11- What proportion of the population is not or only inadequately served with safe drinking water?
----% can't say ☐ prefer not to say ☐

12- What is the frequency and incidence of water shortage?
------ can't say ☐ prefer not to say ☐

13- What proportion of the population regularly obtain their water from private vendors? Is there any evidence of what they pay?
----% can't say ☐ prefer not to say ☐
Comments:

14- How important are water-intensive sectors (i.e. agriculture, industry, fisheries, tourism, etc.) in the national economy?
Comments:

15- Is water scarcity becoming a constraint on the expansion of any major sector?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

FIELD TRIP

Questionnaire

General: "Cnt'd"

16- Is there any indirect supporting evidence, such as the incidence of water-related diseases?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

17- Are the water authorities obliged by law to provide water of certain standard?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

18- Are future water supply options significantly more difficult, costly or environmentally damaging than recent and current projects?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

19- How efficiently is water used by the different sectors, according to relevant technical or international yardsticks?
Comments:

20- What proportion of wastewater is treated and recycled for further use?
Comments:

21- In urban systems, what proportion of water entering the system is unaccounted for?
Comments:

22- Which water sector, or important parts of it, generates large and growing fiscal deficits?
Agriculture ☐ Industrial ☐ Tourism ☐ Fisheries ☐ others ☐
Comments:

23- Which water sector, or important parts of it, fails to cover its recurrent costs of operation and maintenance?
Agriculture ☐ Industrial ☐ Tourism ☐ Fisheries ☐ others ☐
Comments:

FIELD TRIP

Questionnaire

General: "Cnt'd"

24- Is privatization scheduled for water sector? What form is it likely to take?
Yes ☐ No ☐ Don't know ☐ prefer not to say ☐
Comments:

25- Do the farmers know that there is a critical timing of giving/ not giving water that best suits plant growth, and maximise yields?
Yes ☐ No ☐ Don't know ☐ prefer not to say ☐
Comments:

26- Is there any govermental limits for water consumption? Or just they (agriculture-industry-domestic) can take what you need?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

27- What is the price of 1 m^3 of water for different sectors?
Don't know ☐ prefer not to say ☐
Comments:

28- Is there a problem in the water availability? (in sustainable context)
Yes ☐ No ☐ Don't know ☐ prefer not to say ☐
Comments:

29- Is there a problem in the water suitability? (in sustainable context)
Yes ☐ No ☐ Don't know ☐ prefer not to say ☐
Comments:

Agriculture

1- Starting when can you say that the crop yield has changed considerably?
5 years ☐ 10 years ☐ Others ☐ after a certain event ☐ no change ☐
Comments:

2- The change was to:
much better ☐ better ☐ can't say ☐ worse ☐ much worse ☐
Comments:

3- How often does that happen?
5 years ☐ 10 years ☐ Others ☐ after a certain event ☐ only once ☐
Comments:

4- Do you expect changes in the future?
Yes ☐ No ☐ can't say ☐
Comments:

5- If Yes when (after what), why, and how much better?
Comments:

6- If No why, and how much worse?
Comments:

7- Are you satisfied with the water QUANTITY allocated to you?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

8- If Yes, is it too much, and why are you satisfied?
Comments:

Agriculture: "Cnt'd"

9- If no, why, and which amount will satisfy your process?
Comments:

10- What do you suggest to increase the water supply?
Comments:

11- Are you satisfied with the water QUALITY allocated to you?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

12- If Yes, is it too good, and why are you satisfied?
Comments:

13- Will you agree if we reduce the amount of water by 10%? How will it affect?
yes ☐ no ☐ don't know ☐ prefer not to say ☐
Comments:

14- If no, why, and which amount will satisfy your process?
Comments:

15- What do you suggest to improve the water QUALITY?
Comments:

16- How often do you irrigate and how much do you abstract?
Comments:

17- Is there any evidence of agricultural residue manipulation?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

Agriculture: "Cnt'd"

18- If yes, what and to what extent?
Comments:

19- Is there any cropping pattern involved in your farm? What?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

20- Do you prefer to stick to a certain crop(s)/certain area in your farm? Which crop?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

21- How much herbicides/fertilizers do you consume?
can't say ☐ prefer not to say ☐
Comments:

22- Do you have governmental limits for water consumption? Or just you can take what you need?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

23- What is the main source of your water supply?
Surface Water ☐ Ground Water ☐ Others ☐
Comments:

Industry:

1- Starting when can you say that the QUALITY of water used for different industrial stages has deteriorated considerably?
5 years ☐ 10 years ☐ after a certain event ☐ Others ☐ no change ☐
Comments:

2- What is the effect of water on your products?
Direct ☐ High ☐ Moderate ☐ Low ☐ Indirect ☐
Comments:

3- If there's a direct effect of water, Starting when can you say that the QUALITY of your products has changed considerably?
5 years ☐ 10 years ☐ after a certain event ☐ Others ☐ no change ☐
Comments:

4- The change was to:
much better ☐ better ☐ can't say ☐ worse ☐ much worse ☐
Comments:

5- Do you expect changes in the future?
Yes ☐ No ☐ can't say ☐
Comments:

6- If Yes when (after what), why, and how much better?
Comments:

7- If No why, and how much worse?
Comments:

8- Are you satisfied with the water QUANTITY allocated to you?
Yes ☐ No ☐ can't say ☐ prefer not to say ☐
Comments:

Industry: "Cnt'd"

9- If Yes, is it too much, and why are you satisfied?

Comments:

10- Will you agree if we reduce the amount of water by 10%? How will it affect?

yes ☐ no ☐ don't know ☐ prefer not to say ☐

Comments:

11- If no, why, and which amount will satisfy your process?

Comments:

12- What do you suggest to increase the water supply?

Comments:

13- Are you satisfied with the water QUALITY allocated to you?

Yes ☐ No ☐ can't say ☐ prefer not to say ☐

Comments:

14- If Yes, is it too good, and why are you satisfied?

Comments:

15- If No, which parameter do you think is most critical for your industry?

Comments:

16- If no, why, and which amount will satisfy your process?

Comments:

17- What do you suggest to improve the water QUALITY?

Comments:

Fish Farming

1- Starting when can you say that the QUANTITY of fish has changed considerably?

5 years ☐ 10 years ☐ after a certain event ☐ Others ☐ no change ☐

Comments:

2- Starting when can you say that the QUALITY of fish has changed considerably?

5 years ☐ 10 years ☐ after a certain event ☐ Others ☐ no change ☐

Comments:

3- Starting when can you say that the VARIETY of fish has changed considerably?

5 years ☐ 10 years ☐ after a certain event ☐ Others ☐ no change ☐

Comments:

4- The change was to:

much better ☐ better ☐ can't say ☐ worse ☐ much worse ☐

Comments:

5- Do you expect changes in the future?

Yes ☐ No ☐ can't say ☐

Comments:

6- If Yes when (after what), why, and how much better?

Comments:

7- If No why, and how much worse?

Comments:

8- Are you satisfied with the water QUANTITY allocated to you?

Yes ☐ No ☐ can't say ☐ prefer not to say ☐

Comments:

Fish Farming: "Cnt'd"

9- If Yes, is it too much, and why are you satisfied?

Comments:

10- Will you agree if we reduce the amount of water by 10%? How will it affect?

yes ☐ no ☐ don't know ☐ prefer not to say ☐

Comments:

11- If no, why, and which amount will satisfy your process?

Comments:

12- What do you suggest to increase the water supply?

Comments:

13- Are you satisfied with the water QUALITY allocated to you?

Yes ☐ No ☐ can't say ☐ prefer not to say ☐

Comments:

14- If Yes, is it too good, and why are you satisfied?

Comments:

15- Will you agree if we reduce the amount of water by 10%? How will it affect?

yes ☐ no ☐ don't know ☐ prefer not to say ☐

Comments:

16- If no, why, and which amount will satisfy your process?

Comments:

17- What do you suggest to improve the water QUALITY?

Comments:

Fish Farming: "Cnt'd"

18- Institutional cooperation between water development agencies and fishery administrations needs to be strengthened to address common interests. Is that already taking place?

Comments:

19- What do you suggest to improve the water QUALITY?

Comments:

Domestic & recreational:

1- Starting when can you say that the QUALITY of water has changed considerably?

5 years □ 10 years □ after a certain event □ Others □ no change □

Comments:

2- Is the QUALITY of water provided adequate?

Yes □ No □ can't say □ prefer not to say □

3- What is the evidence on the incidence of water-related illness?

Comments:

4- Do households (you) take their own precautions to ensure the safety of their drinking water?

Yes □ No □ can't say □ prefer not to say □

Comments:

5- Is there any governmental limits for water consumption? Or just you can take what you need?

Yes □ No □ can't say □ prefer not to say □

Comments:

6- What is the price of 1 m^3 of water for different sectors?

don't know □ prefer not to say □

Comments:

7- What proportion of the population is not or only inadequately served with safe drinking water?

----% can't say □ prefer not to say □

Comments:

8- What is the frequency and incidence of water shortage?

------ can't say □ prefer not to say □

Comments:

Domestic & recreational: "Cnt'd"

9- What proportion of the population regularly obtain their water from private vendors? Is there any evidence of what they pay?

----% can't say □ prefer not to say □

Comments:

10- Is there any indirect supporting evidence, such as the incidence of water-related diseases?

Yes □ No □ can't say □ prefer not to say □

Comments:

11- Are the water authorities obliged by law to provide water of certain standard?

Yes □ No □ can't say □ prefer not to say □

Comments:

ANNEX QL.2

Amounts of Agrochemicals Used in Different Farms

Specific Gravity	**1.3**	Kg/lt	Fertilizerz/chemicals	33	Flowers
				100	Fodder
				66	Average

Farm	**Irrigated Area**		**Activity**	**Amount**						**Total (ton/Year)**	
				"Total" Area		Per Hectare		Per m^2			
	ha	m^2		lt/day	Kg/day	lt/day	Kg/day	lt/day	Kg/day	Per ha	Per m^2
Sher	200	2.0E+06	Flower	18	600	0.09	3	921	30000	1.14	11395
Sulmac	450	4.5E+06	Flower	52	1694	0.12	4	1156	37644	1.43	14298
Kijabe	40	4.0E+05	Flower	8	250	0.19	6	1919	62500	2.37	23739
Aberdare	24	2.4E+05	Vegetables	1	72	0.05	3	453	30000	1.12	11172
Three point	500	5.0E+06	Vegetables	23	1500	0.05	3	453	30000	1.12	11172
Delamere	1200	1.2E+07	Fodder	24	2400	0.02	2	200	20000	0.74	7400

Average Chemicals Used ton/ha.year		
	Flowers	**1.65**
	Vegetables	**1.12**
	Fodder	**0.74**

File Name: agrochem

Page: 1/1

Date: 4/6/99

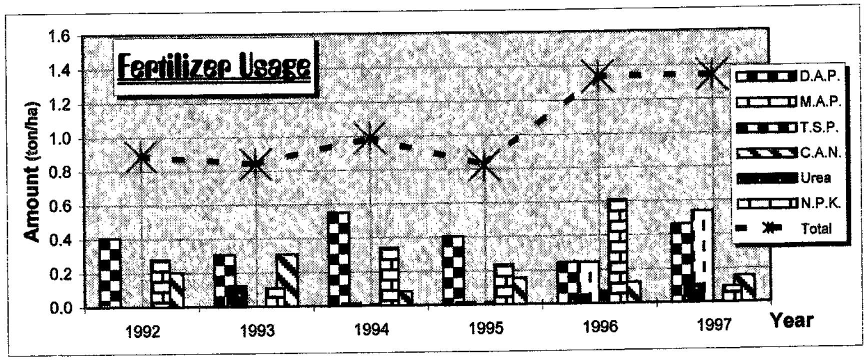
Types of Agrochemicals with Amounts in Stock

Source: Naivasha Divisional Extension Office

YEAR	DAP	MAP	TSP	CAN	ASN	S/A	Urea	20:20:10	23:23:00	20:10:10	20:20:00	17:17:17	Others_1	Others_2	N.P.K.	TOTAL
1992	60	0	0	30	0	0	0	0	10	0	8	8	15	0	41	131
1993	45	0	0	45	0	0	18	0	3	5	3	5	0	0	16	124
1994	81	0	1	12	0	0	2	0	10	40	0	0	0	0	50	146
1995	60	0	2	23	0	1	2	0	2	30	3	0	0	0	35	123
1996	40	40	12	20	0	0	8	0	8	60	8	4	20	.	100	220
1997	60	70	0	20	0	0	13	10	2	0	0	0	0	0	12	175

YEAR	DAP	MAP	TSP	CAN	ASN	S/A	Urea	20:20:10	23:23:00	20:10:10	20:20:00	17:17:17	Others_1	Others_2	N.P.K.	TOTAL
1992	0.41	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.07	0.00	0.05	0.05	0.10	0.00	0.28	0.887
1993	0.30	0.00	0.00	0.30	0.00	0.00	0.12	0.00	0.02	0.03	0.02	0.03	0.00	0.00	0.11	0.840
1994	0.55	0.00	0.01	0.08	0.00	0.00	0.01	0.00	0.07	0.27	0.00	0.00	0.00	0.00	0.34	0.989
1995	0.40	0.00	0.01	0.15	0.00	0.01	0.01	0.00	0.01	0.20	0.02	0.00	0.00	0.00	0.23	0.823
1996	0.24	0.24	0.07	0.12	0.00	0.00	0.05	0.00	0.05	0.36	0.05	0.02	0.12	0.00	0.61	1.338
1997	0.46	0.54	0.00	0.15	0.00	0.00	0.10	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.09	1.341

N.B.
- values are what's available on the stock
- in the year 1996, original data is being multiplied by 4, as what was sold was one quarter of the stock



File Name: agrochem

Page: 1/1

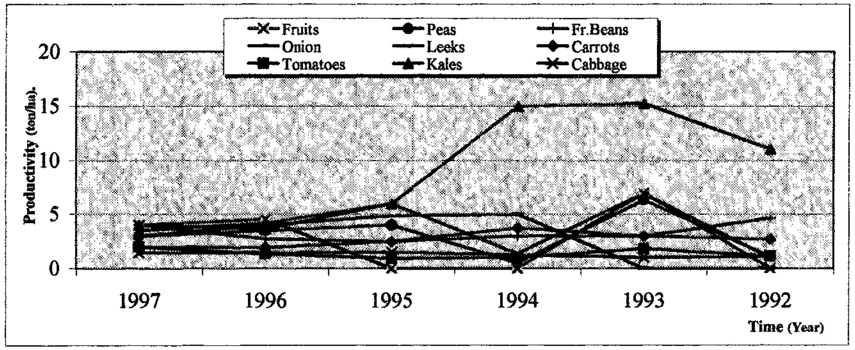
Date: 4/13/99

Historical Crop Yield

Crop	Yield (tonne) 1997	1996	1995	1994	1993	1992	Area (ha) 1997	1996	1995	1994	1993	1992
Maize	748	.	1386	608	.	4103	2490	.	2771	3040	.	2735
Wheat	4450	.	1270	919	.	3765	4450	.	3176	4594	.	2689
Sorghum	1	.	9	12	.	.	4	.	31	30	.	.
Millet	2	.	1	.	.	.	5	.	3	.	.	.
Barley	.	.	.	.	.	288	.	.	.	.	.	96
Beans	660	.	482	356	.	.	1100	.	1070	1778	.	.
Garden Peas	120	.	2	.	.	.	40	.	11	.	.	.
Grains	.	.	.	.	.	.	.	.	.	.	.	.
Lab Lab	10	.	.	.	.	.	5	.	.	.	.	.
Potatoes	1314	.	514	32	.	4797	659	.	411	630	.	1599
Cassava	.	.	.	.	.	.	.	.	.	.	.	.
Sunflower	.	.	.	.	.	.	.	.	.	.	.	.
Soya Beans	.	.	.	.	.	.	.	.	.	.	.	.
G.Nuts	.	.	.	.	.	.	.	.	.	.	.	.
Rapeseed	.	.	.	.	.	.	.	.	.	.	.	.
Pyrethum	660	.	.	163	327	466	3300	.	.	3266	3266	3107
Tea	.	.	.	.	.	.	.	.	.	.	.	.
Castor	23	.	.	.	.	.	45	.	.	.	.	.
Tobacco	.	.	.	.	.	.	.	.	.	.	.	.
Sugercane	.	.	.	.	.	.	.	.	.	.	.	.
Sisal	.	.	.	.	.	.	.	.	.	.	.	.
Cabbage	960	613	440	324	217	961	661	420	293	261	217	854
Kales	372	400	606	1500	1450	1050	93	110	101	100	95	95
Tomatoes	46	60	20	81	140	63	23	45	22	81	76	56
Carrots	208	340	425	638	765	443	104	176	170	171	255	164
Leaks	96	188	340	450	.	.	32	47	70	90	.	.
Onion	501	710	1008	185	1600	284	143	170	168	135	230	300
Frensh Beans	1144	780	700	864	816	1400	286	286	280	288	272	300
Peas	120	371	640	79	1040	213	40	106	160	158	164	194
Flowers (million st)	24030	.	24030	50694	.	.	534	.	534	356	.	.
Strawberries	45	.	54	1716	54	600	3	.	3	10	3	75
Passion Fruits	88	100	.		140	.	22	22	.	.	20	.
Citrus	4530	2276	3216	860	2540	17	302	293	10	14	254	247
Grapes	1245	1440	1200	825	1100	1375	83	83	70	27	55	55

Crop	Productivity Index (Tonne/ha) 1997	1996	1995	1994	1993	1992	Total
Maize	0.3	.	0.5	0.2	.	1.5	**2.5**
Wheat	1.0	.	0.4	0.2	.	1.4	**3.0**
Sorghum	0.3	.	0.3	0.4	.	.	**1.0**
Millet	0.4	.	0.3	.	.	.	**0.7**
Barley	.	.	.	.	.	.	**0.0**
Beans	0.6	.	0.5	0.2	.	.	**1.3**
Garden Peas	3.0	.	0.2	.	.	.	**3.2**
Grains		.	.	.	.	.	**0.0**
Lab Lab	2.0	.	.	.	.	.	**2.0**
Potatoes	2.0	.	1.3	0.1	.	3.0	**6.3**
Cassava	.	.	.	.	.	.	**0.0**
Sunflower	.	.	.	.	.	.	**0.0**
Soya Beans	.	.	.	.	.	.	**0.0**
G.Nuts	.	.	.	.	.	.	**0.0**
Rapeseed		.	.	.	.	.	**0.0**
Pyrethum	0.2	.	.	0.1	0.1	0.2	**0.5**
Tea	.	.	.	.	.	.	**0.0**
Castor	0.5	.	.	.	.	.	**0.5**
Tobacco	.	.	.	.	.	.	**0.0**
Sugercane	.	.	.	.	.	.	**0.0**
Sisal	.	.	.	.	.	.	**0.0**
Cabbage	1.5	1.5	1.5	1.2	1.0	1.1	**7.8**
Kales	4.0	3.6	6.0	15.0	15.3	11.1	**55.0**
Tomatoes	2.0	1.3	0.9	1.0	1.8	1.1	**8.2**
Carrots	2.0	1.9	2.5	3.7	3.0	2.7	**15.9**
Leaks	3.0	4.0	4.9	5.0	.	.	**16.9**
Onion	3.5	4.2	6.0	1.4	7.0	0.9	**22.9**
Frensh Beans	4.0	2.7	2.5	3.0	3.0	4.7	**19.9**
Peas	3.0	3.5	4.0	0.5	6.3	1.1	**18.4**
Flowers (million st)	45.0	.	45.0	42.0	.	.	**132.0**
Strawberries	15.0	.	18.0	18.0	18.0	8.0	**77.0**
Passion Fruits	4.0	4.5	.	.	7.0	.	**15.5**
Citrus	15.0	7.8	10.0	61.4	10.0	0.1	**104.3**
Grapes	15.0	17.3	17.1	30.6	20.0	25.0	**125.0**
	2.9					3.6	

Crop	Normalized Yield (Y/Y_{tot}) 1997	1996	1995	1994	1993	1992	Max	Normalized Yield (Y/Y_{max}) 1997	1996	1995	1994	1993	1992
Maize													
Wheat													
Sorghum													
Millet													
Barley													
Beans													
Garden Peas													
Grains													
Lab Lab													
Potatoes													
Cassava													
Sunflower													
Soya Beans													
G.Nuts													
Rapeseed													
Pyrethum													
Tea													
Castor													
Tobacco													
Sugercane													
Sisal													
Cabbage	0.2	0.2	0.2	0.2	0.1	0.1	**1.5**	1.0	1.0	1.0	0.8	0.7	0.8
Kales	0.1	0.1	0.1	0.3	0.3	0.2	**15.3**	0.3	0.2	0.4	1.0	1.0	0.7
Tomatoes	0.2	0.2	0.1	0.1	0.2	0.1	**2.0**	1.0	0.7	0.5	0.5	0.9	0.6
Carrots	0.1	0.1	0.2	0.2	0.2	0.2	**3.7**	0.5	0.5	0.7	1.0	0.8	0.7
Leaks	0.2	0.2	0.3	0.3	.	.	**5.0**	0.6	0.8	1.0	1.0	.	.
Onion	0.2	0.2	0.3	0.1	0.3	0.0	**7.0**	0.5	0.6	0.9	0.2	1.0	0.1
Frensh Beans	0.2	0.1	0.1	0.2	0.2	0.2	**4.7**	0.9	0.6	0.5	0.6	0.6	1.0
Peas	0.2	0.2	0.2	0.0	0.3	0.1	**6.3**	0.5	0.6	0.6	0.1	1.0	0.2
Flowers (million st)	0.3	.	0.3	0.3	.	.	**45.0**	1.0	.	1.0	0.9	.	.
Strawberries	0.2	.	0.2	0.2	0.2	0.1	**18.0**	0.8	.	1.0	1.0	1.0	0.4
Passion Fruits	0.3	0.3	.	.	0.5	.	**7.0**	0.6	0.6	.	.	1.0	.
Citrus	0.1	0.1	0.1	0.6	0.1	0.0	**61.4**	0.2	0.1	0.2	1.0	0.2	0.0
Grapes	0.1	0.1	0.1	0.2	0.2	0.2	**30.6**	0.5	0.6	0.6	1.0	0.7	0.8
	0.18	0.16	0.19	0.23	0.23	0.13		0.64	0.57	0.69	0.76	0.80	0.53



File Name: Productivity
Sheet: Summary

Page: 1/1

Date: 4/13/99

Various Species Catches for different Years

1997

	No. of Boats	O.Leucostictus			(Bass) M. Salmoides			T.Zilli			(Crayfish) P.Clarkii			Total		
		No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh
Jan	13	2178	350	25100	1280	414	34542	1084	131	8452	?	2350	140033	4542	3245	208127
Feb	16	1389	198	15282	896	303	25043	5548	600	41060	?	3445	241505	7833	4546	322890
Mar	16	2194	300	21799	873	218	19704	8803	842	61911	?	3600	295799	11870	4960	399213
Apr	18	3027	348	29171	1870	369	35756	13951	1444	86808	?	2175	175789	18848	4335	327334
May	15	2703	311	26556	909	353	37687	8819	937	57872	?	4115	266209	12431	5716	388324
Jun	18	2507	632	55420	1387	377	40413	6446	650	44519	?	1715	111500	10340	3374	251852
Jul	17	3165	530	46536	1803	505	45180	8343	942	59306	?	1670	111050	13311	3647	262072
Aug	17	3625	439	33412	3107	847	74087	13331	1703	95813	?	1190	79250	20063	4178	282542
Sep	15	1669	200	15205	4693	1181	107557	11594	1471	87253	?	855	54225	17956	3707	264240
Oct	14	1435	178	14302	5029	1418	122273	6089	737	43761	?	570	35175	12553	2903	215511
Nov	12	600	74	6009	2623	745	73692	1699	204	13742	?	840	49800	4922	1863	143243
Dec	11	1192	156	11287	1621	499	48337	6112	681	50932	?	1285	73750	8925	2621	184306
Total	**–**	**25684**	**3714**	**300079**	**26091**	**7228**	**664251**	**91819**	**10341**	**651229**	**?**	**23810**	**1634095**	**143594**	**45092**	**3249654**

	No. of Boats	O.Leucostictus			(Bass) M. Salmoides			T.Zilli			(Crayfish) P.Clarkii			Total		
		No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No.	kg/boat	Ksh
Jan	13	6.2	26.9	71.7	3.1	31.8	83.4	8.3	10.0	64.8	#VALUE!	180.8	59.6		249.8	
Feb	16	7.0	12.4	77.2	3.0	18.9	82.7	9.2	37.5	68.4	#VALUE!	215.3	70.1		284.1	
Mar	16	7.3	18.7	72.8	4.0	13.6	90.4	10.5	52.6	73.5	#VALUE!	225.0	82.2		310.0	
Apr	18	8.7	19.3	83.9	5.1	20.5	97.0	9.7	80.2	60.0	#VALUE!	120.8	80.8		240.8	
May	15	8.7	20.7	85.4	2.6	23.5	106.9	9.4	62.5	61.8	#VALUE!	274.3	64.7		381.0	
Jun	18	4.0	35.1	87.8	3.7	20.9	107.2	9.9	36.1	68.5	#VALUE!	95.3	65.0		187.4	
Jul	17	6.0	31.2	87.8	3.6	29.7	89.5	8.9	55.4	63.0	#VALUE!	98.2	66.5		214.5	
Aug	17	8.3	25.8	76.2	3.7	49.8	87.5	7.8	100.2	56.3	#VALUE!	70.0	66.6		245.8	
Sep	15	8.3	13.3	76.0	4.0	78.7	91.1	7.9	98.1	59.3	#VALUE!	57.0	63.4		247.1	
Oct	14	8.1	12.7	80.6	3.5	101.3	86.2	8.3	52.6	59.4	#VALUE!	40.7	61.7		207.3	
Nov	12	8.1	6.2	81.2	3.5	82.1	98.9	8.3	17.0	67.5	#VALUE!	70.0	59.3		155.2	
Dec	11	7.6	14.2	72.4	3.2	45.4	96.9	9.0	61.9	74.8	#VALUE!	118.8	57.4		238.2	
Avg.	**15**	**7.4**	**19.7**	**79.4**	**3.6**	**41.4**	**93.1**	**8.9**	**55.3**	**64.8**	**#VALUE!**	**130.4**	**66.4**		**247**	**0**

1996

	No. of Boats	O.Leucostictus			(Bass) M. Salmoides			T.Zilli			(Crayfish) P.Clarkii			Total		
		No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh
Jan	8	13555	1861	124033	287	92	6492	1880	215	10475	?	1675	145725	15722	3843	286725
Feb	10	13626	1749	112613	1077	324	24257	1959	217	11228	?	0	0	16662	2289	148098
Mar	15	16664	2160	136888	5225	480	32851	7449	836	37396	?	4050	352350	29338	7525	559485
Apr	20	13592	1912	127455	7177	1902	179270	15062	1769	73738	?	3980	346260	35831	9583	726723
May	22	7689	1288	74802	7051	1984	139668	16493	2141	86556	?	0	0	31233	5393	301026
Jun	22	7731	1136	73244	6790	1945	137015	13615	1818	73220	?	0	0	28136	4898	283479
Jul	25	4570	705	45189	3717	1104	77996	15526	2147	107440	?	0	0	23813	3956	230635
Aug	27	2813	460	28664	3082	1011	77212	17846	2459	130710	?	0	0	23741	3929	236586
Sep	25	2323	333	22969	5040	1519	117814	9763	1273	70224	?	0	0	17126	3124	211007
Oct	23	3796	553	39535	4248	1284	103476	2741	355	20027	?	0	0	10785	2191	163037
Nov	22	2363	365	23909	4984	1479	122125	949	133	7554	?	0	0	8296	1976	153588
Dec	20	1890	297	21486	5079	1486	118235	734	87	5717	?	3701	340850	7703	5570	486288
Total	**–**	**90612**	**12817**	**830797**	**53757**	**14586**	**1136410**	**104017**	**13466**	**634285**	**0**	**13406**	**1185185**	**246386**	**54275**	**3786677**

	No. of Boats	O.Leucostictus			(Bass) M. Salmoides			T.Zilli			(Crayfish) P.Clarkii			Total		
		No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No.	kg/boat	Ksh
Jan	8	7.3	232.6	66.6	3.1	11.5	70.6	8.8	26.8	48.8	#VALUE!	209.4	87.0		480.3	
Feb	10	7.8	174.9	64.4	3.3	32.4	75.0	9.0	21.7	51.9	#VALUE!	0.0	#DIV/0!		228.9	
Mar	15	7.7	144.0	63.4	10.9	32.0	68.5	8.9	55.7	44.8	#VALUE!	270.0	87.0		501.6	
Apr	20	7.1	95.6	66.7	3.8	95.1	94.3	8.4	89.4	41.2	#VALUE!	199.0	87.0		479.1	
May	22	6.0	58.5	58.1	3.6	89.3	71.1	7.7	97.3	40.4	#VALUE!	0.0	#DIV/0!		245.1	
Jun	22	6.8	51.6	64.5	3.5	88.4	70.5	7.5	82.6	40.3	#VALUE!	0.0	#DIV/0!		222.8	
Jul	25	6.5	28.2	64.2	3.4	44.2	70.6	7.2	85.9	50.0	#VALUE!	0.0	#DIV/0!		158.2	
Aug	27	6.1	17.0	62.3	3.0	37.4	76.4	7.3	91.1	53.2	#VALUE!	0.0	#DIV/0!		145.5	
Sep	25	7.0	13.3	69.0	3.3	60.7	77.6	7.7	50.9	55.2	#VALUE!	0.0	#DIV/0!		125.0	
Oct	23	6.9	24.0	71.6	3.3	55.8	80.6	7.7	15.4	56.4	#VALUE!	0.0	#DIV/0!		95.3	
Nov	22	6.5	16.6	65.6	3.4	67.2	82.6	7.1	6.0	56.8	#VALUE!	0.0	#DIV/0!		89.8	
Dec	20	6.4	14.8	72.5	3.4	74.3	79.6	8.4	4.4	65.7	#VALUE!	165.1	92.1		278.5	
Avg.	**20**	**6.8**	**72.6**	**65.7**	**4.0**	**57.3**	**76.4**	**8.0**	**52.3**	**50.4**	**#VALUE!**	**72**	**#DIV/0!**		**254**	**0**

1995

	No. of Boats	O.Leucostictus			(Bass) M. Salmoides			T.Zilli			(Crayfish) P.Clarkii			Total		
		No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh
Jan	15	3204	476	37163	1499	425	33544	5105	612	25944	?	0	0		1512	96651
Feb	17	5317	1127	90299	1181	355	26826	3521	418	20884	?	2250	45000		4150	183009
Mar	20	11077	1540	113108	2223	672	49058	4220	586	25014	?	2844			5642	187270
Apr	21	22511	3216	202839	3871	1009	77174	6382	753	30127	?	2936	58720		7914	368860
May	22	27457	4249	180423	13524	987	72548	10272	1368	41629	?	3168	63360		9771	357960
Jun	24	43074	7118	251334	5000	1462	97737	12065	1706	45615	?	2922	58440		13208	453126
Jul	23	62239	11068	337761	5366	1713	102819	13792	2059	47236	?	0	0		14839	487816
Aug	25	37966	6712	236530	2364	806	48436	14318	2193	59396	?	0	0		9711	344362
Sep	23	14943	2423	116428	977	343	20213	9401	1175	39748	?	1380	27600		5320	203989
Oct	19	6570	1080	60460	920	329	21699	4775	694	32028	?	950	19000		3053	133187
Nov	15	4529	744	43531	230	99	5661	1807	266	16011	?	2907	58140		4016	123843
Dec	7	8786	1223	76999	99	52	4163	2127	266	14699	?	2100	42000		3640	137861
Total	**–**	**247673**	**40972**	**1746965**	**37054**	**8250**	**560178**	**87794**	**12094**	**398331**	**0**	**21457**	**372260**	**0**	**82773**	**3077734**

	No. of Boats	O.Leucostictus			(Bass) M. Salmoides			T.Zilli			(Crayfish) P.Clarkii			Total		
		No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No.	kg/boat	Ksh
Jan	15	6.7	31.7	78.2	3.5	28.3	78.9	8.3	40.8	42.4	#VALUE!	0.0	20.0		100.8	
Feb	17	4.7	66.3	80.1	3.3	20.9	75.6	8.4	24.6	50.0	#VALUE!	132.4	20.0		244.1	
Mar	20	7.2	77.0	73.5	3.3	33.6	73.0	7.2	29.3	42.7	#VALUE!	142.2	0.0		282.1	
Apr	21	7.0	153.1	63.1	3.6	48.0	76.5	8.5	35.8	40.0	#VALUE!	139.8	20.0		376.8	
May	22	6.5	193.1	42.5	13.7	44.8	73.5	7.5	62.2	30.4	#VALUE!	144.0	20.0		444.1	
Jun	24	6.1	296.6	35.3	3.4	60.9	66.9	7.1	71.1	26.7	#VALUE!	121.8	20.0		550.3	
Jul	23	5.6	481.2	30.5	3.1	74.5	60.0	6.7	89.5	22.9	#VALUE!	0.0	20.0		645.2	
Aug	25	5.7	268.5	35.2	2.9	32.2	60.1	6.5	87.7	27.1	#VALUE!	0.0	20.0		388.4	
Sep	23	6.2	105.3	48.1	2.9	14.9	59.0	8.0	51.1	33.8	#VALUE!	60.0	20.0		231.3	
Oct	19	6.1	56.8	56.0	2.8	17.3	66.0	6.9	36.5	46.1	#VALUE!	50.0	20.0		160.7	
Nov	15	6.1	49.6	58.5	2.3	6.6	60.2	6.8	17.7	60.2	#VALUE!	193.8	20.0		267.7	
Dec	7	7.2	174.6	63.0	1.9	7.4	80.8	8.0	38.0	55.3	#VALUE!	300.0	20.0		520.0	
Avg.	**19**	**6.2**	**162.8**	**55.3**	**3.9**	**32.5**	**69.2**	**7.5**	**48.7**	**39.8**	**#VALUE!**	**107.0**	**18.3**		**351**	**0**

File Name: fish

Various Specious Catches for different Years

1994

	No. of Boats	O Leucostictus			(Bass) M. Salmoides			T Zilli			(Crayfish) P Clarkii			Total		
		No	Kg	Ksh	No	Kg	Ksh	No	Kg	Ksh	No	Kg	Ksh	No	Kg	Ksh
Jan	20	17881	4205	0	2431	1044	0	198	37	0	?	960	0		6246	0
Feb	19	17074	3787	0	1409	624	0	263	55	0	?	1753	0		6219	0
Mar	15	25409	5143	0	910	505	0	707	117	0	?	3014	0		8779	0
Apr	15	16708	3381	0	498	240	0	70	12	0	?	1568	0		5201	0
May	15	14578	2871	0	542	248	0	256	51	0	?	30	0		3200	0
Jun	18	10794	2422	0	307	150	0	279	60	0	?	23	0		2655	0
Jul	18	8318	1579	0	135	65	0	1525	229	0	?	51	0		1924	0
Aug	19	10316	1729	0	191	81	0	1607	191	0	?	76	0		2077	0
Sep	19	6778	1144	0	552	197	0	2349	288	0	?	85	0		1714	0
Oct	19	6695	1115	0	1588	502	0	1951	225	0	?	70	0		1912	0
Nov	16	3573	652	0	2020	613	0	1446	200	0	?	143	0		1608	0
Dec	13	1855	333	0	2410	717	0	2023	243	0	?	45	0		1338	0
Total	--	139979	28361	0	12993	4986	0	12674	1708	0	0	7818	0	0	42873	0

	No. of Boats	O Leucostictus			(Bass) M. Salmoides			T Zilli			(Crayfish) P Clarkii			Total		
		No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No	kg/boat	Ksh
Jan	20	4.3	210.3	0.0	2.3	52.2	0.0	5.4	1.9	0.0	#VALUE!	48.0	0.0		78.1	
Feb	19	4.5	199.3	0.0	2.3	32.8	0.0	4.8	2.9	0.0	#VALUE!	92.3	0.0		81.8	
Mar	15	4.9	342.9	0.0	1.8	33.7	0.0	6.0	7.8	0.0	#VALUE!	200.9	0.0		146.3	
Apr	15	4.9	225.4	0.0	2.1	16.0	0.0	5.8	0.8	0.0	#VALUE!	104.5	0.0		86.7	
May	15	5.1	191.4	0.0	2.2	16.5	0.0	5.0	3.4	0.0	#VALUE!	2.0	0.0		53.3	
Jun	18	4.5	134.6	0.0	2.0	8.3	0.0	4.7	3.3	0.0	#VALUE!	1.3	0.0		36.9	
Jul	18	5.3	87.7	0.0	2.1	3.6	0.0	6.7	12.7	0.0	#VALUE!	2.8	0.0		26.7	
Aug	19	6.0	91.0	0.0	2.4	4.3	0.0	8.4	10.1	0.0	#VALUE!	4.0	0.0		27.3	
Sep	19	5.9	60.2	0.0	2.8	10.4	0.0	8.2	15.2	0.0	#VALUE!	4.5	0.0		22.6	
Oct	19	6.0	58.7	0.0	3.2	26.4	0.0	8.7	11.8	0.0	#VALUE!	3.7	0.0		25.2	
Nov	16	5.5	40.8	0.0	3.3	38.3	0.0	7.2	12.5	0.0	#VALUE!	8.9	0.0		25.1	
Dec	13	5.6	25.6	0.0	3.4	55.2	0.0	8.3	18.7	0.0	#VALUE!	3.5	0.0		25.7	
Avg.	17	5.2	139.0	0.0	2.5	24.8	0.0	6.6	8.4	0.0	#VALUE!	39.7	0		53	0

1993

	No. of Boats	O Leucostictus			(Bass) M. Salmoides			T Zilli			(Crayfish) P Clarkii			Total		
		No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh
Jan	20	21400	6471	0	607	429	0	55	11	0	?	1200	0		8110	0
Feb	21	10940	3427	0	1445	841	0	28	8	0	?	2405	0		6680	0
Mar	29	10044	3004	0	2962	1571	0	191	44	0	?	3700	0		8318	0
Apr	23	4484	1917	0	2301	1209	0	389	77	0	?	4504	0		7707	0
May	19	8809	2503	0	3759	1825	0	844	153	0	?	3731	0		8212	0
Jun	30	11935	3409	0	5701	2697	0	1968	373	0	?	2628	0		9107	0
Jul	31	11476	3422	0	7707	3492	0	4492	831	0	?	1701	0		9446	0
Aug	29	10627	2898	0	9824	4119	0	3515	680	0	?	2750	0		10447	0
Sep	29	13011	3624	0	8971	3616	0	2868	696	0	?	3107	0		11042	0
Oct	26	9456	2484	0	6604	2773	0	2430	441	0	?	1350	0		7047	0
Nov	29	21501	5320	0	5757	2434	0	2610	490	0	?	1050	0		9294	0
Dec	25	22320	5351	0	3887	1578	0	1452	240	0	?	3640	0		10808	0
Total	--	156003	43827	0	59525	26580	0	20842	4042	0	0	31766	0	0	108215	0

	No. of Boats	O Leucostictus			(Bass) M. Salmoides			T Zilli			(Crayfish) P Clarkii			Total		
		No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No.	kg/boat	Ksh
Jan	20	3.3	323.5	0.0	1.4	21.4	0.0	5.0	0.6	0.0	#VALUE!	60.0	0.0		101.4	
Feb	21	3.2	163.2	0.0	1.7	40.0	0.0	3.5	0.4	0.0	#VALUE!	114.5	0.0		79.5	
Mar	29	3.3	103.6	0.0	1.9	54.2	0.0	4.4	1.5	0.0	#VALUE!	127.6	0.0		71.7	
Apr	23	2.3	83.3	0.0	1.9	52.6	0.0	5.1	3.3	0.0	#VALUE!	195.8	0.0		83.8	
May	19	3.5	131.7	0.0	2.1	96.1	0.0	5.5	8.1	0.0	#VALUE!	196.4	0.0		108.0	
Jun	30	3.5	113.6	0.0	2.1	89.9	0.0	5.3	12.4	0.0	#VALUE!	87.6	0.0		75.9	
Jul	31	3.4	110.4	0.0	2.2	112.6	0.0	5.4	26.8	0.0	#VALUE!	54.9	0.0		76.2	
Aug	29	3.7	99.9	0.0	2.4	142.0	0.0	5.2	23.4	0.0	#VALUE!	94.8	0.0		90.1	
Sep	29	3.6	124.9	0.0	2.5	124.7	0.0	4.1	24.0	0.0	#VALUE!	107.1	0.0		95.2	
Oct	26	3.8	95.5	0.0	2.4	106.6	0.0	5.5	16.9	0.0	#VALUE!	51.9	0.0		67.8	
Nov	29	4.0	183.4	0.0	2.4	83.9	0.0	5.3	16.9	0.0	#VALUE!	36.2	0.0		80.1	
Dec	25	4.2	214.0	0.0	2.5	63.1	0.0	6.1	9.6	0.0	#VALUE!	145.6	0.0		108.1	
Avg.	26	3.5	145.6	0.0	2.1	82.3	0.0	5.0	12.0	0.0	#VALUE!	106.0	0.0		86	0

1992

	No. of Boats	O Leucostictus			(Bass) M. Salmoides			T Zilli			(Crayfish) P Clarkii			Total		
		No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh	No.	Kg	Ksh
Jan	35	35967	29082	610722	346	265	4186	7	2	18	?	5261	78960		34610	693886
Feb	36	62635	28335	340020	1695	815	17930	4	1	12	?	4496	67440		33647	425402
Mar	37	69952	22341	402129	2788	1505	34615	9	3	24	?	5410	81150		29258	517918
Apr	30	53323	29461	589210	1209	924	22164	36	9	135	?	3010	45150		33403	656859
May	29	40648	16067	342227	1203	727	11123	71	22	193	?	3260	48900		20076	402443
Jun	37	45731	17224	382362	1802	1214	24280	648	131	1292	?	1030	15450		19598	423384
Jul	?	?	11398	250745	?	1236	27799	?	64	694	?	900	13500		13597	292738
Aug	?	35866	9644	236760	1177	755	19164	257	93	884	?	1680	24300		12172	281108
Sep	?	19579	6736	186000	1000	630	19838	197	53	519	?	1285	19275		8703	225632
Oct	29	29009	9862	254397	989	665	16886	426	129	1008	?	900	13500		11555	285791
Nov	23	15929	5222	156162	523	416	12938	187	54	387	?	1000	15000		6691	184487
Dec	22	21635	7013	215900	739	482	15576	126	34	309	?	4300	64500		11829	296285
Total	--	430294	192382	3966634	13471	9631	226498	1968	593	5475	0	32532	487125	0	235137	4685732

	No. of Boats	O Leucostictus			(Bass) M. Salmoides			T Zilli			(Crayfish) P Clarkii			Total		
		No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No/Kg	kg/boat	Ksh/Kg	No.	kg/boat	Ksh
Jan	35	1.2	830.9	21.0	1.3	7.6	15.8	3.5	0.1	9.0	#VALUE!	150.3	15.0		988.8	
Feb	36	2.2	787.1	12.0	2.1	22.6	22.0	4.0	0.0	12.0	#VALUE!	124.9	15.0		934.6	
Mar	37	3.1	603.8	18.0	1.9	40.7	23.0	3.6	0.1	9.6	#VALUE!	146.2	15.0		790.8	
Apr	30	1.8	982.0	20.0	1.3	30.8	24.0	4.0	0.3	15.0	#VALUE!	100.3	15.0		1113.4	
May	29	2.5	554.0	21.3	1.7	25.1	15.3	3.2	0.8	8.8	#VALUE!	112.4	15.0		692.3	
Jun	37	2.7	465.5	22.2	1.5	32.8	20.0	5.0	3.5	9.9	#VALUE!	27.8	15.0		529.7	
Jul	?	2.7	#VALUE!	22.0	1.5	#VALUE!	22.5	5.0	#VALUE!	10.9	#VALUE!	#VALUE!	15.0		#VALUE!	
Aug	?	3.7	#VALUE!	24.5	1.6	#VALUE!	25.4	2.8	#VALUE!	9.5	#VALUE!	#VALUE!	14.5		#VALUE!	
Sep	?	2.9	#VALUE!	27.6	1.6	#VALUE!	31.5	3.8	#VALUE!	9.9	#VALUE!	#VALUE!	15.0		#VALUE!	
Oct	29	2.9	340.1	25.8	1.5	22.9	25.4	3.3	4.4	7.8	#VALUE!	31.0	15.0		398.4	
Nov	23	3.1	227.0	29.9	1.3	18.1	31.1	3.5	2.3	7.2	#VALUE!	43.5	15.0		290.9	
Dec	22	3.1	318.8	30.8	1.5	21.9	32.3	3.7	1.5	9.1	#VALUE!	195.5	15.0		537.7	
Avg.	31	2.7	567.7	22.9	1.6	24.7	24.0	3.8	1.5	9.9	#VALUE!	103.6	15.0		697	0

File Name: fish Page: 2/4 Date: 4/6/99

Various Specious Catches for different Years

1991

	No. of Boats	O.Leucostictus No.	O.Leucostictus Kg	O.Leucostictus Ksh	(Bass) M. Salmoides No.	(Bass) M. Salmoides Kg	(Bass) M. Salmoides Ksh	T.Zilli No.	T.Zilli Kg	T.Zilli Ksh	(Crayfish) P.Clarkii No.	(Crayfish) P.Clarkii Kg	(Crayfish) P.Clarkii Ksh	Total No.	Total Kg	Total Ksh
Jan	28	?	12311	224855	?	3825	71539	?	83	812	?	2200	33000		18418	330206
Feb	32	54199	15144	266470	5672	2849	54140	61	14	132	?	3400	51000		21406	371743
Mar	30	90577	17861	288637	6854	3271	60761	164	33	402	?	4500	67500		25664	417300
Apr	30	77321	25032	379668	8275	3984	70543	14	4	28	?	5200	78000		34219	528240
May	33	58245	20349	339410	10070	4805	78047	78	16	76	?	2470	37050		27640	454583
Jun	37	83653	28809	419526	9516	4936	79155	42	12	81	?	1634	24510		35391	523273
Jul	38	52245	19340	335635	10619	5789	107758	63	18	119	?	1415	21225		28562	464738
Aug	40	49204	17145	298461	8433	4834	91627	33	8	107	?	2689	40335		24676	430530
Sep	40	54824	19328	447076	5481	3148	51789	111	38	222	?	2123	31845		24637	530932
Oct	39	46019	16775	296665	3445	1780	34350	23	7	50	?	1692	25380		20253	356445
Nov	38	36559	13302	270276	3486	1863	39008	17	5	52	?	1400	21000		16569	330336
Dec	38	?	18607	226468	?	1725	28219	?	19	144	?	3540	53100		23891	307931
Total	**–**	**602846**	**224001**	**3793148**	**71851**	**42807**	**766937**	**606**	**254**	**2225**	**0**	**32263**	**483945**	**0**	[illegible]	**5046254**

	No. of Boats	O.Leucostictus No/Kg	O.Leucostictus kg/boat	O.Leucostictus Ksh/Kg	(Bass) M. Salmoides No/Kg	(Bass) M. Salmoides kg/boat	(Bass) M. Salmoides Ksh/Kg	T.Zilli No/Kg	T.Zilli kg/boat	T.Zilli Ksh/Kg	(Crayfish) P.Clarkii No/Kg	(Crayfish) P.Clarkii kg/boat	(Crayfish) P.Clarkii Ksh/Kg	Total No.	Total kg/boat	Total Ksh
Jan	28	3.5	439.7	18.3	2.0	136.6	18.7	4.5	3.0	9.8	#VALUE!	78.6	15.0		657.8	
Feb	32	3.6	473.2	17.6	2.0	89.0	19.0	4.5	0.4	9.8	#VALUE!	106.3	15.0		668.9	
Mar	30	5.1	595.4	16.2	2.1	109.0	18.6	5.0	1.1	12.2	#VALUE!	150.0	15.0		855.5	
Apr	30	3.1	834.4	15.2	2.1	132.8	17.7	4.0	0.1	8.0	#VALUE!	173.3	15.0		1140.6	
May	33	2.9	616.6	16.7	2.1	145.6	16.2	4.9	0.5	4.8	#VALUE!	74.8	15.0		837.6	
Jun	37	2.9	778.6	14.6	1.9	133.4	16.0	3.5	0.3	6.8	#VALUE!	44.2	15.0		956.5	
Jul	38	2.7	508.9	17.4	1.8	152.3	18.6	3.5	0.5	6.6	#VALUE!	37.2	15.0		699.0	
Aug	40	2.9	428.6	17.4	1.7	120.9	19.0	4.4	0.2	14.3	#VALUE!	67.2	15.0		616.9	
Sep	40	2.8	483.2	23.1	1.7	78.7	16.5	3.0	0.9	5.9	#VALUE!	53.1	15.0		615.9	
Oct	39	2.7	430.1	17.7	1.9	45.6	19.3	3.5	0.2	7.7	#VALUE!	43.4	15.0		519.3	
Nov	38	2.7	350.0	20.3	1.9	49.0	20.9	3.8	0.1	11.6	#VALUE!	36.8	15.0		436.0	
Dec	38	2.7	469.7	12.2	1.9	45.4	16.4	3.8	0.5	7.8	#VALUE!	93.2	15.0		628.7	
Avg	**35**	**3.1**	**535.7**	**17.2**	**1.9**	**103.2**	**18.1**	**4.0**	**0.6**	**8.8**	**#VALUE!**	**79.8**	**15.0**		**719**	**0**

1990

	No. of Boats	O.Leucostictus No.	O.Leucostictus Kg	O.Leucostictus Ksh	(Bass) M. Salmoides No.	(Bass) M. Salmoides Kg	(Bass) M. Salmoides Ksh	T.Zilli No.	T.Zilli Kg	T.Zilli Ksh	(Crayfish) P.Clarkii No.	(Crayfish) P.Clarkii Kg	(Crayfish) P.Clarkii Ksh	Total No.	Total Kg	Total Ksh
Jan	31	?	11487	229740	?	2988	80556.48	?	99	?	?	?	?	?	14574	310296
Feb	32	?	11279	190381.1	?	3598	71960	?	99	?	?	?	?	?	14976	262341
Mar	35	?	11715	199146.5	?	3829	78867.1	?	39	?	?	?	?	?	15582	278014
Apr	32	?	9163	170431.8	?	2981	59610	?	49	?	?	?	?	?	12193	230042
May	34	?	8445	158756.6	?	5729	113997.2	?	25	?	?	?	?	?	14198	272754
Jun	36	?	5643	104056.9	?	6665	153283.5	?	5	?	?	?	?	?	12312	257340
Jul	37	?	6861	149558.9	?	8397	187242	?	9	?	?	?	?	?	15266	336801
Aug	30	?	6678	117524	?	7483	151904.9	?	20	?	?	?	?	?	14181	269429
Sep	33	?	7904	146224	?	6131	115875.9	?	8	?	?	?	?	?	14043	262100
Oct	31	?	8470	149072	?	5560	101294.1	?	5	?	?	?	?	?	14035	250366
Nov	33	?	9093	180031.5	?	4969	93417.2	?	19	?	?	?	?	?	14080	273449
Dec	28	?	10788	194184	?	4120	65088.1	?	15	?	?	?	?	?	14922	259272
Total	**–**	**0**	**107523**	**1989107**	**0**	**62447**	**1273096**	**0**	**389**	**0**	**0**	**0**	**0**	**0**	[illegible]	**3262204**

	No. of Boats	O.Leucostictus No/Kg	O.Leucostictus kg/boat	O.Leucostictus Ksh/Kg	(Bass) M. Salmoides No/Kg	(Bass) M. Salmoides kg/boat	(Bass) M. Salmoides Ksh/Kg	T.Zilli No/Kg	T.Zilli kg/boat	T.Zilli Ksh/Kg	(Crayfish) P.Clarkii No/Kg	(Crayfish) P.Clarkii kg/boat	(Crayfish) P.Clarkii Ksh/Kg	Total No.	Total kg/boat	Total Ksh
Jan	31	#VALUE!	370.5	20.0	#VALUE!	96.4	27.0	#VALUE!	3.2	9.2	#VALUE!	#VALUE!	12.2		470.1	
Feb	32	#VALUE!	352.5	16.9	#VALUE!	112.4	20.0	#VALUE!	3.1	17.4	#VALUE!	#VALUE!	12.5		468.0	
Mar	35	#VALUE!	334.7	17.0	#VALUE!	109.4	20.6	#VALUE!	1.1	8.0	#VALUE!	#VALUE!	12.7		445.2	
Apr	32	#VALUE!	286.3	18.6	#VALUE!	93.1	20.0	#VALUE!	1.5	1.0	#VALUE!	#VALUE!	12.7		381.0	
May	34	#VALUE!	248.4	18.8	#VALUE!	168.5	19.9	#VALUE!	0.7	10.8	#VALUE!	#VALUE!	12.8		417.6	
Jun	36	#VALUE!	156.8	18.4	#VALUE!	185.1	23.0	#VALUE!	0.1	9.1	#VALUE!	#VALUE!	12.6		342.0	
Jul	37	#VALUE!	185.4	21.8	#VALUE!	226.9	22.3	#VALUE!	0.2	11.3	#VALUE!	#VALUE!	12.4		412.6	
Aug	30	#VALUE!	222.6	17.6	#VALUE!	249.4	20.3	#VALUE!	0.7	11.5	#VALUE!	#VALUE!	12.4		472.7	
Sep	33	#VALUE!	239.5	18.5	#VALUE!	185.8	18.9	#VALUE!	0.2	10.5	#VALUE!	#VALUE!	12.5		425.5	
Oct	31	#VALUE!	273.2	17.6	#VALUE!	179.3	18.2	#VALUE!	0.2	10.0	#VALUE!	#VALUE!	12.4		452.7	
Nov	33	#VALUE!	275.5	19.8	#VALUE!	150.6	18.8	#VALUE!	0.6	9.3	#VALUE!	#VALUE!	12.5		426.7	
Dec	28	#VALUE!	385.3	18.0	#VALUE!	147.1	15.8	#VALUE!	0.5	12.0	#VALUE!	#VALUE!	13.0		532.9	
Avg	**–**	**#VALUE!**	**277.6**	**18.6**	**#VALUE!**	**159**	**20.4**	**#VALUE!**	**1**	**10.0**	**#VALUE!**	**#VALUE!**	**12.6**		**437**	**0**

1988

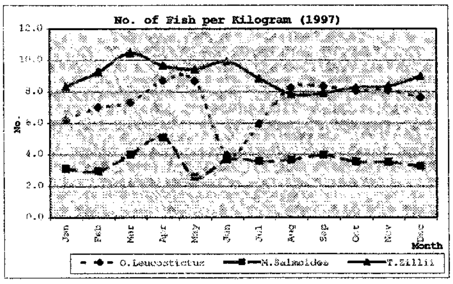
	No. of Boats	O.Leucostictus No.	O.Leucostictus Kg	O.Leucostictus Ksh	(Bass) M. Salmoides No.	(Bass) M. Salmoides Kg	(Bass) M. Salmoides Ksh	T.Zilli No.	T.Zilli Kg	T.Zilli Ksh	(Crayfish) P.Clarkii No.	(Crayfish) P.Clarkii Kg	(Crayfish) P.Clarkii Ksh	Total No.	Total Kg	Total Ksh
Jan	13	?	1400	29000	?	600	14000	?	0	0	?	3900	45000	?	5900	88000
Feb	16	?	100	1000	?	1800	40000	?	0	0	?	2700	32000	?	4600	73000
Mar	16	?	300	6000	?	1400	33000	?	0	0	?	3200	39000	?	4900	78000
Apr	18	?	1100	23000	?	1700	38000	?	0	0	?	2600	26000	?	5400	87000
May	15	?	500	12000	?	800	23000	?	0	0	?	1400	15000	?	2700	50000
Jun	18	?	700	18000	?	1000	27000	?	0	0	?	400	5000	?	2100	50000
Jul	17	?	1800	44000	?	800	22000	?	100	1000	?	0	0	?	2700	67000
Aug	17	?	2700	56000	?	1000	28000	?	100	1000	?	0	0	?	3800	85000
Sep	15	?	2200	48000	?	1100	31000	?	200	2000	?	0	0	?	3500	81000
Oct	14	?	3000	61000	?	1200	31000	?	300	2000	?	0	0	?	4500	94000
Nov	12	?	3900	72000	?	1500	36000	?	200	2000	?	0	0	?	5600	110000
Dec	11	?	4400	85000	?	2100	43000	?	100	1000	?	0	0	?	6600	129000
Total	**–**	**0**	**22100**	**455000**	**0**	**15000**	**366000**	**0**	**1000**	**9000**	**0**	**14200**	**162000**	**0**	[illegible]	**992000**

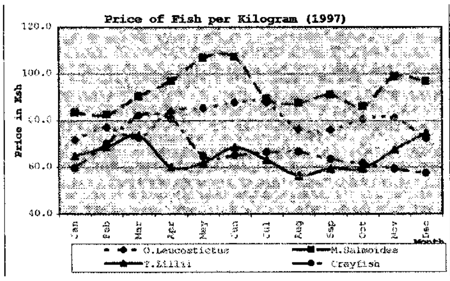
	No. of Boats	O.Leucostictus No/Kg	O.Leucostictus kg/boat	O.Leucostictus Ksh/Kg	(Bass) M. Salmoides No/Kg	(Bass) M. Salmoides kg/boat	(Bass) M. Salmoides Ksh/Kg	T.Zilli No/Kg	T.Zilli kg/boat	T.Zilli Ksh/Kg	(Crayfish) P.Clarkii No/Kg	(Crayfish) P.Clarkii kg/boat	(Crayfish) P.Clarkii Ksh/Kg	Total No.	Total kg/boat	Total Ksh
Jan	13	#VALUE!	107.7	20.7	#VALUE!	46.2	23.3	#VALUE!	0.0	10.0	#VALUE!	300.0	11.5		453.8	
Feb	16	#VALUE!	6.3	10.0	#VALUE!	112.5	22.2	#VALUE!	0.0	11.0	#VALUE!	168.8	11.9		287.5	
Mar	16	#VALUE!	18.8	20.0	#VALUE!	87.5	23.6	#VALUE!	0.0	10.0	#VALUE!	200.0	12.2		306.3	
Apr	18	#VALUE!	61.1	20.9	#VALUE!	94.4	22.4	#VALUE!	0.0	11.0	#VALUE!	144.4	10.0		300.0	
May	15	#VALUE!	33.3	24.0	#VALUE!	53.3	28.8	#VALUE!	0.0	10.0	#VALUE!	93.3	10.7		180.0	
Jun	18	#VALUE!	38.9	25.7	#VALUE!	55.6	27.0	#VALUE!	0.0	11.0	#VALUE!	22.2	12.5		116.7	
Jul	17	#VALUE!	105.9	24.4	#VALUE!	47.1	27.5	#VALUE!	5.9	10.0	#VALUE!	0.0	11.0		158.8	
Aug	17	#VALUE!	158.8	20.7	#VALUE!	58.8	28.0	#VALUE!	5.9	10.0	#VALUE!	0.0	10.0		223.5	
Sep	15	#VALUE!	146.7	21.8	#VALUE!	73.3	28.2	#VALUE!	13.3	10.0	#VALUE!	0.0	11.0		233.3	
Oct	14	#VALUE!	214.3	20.3	#VALUE!	85.7	25.8	#VALUE!	21.4	6.7	#VALUE!	0.0	10.0		321.4	
Nov	12	#VALUE!	325.0	18.5	#VALUE!	125.0	24.0	#VALUE!	16.7	10.0	#VALUE!	0.0	11.0		466.7	
Dec	11	#VALUE!	400.0	19.3	#VALUE!	190.9	20.5	#VALUE!	9.1	10.0	#VALUE!	0.0	10.0		600.0	

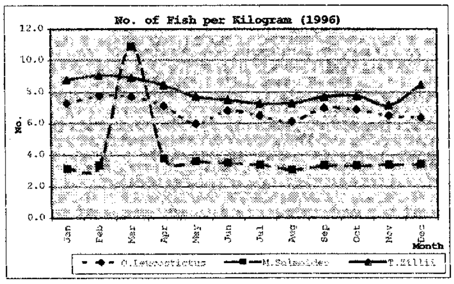
File Name: fish　　Page: 3/4　　Date: 4/6/99

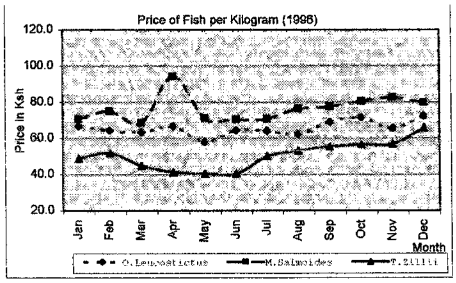
Various Specious Catches for different Years

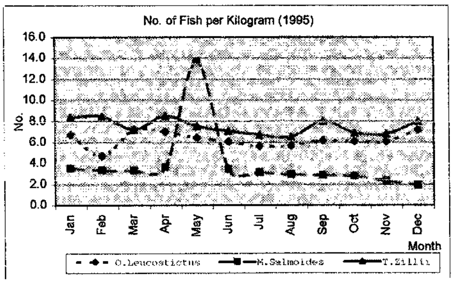
Avg.	–	#VALUE!	134.7	20.5	#VALUE!	86	25.1	#VALUE!	6	10.0	#VALUE!	77	11.0		304	0

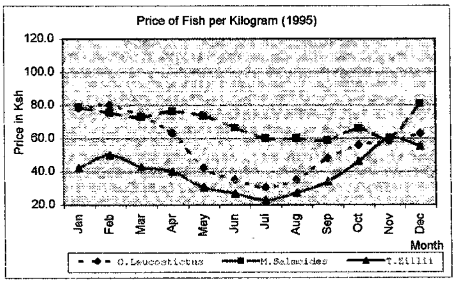


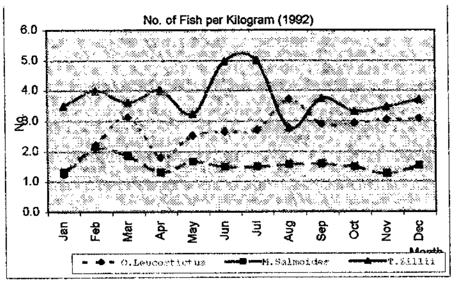


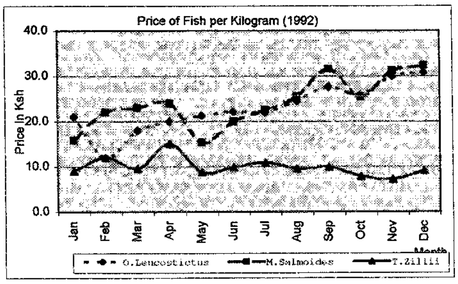








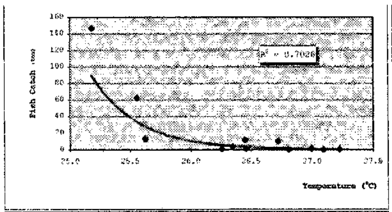


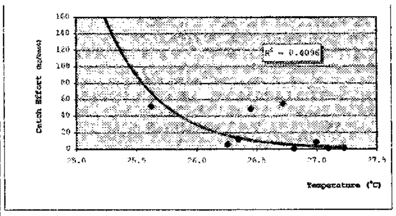


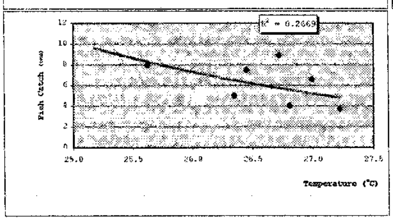
Temperature effects on the Exploited Fish Species

For Tilapia Zillii

	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Temperature	26.7	25.6	26.4	27.0	26.3	27.2	26.8	27.1	26.5	26.3	27.2	25.6	25.2
Kg/boat	55.34	52.26	48.69	8.42	11.99	1.45	0.65	1.01		6.02			
Kg	10.3	13.5	12.1	1.7	4.0	0.6	0.3	0.4	1.6	1.0		62.8	146.8
No/Kg	8.9	8.0	7.5	6.6	5.0	3.8	4.0						

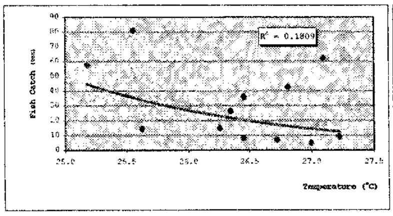


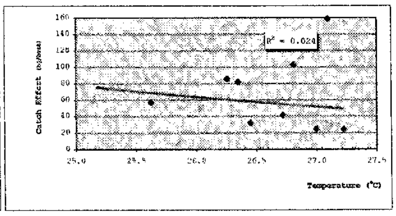


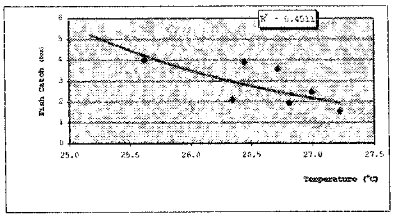


For Salmoides

	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Temperature	26.7	25.6	26.4	27.0	26.3	27.2	26.8	27.1	26.5	26.3	27.2	25.6	25.2
Kg/boat	41.36	57.35	32.46	24.81	82.26	24.71	103.20	159.00		85.86			
Kg	7.2	14.6	8.3	5.0	26.6	9.6	42.8	62.4	36.4	15.0		81.1	58.0
No/Kg	3.6	4.0	3.9	2.5	2.1	1.6	1.9						

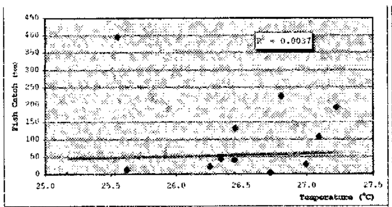


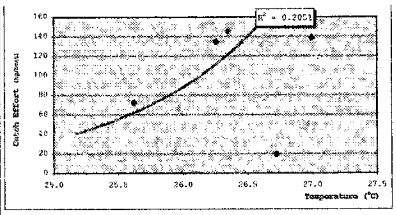


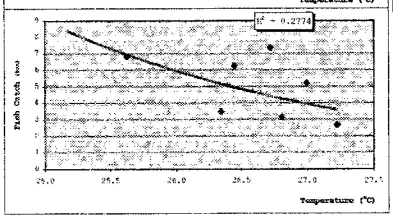


For Leucostictus

	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Temperature	26.7	25.6	26.4	27.0	26.3	27.2	26.8	27.1	26.5	26.3	27.2	25.6	25.2
Kg/boat	19.71	72.60	162.82	138.98	145.60	567.69	535.71	277.56		134.72			
Kg	3.7	12.8	41.0	28.4	43.8	192.4	224.0	107.5	131.5	22.1		396.2	
No/Kg	7.4	6.8	6.2	5.2	3.5	2.7	3.1						







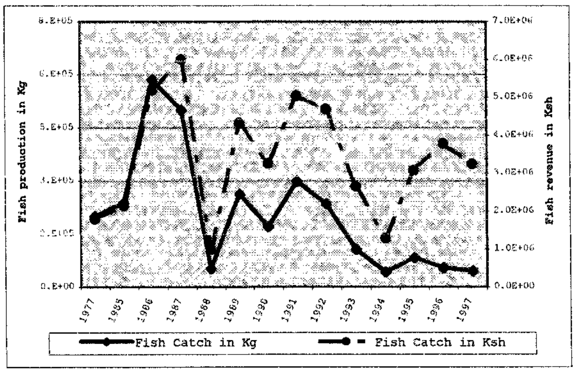
File Name: Annex_Fish Page: 1/1 Date: 4/6/99

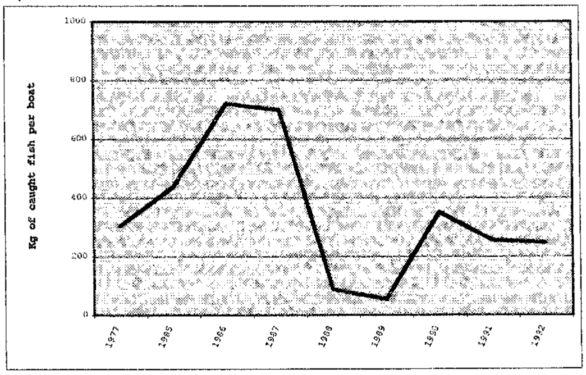
Fish Summary

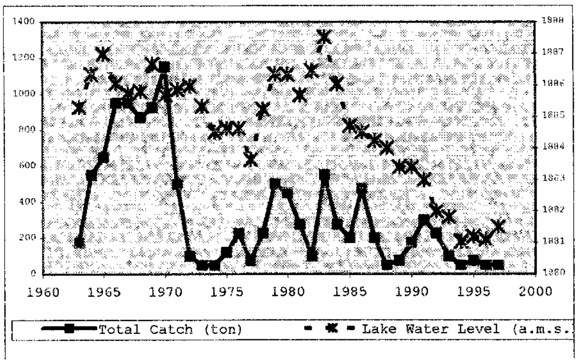
Year	Fish Catch in Kg	Fish Catch in Ksh	Ksh/Kg	kg/boat
1977	200000	1800000	9.0	?
1985	238007	2142059	9.0	?
1986	585200	5187000	8.9	?
1987	500000	6000000	12.0	?
1988	52300	992000	19.0	304
1989	263298	4330179	16.4	?
1990	170359	3262204	19.1	437
1991	299324	5046254	16.9	719
1992	235137	4685732	19.9	697
1993	106215	2655363	25.0	86
1994	42873	1286190	30.0	53
1995	82773	3077734	37.2	351
1996	54275	3786677	69.8	254
1997	45092	3249654	72.1	247
Avg.	205346	3392932	26.0	350

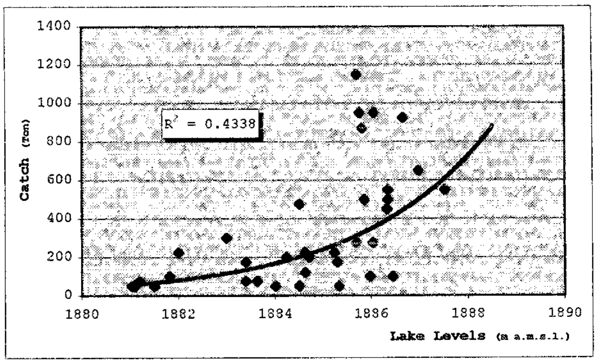
Notes:

1- The fish catch has dropped considerably by the year 1988 as there was a very low lake levels.
2- The fish catch was very high in the year 1986 as it includes barbus. This species is usually found in rivers (reverine fish) as it likes cooler water and Malewa river is usually cooler than the lake.
3- Fish breeding zone is up to 100 m far from the lake shore, where fishing is not allowed.
4- In the fish breeding zone, there is shallow water where you can go on foot whithout a boat. Nad that's where the illeagal fishing takes place.
5- Farm guards sometimes allow some homeless people to go inside their ffarms to fish without a fishing license.
6- Seining is not allowed in Naivasha as it's a RAMSAR site. (for details of Seining look at the original paper by Joyce)
7- Wrong timing, methods, like undersized nets, are the ways of illeagal fishing.
8- The percentage of illeagal fishing has increased considerable over the last 5 years as the unemployment rate has increased, and even the employed people are under employed or low earning. The cost of living is increasingly high without a relevant increase in the income levels.
8- Tilapia Zilii and Oreochromis leucostictus better grow in 25°C-28°C, and a pH of 6.8-7.0









File Name: fish Page:1/1 Date: 4/6/99

Water Quality Analysis

Sample Codes

"Done in Kanater"

Sample Code	Discription	Sampling Date	Bottle No.
1	Olkaria Geothermal Plant	10-Oct-99	(1/2)
2	Olkaria Geothermal Plant	10-Oct-99	(2/2)
3	Brixia, Top Hill, Bore Hole, Domestic Use, Some Irrigation.	10-Oct-99	(1/1)
4	Delamere, Nearest borehole to the lake, Pump 3	12-Oct-99	(1/1)
5	Delamere, a borehole at the same distance as pump3, Pump 2	12-Oct-99	(1/1)
6	Brixia, Down Lake, Bore Hole, Irrigation, No domestic	10-Oct-99	(1/1)

Samples Done in Egypt

Values are in mg/l

Cations

Sample No.	Sampling Date	Ag	Al	B	Ba	Bi	Ca	Cd	Cu	Fe	Co	Ni	Ga	In	K	Li	Mg	Mn	Na	Pb	Zn	Cr	Ti
1	10-Oct-98	-0.080	-0.450	1.640	0.201	-0.046	-2.550	-0.072	0.241	-2.590	-0.058	-0.392	0.010	-0.026	15.300	0.324	0.530	-0.196	192.000	-0.182	-0.818	-0.545	-0.088
2	10-Oct-98	-0.095	-0.616	1.050	-0.217	-0.046	-2.730	-0.070	-0.239	-2.590	-0.052	-0.372	-0.054	-0.040	15.700	0.279	-0.746	-0.195	192.000	-0.235	-0.825	-0.582	-0.147
3	10-Oct-98	0.038	-0.204	-0.256	-0.058	0.103	29.600	-0.026	-0.011	0.974	-0.018	-0.123	-0.016	0.006	16.100	-0.013	18.400	0.048	39.000	-0.061	-0.204	-0.222	-0.078
4	12-Oct-98	-0.035	-0.240	-0.338	-0.075	-0.067	11.800	-0.025	-0.063	-0.991	-0.024	-0.147	-0.039	0.000	6.950	-0.025	1.230	-0.066	30.000	-0.099	-0.274	-0.231	0.065
5	12-Oct-98	-0.035	0.257	-0.374	-0.071	-0.033	52.500	-0.027	-0.078	-0.968	0.027	-0.161	-0.050	-0.003	10.900	-0.021	5.910	-0.063	26.600	-0.090	-0.292	-0.225	0.080
6	10-Oct-98	-0.033	-0.201	-0.407	-0.029	-0.024	22.200	-0.029	-0.059	-0.251	-0.018	-0.085	-0.012	0.075	11.900	0.000	15.300	-0.061	34.800	-0.052	-0.187	-0.223	-0.095

Anions

Sample No	Sampling Date	F	CL	NO_3	PO_4	SO_4
1	10-Oct-98	104.075	341.508	0.925	0.000	36.909
2	10-Oct-98	109.784	366.781	0.000	0.000	27.046
3	10-Oct-98	4.083	39.614	2.095	0.000	11.103
4	12-Oct-98	1.296	11.156	2.122	0.000	4.984
5	12-Oct-98	1.173	89.294	5.719	0.000	53.234
6	10-Oct-98	2.236	41.140	10.098	0.000	15.295

File Name: csample   Page: 1/1   Date: 4/6/99

Water Quality Guidelines

GUIDELINES FOR DISCHARGE INTO PUBLIC WATERCOURSE.

pH................................	6.0-9.0
BOD (5 days at 20^{o}C) not to exceed..	20 mg/l
COD not to exceed..................	50 mg/l
Total Suspended Solids not to exceed	30 mg/l
n-Hexane extrcat not to exceed......	30 mg/l
Oils (Mineral Animal & Vegetable)...	5.0 mg/l
Total Phenol not to exceed..........	2.0 mg/l
Copper (Cu) not to exceed...........	0.05 mg/l
Zinc (Zn) not to exceed............	0.5 mg/l
Lead (Pb) not to exceed............	0.1 mg/l
Arsenic (As) not to exceed..........	0.002 mg/l
Total Mercury (Hg) not to exceed....	0.005 mg/l
Alkyl Mercury not to exceed.........	0.001 mg/l
PCB (Polchlorinated Biphenyl) not to exceed............................	0.003 mg/l
Pesticides residues not to exceed...	0.05 mg/l
Sulphates not to exceed............	500 mg/l
Dissolved Manganese (Mn)	1.0 mg/l
Chromium (total)...................	0.1 mg/l
Chloride not to exceed.............	1000 mg/l
Fluoride not to exceed.............	2.0 mg/l
Coliform bacteria..................	1000/100ml
Free Ammonia not to exceed..........	0.2 mg/l
Sulphides (S^{-}) not to exceed........	0.1 mg/l
Cadmium (Cd) not to exceed.........	0.05 mg/l
Cyanide (CN^{-}) total not to exceed...	0.1 mg/l
Organic Phosphorous not to exceed...	1.0 mg/l
Chromium (six) (Cr^{6+}) not to exceed	0.005 mg/l
Total Dissolved Solids not to exceed	1200 mg/l
Selenium (Se) not to exceed.........	0.05 mg/l
Nickel (Ni) not to exceed..........	1.0 mg/l
Barium (Ba) not to exceed..........	2.0 mg/l
Temperature not to exceed.......... temperature of the water body.	+/-2^{o}C of ambient
Oil/grease.........................	Nil (no trace)
Toxic Substances...................	Nil
Odour.............................. nose.	Not objectionable to the
Colour............................	Not objectionable to the eyes OR not to exceed 5 mgPt/l

NB. No person shall discharge into any watercourse any of the following substances;

- Calcium Carbide
- Chloroform
- Condensing water
- Degreasing solvents
- Inflamable solvents

GUIDELINES FOR DISCHARGE INTO PUBLIC SEWERS.

pH.................................	6.0-9.0
BOD (5days at 20°C) not to exceed...	500 mgO_2/l
COD not to exceed..................	1000 mg O_2/l
Temperature not to exceed...........	27°C +/- 2°C
Total Suspended Solids not to exceed	500 mg/l
Total non-volatile Dissolved Solids not to exceed......................	2000 mg/l
Detergents not to exceed............	15 mg/l
Phenols not to exceed...............	10 mg/l
Oils/grease not to exceed...........	10 mg/l
Soaping Oils and Fats not to exceed.	50 mg/l
Hydrocarbons not to exceed..........	20 mg/l
Hydrocarbons (cyclic)...............	5 mg/l
Silver (Cyclic Ag) not to exceed....	2 mg/l
Arsenic (As)........................	0.2 mg/l
Barium (Ba) not to exceed...........	10 mg/l
Cadmium (Cd) not to exceed..........	0.5 mg/l
Chlorite not to exceed..............	2 mg/l
Cyanide (CN^-) not to exceed.........	0.5 mg/l
Total Cyanide not to exceed.........	2.0 mg/l
Cobalt (Co) not to exceed...........	1.0 mg/l
Chromium six (Cr^{6+}) not to exceed...	0.05 mg/l
Total Chromium (Cr) not to exceed...	1.0 mg/l
Copper (Cu) not to exceed...........	1.0 mg/l
Mercury (Hg) not to exceed..........	0.01 mg/l
Ammoniacal Nitrogen ($N-N_4/NH_3$)not to exceed............................	20 mg/l
Nikel (Ni) not to exceed............	1.0 mg/l
Nitrates (NO_3) not to exceed........	20 mg/l
Lead (Pb) not to exceed.............	1.0 mg/l
Total Phosphorous not to exceed.....	30 mg/l
Sulphur (S) not to exceed...........	2.0 mg/l
Sulphide (S^2) not to exceed.........	2.0 mg/l
Selenium (Se) not to exceed.........	0.2 mg/l
Tin (Sn) not to exceed..............	5.0 mg/l
Sulphite (SO_3^{2-}) not to exceed......	50 mg/l
Sulphate (SO_4^{2-}) not to exceed......	1000 mg/l
Zinc (Zn) not to exceed.............	5.0 mg/l
Total non Ferous metals not to exceed	10 mg/l
Chlorides (Cl^{1-}) not to exceed......	1000 mg/l

NB. No person shall discharge into the sewers any of the following substances;

- Calcium Carbide
- Chloroform
- Condensing water
- Degreasing solvents
- Radioactive residues
- Inflamable solvents
- Substances likely to interfere with the sewers.

ANNEX PR.1

Selection of the Location:

The selection of the location of the new reservoir was done at the aid of the GIS techniques. Different criterions were satisfied in the new location. Using the index overlay method **[Carter, 1994]** with multi-class maps, we were able to examine all the involved criteria in a GIS context. The first three maps, i.e. Slope, DEM and soil have been reclassified to few classes, which were assigned internal weights of preferences. Moreover, every single map was assigned a weight which represents its' importance in the process of selection. The other two maps were helping in a binary selection scheme, meaning wherever is true, a reservoir can not be established. Those criterions accompanied by their weights are:

Criterion	Description	Weight
Slope	Lowest slopes available	Low (3)
DEM	Elevation classes, high is preferred	Medium (7)
Soil	Permeability classes, clay is preferred	Medium(6)
Roads	Binary selection, no roads	(Binary)
Cities	Binary selection, outside cities	(Binary)

High elevation is preferred to get high rainfall to capture it and to minimize losses. Clay is also preferred to increase the residence time before reaching the groundwater. That will alleviate any chance of having a rising ground water level. Moreover, giving place and time for the filtering effect to take place. (From the agrochemicals).

Finally, a suitability, for the establishment of the reservoir, map **[Plate 5-1]** is obtained, and later on overlaid by the drainage map to have a sensible compromise of the location of the dam. The location of the new dam was selected to be at the coordinates of UTM (37, 211050, 9951270), which is near both Gilgil and Oleolondo towns, at the Malewa river at an approximate elevation of 2020 m a.m.s.l., lying in a zone of moderately suitable at a score of 6.63 (maximum is 9.25).

Water Budget:

- **Assumptions:**
  - The reservoir will reduce Lake Levels by 1.0 meter.
  - In case of any serious water shortage gates could be opened to release water needed downstream.
  - No water supply schemes to any other city is expected to run on this reservoir.
  - Volume of water entrapped in the new reservoir is $100*10^6$ m^3.
  - A corresponding surface area depends, of course, on the location and the topography. An average of 10.0 km^2 is being estimated after going through various GIS processes for the particular sites on the tributaries of Malewa.
  - Evaporation rate is assumed to be less than around the lake, as temperature is highly correlated to the elevation meaning higher elevation result in a lower temperature. Knowing that the reservoir location is in higher elevation than the lake.

* Amount of annual inputs to the new reservoir should be assumed to equal the abstraction and/or losses from it (either for small evaporation due to the small surface area or for any small scale farming activities that might take place in the region).
* Trapping sediments is a kind of conserving the lake from further contamination as sediments are the indirect contamination agents for their ability to hold nutrients. Moreover, that will alleviate the silting up of the lake.
* Further development of the project is being put under severe control of the decision-makers in the area. Future expansion should be put in the agenda in case of economic development needs.

* **Consequences:**

* Evaporation is reduced by a value can be quickly estimated as (area*1.70); while surface area reduction (in meters) of the lake, or directly get from the figure shown here.

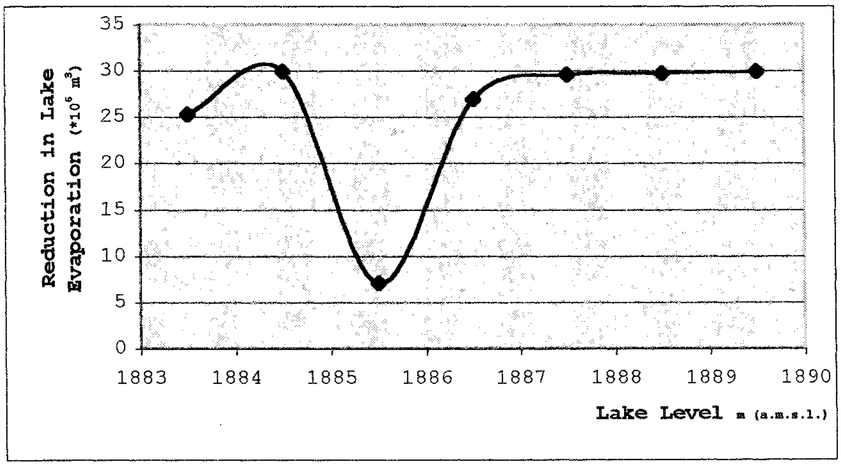


Figure 1: Reduction in Lake Evaporation for 1.0 Meter Strip.

* No threats could be expected downstream.
* No further inter-catchmental abstraction.
* This volume is taken from lake Naivasha only once.
* Evaporation rate in the reservoir is much less than the evaporation rate in the lake. On top of that the surface area of the reservoir is less than the surface area of the lake. Accordingly, the total evaporation from reservoir will be much less than from the lake for the same surface area.
* Less pollution into the lake, hence better quality of the lake waters.

* **Figures:**

* Evaporation reduction is assumed on average to be $(15*10^6)*1.70 = 25.5*10^6$ m^3/year. An average of the previous graph is $27*10^6$ m^3/year.
* Volume of water in the new reservoir is $100*10^6$ m^3.
* Surface area of the new reservoir is 10.0 km^2.
* Evaporation rate from the reservoir is assumed to be 80% of the lake evaporation rate (1700 mm/year) which equals to 1360 mm/year, based on the elevation temperature equation, and the calculation

of energy balance equation. Then total evaporation equals to $10*10^6$ m^3/year.

- ★ Abstraction and/or losses from the new reservoir is estimated to be less than $40*10^6$ m^3/year.
- ★ Total abstraction and/or losses from the new reservoir is estimated to be $50*10^6$ m^3/year.

★ **Conclusion:**

- ★ Reduction in Evaporation from the lake surface area is a huge number equals one third of the amount needed for unstressed irrigation for the lake area.
- ★ Flexible settings of the project.
- ★ No reduction in water availability on the catchment scale.
- ★ No profound effect on the lake levels downstream.
- ★ Better control on the water quality of the lake downstream. (in sediments)
- ★ Last thing to say here is that the new reservoir could be utilized in hydropower generation. In that case another criterion should be involved in the location selection. Which is the future expansion of the surface area itself.

Design:

- ★ Location : **UTM (37,211050,9951270)**
- ★ River/Tributary : **Malewa**
- ★ Estimated Area : **10.0 Km^2**
- ★ Annual Flow : **$50.0*10^6$ m^3**
- ★ Sediment Yield : **0.12 ton/ha.yr**
- ★ Dam Depth : **30.0 m**
- ★ Average Depth : **10.0 m**
- ★ Total Volume : **$100.0*10^6$ m^3**

Table 1: Comparison between the Current Situation and the New Suggested Scenario.

Parameter	Current	New Scenario			
		Lake	Reservoir	Total	Better by
Area (km^2)	133	116	10	**126**	**7**
Evaporation (mm/d)	4.61	4.61	3.7	4.5	(--)
Total Evaporation ($*10^6$ m^3/yr)	227	195	13	**208**	**19**
Water share (lt/capita.day)	55	(-)	(-)	**256**	**201**

ANNEX PR.2

Tropical Livestock Unit:

Source [FAO & IIASA, 1993]

It is the nonphysical representation of a mature animal weighing 250 kg.

Conversion table for selected livestock:

Camel	Cow	Donkey	Sheep	Goat
1.25 (TLU)	1.00 (TLU)	0.50 (TLU)	0.10 (TLU)	0.08 (TLU)

Conversion table for selected wildlife:

Buffalo	Giraffe	Zebra	Waterbuck	Impala
1.50 (TLU)	1.10 (TLU)	0.85 (TLU)	0.50 (TLU)	0.10 (TLU)

Some selected characteristics of the TLU:

Aspect	Unit	Value	Remarks
Water Consumption	(lt/head.day)	25	
Milk Production	(lt/day)	3-5	When applicable!
Milk Production (Total)	(lt)	400	During Rearing period
Beef Production	(kg/TLU)	20-30	
Dry Matter Intake (DMI)	(kg/TLU)	3700-7200	For life time

Water Consumption of Wildlife/Livestock:

	Adult		Juveniles	Total	TLU	Water Consumption			
	Male	Female				Watering	lt/day	m³/yr	catchment
Zebra	83	255	48	337	0.85	0.00	7151	2612	52235
Impala	66	137	33	206	0.10	0.00	515	188	3758
Elands	4	27	17	37	0.75	0.00	690	252	5040
Giraffe	3	4	3	8	1.10	0.00	223	81	1627
Water Buck	13	22	9	37	0.50	0.00	466	170	3406
Thomson Gazelle	11	52	13	64	0.20	0.00	322	117	2349
Cattle	--	--	--	35000	1.00	2.00	875000	345161	1725806
Sheep	--	--	--	35000	0.10	0.00	87500	31959	159797
Ccamel				0	0.50	2.00	0	0	0
Buffalo				100	1.50	0.00	3750	1370	6848
Elephant				0	9.10	0.00	0	0	0
								Total	**1960867**

Output of livestock products per herd TLU

Livestock System	Product	Unit	Technology Used		
			Low	Intermediate	High
Cattle	Milk	(lt/TLU)	264.8	567.8	901.5
	Meat	(kg/TLU)	24.6	27.9	19.8
Goat	Milk	(lt/TLU)	-	263.7	2166.7
	Meat	(kg/TLU)	92.6	114.6	132.7
Sheep	Milk	(lt/TLU)	70.5	123.0	145.0
	Meat	(kg/TLU)	11.9	20.8	25.0
Camel	Milk	(lt/TLU)	96.2	120.6	144.3
	Meat	(kg/TLU)	1.9	2.4	2.9

Values in this table may seem strange, as meat production out of the cattle is expected to be higher than from goat and sheep. But those values are normalized to the real production in the sense that cattle are majorly targeted for milk production rather than meat production. (For this research done by FAO & IIASA)

ANNEX PR.3

The Final Evaluation Matrix

Criteria	Scenario 1 No Go	2 Deforestation	3 Mulching	4 Rain-Fed	5 Night Irrigation	6 New Reservoir
Environment	0.30	0.33	0.00	0.71	0.30	0.34
Social	0.10	0.43	0.56	0.61	0.16	0.69
Costs	0.00	0.07	0.07	0.34	0.11	0.67
Applicability	0.88	0.68	0.48	0.57	0.73	0.72
GW Recharge	0.52	0.63	0.57	0.40	0.74	0.18
Employment	0.00	0.04	0.39	1.00	0.00	0.16
Income	0.91	0.91	0.91	0.91	0.91	1.00
Management	0.95	0.61	0.52	0.27	0.70	0.54

File Name: Multicriteria

Sheet: Evaluation Matrix
Page: 1/14

Date: 4/16/99

Criteria: Environment

Summary:

			Original Scores			Standardized Scores			Final
			Ag-Chem	Erosion	Nat.Veg.	Ag-Chem	Erosion	Nat.Veg.	Score
Scenario	1		76,806	31,807	0	0.00	0.90	0.00	**0.30**
	2		76,806	32,323	0	0.00	1.00	0.00	**0.33**
	3		76,806	27,151	0	0.00	0.00	0.00	**0.00**
	4		132,668	27,807	55,000	1.00	0.13	1.00	**0.71**
	5		76,806	31,807	0	0.00	0.90	0.00	**0.30**
	6		83,808	31,064	6,900	0.13	0.76	0.13	**0.34**
		min	76,806	27,151	0	Diff.	Diff	Max	
		max	132,668	32,323	55,000				

Agro-Chemicals:

Scenario 1

	Area (ha)			Agro-Chemicals Input (ton/ha.yr)		
	Flower	Fodder	Vegetable	Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	1.65	0.74	1.12
Increase	0	0	0			
Total	1,200	2,743	65,159	Agro-Chemical Score		
					76,806	

Scenario 2

Percentage of Deforestation: 10%

	Area (ha)			Agro-Chemicals Input (ton/ha.yr)		
	Flower	Fodder	Vegetable	Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	1.65	0.74	1.12
Increase	0	0	0			
Total	1,200	2,743	65,159	Agro-Chemical Score		
					76,806	

Scenario 3

Percentage of Mulching: 30%

	Area (ha)			Agro-Chemicals Input (ton/ha.yr)		
	Flower	Fodder	Vegetable	Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	1.65	0.74	1.12
Increase	0	0	0			
Total	1,200	2,743	65,159	Agro-Chemical Score		
					76,806	

Scenario 4

	Area (ha)			Agro-Chemicals Input (ton/ha.yr)		
	Flower	Fodder	Vegetable	Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	1.65	0.74	1.12
Increase	0	0	50,000			
Total	1,200	2,743	115,159	Agro-Chemical Score		
					132,668	

Scenario 5

	Area (ha)			Agro-Chemicals Input (ton/ha.yr)		
	Flower	Fodder	Vegetable	Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	1.65	0.74	1.12
Increase	0	0	0			
Total	1,200	2,743	65,159	Agro-Chemical Score		
					76,806	

Scenario 6

	Area (ha)			Agro-Chemicals Input (ton/ha.yr)		
	Flower	Fodder	Vegetable	Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	1.65	0.74	1.12
Increase	500	800	5,000			
Total	1,700	3,543	70,159	Agro-Chemical Score		
					83,808	

Criteria: Environment

Erosion:

Total Catchment Area (ha) 329,211
Average Sediment Yield (ton/ha/yr) 0.12

Scenario 1

	Area (ha)				Sediment Yield (ton/ha.yr)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.01	0.02	0.04	0.00
Increase	0	0	0	0				
Total	1,200	2,743	65,159	17,330	Erosion Score			
					31,807			

Scenario 2

Percentage of Deforestation: 10%

	Area (ha)				Sediment Yield (ton/ha.yr)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.01	0.02	0.04	0.00
Increase	0	0	0	0	Additional Erosion Prone Area			4303
Total	1,200	2,743	65,159	17,330	Erosion Score			
					32,323			

Scenario 3

Percentage of Mulching: 30%

	Area (ha)				Sediment Yield (ton/ha.yr)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.01	0.02	0.04	0.00
Increase	0	0	0	0	Reduction in Erosion Prone Area			38796
Total	1,200	2,743	65,159	17,330	Erosion Score			
					27,151			

Scenario 4

	Area (ha)				Sediment Yield (ton/ha.yr)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.01	0.02	0.04	0.00
Increase	0	0	50,000	0	Additional Erosion Prone Area			0
Total	1,200	2,743	115,159	17,330	Erosion Score			
					27,807			

Scenario 5

	Area (ha)				Sediment Yield (ton/ha.yr)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.01	0.02	0.04	0.00
Increase	0	0	0	0	Additional Erosion Prone Area			0
Total	1,200	2,743	65,159	17,330	Erosion Score			
					31,807			

Scenario 6

	Area (ha)				Sediment Yield (ton/ha.yr)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.01	0.02	0.04	0.00
Increase	500	800	5,000	1,733	Additional Erosion Prone Area			0
Total	1,700	3,543	70,159	19,063	Erosion Score			
					31,064			

Criteria: Environment

Natural Vegetation Loss:

Scenario 1

	Area (ha) Flower	Fodder	Vegetable	Extra Accompanied Loss (%) Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	20%	0%	10%
Increase	0	0	0			
Total	1,200	2,743	65,159	Natural Vegetation Loss Score		
				0		

Scenario 2

Percentage of Deforestation: 10%

	Area (ha) Flower	Fodder	Vegetable	Extra Accompanied Loss (%) Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	20%	0%	10%
Increase	0	0	0			
Total	1,200	2,743	65,159	Natural Vegetation Loss Score		
				0		

Scenario 3

Percentage of Mulching: 30%

	Area (ha) Flower	Fodder	Vegetable	Extra Accompanied Loss (%) Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	20%	0%	10%
Increase	0	0	0			
Total	1,200	2,743	65,159	Natural Vegetation Loss Score		
				0		

Scenario 4

	Area (ha) Flower	Fodder	Vegetable	Extra Accompanied Loss (%) Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	20%	0%	10%
Increase	0	0	50,000			
Total	1,200	2,743	115,159	Natural Vegetation Loss Score		
				55,000		

Scenario 5

	Area (ha) Flower	Fodder	Vegetable	Extra Accompanied Loss (%) Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	20%	0%	10%
Increase	0	0	0			
Total	1,200	2,743	65,159	Natural Vegetation Loss Score		
				0		

Scenario 6

	Area (ha) Flower	Fodder	Vegetable	Extra Accompanied Loss (%) Flower	Fodder	Vegetable
Current	1,200	2,743	65,159	20%	0%	10%
Increase	500	800	5,000			
Total	1,700	3,543	70,159	Natural Vegetation Loss Score		
				6,900		

Criteria: Social

Summary:

Scenario		Original Scores			Standardized Scores			Final
		W-Share	L.Ctrl.	R.Pref.	Ag-Chem	Erosion	Nat.Veg.	Score
1		55	6,913	10	0.06	0.15	0.11	**0.10**
2		797	11,015	20	0.85	0.23	0.22	**0.43**
3		939	10,773	40	1.00	0.23	0.44	**0.56**
4		55	47,651	70	0.06	1.00	0.78	**0.61**
6		103	6,913	20	0.11	0.15	0.22	**0.16**
7		256	37,714	90	0.27	0.79	1.00	**0.69**
	min	55	6,913	10	Max	Max	Max.	
	max	939	47,651	90				

Per Capita Water Share:

	Water Share (lt/capita.day)
Scenario 1	55
Scenario 2	797
Scenario 3	939
Scenario 4	55
Scenario 5	103
Scenario 6	256

Land Control:

	Percent of Controlable Area	Total Area (ha)	Controlled Area [score]
Scenario 1	10%	69,127	6,913
Scenario 2	15%	73,431	11,015
Scenario 3	10%	107,729	10,773
Scenario 4	40%	119,127	47,651
Scenario 5	10%	69,127	6,913
Scenario 6	50%	75,427	37,714

Relative Preference:

	Relative Preference
Scenario 1	10
Scenario 2	20
Scenario 3	40
Scenario 4	70
Scenario 5	20
Scenario 6	90

Criteria: Costs

Summary:

Scenario		Original Scores Set-Up	Original Scores Mngmnt	Original Scores Maintenance	Standardized Scores Set-Up	Standardized Scores Mngmnt	Standardized Scores Maintenance	Final Score
1		0	0	0	0.000	0.000	0.000	0.000
2		21,515	0	0	0.215	0.000	0.000	0.072
3		19,301	3,860	1,930	0.193	0.008	0.002	0.068
4		100,000	5,000	2,500	1.000	0.010	0.003	0.338
6		9,137	83,432	83,432	0.091	0.167	0.083	0.114
7		0	500,000	1,000,000	0.000	1.000	1.000	0.667
	min	0	0	0	Max	Max	Max	
	max	100,000	500,000	1,000,000				

Set-Up Costs:

Scenario 1

Area (ha) No Go	**Costs** (US$/ha) No Go
0	0.00
Score	0

Scenario 2

Area (ha) Deforestation	**Costs** (US$/ha) Deforestation
4,303	5.00
Score	21,515

Scenario 3

Area (ha) Mulching	**Costs** (US$/ha) Mulching
38,601	0.50
Score	19,301

Scenario 4

Area (ha) Rain-Fed	**Costs** (US$/ha) Rain-Fed
50,000	2.00
Score	100,000

Scenario 5

Area (ha) Irrigation	**Costs** (US$/ha) Lights
4,568	2.00
Score	9,137

Scenario 6

Volume New Reservoir Volume (m^3)	**Costs** (US$/m3) Construction
100,000,000	0.50
Score	50,000,000

Criteria: Costs

Management Costs:

Scenario 1

Area (ha)	Costs (US$/ha)
No Go	No Go
0	0.00
Score	0

Scenario 2

Area (ha)	Costs (US$/ha)
Deforestation	Deforestation
4,303	0.00
Score	0

Scenario 3

Area (ha)	Costs (US$/ha)
Mulching	Mulching
38,601	0.10
Score	3,860

Scenario 4

Area (ha)	Costs (US$/ha)
Rain-Fed	Rain-Fed
50,000	0.10
Score	5,000

Scenario 5

Area (ha)	Costs (US$/ha.day)
Irrigation	Lights
4,568	0.10
Score	166,864

Scenario 6

Volume	Costs (US$/m^3.year)
New Reservoir Volume (m^3)	Management
100,000,000	0.005
Score	500,000

Criteria: Costs

Maintenance Costs:

Scenario 1

Area (ha) No Go	**Costs** (US$/ha) No Go
0	0.00
Score	0

Scenario 2

Area (ha) Deforestation	**Costs** (US$/ha) Deforestation
4,303	0.00
Score	0

Scenario 3

Area (ha) Mulching	**Costs** (US$/ha) Mulching
38,601	0.05
Score	1,930

Scenario 4

Area (ha) Rain-Fed	**Costs** (US$/ha) Rain-Fed
50,000	0.05
Score	2,500

Scenario 6

Area (ha) Irrigation	**Costs** (US$/ha.day) Lights
4,568	0.05
Score	83,432

Scenario 7

Volume New Reservoir Volume (m^3)	**Costs** (US$/$m^3$.year) Management
100,000,000	0.010
Score	1,000,000

Criteria: Applicability

Summary:

Scenario			Original Scores			Standardized Scores			Final
			Access.	Feasib.	Sustain.	Access.	Feasib.	Sustain.	Score
	1		100	70	60	1.00	1.00	0.63	**0.88**
	2		80	60	40	0.80	0.86	0.38	**0.68**
	3		60	50	20	0.60	0.71	0.13	**0.48**
	4		70	70	10	0.70	1.00	0.00	**0.57**
	5		100	30	70	1.00	0.43	0.75	**0.73**
	6		60	40	90	0.60	0.57	1.00	**0.72**
		min	60	30	10	Max	Max	Diff.	
		max	100	70	90				

Accessibility

		Accessibility (subjective)
Scenario	**1**	100
Scenario	**2**	80
Scenario	**3**	60
Scenario	**4**	70
Scenario	**5**	100
Scenario	**6**	60

Feasibility:

		Feasibility (subjective)
Scenario	**1**	70
Scenario	**2**	60
Scenario	**3**	50
Scenario	**4**	70
Scenario	**5**	30
Scenario	**6**	40

Sustainability:

		Sustainability (subjective)
Scenario	**1**	60
Scenario	**2**	40
Scenario	**3**	20
Scenario	**4**	10
Scenario	**5**	70
Scenario	**6**	90

Criteria: GW Recharge

Summary:

		Original Scores			Standardized Scores			Final
		Simulation	None	None	Diff.	Max.	Sum.	Score
Scenario	1	70	.	.	0.60	0.78	0.17	**0.52**
	2	80	.	.	0.80	0.89	0.19	**0.63**
	3	75	.	.	0.70	0.83	0.18	**0.57**
	4	60	.	.	0.40	0.67	0.14	**0.40**
	6	90	.	.	1.00	1.00	0.22	**0.74**
	7	40	.	.	0.00	0.44	0.10	**0.18**
	min	40	.	.				
	max	90	.	.				

Ground Water Recharge:

	Simulation (subjective)
Scenario 1	70
Scenario 2	80
Scenario 3	75
Scenario 4	60
Scenario 5	90
Scenario 6	40

Criteria: Employment

Summary:

Scenario	Total	Original Scores Start-Up	Original Scores Running	Original Scores None	Standardized Scores Labour	Standardized Scores Running	Standardized Scores None	Final Score
1	607,637	0	607,637	.	0.00	0.00	.	**0.00**
2	641,296	33,659	607,637	.	0.09	0.00	.	**0.04**
3	911,103	303,466	607,637	.	0.78	0.00	.	**0.39**
4	1,389,844	391,103	998,740	.	1.00	1.00	.	**1.00**
6	607,637	0	607,637	.	0.00	0.00	.	**0.00**
7	732,753	66,469	666,284	.	0.17	0.15	.	**0.16**
	min	0	607,637	0	Diff.	Diff.		
	max	391,103	998,740	0				

Start-Up Labour:

Scenario 1

	Area (ha) Flower	Fodder	Vegetable	Water	Labour Intensity (labour/ha) Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	0	0	0	0	Extra Labour Requirement (are			0
Total	1,200	2,743	65,159	17,330	Start-Up Labour Score			
						0		

Scenario 2

	Area (ha) Flower	Fodder	Vegetable	Water	Labour Intensity (labour/ha) Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	0	0	0	0	Extra Labour Requirement (are			4303
Total	1,200	2,743	65,159	17,330	Start-Up Labour Score			
						33,659		

Scenario 3

	Area (ha) Flower	Fodder	Vegetable	Water	Labour Intensity (labour/ha) Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	0	0	0	0	Extra Labour Requirement (are			38796
Total	1,200	2,743	65,159	17,330	Start-Up Labour Score			
						303,466		

Scenario 4

	Area (ha) Flower	Fodder	Vegetable	Water	Labour Intensity (labour/ha) Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	0	0	50,000	0	Extra Labour Requirement (are			0
Total	1,200	2,743	115,159	17,330	Start-Up Labour Score			
						391,103		

Scenario 5

	Area (ha) Flower	Fodder	Vegetable	Water	Labour Intensity (labour/ha) Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	0	0	0	0	Extra Labour Requirement (are			0
Total	1,200	2,743	65,159	17,330	Start-Up Labour Score			
						0		

Scenario 6

	Area (ha) Flower	Fodder	Vegetable	Water	Labour Intensity (labour/ha) Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	500	800	5,000	1,733	Extra Labour Requirement (are			1000
Total	1,700	3,543	70,159	19,063	Start-Up Labour Score			
						66,469		

Criteria: Employment

Running Labour:

Scenario 1

	Area (ha)				Labour Intensity (labour/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	0	0	0	0				
Total	1,200	2,743	65,159	17,330	Running Labour Score			
					607,637			

Scenario 2

	Area (ha)				Labour Intensity (labour/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	0	0	0	0				
Total	1,200	2,743	65,159	17,330	Running Labour Score			
					607,637			

Scenario 3

	Area (ha)				Labour Intensity (labour/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	0	0	0	0				
Total	1,200	2,743	65,159	17,330	Running Labour Score			
					607,637			

Scenario 4

	Area (ha)				Labour Intensity (labour/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	0	0	50,000	0				
Total	1,200	2,743	115,159	17,330	Running Labour Score			
					998,740			

Scenario 5

	Area (ha)				Labour Intensity (labour/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	0	0	0	0				
Total	1,200	2,743	65,159	17,330	Running Labour Score			
					607,637			

Scenario 6

	Area (ha)				Labour Intensity (labour/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	18.72	5.00	7.82	3.56E+00
Increase	500	800	5,000	1,733				
Total	1,700	3,543	70,159	19,063	Running Labour Score			
					666,284			

Criteria: Income

Summary:

			Original Scores			Standardized Scores			Final
			Product.	**None**	**None**	**Diff.**	**Max.**	**None**	**Score**
Scenario	1		98,153	.	.	0.00	0.91	.	**0.91**
	2		98,156	.	.	0.00	0.91	.	**0.91**
	3		98,183	.	.	0.00	0.91	.	**0.91**
	4		98,192	.	.	0.00	0.91	.	**0.91**
	6		98,153	.	.	0.00	0.91	.	**0.91**
	7		107,969	.	.	1.00	1.00	.	**1.00**
		min	98,153	.	.				
		max	107,969	.	.				

Productivity:

Scenario 1

	Area (ha)				Productivity (US$/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.04	2.32	0.78	5,660
Increase	0	0	0	0	Extra Productive Area (ha)			0
Total	1,200	2,743	65,159	17,330	Productivity Score			
					98,153,049			

Scenario 2

	Area (ha)				Productivity (US$/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.04	2.32	0.78	5,660
Increase	0	0	0	0	Extra Labour Requirement (area			4303
Total	1,200	2,743	65,159	17,330	Productivity Score			
					98,156,394			

Scenario 3

	Area (ha)				Productivity (US$/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.04	2.32	0.78	5,660
Increase	0	0	0	0	Extra Labour Requirement (area			38796
Total	1,200	2,743	65,159	17,330	Productivity Score			
					98,183,210			

Scenario 4

	Area (ha)				Productivity (US$/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.04	2.32	0.78	5,660
Increase	0	0	50,000	0	Extra Labour Requirement (area			0
Total	1,200	2,743	115,159	17,330	Productivity Score			
					98,191,920			

Scenario 5

	Area (ha)				Productivity (US$/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.04	2.32	0.78	5,660
Increase	0	0	0	0	Extra Labour Requirement (area			0
Total	1,200	2,743	65,159	17,330	Productivity Score			
					98,153,049			

Scenario 6

	Area (ha)				Productivity (US$/ha)			
	Flower	Fodder	Vegetable	Water	Flower	Fodder	Vegetable	Water
Current	1,200	2,743	65,159	17,330	0.04	2.32	0.78	5,660
Increase	500	800	5,000	1,733	Extra Labour Requirement (area			1000
Total	1,700	3,543	70,159	19,063	Productivity Score			
					107,969,185			

Criteria: Management

Summary:

		Original Scores		.	Standardized Scores		.	Final
		On-Site	Off-Site	.	On-Site	Off-Site	.	Score
Scenario	1	90	90	.	0.90	1.00	.	**0.95**
	2	100	20	.	1.00	0.22	.	**0.61**
	3	60	40	.	0.60	0.44	.	**0.52**
	4	20	30	.	0.20	0.33	.	**0.27**
	6	40	90	.	0.40	1.00	.	**0.70**
	7	30	70	.	0.30	0.78	.	**0.54**
	min	20	20	.	Max.	Max.	.	
	max	100	90	.				

On-Site:

	On-Site Management (subjective*)
Scenario 1	90
Scenario 2	100
Scenario 3	60
Scenario 4	20
Scenario 5	40
Scenario 6	30

Off-Site:

	)ff-Site Management (subjective*
Scenario 1	90
Scenario 2	20
Scenario 3	40
Scenario 4	30
Scenario 5	90
Scenario 6	70

ANNEX PR.4

Part 3 Calculations

	Exchange Rate (US$/KSH	**61**										
		Flowers (Stems)	**Vegetables** (kg)	**Fodder** (kg)	**Diaries** (lt)	**Natives** (Capita)	**Tourists** (Capita)	**Fisheries** (kg)	**Wildlife** (--)	**Environment** (--)		
Production												
	Crops/year	1	4.0	1.0	365.3	50.0	250.0					
	(kg)/ha.crop	2,000,000	3,400	10,000	25,000	350,000	40,000		**20%**	**60%**		
	(kg)/ha.yr	2,000,000	13,600	10,000	9,131,250	6,391,875	30,000	45,092				
Costs												
	ksh/ha.crop	2,000,000	50,000	2,000	500,000	12	2,000	182				
	Exaggeration Coefficie	**1.5**	**1.5**	**1.5**	**1.5**	**1**	**1**	**1**				
	ksh/ha.crop	1,333,333	33,333	1,333	333,333	12	2,000	**3,000**				
	ksh/ha.yr	1,333,333	133,333	1,333	121,750,000	76,702,500	60,000,000	546,000				
	US $/ha.yr	**$21,858**	**$2,186**	**$22**	**$1,995,902**	**$1,257,418**	**$983,607**	**$8,951**				
Return												
	avg. Market Price ksh/	10	**95**	**188**	**18**	**0**	**1647**					
	Return coefficient	**0.25**	**0.5**	**0.75**	**0.75**	**0.5**	**7**					
	Return ksh/(kg)	3	47	141	14	0	11529					
	Return US $/(kg)	0.04	0.78	2.32	0.22	0.00	189.00	3,249,654				
	Return US $/ha.yr	**$81,967**	**$10,573**	**$139**	**$2,020,850**	**$0**	**$7,560,000**	**$53,273**				
Net Return												
	ksh/ha.yr	3,666,667	511,621	7,142	1,521,875	-76,702,500	401,160,000	2,703,654	80,232,000	240,696,000		
	US $/ha.yr	**$60,109**	**$8,387**	**$117**	**$24,949**	**-$1,257,418**	**$6,576,393**	**$44,322**	**$1,315,279**	**$3,945,836**		
		Per Hectare				For the whole Catchment						
	For Fodder: one TLU produces 30 kg meat, and its Dry Matter Intake (DMI) is assumed to be 5,000 kg of fodder **[FAO & IIASA,193]**.											
		6	8	3.5	3.5	-	-	-	-	-	Diverted	Water Use (mm/day)
		4	5	3	3	-	-	-	-	-	Delivered	
		2	3.2	2.9	2.9	-	-	-	-	-	Actual	
		2.19	2.92	1.28	1.66E+07	6.28E+06	7.17E+05	1.33E+04	1.98E+06	1.06E+09	Diverted	Water Use (m³m²yr)
		1.46	1.83	1.10	1.44E+07	6.28E+06	7.17E+05	1.33E+04	1.98E+06	1.06E+09	Delivered	
		0.73	1.17	1.06	1.39E+07	6.28E+06	7.17E+05	1.33E+04	1.98E+06	1.06E+09	Actual	
		2.74	**0.29**	**0.01**	**0.15**	**-0.20**	**9.17**	**3.32**	**0.66**	**0.004**	**Diverted**	**Productivity Factor** (US$/m³)
		4.11	**0.46**	**0.01**	**0.17**	**-0.20**	**9.17**	**3.32**	**0.66**	**0.004**	**Delivered**	
		8.23	**0.72**	**0.01**	**0.18**	**-0.20**	**9.17**	**3.32**	**0.66**	**0.004**	**Actual**	

File Name: Productivity
Sheet: Part 03

Page: 1/1

Date: 4/14/99