8.4.4 Anticipated environmental impacts

(1) Malewa River

Reservoir site:

The proposed reservoir will inundate 3.9 km^2 of bush and grazing land and about 13 hectares of arable land. The area is presently occupied by 5 families totalling some 30 people; these families will require compensation, relocation and resettlement. No further adverse impacts from the construction and location of the reservoir are anticipated at the site.

The water impounded by the dam will have a mean retention time of about 8 months; during this time a certain degree of change in the water quality is to be expected. The JICA Malewa Dam study team carried out a modelling exercise to assess the probable significance of these changes and concluded that some parameters eg. COD will deteriorate and the reservoir water will become more nutrient-rich. However, the overall impact of eutrophication will not be environmentally significant or adversely affect Lake Naivasha.

Downstream of the damsite:

At full project development, on average, 27% (166,000 m3/d) of the river flow will be diverted from the Malewa below the dam into the Turasha River. Adverse impacts to downstream users and the river ecosystem will be experienced by this reduction, especially in the dry season, unless provision is made to supply adequate compensation flow at this time.

(2) Lake Naivasha

Changes in lake water balance:

The water level in the lake is determined by the balance between the following opposing input and output mechanisms:-

Input	Output
River inflows	Evaporation
Rainfall	?Underground outflow?
Seepage-in	Seepage-out
	Abstraction

River inflows represent the major input to the lake and a majority of this water comes from the Malewa system. Thus implementation of the project will inevitably lower the lake level in relation to the without-project level.

Again the JICA Study team have produced a mathematical model to simulate the impacts of various magnitudes of water diversion from the Malewa. Some of the results of this simulation are given in Table N8.11. Under existing conditions the mean lake level is around 1,885.2 m.a.s.l and fluctuates by about 2 metres around the mean level. Lake area varies around a mean of 185 km^2 between 138 and 297 km^2. At full project development when 166,000 m^3/d of water will be diverted from the lake the mean level is predicted to fall by 2.1 metres which will reduce the lake area to a mean of 139 km^2, a reduction of 46 km^2 or 25%.

Water quality changes:

A further simulation model predicts that little change will occur in lake water quality as a result of a lower mean lake level. The predicted reduction in area and volume of the lake caused by the project falls within the natural limits and since the natural low water level causes few significant changes and produces no deleterious problems for water users it is assumed this situation will prevail with the project. The lack of change in the pH is especially important since any further increase would begin to pose problems for irrigated agriculture using lake water.

Impacts on groundwater resources:

Although no hard data are available it is deemed unlikely that the changes caused to Lake Naivasha by the project will affect groundwater resources to an extent exceeding those experienced during natural water level changes. Any problems experienced at natural low and very low lake levels will become more frequent and persist for longer but no information is at hand as to what problems currently occur. The fact that no serious drawdown occurred during the severe drought of 1988 supports this view however.

Impacts on agriculture:

A reduction in mean lake level by the project will cause impacts on agriculture in a number of ways:-

* First, at full project development the lake area will reduce by almost 45 km^2 exposing the fertile soils of the lake bed for cultivation or livestock production.

* Second, the lower level will necessitate the restructuring of irrigation pump installations and pipelines, and the rebuilding or extension of lakeside jetties. It should be noted that this is not anticipated until the lake level falls below about 1,880 metres; the lake is not expected to fall to this level until low water levels occur after full project development.

* Third, the possibility of pH changes adversely affecting the irrigated horticulture and flower growing enterprises around the lake was once thought to be a potential problem with serious economic implications; however, if the simulation model of water quality is well founded then this problem is relegated to a much lower order of probability.

Ecological impacts:

The reduction in lake area will adversely affect the shoreline vegetation with uncertain consequences. Since the project is planned to develop in stages it may be possible for the north swamp *Papyrus* to adjust to the new water levels without serious repercussions. The existing shallow areas in the north-eastern section of the lake will reduce in size substantially and the submerged aquatic weeds in that area will be affected. Again, if the project is phased the plants will probably be able to adjust and recolonise other areas given time.

Impacts on the lake fishery:

Reduction in lake volume and especially lake area will inevitably reduce fish production in the lake. This is supported by existing data correlating fish yields with lake level. In addition, if the area of weedy shallows is reduced disproportionately there may be a significant loss of breeding sites especially for the various species of tilapia which will further limit fish production and fishery yields.

(3) Lake Nakuru

It is clear that Lake Nakuru will be much more adversely affected by the implementation of this project than Lake Naivasha. The increase in water input into Nakuru town, and the corresponding increase in the volume of effluent produced will have far reaching and potentially devastating impacts on the lake which is the receiving water for this poorly treated effluent.

Changes in lake water balance:

A model simulation of water balance within the Lake Nakuru catchment has been carried out by the JICA team and selected results are given in Table N8.12.

These results indicate dramatic changes in the depth and area of the lake at different stages of project implementation which will, without doubt, have significant impacts on the National Park and the town. To bring these changes into focus it should be noted that at full project development;

1) the mean depth of the lake will increase from 2.3 to 11.5 metres, a five fold increase,

2) the mean lake area will increase from 44 km^2 to 81 km^2, a rise of nearly 46%, and,

3) the lake will occupy nearly 43% of the entire park, up from 23%.

The consequences of these dramatic changes are considered in the following sections.

Inundation of resources:

At full implementation and with the lake extending well beyond its present maximum size the following resources will be either inundated or reduced in size:-

1) the perimeter road will be entirely submerged and the cost of re-routing and reconstruction must be included in project costings (that is assuming there is any reason to rebuild the road in the absence of a game park).

2) the lake will extend beyond the park boundary and inundate about 12_km^2 of Nakuru municipal land (though not the built-up areas),

3) approximately 25 km^2 of park grassland will be covered.

Water quality changes:

Water quality is expected to change substantially as the volume of effluent entering the lake increases; two major changes are expected:-

1) **Reduction of salinity and alkalinity**: of equal significance to the great increase in the area of the lake is the corresponding decrease in the salinity and alkalinity of the lake water which will become drastically more dilute.

2) **Reduction of dissolved oxygen concentration**: the inflow of effluent retaining a considerable COD (and by implication a high BOD) will most probably lower or even totally deoxygenate the lake water especially near the lake bottom. In addition, oxygen stress (hyper-saturation during the day time, and deoxygenation at night) may also occur due to photosynthesis by algal blooms produced by the inflow of nutrients in the effluent. The high concentration of nutrients will probably cause hyper-eutrophication of the water as they accumulate in this closed basin with further adverse environmental consequences (see below).

Ecological impacts:

Several major adverse ecological impacts can be anticipated as a consequence of project implementation and the increase in effluent flow into Lake Nakuru, these include:-

1) **Impacts on the flamingo population**: as has been described earlier, the park exists and is internationally renown primarily as a sanctuary for the lesser flamingo and that this bird feeds only on the microscopic alga *Spirulina platensis* which dominates the lake phytoplankton. This alga is highly specialized and restricted to living in waters of high salinity and alkalinity. A great concern is that the dilution of the lake with treated effluent will eliminate *Spirulina* and the flamingoes will consequently migrate elsewhere thus depriving the Nakuru National Park of its raison d'etre.

2) **Loss of fish eating birds**: should the changed conditions in the lake adversely affect the introduced species of tilapia on which the fish-eating birds depend then the bird populations will also suffer. This species of fish, although ecologically tolerant, may not survive the expected changes especially if oxygen levels are reduced significantly, as well they might, by decomposition and plant respiration.

3) **Hyper-eutrophication**: an excessive inflow of nutrients into the lake which cannot be removed in the absence of an outflow, will, in time, increase in concentration to a point where they can support dense populations of algae (though not *Spirulina*). The lake will then effectively become a vast oxidation or perhaps maturation pond providing tertiary treatment for the effluent. During long dry periods when the lake might otherwise have dried up completely the lake will consist entirely of undiluted final effluent. The absence of an outlet and the excessive depth will be all that distinguishes the lake from a standard oxidation pond.

4) **Wildlife impacts**: the loss of 25 km^2 of grassland around the lake will restrict the ranges of the plains game which inhabit the park and increase population densities unless some culling is carried out. Whether this will cause serious problems cannot be assessed with information presently at hand.

8.4.5 Mitigation of impacts

(1) *Malewa River*: resettlement and compensation of the families displaced and dispossessed by the reservoir is required and adequate compensation flow for downstream users must be assured. The JICA team recommend flows of between 0.22 and 0.83 m^3/sec for different river sections in wet and dry seasons (for details see JICA 1990).

(2) *Lake Naivasha*: conservation of the lake is vital for both environmental and economic reasons because of its importance in tourism and horticultural export production. To ensure the long term survival of these valuable enterprises and the lake ecosystem the extent of water extraction for transfer to Nakuru should not lower the lake below recent low water levels. Although it is not possible to specify

a quantitatively justifiable lower level the 1880 metre level reached during the 1988 drought could be used as a guideline as suggested by the JICA team. If this criterion is applied, it is estimated that the proposed project transfer will need to be reduced to 73% of that proposed to maintain the lake above this level.

An additional alternative approach would be to control population increase and water-demanding industrial development in Nakuru in order to minimize future increases in water demand and effluent production.

(3) *Lake Nakuru*: as noted previously the impacts on Lake Nakuru are far more severe than those predicted for Lake Naivasha. Few viable options exist to minimize these impacts; among the possible options are:-

1) diversion of all, or a major portion of the effluent from the lake for treatment outside the Lake Nakuru catchment; some treated effluent may be used to manage the lake level to maintain the lake level through excessively dry periods. Such manipulation of the ecosystem, however, will need careful planning and study before hand.

2) limit future expansion of Nakuru especially controlling the development of water consuming and wet effluent producing industries by which means the future water demand and effluent production may be reduced to more manageable proportions.

N9. THE ARID AND SEMI-ARID LANDS OF KENYA

9.1 Introduction

The arid and semi-arid lands occupy 439,000 square kilometres which represent 83% of the total land area of Kenya. These lands support 3 to 4 million people (15-20% of the Kenya population) and approximately 50% of the national livestock herd. The area contributes 3% to the annual agricultural output and 7% to commercial production. A major portion of the nations wildlife resources also occur in ASAL Districts.

The agro-ecological zoning system used to define the biological production capacities of different regions of the country was established in 1979 and revised in 1982. Details of the seven zone classification were published in the Farm Management Handbook (1982) in which the arid and semi-arid lands were classified as zones IV-VII. The basis of definition for all zones is moisture availability and is derived from the balance between rainfall and evapotranspiration (%r/EO). These data are summarized in Table N9.1.

On this basis 22 Districts have 30% or more of their land area classified as ASAL and six Districts are entirely ASAL; the latter comprise 62% of all ASAL land. In addition, a further 5 Districts have more than 85% of their area classed as ASAL and these eleven together contain 90% of Kenya's ASAL area (Table N9.2). At the Provincial level Central, Nairobi, Nyanza and Western Provinces have no ASAL land; in contrast North Eastern Province has no land which is not ASAL. The geographical distribution of the ASAL areas is shown on Figure N9.1.

With regard to the future development of the ASAL areas the following paragraphs summarize the main points to be borne in mind and are drawn from several existing study reports:-

1) The ASAL area is not an homogeneous entity but consists of two distinct sub-units with contrasting land use; zones IV and V are characterised by settled agriculture dominated by cropping with some livestock production, while zones VI and VII are primarily pastoral areas where livestock dominate and cropping plays a minor (but steadily increasing) role.

2) A majority of the ASAL area has a distinct advantage for livestock production, wildlife utilization and tourism, and this advantage should be exploited; ASAL should not attempt to compete with the higher potential areas with regards to crop production.

3) As stated in the ASAL Policy Development document (1990) "One conclusion of fundamental importance is the ASAL do not constitute a major reserve of productive land to accommodate the overspill of people from the high potential areas". it is also stated that "It is unlikely that ASAL will be a source of surplus crops for inter-regional trade and export".

4) Water is NOT the primary constraint in the production systems of the ASAL areas; vegetation (plant biomass) for fodder is the main constraint. Provision of additional water without a comparable increase in the availability of biomass (food for stock) is counter-productive and leads to enlarged herds and degraded rangeland particularly in zones VI and VII.

5) Access to dry-season forage and grazing is the ultimate critical constraint in zones VI and VII; deprived of such biomass-rich resources pastoralists will be marginalized into famine. These refuge habitats must be protected from encroachment by legally vesting (adjudicating) them in favour of traditional management groups such as the clan or sub-clan. It is important that these refuges, which are normally productive biomass sites, are not converted into arable or irrigated lands at the expense of pastoralism since arable cultivation of any kind in ASAL areas is a high risk enterprise carrying real dangers of land degradation while nomadic-pastoralism has a proven track record for long-term sustainable production.

6) The importance of the impacts of upland water resource utilization in the high potential areas on ASAL must be appreciated. Expansion and intensification of agriculture in the highland catchments will reduce the volume and quality of water flowing to the lowland ASAL areas; thus development in one region can detrimentally affect the prosperity and viability of downstream communities.

9.2 ASAL Profile

9.2.1 Physical and natural resources

(1) Climate

By definition the ASAL are dry and hot with a rainfall to evapotranspiration ratio of less than 0.5, ie. evaporation exceeds rainfall by at least a factor of two. This is the key factor limiting vegetation growth and thereby agriculture, livestock and wildlife production in ASAL regions. Rainfall figures used in the definition of the four ASAL zones are given in Table N9.1, further climatic data for selected locations are given in Table N9.3.

Rainfall is not only sparse in these areas but is also characterized by high variability between years and seasons, it is also extremely unpredictable; the rains are thus very unreliable and this greatly reduces their usefulness in agriculture. In addition, the rain often occurs as very localized but intense storms which affect only a limited area but often cause more harm than good; flash flooding is common and runoff very rapid due to the sparse vegetation cover and the tendency of ASAL soils to become sealed. Consequently there is little chance for infiltration and seepage to help recharge either soil moisture or groundwater resources. Accumulated surface water subsequently evaporates quickly in the high ambient temperatures.

Evaporation is further increased by strong dry winds which are also a feature of ASAL regions.

Droughts are a recurring problem in ASAL. Human, livestock and wildlife populations have been repeatedly devastated in recent decades with attendant disastrous impacts on the natural environment as a whole.

(2) Population

According to official statistics population growth, which was higher in the ASAL than the national average between 1969 and 1979 censuses, has fallen to near parity at around 4% per annum. Population size has increased due to the combination of local population growth and immigration of people displaced from the over-crowded high and medium potential lands in agro-ecological zones I to III. Recent estimates of ASAL District population size suggest a figure of 8 million people, of whom 3 to 4 million reside in the truly ASAL zone areas of these Districts (Ref:AS1).

Population trends vary significantly between ASAL Districts; based on 1989 estimated figures (Ref: AS2) nine Districts showed high growth rates (>4.9%) coupled with high immigration rates (116 to 268 immigrants per 1000 head of local population); the remainder had lower growth rates (<3.9%) and a net outward movement of people. Turkana District is unique in having a negative growth rate of 0.2% and the highest rate of out-migration at minus 539/1000 local capita (Ref:AS2).

The generally small populations in ASAL in relation to the higher than average area of the ASAL Districts means population density is, in absolute terms very low. However, in relation to the carrying capacity of the environment density levels for people and certainly for livestock and possibly wildlife may well be high or excessive in some Districts even now.

Population density figures are given in Table N9.2 for all ASAL Districts; the range of densities from 1.3 to 4.0 listed for the 100% ASAL is indicative of the carrying capacity of arid regions. It must be realized that overall higher density figures in a majority of Districts which are not 100% ASAL indicate that in the higher potential non-ASAL regions within any specified District very high densities may exist while in the ASAL regions of the same District densities are very low. In general the actual arid and semi-arid areas of a District do not support populations exceeding 3 to 4 persons per square kilometre. The mean population density for 100% ASAL Districts is 2.5 ± 1; for all other ASAL Districts the mean density 31 ± 30; these figures can be compared with a mean of 181 ± 86 for 17 non-ASAL Districts (maximum population density is reported from Kisii at 396 persons per km2. (Statistical Abstract, 1989).

(3) Soils

Soils in ASAL are highly variable in quality and fertility; generally they constrain agriculture for various reasons including:-

a. low natural fertility with phosphate the limiting factor,
b. prone to capping,
c. prone to compaction,
d. heavier clay soils often subject to salinity and sodicity,
e. clays difficult to work with traditional tools,
f. light to medium texture makes them vulnerable to erosion.

Traditionally these problems have been circumvented by shifting cultivation, but this system is falling into disuse and the fallow period is becoming shorter and less effective in restoring the soil.

In terms of rangeland vegetation growth and the production of livestock and wildlife the limiting factor is rainfall and not problems of soil fertility.

Soil erosion and land degradation are clearly serious problems in some localities within the ASAL Districts but appear to be of only minor significance over much of the arid and semi-arid lands. Locally severe degradation is recognized as being particularly serious in West Pokot, Baringo and the whole of North Eastern Province. In these areas gully and sheet erosion and surface sealing are common. Severe rain induced erosion is also occurring on the hilly pastures in Machakos and Kitui; wind induced erosion is a growing problem around settlements where the land surface has been total stripped of vegetative cover. In general, the worst soil conservation problems occur on sloping land in marginal rainfall areas where land use is intensive ie. especially in zone IV, and around settlements.

(4) Water resources

Four major river catchments (Rift Valley, Tana, Athi and Ewaso Ngiro North) convey surface water to the ASAL areas. These rivers rise in the central highlands and are subject to wide seasonal and inter-annual variations in discharge and silt content as cultivation and deforestation increase in the upper reaches. These same rivers are also subject to continuing regulation principally for hydropower generation. With the exception of the Tana, none provide sufficient flow to sustain extensive irrigation. A large majority of ASAL water courses are ephemeral, existing only briefly after rainfall and do not provide a reliable sources of supply unless trapped in either natural or artificial pans or dams.

Of concern is the observation that dry season flows of some ASAL rivers have apparently decreased in recent years; principal causes are thought to be:-

a) greater upstream dam construction and abstraction, and

b) increase in the rate of runoff after rain and a consequent reduction in rainfall infiltration and storage due to deforestation and poor land management in the upper catchments.

In ASAL area, the protection of water resources catchments is particularly important to ensure the long-term low flow yield. Deforestation should principally be prohibited and afforestation be encouraged.

On the other hand the extremes of peak and low flows have been moderated by river regulation to provide a more consistent supply; this effect is now particularly noticeable on the Tana and the Turkwel.

Several large lakes exist in ASAL Districts including lakes Turkana, Bogoria, Elementeita and Magadi but these are all saline and unusable for water supply; only lakes Baringo and Jipe are fresh and have any potential for water supply for domestic and irrigation purposes.

Information on groundwater resources in ASAL regions is limited. What is clear is that water drawn from shallow wells varies greatly in both quantity and quality from place to place and between seasons and years. These sources are unreliable and depend on the vagaries of rainfall and river flood regimes.

The principal hope for improving the water supply to the ASAL areas is through *water harvesting* and progress towards developing appropriate techniques and technologies is well under way. What is needed in the future is the extension and distribution of these techniques to a wider area of the arid and semi-arid lands.

(5) Natural vegetation

ASAL vegetation resources comprise grassland and woody scrub or bush; large areas of woodland and forest are typically absent.

Much of the arid and semi-arid area is dry grassland which relies on irregular and erratic rainfall; production is consequently highly variable both seasonally and inter-annually. Better quality and more abundant vegetation develops in small isolated areas naturally favoured with greater rainfall or dew; such areas occur on highlands masses such as Marsabit and Kulal; other similarly productive areas occur on the floodplains of the major rivers and in swamps and marshes. In some locations (eg. river floodplains) better soils also contribute towards higher productivity. In recent years large areas of ASAL grassland have been under-utilized by man because of security problems and banditry in these areas; wildlife populations have consequently benefited.

Woody vegetation is less affected and less dependent upon rainfall than grassland communities; even so, the density of bush and tree cover is generally low in ASAL

though very widespread. Thin, discontinuous strips of riverine forest or woodland occur along the Tana, Turkwel and other major permanent rivers and provide dry season refuge, fodder and other essential resources to man and wildlife populations.

The mountain, riverine and swampland high production areas scattered within the unproductive mass of the ASAL, are key elements within the annual cycle of migration of pastoralists and wildlife and provide vital dry season grazing, fuel, fodder, shelter and other resources without which many of these pastoral systems would be unsustainable. Traditionally the key production areas were used in common by livestock and wildlife alike and were not subject to demarcation, adjudication or individual ownership or control. Yet increasingly today, it is these key production areas or refuges which, because of their very productivity, are earmarked for "development" by cultivators to the exclusion of the indigenous pastoralists and wildlife populations. Regretably, this is happening despite the fact that the ASAL areas are known to be best suited to livestock production and wildlife utilization, and still the pastoralist are being inexorably driven towards increased dependence on cropping and off-farm income generation to sustain themselves as their traditional lifestyle and rangelands are denied them.

(6) Wildlife and tourism

The natural resources of ASAL areas on the whole suffer from over-exploitation as is the case with most of the resources discussed in the previous sections. In contrast the extensive potential for wildlife and tourism offered by ASAL is a unique and major case of under-utilization of resources and opportunity. Wildlife utilization and tourism represent ASAL resources with considerable potential for growth and development.

Most of Kenya's wildlife populations and resources, most national parks and reserves, and much of the tourist infrastructure occur in ASAL. It therefore follows that ASAL areas contribute substantially to the national economy especially in terms of foreign exchange earnings and employment. However, despite the importance of ASAL to the tourism industry ASAL remain under-developed and lag behind the rest of the nation in economic development, standard of living and quality of life; the benefits generated for the country by wildlife and tourism are generally retained in the more affluent urban areas while the ASAL peoples bear the costs and dangers alone.

There is then considerable scope for further development and expansion of wildlife and tourism in ASAL. This expansion may include among other options the possibility of reintroducing sport hunting as an additional form of wildlife utilization and the selective cropping of game for consumption and/or export as a component of parks management programmes.

9.2.2 Human and agricultural resources

(1) Agricultural systems

The inhabitants of ASAL areas pursue two contrasting lifestyles and modes of subsistence, namely, as;

i. **Smallholders:** who are occupied in mixed farming on plots of 2 ha or less, mainly in AEZ IV-V. Those in zone IV (700-850 mm rainfall) typically follow sedentary agricultural practices growing maize (the preferred crop, though not the most suitable) and millet and/or sorghum, usually inter-mixed with legumes (cowpeas and grams). Most zone IV farmers maintain livestock though many of the poorer farmers have none. Stock numbers are decreasing as land is diverted to food crop production. Crops grown are for subsistence and yields are low and variable; cash is derived from other sources which may include charcoal burning and unskilled labouring. Districts where this system is employed include lowland Machakos, and parts of Kitui, Embu and Baringo. These Districts together account for over 50% of the ASAL population.

   In zone V (550-700 mm rainfall) the drier climate requires the adoption of shifting cultivation with the addition of livestock (mainly goats) grazing communal pastures. The ideal crops are sorghum and millet but again maize is preferred due to taste and the reduced need for bird scaring; crop failures are none-the-less common. Mixed cropping of legumes and cereals is normal in this zone. Water harvesting would most likely prove very effective in these areas if introduced. Soil erosion and poor soil fertility are the major production constraints in this zone which is typified by low lying parts of Kitui District.

ii. **Pastoralists:** are stock herders living mainly in AEZ VI (300-500mm rainfall) and VII (200-300 mm rainfall); these zones account for 10% of the population and 60% of the total ASAL area. Nearly all those living in zone VI are increasingly involved in cropping to some extent to supplement their diet of animal derived products especially milk and to a decreasing extent blood; stock are sold or traded for cash. Cropping relies on natural water collection sites eg. valley bottoms, swamps and other refuge areas.

Overall the population of ASAL regions is distributed by occupation as follows:-

* Pure pastoralists: ..... 1 million (20% of ASAL population),
* Pastoralism + cropping: ..... 3 million (60% of ASAL population),
* Cultivators: ..... 1 million (20% of ASAL population).

(2) Livestock

The ASAL areas have a distinct advantage over the high production areas in terms of livestock production and this advantage should be maximized and exploited; competing for arable production is not the most advantageous use of ASAL resources. In AEZ VI and VII 86% of the population is involved in the livestock sector; only 2% with chance farming, 7% in commerce and 5% in the public sector. The importance of livestock in the ASAL economy is thus beyond question.

Today over 46% of the Kenya livestock herd is located within the ASAL districts and comprises the following stock animals:-

Cattle	4.3 million
Shoats.	10.8 million
Camels	0.6 million
Donkeys	0.1 million
Total	15.8 million

Not all of these livestock are kept within the actual arid and semi-arid regions of the ASAL Districts; table below shows the actual distribution by ASAL category. This table also shows that a majority of ASAL livestock are kept in the drier Districts which have over 85% ASAL areas. In addition, it may be noted that in the 85% ASAL Districts there are 2 cattle per person in the livestock sector, while there is 1.1 head of cattle per person in the 100% ASAL Districts.

Livestock distribution in ASAL areas.

ASAL category	Cattle	Shoats	Camels	Donkeys
A. 100%ASAL	918,585	3,794,850	519,007	79,699
B. 85%ASAL	1,341,425	2,734,922	65,593	10,334
C. 50-85%ASAL	1,335,261	1,554,358	1,855	4,895
D. 30-50%ASAL	720,788	2,712,876	0	13,338
Total	4,316,059	10,797,006	586,455	108,266

Source: MRDASALW 1990.
Shoats = sheep + goats
Detail of Categoly = see Table N9.2

In addition to these livestock species considerable numbers of poultry are reared for meat and eggs and bee-keeping is also practiced by many ASAL inhabitants.

(3) Pastoral strategies for survival

The inhabitants of ASAL regions live in a harsh and very demanding environment and often exist at the brink of survival. They have, through trial and error, evolved a complex lifestyle for survival in these areas of extreme climatic variability and erratic rainfall. They have developed social systems which acknowledge the stringent biological and physical constraints of ASAL regions as a whole and within specific localities in their territories. These systems are known to work and have sustained these people for many centuries. Any development projects must also plan to work within these constraints and not attempt to overcome them or ignore them, for to do so will inevitably deplete or damage natural resources and the ecological processes which sustain the natural communities and their environment.

Most pastoral production activities are linked to survival tactics rather than to long term strategic planning. This includes sophisticated risk spreading or risk minimizing priorities based on a intimate knowledge and understanding of their environment. Activities which realise immediate benefits enabling them to subsist are the usual choice. Thus, for example, the stock herders primary objective is survival for themselves and their stock and not meat production; milk production is emphasised over meat production and large herds are kept which contain a high proportion of breeding females. The system evolved is thus less risky than traditional dry land farming, more economical and less taxing on the environment; above all it is demonstrably sustainable.

One consequence of this approach to life is that, at times, these tactics may cause short term over-exploitation of the natural resources. In the long term, however, the basic and essential mobility of the pastoralists and their migrations between different wet and dry season grazing areas was a sustainable strategy in concert with the environment and did not lead to irrevocable environmental damage. In recent years, however, encroachment into these crucial key production areas by farmers and irrigators is undermining this strategy to an increasing extent.

The pastoral strategies evolved in response to the ASAL conditions and particularly to the extremes of drought can be summarized as follows:-

a) use of wet and dry season grazing areas; this rotation reduces grazing pressure on each area and also acts to limit stock disease,
b) herd splitting to avoid loss of the entire stock,
c) emphasis on large herds for milk production,
d) trend towards a greater proportion of small stock, goats and sheep,
e) keeping of stocks of mixed species and feeding requirements eg. a mix of grazers and browsers,
f) keeping of indigenous stock species better adapted to tolerate dry conditions and food shortages,
g) protected access to tree products and resources,

h) development of social networks of reciprocal claims and mutual assistance which are exercised during periods of local stress, this involves clans with different grazing areas helping one another out when one clans grazing area, for example, lacks rainfall and cannot support the livestock,

i) ownership of individual trees in the dry season grazing areas, eg. in riverine or mountain forests which promotes conservation and good management.

(4) Key production areas

During the wet season when water and grass are readily available over a wide area of rangeland the flocks and herds are widely dispersed and far from the sites of permanent settlement. Grass will be abundant where rain has fallen, and the mobility of the pastoralists allows them to exploit this dispersed resource opportunistically. In each rainy season the rain falls haphazardly producing grass in patches throughout the nomads range; without mobility and the freedom to move to where the grass is most plentiful the pastoral-nomadism cannot be sustained.

During the dry season when fodder and water are absent or scarce out on the rangelands the herds concentrate in the small areas of higher production where water is naturally more abundant the year round (see Section 9.2.1). These dry season refuges are fallback areas and form the backbone of the pastoral economy; without them, or with restricted access to them, the pastoralists are forced to remain in the wet season rangelands for extended periods which results in hardship for them and causes over-grazing and land degradation to the environment.

As population pressure in the ASAL Districts increases, cultivation and settlement are rapidly expanding into the key production refuge areas. These refuges are essentially the controlling factor which determines the ASAL carrying capacity in terms of people, livestock and wildlife. They are the limiting factor; the ASAL resource in least supply in relation to demand. By denying this resource to the pastoralist the valuable grass production of the rangelands will be under-utilized and wasted because the sustainable size of the domestic and wildlife herds is limited mainly by the availability of dry season fodder which in turn is determined by the area of available key production grazing land.

Thus all boundaries and barriers, whether they are farms, roads, railways, irrigation schemes, national parks or forest reserves, all either diminish the actual area of the key production refuges available to the pastoralist, or impede their migration routes to these areas. In consequence the highly evolved pastoral systems have been distorted by the excision of their most vital resource. As a further consequence pastoralism is now causing environmental degradation to the wet season pastures as the traditional rotation of grazing areas becomes more and more restricted. The degradation of the land is then used to demonstrate the superiority of cultivation over the nomadic-pastoral way of life and to justify the sedentarization and domestication of the pastoral people.

Pressure on the key production areas also comes through the influence of external activities in the upper catchments of rivers flowing through the ASAL areas. As mentioned in Section 9.2.1, the intensification of agriculture, the damming and regulation of rivers, and the increasing abstraction of water for supply are jointly reducing the dry season flows of many rivers to the detriment of the ASAL key production areas.

9.3 Environmental Issues and Conflicts

9.3.1 *Background*

The soil, water, vegetation and wildlife resources of Kenya's ASAL region support four basic biological and economic production systems:

(i) dry land and irrigated crop cultivation,
(ii) livestock husbandry,
(iii) wood harvesting and wood products manufacture, and
(iv) wildlife and tourism utilization.

Each production system is constrained in different ways by the natural environment, and each has the potential to adversely affect the environment. To varying extents these four productions systems overlap in their resource requirements and may either compete or conflict. Management aims to minimize both the impacts and the conflicts between these production systems through the implementation of sound environmental conservation measures.

To this end management aims to make maximum sustainable use of available land and other resources with the following priorities:-

a) use land and its resources for maximum overall benefits,
b) manage natural resources to most equitably distribute benefits,
c) use land wisely so as to prevent degradation and reduction of future production potential,
d) rehabilitate degraded land to previous potential production levels.

9.3.2 Ecological constraints on production

The ecological constraints under which the four production systems must operate in ASAL regions and which have the greatest influence on natural resources and land use can be summarized as follows:-

a) generally low productivity of vegetation which reduces the potential for animal production and results from low rainfall,

b) generally low availability of surface and accessible groundwater of suitable quality for domestic, livestock and agricultural use,

c) the overall unreliable and erratic nature of rainfall with large geographical, seasonal and inter-annual variation in quantity and intensity, which limits reliable vegetation growth,

d) because of the unreliable nature of rainfall in quantity and time of year; and because it is unpredictable within a useful time frame ground preparation and sowing can rarely be timed to achieve the best results; crop yields are therefore low, unreliable and harvests often fail.

Thus, although the major constraint on development of ASAL areas is generally perceive by the inhabitants of these areas to be the lack of water the provision of water alone can in itself cause serious and counter-productive problems. Water points for man and livestock, including boreholes, shallow wells and pans invariably become focal points for population concentration with often devastating consequences for the surrounding soils and vegetation. Over-grazing, trampling, and the destruction of woody vegetation for browse and fuel commonly result from water development in ASAL areas especially around settlements.

It is apparent that water alone does not meet the needs of the people; if water is provided then the means to increase the availability of food, especially for livestock is an essential partner to water development in these regions. Consequently the provision of additional water must go hand-in-hand with a balanced development of food and fuel-wood resources. Water for fodder, crops and trees is as important as water for consumption by man and his stock. Where irrigation cannot be developed from surface waters then water harvesting offers the most promising sustainable alternative and deserves further investigation.

9.3.3 Land use trends

(1) Population growth

Changes in land use within the ASAL Districts result from the combined impact of local population growth coupled with the immigration of people looking for land from the over-populated high and medium potential agricultural lands. This has led to population growth in the ASAL which exceeded the national average of 4% between 1969-1979 and which has now come to parity. Needless to say this rapid increase has put the natural resources of the ASAL under considerable strain especially in the more favoured areas of zones IV and V.

(2) Sedentarization of nomads

Pastoral nomads who traditionally moved freely throughout the ASAL areas to take advantage of transient grazing opportunities, water supplies or to avoid conflicts with rustlers or cross-border disputes are now tending to settle either permanently or semi-permanently in many locations. Sedentarization is encouraged by the

additional advantages offer for healthcare, water supplies, employment, and perhaps most importantly, to provide access to education for the children. Settlement of a part of a family or larger social unit while other members continue the nomadic way of life is common.

(3) Encroachment into key production areas

The crucial importance of the dry season grazing reserves for pastoral nomads has been outlined in previous sections and represents one of the most significant land use changes occurring in ASAL areas. The on-going conversion of these areas to arable cultivation or irrigated agriculture will result in the marginalization of large numbers of pastoral nomads into famine. Wildlife populations which also follow the same seasonal rotation of grazing are likewise displaced. Because of use of these key areas by wildlife, and to counter their exclusion many important refuge areas, such as the Amboseli swamps, have been gazetted as National Parks and Forest reserves, again to the detriment of the pastoralists.

In this way the extensive dry land resources originally utilized by the pastoral people will become under-utilized and cease to contribute effectively to the national food economy; many pastoralist will become famine relief cases to the further detriment to the country; while the few who farm the key areas will benefit. On balance it would appear that the social and economic trade-off between pastoral use of these areas in relation to cultivation is strongly in favour of pastoral use. In other words it is possible that the number of farmers the key production areas can support year-round is significantly smaller than is the number of pastoralists who use the pasture only seasonally. Pastoralism in these areas also better protects the condition of the grazing and allows continued wildlife use of these areas without undue conflict.

A further consequence of encroachment into dry season grazing areas is the inevitable reciprocal increase in the pressure on the wet season, rainfed rangeland grazing areas which are usually vacated during the dry season when the grass withers and water supplies dry up. In the absence of the rotation between the two seasonal grazing areas the rangelands are more exposed to the danger of over-grazing and land degradation and the pastoralists are forced to seek pasture in the more arid zones.

(4) Land privatisation, demarcation and adjudication

The extent of land adjudication to individual or group-ranch holdings varies considerably between districts. In some marginal and semi-arid areas the process is well advanced; in most of the drier areas in zones VI and VII, and especially in Turkana, Marsabit and North Eastern Province little progress has been made. Privatisation is seen to be beneficial since land ownership provides access to sources of financial credit and, it is believed, generates a better sense of stewardship for the land and resource conservation.

Some adverse effects have also been experienced; private ownership has increased settlement, fences and permanent cultivation in and around the key production refuge areas discussed in the previous section. Even where the key area is not directly affected by demarcation, the patchwork of small holdings and their boundary fences hinders access to the grazing lands and blocks both domestic stock and wildlife migration routes.

In addition the tendency is for the larger land holdings to subsequently become further and further subdivided to plot sizes which are too small either to be sufficiently productive to support the owner and his family, or to effectively conserve soil and water. This fragmentation of the land represents a serious dislocation of sustainable land use in ASAL areas; the solution to the problem will require a major reversal of present policy. The extent of plot size reduction between 1969 and 1989 is shown in Table N9.5 for the area available per person for cultivation. This affects only the higher potential areas within the ASAL Districts; the category A (100% ASAL) Districts are not included since cultivation is generally not practiced. For the Districts included here reduction of between 29% (Lamu) and 56 and 58% (Kitui and Taita, the two category B 85% ASAL Districts) have been recorded in twenty years. The average reduction was 37% for all the listed Districts resulting in a mean plot size of 0.65 ha/person. The smallest plot sizes are now found in Machakos and Taita (0.2 and 0.26 ha/person respectively).

A fundamental problem which exists when trying to restrict subdivision is the difficulty of deciding what minimum area represents a viable plot size. This problem arises because each area to be subdivided is unique in terms of moisture availability and reliability, soil fertility, tendency towards erosion and many other production variables; thus each area will have to be assessed on an individual basis making the process of subdivision more complex and time consuming. In conclusion, no rule-of-thumb minimum plot size can be realistically determined which will be applicable to all areas undergoing subdivision. What is clear is that the minimum size is probably far larger than the average size currently resulting from subdivision.

Land subdivision has been identified as one of the factors causing environmental problem within ASAL. This may be true in the semi-arid areas. However, it is not the case in arid areas as there is no virtual land subdivisions at present. In general, the land subdivision should not be encouraged in the arid areas since it would not be beneficial to the promotion of both livestock and wildlife industries; the main industries in the arid areas. This option is also recommended in recent publications from Kenya Wildlife Services.

(5) Displacement of pastoralists

Displacement from some rangelands has occurred because of conflicts between competing clans or ethnic groups; elsewhere, and particularly in the border regions,

banditry, rustling and clashes with poachers has caused some areas to be abandoned temporarily. The restriction of the people and their herds to smaller areas of grazing land increases the intensity of land use with the attendant risk of over-grazing and resource degradation.

(6) Development of irrigation

During the past few decades there has been a gradual expansion of area under both large and small scale irrigation in ASAL areas. By 1988 over 12,000 hectares were under irrigation in ASAL areas, of this 7,000 (58%) were small scale schemes. These schemes are supplementary to rainfall to various extents and rely on water abstracted from permanent rivers rising in the highlands beyond the ASAL regions; a supply which is becoming more reduced as upper catchment land use develops and utilizes a greater portion of the available river flow.

Irrigation schemes in ASAL regions are almost invariably located in the better watered and more fertile soils of the key production areas and displace other forms of land use as described in previous sections. The costs of developing irrigation, both direct costs (in financial terms for development and maintenance) and indirect (in terms of loss of riverine forests, displacement of nomads and wildlife from dry season grazing areas etc.) have been high and the number of schemes which must be regarded as development failures has, likewise been high. In response to this situation it has been suggested that irrigation should be ranked second to water harvesting as a development priority option in ASAL (Ref:C14 Paper 4). In addition, this paper lists the following reasons in support of downgrading irrigation:-

a) good irrigation sites are very limited,
b) they will support only 1% of the ASAL population,
c) technical problems afflict irrigation schemes more severely than water harvesting,
d) irrigation is more complex and requires greater government support and farmers need more knowledge to operate the schemes,
e) water harvesting is more sustainable under prevailing local conditions.

9.3.4 Resource development

Reduction in present and future biological productivity of soil, water, vegetation and wildlife resources by overuse and misuse is probably the obvious land use problem in Kenya's ASAL areas (Ref:C14). In the main overuse is the predominant characteristic of development in ASAL areas; but one important sector of development potential, namely wildlife and tourism remains under-developed or under-utilized. Where over-use occurs all resources are typically degraded together because of the ecological and physical links between them. Similarly all production systems (see Section 9.3.1) including arable and livestock farming, wood production, and tourism and wildlife utilization are all affected because of their dependence on a common resource base. The extent of resource over-

utilization and damage is not well known or documented and varies considerably between different ASAL areas and zones and between different resources.

(1) Over-utilized resources

Water resources:

Water is a crucial limiting factor to sustainable development in Kenya. Although ample water resources exist, their geographical and temporal distribution is very uneven and no more than in the arid and semi-arid areas of the country. Today Kenya uses nearly 600 million cubic metres of water per year. Of this, 69% goes to agriculture, 18% to domestic use, and 13% to industry. Projections of annual water demand by the year 2000 range from 2,500 million to 5,900 million m3. To ensure the satisfaction of these projected demands it will be vital to harness these resources carefully to avoid compromising the needs of future generations.

a) Sources of water

Water is made available at various points in the hydrological cycle where it can be drawn or intercepted; these points are:-

1) **rivers**; all but a few of the rivers in Kenya are seasonal and ephemeral, they thus provide water over a restricted period of the year and over a narrow geographical area,

2) **lakes**; although Kenya has many medium and large size lakes, especially in the Rift Valley, the majority are either brackish (Turkana) or extremely saline (Bogoria, Nakuru, Elementeita, Magadi); only Lake Victoria, Baringo, Naivasha and Jipe are fresh and suitable as water sources for agricultural or domestic use; lake waters also require to be pumped or hauled to the point of consumption,

3) **groundwater**; data on Kenya's extensive and widespread groundwater resources are sparse, annual abstraction is estimated to be in the region of 17 million m3 (<3% of total water used) which is almost equalled by the rate of natural recharge. The quantity and quality of groundwater sources are, however, seasonally variable and many aquifers in ASAL are brackish or saline. Abstraction usually required lifting the water either by hand or by mechanical means.

4) **rainfall**; of enormous quantities of rainfall on Kenya each year, much is evaporated directly to the atmosphere, more is used by vegetation and then returned to the atmosphere, the balance enters surface and groundwater storage from whence it can be abstracted for supply. The interception of rain water before it reaches the ground or soon after it does so represents the most likely means of satisfying the present and

future water needs in the ASAL areas; this is technique is generally referred to as water harvesting.

Rain water harvesting is not a new technology but one relatively new to Kenya. It has the important benefit that it makes water available to people and vegetation in the same location and at the same time. This then avoids the problems created by the development of groundwater resources which often cause an imbalance between water and livestock fodder availability which can lead to land degradation around the water points to the overall detriment to those intended to benefit. It also makes water available at the point of consumption and reduces the need to pump or haul water over long distances; it can therefore save considerable amounts of time and human (mainly female) labour which can then be diverted to more productive activities.

b) **Water resource priorities**

According to Ref:C14 the inhabitants of ASAL areas list the following water uses in order of the following priority:-

1) domestic drinking water,
2) stock drinking water,
3) subsistence crop cultivation,
4) fodder growing,
5) cash crop watering.

To this list might be added;

6) wildlife water supply.

Generally groundwater can be supplied for drinking purposes to man and his domestic stock, but supplies are too limited and too expensive to provide for all but the smallest irrigation of crops in much of the ASAL area. In any event, and as mentioned above, providing stock with water simply shifts the required balance between the need for water and food and does not necessarily resolve the basic problem; water points become over-grazed and trampled and grass becomes the limiting factor instead of water.

It can be concluded that with the limited scope for small scale irrigation, and the problems associated with groundwater development for all but drinking water supply, water harvesting remains the best and perhaps only option for intensifying food production of ASAL areas by reducing the high risk of crop failure inherent in dry land, rainfed agriculture. The data in the Table below are indicative of the benefits to be gained by supplementing rainfed agriculture with harvested water especially when the rains are poor.

Rainfall	Yields (kg/ha)	
	Rain fed only	*With water harvesting*
Poor	Nil	500
Average	500	800
Good	1,000	1,200

Source: Ref:C14.

c) **Water harvesting**

The water supply potential to be derived from employing water harvesting techniques is estimated at 42 million m3/annum (Ref:C14).

Water harvesting techniques are not described here in detail but include:-

1) rock catchments,
2) sub-surface dams,
3) sand dams,
4) ground and road catchments,
5) roof catchments with tanks,
6) triangular micro-catchments,
7) semi-circular bunds,
8) trapezoidal bunds.

Results from experience with water harvesting in ASAL areas of Kitui District have shown that:-

1) small scale schemes work best,
2) all forms of water harvesting have proven technically feasible with the exception of river spate diversion,
3) harvesting is not successful on slopes exceeding 5%,
4) the soil type profoundly affects the performance and suitability of the various harvesting techniques,
5) adoption rates are higher for domestic and stock water supply than for crop production,
6) schemes not requiring fully sedentarization of the communities involved are preferred,
7) self-help labour can be used successfully,
8) use of local materials is preferred.

Experience from Kenya as a whole indicates that some techniques are particularly suitable for specific purposes in specific agro-ecological zones as follows:-

i) Domestic and stock water supply - suitable zones I to VII
   - rock catchments
   - sub-surface dams
   - ground and road catchments with storage tanks (stock use)
   - roof rain water catchments with storage (domestic use)

ii) Improved cropping - suitable for zones IV and V
   - fanya-juu terrace for soil and water conservation,zone IV
   - contour bunding systems for impounding water, zone V
   - trapezoidal bunding systems, zone V

iii) Range improvement - suitable for zones V to VII
   - semi-circular hoops for grass and shrubs
   - triangular micro-catchments for multipurpose trees (fuel/fodder)

A further benefit and advantage of developing water harvesting techniques lies in the fact that these methods satisfy both short and long-term needs. For example, many attempts to involve the local people in soil conservation in arid lands have failed because the people are too preoccupied with immediate survival than with long-term problems of the environment. Water harvesting, in contrast, achieves the long-term goals of soil conservation while providing for the immediate needs for retaining water for survival. The general approach to environmental conservation should, therefore, be modified to address both short-term and immediate demonstrable benefits as well as long-term benefits.

Wood resources:

Wood products are being widely over-harvested in many areas at levels which cannot be sustained in the medium to long term. This is happening particularly in riverine forests and woodlands (see Section 9.3.3), around settlements and in some higher production mountains within ASAL regions. Wood is being harvested mainly for fuelwood or charcoal production, housing materials and fencing. In ASAL areas near to large urban centres the collection of wood for fuel is particularly intense and devegetated rings extend 10-15 kilometres from many small urban centres as a result of fuelwood collection. In the drier areas such as Mandera, Wajir and Garissa, the task of collecting firewood has changed from taking an hour or two, to a heavy burden which now takes the whole day. This time, usually the womens time, detracts from other vital activities such as child care, crop and/or stock tending.

The immediate consequences of over-utilization are shortages of these and of other products such as livestock and human dry-season food resources (such as *Acacia* pods, nuts and fruits) medicines and extractable gums which are valuable local

commodities. In addition trees, bushes and scrub provide the same or similar benefits as grass in protecting the soil and water against degradation, they also provide valuable shade for man, animals and under-storey vegetation.

Settlement in wildlife dispersal areas near National Parks:

Some of Kenya's most important national parks and reserves in ASAL areas are only small parts of larger ecosystems that extend beyond the park boundaries into public lands. Typically the wildlife populations concentrate in the parks during the dry season, since the parks are usually centred on better watered key production areas, and disperse to the non-park areas of the ecosystem during the rainy season(s) when grass is abundant outside the park. Examples of such parks and reserves include Amboseli National Park, Maasai Mara National Reserve, and the Samburu, Buffalo Springs and Shaba National Reserves. The unprotected areas outside these parks and reserves are essential habitat for their wildlife populations that are so important to tourism. Without the continued availability of theses dispersal areas, the resulting confinement of wildlife within the protected areas throughout the year would degrade the environment drastically with severe ecological and economic consequences.

Land adjudication and settlement have begun to significantly reduce the size of these dispersal areas and to bloke the natural migration corridors of both wildlife and pastoralist. The comparative benefits of keeping these areas open to combined wildlife and pastoral livestock use versus conversion to fenced and farmed settlements requires urgent study and attention by policy makers. Tentative statements (Ref:AS2) suggest that "income generation of ASAL is potentially far higher under wildlife and tourism than under other land uses, especially with respect to foreign exchange income". In this respect, the local landowners and population need to be encouraged to support the conservation of wildlife and wildlife habitats through their greater participation in the economic and employment benefits derived from tourism. At present local people adversely affected by wildlife tourism receive very little economic benefit but often suffer crop losses and damage to life and property because of the presence and proximity of the national parks and reserves to populated areas while others receive all the benefits.

Grassland range resources:

Two contrasting situations appear to prevail in ASAL grassland ranges depending on water availability:-

a) most rangelands used only seasonally (wet season grazing areas) because of limited water supply do not seem to be significantly over-grazed, and here the condition of the range seems more controlled by the weather,

b) in contrast, the traditional dry season grazing areas (key refuge areas, see Section 9.3.3) are suffering from increasing pressure from competitive land

uses which is resulting in over-utilization. One consequence of reduced grazing potential in the dry season refuges is that pastoralist remain in the wet season range for prolonged periods and this is leading to over-grazing and land degradation in these areas.

A further consequence of encroachment into the key production areas by settlers is the increased potential for conflict between the farmers and wildlife populations that also use these same grazing and watering reserves.

Special efforts are, therefore, needed to manage these vital key areas because of the pressures they are facing and because of their importance to environmental quality and all forms of natural resource utilization in ASAL regions. These key areas are the heart of ASAL and without them the ASAL cannot adequately support anything other that the most basic forms of human society.

Impacts of extended water supplies on resources:

Although water shortages are most frequently cited as the principal limiting factor in ASAL development by the inhabitants of these regions as often as not it is a shortage of forage which limits development; this is turn is limited by the scarcity of rainfall, rather than sources of surface water. The distinction between shortages of water for direct consumption by man and his stock, and rainfall needed to provide the grazing for his stock must be kept clear. Providing point sources of water eg. shallow wells or boreholes, in ASAL regions (especially in zones VI and VII) can cause more problems than they solve. Such sources can encourage settlement or over-population in areas where the supply of food, forage, or fuel then becomes equally limiting when the water supply deficit is resolved. Increased stock water also encourages an increase in herd size. The supply of drinking water must remain in balance with the potential to supply food and fuel for the people and forage for the livestock without this balance the over-supply of water can lead to environmental repercussions that are detrimental to the intended beneficiaries. Thus it is rainfall, not water in general, that determines the primary production of rangeland that provides fuelwood, and fodder for the livestock in many parts of the ASAL.

Two exceptions to this caution on providing point water sources in arid areas can be identified:-

a) at intervals along traditional migration routes; these supplies will alleviate hardship during migration but should not be designed to encourage settlement at the location, even here afforestation and regreening could be initiated to upgrade the vegetation resources in the vicinity of the water point,

b) in areas where rainfed grazing is often available during the rains but which lack sufficient surface water sources to provide drinking water for man and

his stock. These places represent areas where the natural balance between surface water and fodder is in favour of fodder.

(2) Under-utilized resources

Under-utilization of wildlife and related tourism resources such as scenery, natural vegetation, wilderness areas and adventure safaris is the single ASAL resource in this category. Most national parks and national reserves, and wildlife populations, are in ASAL areas; ASAL parks and reserves cover nearly 38,000 km2, 86% of the national total.

Kenya's wildlife and the natural habitats that support it in ASAL areas are major attractions for the extremely valuable tourism industry. In recent years tourism has become Kenya's main earner of foreign exchange and an important source of employment and other supplementary benefits. In addition, the combination of wildlife and high quality coastal resorts offered by Kenya is almost unique; though many countries could compete on one or other of these assets few can provide both as effectively as Kenya.

Wildlife and related tourism resources have been under-utilized, in relation to sustainable development of ASAL regions, in four respects:-

1. Inefficient and unproductive management; insufficient investment and misuse of income,

2. Few of the material benefits of wildlife and tourism are enjoyed by the inhabitants of the ASAL areas which discourages active support of tourism or wildlife by the people,

3. Considerable opportunities still exist for expanding and diversifying the industry, particularly into presently undeveloped areas,

4. Virtually no consumptive utilization of wildlife is allowed in Kenya today because of the existing anti-hunting and game cropping policies; substantial economic and ecological benefits could be generated by the implementation of suitable systems of wildlife exploitation if the present management and policy difficulties could be overcome.

Since it is believed that income generation from wildlife and tourism in ASAL areas is greater than from other alternative land use options it is unfortunate that this opportunity is not being fully harnessed; future national planning should ensure that tourism development in ASAL regions is afforded the priority it deserves.

N10. RECOMMENDATIONS

10.1 General Environmental Issues

Recommendations for future action are presented below under the same chapter heading as used in the foregoing Chapters.

N2. Kenya Population

Since rapid population growth is the crux of the problems of economic growth and social development in Kenya today it is recommended that:-

Increased financial and manpower support is provided to the existing family planning and birth control programmes.

N3. Environmental Consequences of Irrigated Agriculture

There are potentially very many physical and social environmental impacts which may attend further irrigation development in Kenya and the following recommendations are designed to mitigate the adverse impacts as much as possible. It is recommended that:-

(1) agricultural development is prioritized as follows -

- improvement of yield and economics of existing rain fed agriculture,
- reduction of post harvest losses through improved storage conditions and facilities,
- rehabilitation and modernization of the existing irrigation schemes,
- development of new irrigation schemes.

(2) several restrictions are placed on the conversion of medium and high potential areas in ASAL regions from dry season refuge pastures to permanent irrigation (see also N9 below).

(3) monitoring of return water quality is undertaken in all existing schemes to assess the impact on the receiving water course.

(4) where applicable eg. Kano & Nyando Plains, the return water from proposed schemes is passed through existing Papyrus swamps to reduce the pollution impact on the receiving water.

(5) the procedures for compensation provision to people adversely affected by the development of irrigation schemes are improved to provide, among other things, the option for land-for-land compensation, relocation and resettlement costs.

(6) further investigations are carried out to assess the present feasibility of integrated pest control and management rather than the current sole reliance on chemical control.

(7) greater consideration is given to the tenants, especially on rice paddy irrigation schemes, for the provision of land for food crop production to avoid problems of malnutrition in monoculture agriculture systems.

N4. The Environmental Impacts of Dams and Reservoirs

(1) the procedures for compensation for people displaced or adversely affected by the construction of dams and reservoirs are streamlined and improved especially with regards to the provision of the option for land-for-land compensation.

(2) where power bores will be produced by intermittent power generation the public are fully protected and made aware of the hazard involved.

(3) adequate compensation flow is returned to the river to maintain its utility to downstream users and its ecology; this is especially important in rivers likely to be used as receiving waters for effluent discharges where dilution is required.

N5. The Environmental Impacts of Deforestation

(1) the rate of reforestation must be increased to exceed the rate of forest removal if a fuelwood and charcoal crisis is to be avoided; new fuelwood plantations in the vicinity of urban centres must be given high priority, as must private-or-farm free management.

(2) the conservation and maintenance of sensitive forested water catchments must be given high priority to protect vital water resources.

N6. Soil Erosion and Conservation

(1) the implementation of existing soil conservation policies should be speeded up through the provision of greater support for existing government institutions and NGO's.

(2) funding for agroforestry research and implementation should be increased.

N7. Water Quality and Water Pollution

(1) monitoring of principal surface and groundwater resources needs to be improved and decisions made on the location and frequency of sample collection to ensure the resulting data suitable for long term management of these resources.

(2) similarly, monitoring of effluent discharges must be improved to avoid pollution of the countries water resources.

(3) the ongoing improvements to the Water Act must be supplemented with active enforcement of legislation; legislation alone does not prevent pollution.

(4) with regard to effluent quality guidelines or standards, it is recommended that the relevance of the existing well-prepared standards (eg. British Royal Commission 20:30 standards) is re-evaluated and alternatively, and more relevant, guidelines proposed for adoption in Kenya.

N8. The Closed Basin Lakes of Kenya

(1) Regular environmental monitoring, including water and effluent quality monitoring, should be implemented as a matter of urgency in those closed basins identified as being under threat from development; these lakes include Naivasha, Nakuru and the Winam Gulf. Lakes Baringo and Bogoria should also be paid attention.

(2) The threat from the Malewa-Nakuru water transfer scheme Phase 2 appears to be a major threat to Lake Nakuru especially. It is recommended that to mitigate the probable impacts of Phase 2 all present and additional effluent generated in the lake catchment is fully and properly treated to a high standard and that the final effluent is discharged outside the lake catchment.

N9. The Arid and Semi-Arid Lands of Kenya

(1) Two major assumptions concerning ASAL must NOT be made namely:-

- that the ASAL constitute a major reserve of productive land available to accommodate overspill population from the high potential areas of Kenya,
- that water is the main constraint on production in ASAL areas, it is not, vegetation is the primary limiting factor.

(2) ASAL development should concentrate on livestock production and wildlife-tourism as the main production bases; these areas cannot compete economically with the high production areas in arable farming.

(3) Great care must be taken when developing water resources in upland (and usually productive) areas which denies water to the lowland ASAL areas down river. This may be best achieved by straightening the existing river basin authorities to ensure planning on a whole catchment basis.

(4) The expansion of water harvesting techniques in appropriate areas is to be recommended.

(5) Key production areas used by pastoralists livestock and wildlife must be protected from further conversion to arable agriculture and settlement. Without these dry season refuges wildlife and pastoral populations will suffer and decline. If migrant populations are denied access to these vital dry season areas of refuge the wet season grazing potential of the rangelands will be wasted, and the range degraded through over-exploitation in the dry season.