TOWARDS AN ENVIRONMENTALLY SENSITIVE FORM OF PASTORALISM: AN INDICATIVE COST-BENEFIT ANALYSIS

BY

OMBAM REGINA AKOTH

Research paper submitted to the Department of Economics, University of Nairobi, in partial fulfilment of the Requirements for the Degree of Master of Arts in Economics

1993

This research paper is my original work and has not been presented for a degree in another University.

OMBAM REGINA AKOTH

This research paper has been submitted for examinations with our approval as University supervisors.

DR. MOHAMUD A. JAMA

DR. PETER K. KIMUYU

ABSTRACT

This paper describes the environmental problems facing the development of Kenya's arid and semi arid lands (ASALs) today. The problems arise because of a rapidly declining resource base in the ASAL as a result of overexploitation and misuse, following basic land use conflicts. The extent of the overutilisation or resource damage is not well known and varies from one agro-ecological zone to another and from resource to resource in the ASAL; those most affected include soil, water, range, forest, livestock and wildlife. As a result of increased population in the ASAL, these resources are under stress. Many of the development programmes do not address the needs of the people who live in the ASAL. There is a need to shift the objective of ASAL development from a preoccupation with economic growth and the idea that ASAL should make a contribution to GNP through interregional trade and export to sustainable development that enables the communities in the ASAL to support themselves at a good a standard of living as possible.

Drought and desertification are still a major drawback in the development process of the arid and semi-arid regions despite long periods of environmental awareness.

The study aims at finding a more environmental friendly form of land-use undertaking in the arid lands of Kenya where Pastoralism is the main economic domain. In this respect,we compare the economic and environmental benefits of camels to those of cows.The analysis is done in a Cost-Benefit framework by considering the benefits accruing to camel keeping compared to those of cattle keeping considering the two as alternative land- uses though they are

ABSTRACT

This paper describes the environmental problems facing the development of Kenya's arid and semi arid lands (ASALs) today. The problems arise because of a rapidly declining resource base in the ASAL as a result of overexploitation and misuse, following basic land use conflicts. The extent of the overutilisation or resource damage is not well known and varies from one agro-ecological zone to another and from resource to resource in the ASAL; those most affected include soil, water, range, forest, livestock and wildlife. As a result of increased population in the ASAL, these resources are under stress. Many of the development programmes do not address the needs of the people who live in the ASAL. There is a need to shift the objective of ASAL development from a preoccupation with economic growth and the idea that ASAL should make a contribution to GNP through interregional trade and export to sustainable development that enables the communities in the ASAL to support themselves at a good a standard of living as possible.

Drought and desertification are still a major drawback in the development process of the arid and semi-arid regions despite long periods of environmental awareness.

The study aims at finding a more environmental friendly form of land-use undertaking in the arid lands of Kenya where Pastoralism is the main economic domain. In this respect,we compare the economic and environmental benefits of camels to those of cows.The analysis is done in a Cost-Benefit framework by considering the benefits accruing to camel keeping compared to those of cattle keeping considering the two as alternative land- uses though they are

not mutually exclusive. The main findings of the study were: Camel pastoralism is a more environmental friendly land-use undertaking than cattle pastoralism. The costs of camel keeping are very high but the returns from an economic point of view are much higher showing that the risks of adopting camels in this arid environment are rather minimal. Adopting camels in this harsh environment is indeed an economic as well as an environmental plus to the pastoralists and will ensure that development programmes too,will address the needs of the pastoralists now as well as in the future.

TABLE OF CONTENTS

CHAPTER ONE: INTRODUCTION

1.1 THE ARID ENVIRONMENT

Arid lands seem to be peripheral and apart from their oil and mineral wealth, almost useless lands. Land-use planning in arid lands concerns principally the desert-edge agriculture and focuses on stopping the extension of desert-like conditions. But this was not always so. For the specialist, arid lands are not the abandoned and bleak lands of popular imagination. They have an array of highly adapted plant and animal species. Until recently, arid lands formed discrete and important geographical regions with diversified economies based on nomadic pastoralism, oasis agriculture, salt mining and specialist long distance trade, and were an essential link in wider economic and ecological complementarities. On this rich economic base, politically and militarily powerful societies grew, often dominating their sedentary neighbours. But with growth of modern state administration and industrial economies, desert-edge agriculture has been re oriented towards urban growth in wetter areas and modern communication networks have bypassed deserts. As a result, arid lands have become progressively more marginal to economic and political life, a marginality often increased rather than reduced by the development of oil and mining enclaves directly linked to advanced industrial economies. Arid lands now fulfil a classic role of such marginal areas by supplying cheap raw materials, labour and commodities such as livestock for rapidly developing economic regions elsewhere. As a result, arid lands are losing biological and economic potential.

Traditional pastoral societies developed economic strategies resembling the ecological

strategies shared by all arid and semi-arid zone organisms. The ecological attributes necessary for organisms (plant and animals) to survive such arid conditions are:

- Tolerance of extreme conditions, especially extreme drought and heat.
- Ability to recover rapidly when conditions are good.
- Adaptation to the transitions between pulse and reserve phases.
- Flexible and opportunistic feeding habits.
- Nomadic migrations.
- Special distribution patterns with concentrations in favourable areas.

Considering the above attributes, it is of importance to note that pastoralists are flexible and opportunistic in the use of pasture resources, they move and have integrated the grazing economy with complementary economies in a way that allows population and economic activity to shift between different activities as conditions change, and allow rapid expansion of pasture resources in good rainfall years. This regional economic interdependence between complimentary desert, steppe and savanna economies is well exemplified by the pre-colonial West African Sahara, Sahel and Savanna. A good example is that of the Tuareg nobles, who ran the pastoral and desert trading economies and maintained a commercial infrastructure in the agricultural areas and towns in the savanna. There was exchange of goods and of labour between these economic sectors and more important, the chain of integrated activities linking the desert to the savanna provided a safety valve for pastoralists during drought. When rain failed and plant production in the desert edge and steppe areas was very low, pastoralists migrated to the southern end of their trading chain where, because of their land holdings, they were assured of access to

pasture and to other non-pastoral activities. The desert and Sahel economy contracted in these drought periods and its centre of gravity shifted into the savanna. In good periods, the reverse happened, and the pastoral economy expanded to take advantage of their abundant pasture.

Various economic products were integrated by the economic operations of many African pastoral economies and societies to the edge of disaster so that environmental destruction was widespread and serious droughts precipitated famine. In resource rich areas, on the other hand, the emigration of adult men or of whole families to a rapidly expanding extractive or urban construction centre left pastoral economies without labour, and led to a rapid decline in pastoral production and to unused pasture resources.

Development of rangelands focuses on means of increasing livestock productivity both for improved standards of living and subsistence. Livestock production is the only economic domain where its development is often seen to require a certain devolution of the system of production through sedentarization of pastoralists, decreased mobility of herds and destocking. Long term climatic changes in the arid and semi-arid regions compounded by man's activities such as cultivation, overstocking, inappropriate land-use methods and insecurity have produced almost irreversible changes on the margins of the world's deserts. This has led to long periods of drought and the desert spread whereas pastoral production centres around pasture and water. In this respect, one can argue that pastoralism as a system of supplying provisions is actually breaking down. This is despite the fact that pastoralism is probably the most adaptive and potentially viable economic system in semi-arid and arid land ecosystems requiring rational and long-term approaches to land use management.

In the light of the ecological characteristics of arid and semi-arid lands, and the precarious present state of most such areas, it is desirable to look for new general development policies for these areas. Deserts and arid grasslands are ecologically unstable, but resilient: unstable in the sense that there are quantitatively large annual variations in plant and animal growth, but resilient in that unless there is gross misuse, they are able to recover high productivity in good years.

This resilience is the result of the stabilizing mechanisms listed above, such as flexibility, opportunism and the ability to recover from drought rapidly. Human use of such lands should build on these basic ecological strategies; planning should seek to recreate at a higher level of productivity, the traditional advance and withdrawal strategy integrated with neighbouring economies of previous desert and steppe pastoralist users. In economic terms this means, not aiming at stable yields through large technological and institutional investments but rather at a management which accepts fluctuations in yield, aims to make productive use of these grasslands in good years and accepts small or nil yields in bad years. The best way to achieve this is by extensive pastoralism which builds on the flexibility of existing nomadic pastoral societies in which grazing pressure is closely adjusted to the amount of energy fixed by plants each year.

1.2 STATEMENT OF THE PROBLEM

Drought and desertification should be viewed as natural phenomena although they may result from the extreme outcome of the interaction between man and nature. The paradox of development in the arid and semi-arid lands is that there seems to be a great

potential for improvement in the agricultural and livestock production systems and thereby the quality of life of the arid lands residents while at the same time the constraints to achieving that potential are so powerful and pervasive as to thwart all efforts towards improvement.

Desertification is the degradation of both the living and non-living environment of an ecosystem caused by man's interventions and abuses. The process is marked by increasing micro-aridity and declining productivity and the end-product is a state in which photosynthesis is of little use to man and animal. The effects of increasing micro-aridity on livestock and crop-production is hard to determine, but great. Since aridity and productivity are inversely related, increased micro-aridity on either crop, pasture or forest land can only represent a reduction in crop, meat, milk or wood production. It cannot be otherwise and therefore management aimed at reversing this downward trend must be a vital consideration in any land-use attempt.

Arid lands can be subdivided into three parts: semi-arid, arid and extremely arid. The essential environmental characteristic which distinguishes the arid lands is lack of precipitation, variations in temperatures from one region to another, intense solar radiation and high evapotranspiration rates. There is less water to support plant and animal life. Rainfall is too low and scattered to permit successful irrigation except in special circumstances (for example, using underground water). There is limited plant growth due to the quantity of available water as plant production is directly related to rainfall. Rainfall in arid land is not only scarce but irregular and several years may pass without effective rain. Water is the main limiting factor in plant growth. Variability in rainfall leads to great variability in plant

growth and thus in energy available for domestic animals and human use. The great variation in plant productivity creates problems for animal use of the environment. Less water to support plant and animal life plagued with variable probability by frequent and prolonged droughts makes the arid and semi-arid regions present the most serious problems of development. However, there are specific, although limited solutions for the use of arid regions and the conflict between methods of land-use and the choice becomes even more difficult with increasing population densities of human and animals.

As a result of this, famine and its ever-waiting companion starvation, have plagued the people of the arid lands ever since they began to struggle with such a harsh environment. This clearly shows that much more attention should be paid to the problems of these fragile lands.

Environmental degradation is rampant in the economically and socially strained countries of sub saharan Africa. Some of the critical environmental problems are: deforestation, soil erosion, aridization and loss of genetic diversity of flora and fauna. These problems are not isolated but interlinked in a process known as desertification. For example, reduction of vegetation cover as a result of unsustainable exploitation of the land can give rise to loss of biological productivity and exposure of the soil surface to accelerated incidences of water and wind erosion leading to reduction in soil organic matter and nutrient content. The resulting loss of habitats undermines the very basis of agricultural production and the prospects of developing improved varieties of crops and livestock. Degradation of the vegetation can also affect the climate, locally, regionally and most probably globally.

The widespread environmental degradation in Africa has been largely attributed to

the absence of environmental awareness or consciousness among the poor in Africa (Plumwood and Routley,1982). However our contention is that the foremost causes are human population pressure and outside influences (eg.modernisation) leading to overexploitation and poor management of resources (forests, soils, water, atmosphere etc.) through overcultivation, overgrazing, deforestation, poor irrigation practices, pollution etc.).

Human and livestock pressure often plays a role when the numbers of people and animals surpass sustainable levels in fragile, arid, semi-arid and subhumid ecosystems. These are often exacerbated by other factors such as social and political systems which lead to unequal access to resources; inequitable financial arrangements and terms of trade which force some developing country populations to overexploit their land merely to survive; development conflict between export based cash crops and foreign exchange needs on one hand and basic food security for the poor on the other. Where cashcropping is important there is often the tendency for cash crops to take up the best land while subsistence farmers are forced into marginal lands or land unsuitable for cultivation and particularly vulnerable to desertification.

The consequences of poor resource management manifest themselves differently in different countries. But whatever the variations the impact will eventually be measured in economic and social terms (Brown 1988, pp3). For example, the demand for household fuel poses a clear threat to economic development in several countries. It has led to denuded forests near rural villages and round towns and cities. With the loss of tree cover comes increased erosion and lower crop yields. Where dried dung is used in place of scarce

fuelwood, the soil is robbed of its natural replenishment. The resulting loss of soil fertility reduces harvests which in turn means poverty for the dependent population.

Desertification means a deteriorating spiral of declining production, increasing poverty and diminished potential productivity (Darkoh, 1980, 1989). It exacerbates poverty which in turn exacerbates desertification because as the pressure increases the inhabitants are forced to intensify overexploitation of their land just to survive. In doing so they cause further diminution of its productivity and so the cycle continues.

The social cost of environmental degradation is best illustrated by the experience in the Ethiopian highlands and all across the Sahel: starvation, death and the forced exodus of millions of environmental refugees moving in a desperate search for survival to urban areas or to other less degraded areas elsewhere.

The human cost of environmental degradation is immense; entire societies and cultures are threatened. The pastoralists are a case in point. For most of them the loss of their livelihood means a life in relief camps or in the shanty towns mushrooming around the major cities. Our Common Future, the report of the World Commission on Environment and Development (WCED 1987) underlines the connection between poverty, international policy and environmental degradation. The report emphasizes that poverty itself pollutes the environment".....Those who are hungry and poor will often destroy their immediate environment in order to survive(WCED 1987 pp 28). They will cut forests, overgraze grasslands,overuse marginal lands and crowd in congested cities. The cumulative effect of these changes is so far reaching as to make poverty itself a major global scourge(WCED ibid.)

Nowhere is this connection more graphically illustrated than among the famine ravaged people of subsaharan Africa who have become a familiar sight on European and American television screens in recent years. To quote again from Our Common Future, their plight:

".....illustrates the way in which economics and ecology can interact destructively and trip into disaster. Triggered by drought, its real causes lie deeper. They are found in national policies that have too little attention, too late, to the needs of smallholder agriculture and to the threats posed by rapidly rising populations. Their roots extend also to a global economic system that takes more out of a poor continent than it puts in. Debts they cannot pay for force African nations relying on commodity sales to overuse their fragile soils thus turning good land into desert. Trade barriers in the wealthy nations ....and in many developing ones....make it hard for Africans to sell their goods for reasonable returns putting yet more pressure on ecological systems. Aid from donor nations has not only been inadequate in scale but too often has reflected the priorities of nations giving aid, rather than the needs of the recipients"(WCED 1977 pp6).

Most African countries are trapped in production structures and political systems which make it difficult to envisage real progress for the wider population in the short term. Political and social conditions have not been conducive to open debate about environmental problems, nor the establishment of efficient public bodies to deal with the issues. Lack of knowledge, resources and administrative capacity have all contributed to abandoning the pastoralists and leaving them to struggle for survival, assuming that they will live in harmony with nature is a misjudged perception. A major concern is the immediate food requirements of the pastoralists and the need to improve their well being by making them self sufficient and contribute to the national economy, enhancing their social and cultural integrity and at the same time seek solutions to the urgent environmental problems associated with desert encroachment and ecological degradation.

It is evident from the foregoing that pastoralists have been caught up in a web of development activities and consequences of which they have little understanding and control. The dilemma that faces the pastoralists in Kenya is, therefore, how to cope with a changed production environment that has been dictated by exogenous factors, while maintaining their traditional way of life. On the other hand, a challenge that confronts policy makers, planners, researchers and other development agencies towards a realization of the full potential of ASALs, is how to achieve an improved and sustainable production from the drylands. Increase in herd population for milk and meat production has led to overgrazing which reduces rangelands productivity, enhances desertification and adversely affects rangelands stability. This calls for a system of land-use and range management that allows long-term pastoral exploration of all natural resources without serious environmental degradation.

1.3 OBJECTIVES OF THE STUDY

In achieving an understanding for the rational management and rehabilitation for the arid and semi-arid areas of Kenya as far as pastoralism is concerned, the specific objective is:

- To determine the relative role of different livestock species in causing desertification and determine the most appropriate type of livestock and their relative proportions on a specific type of rangelands.

To be able to achieve the above mentioned objective, the following hypotheses can be tested:

i) That camel pastoralism is a more economically and environmental friendly land-use undertaking than cattle pastoralism.

ii) If returns from cattle keeping are decreasing over time relative to returns from camel keeping,it will suffice for the choice of the optimal policy to consider the present values of only one land-use system.

1.4 SIGNIFICANCE OF THE STUDY

Arid and semi-arid lands (ASALs) comprise about 80 per cent of Kenya's total land surface area, support well over 25 per cent of the human population and slightly over half of the livestock population. A majority of the inhabitants are pastoralists although agro-pastoral and farming communities do exist (The Sixth National Development Plan 1989 - 1993). However, it was only in the 1970s that a major evaluation of the potential contribution that ASAL areas would make to the national economy was done. Development projects introduced to facilitate livestock production had a basis on western ranch style systems and these projects have been and continue to be implemented in the arid lands although serious flaws in their design have meant that such 'thought out' ideas by experts are not working. Basically, four models have been proposed and implemented, with varying degrees of success. The models are grazing schemes, group ranching, commercial ranching and grazing blocks. With the introduction of these models, environmental degradation and the threat of desert encroachment are more or less a permanent phenomena in some areas. Famine relief

measures and rural poverty are the symptoms of a wider and complex problem that calls for alternative approaches for pastoral systems development.

The future of the ASALs in Kenya lies in pastoralism backed by proper environmental management at least in the short and medium terms. The importance of the arid and semiarid areas should be given much recognition and be accorded special attention considering that they have substantial potential for development though at higher costs than the rest of the country; most of the poorer people live in these areas hence the need to improve their living conditions through increased productivity and creation of employment opportunities that would enable them to equitably share the benefits of development; and the increasing problem of soil erosion and environmental degradation, the threat of desertification and the negative consequences of phenomena such as hunger and malnutrition which manifest themselves most severely in these areas often calling for diversion of public resources to famine relief operations. The study hopes to be of help to researchers, decision makers, planners and development economists for it focuses on how to improve pastoral production system in a way that is sustainable and ensures human survival in the dry lands.

Research on land degradation and soil conservation should have as its fundamental aim the promotion of sustainable utilization of resources. It should enable scholars in this region to study the multifaceted causes of environmental degradation and find solutions to the problem. As a prerequisite to sustainable use of natural resources in the country local researchers must be able to analyze and assess the country's resources realistically. There is need therefore to support endeavours to upgrade environmental considerations as a pre-condition to embarking on sustainable development.

1.5 ORGANISATION OF PRESENTATION.

The paper begins by introducing us to the general situation in the arid land environment with special reference to the potential of the supposed bleak lands, hence hinting at the need for the government to redefine some of its development priorities so that they include arid land development processes too.

The sub-section immediately after states the problem of the study explicitly, specifies the objectives of the study and the significance of the study.

In the next chapter, we present a review of the existing literature on the issues of desertification and pastoralism and how cost-benefit analysis has been applied to problems of environmental design. Then there is chapter three which points at the methodology employed in the study including data base and the testing procedure.

In chapter four, we present the empirical results by looking at the economic and social profitability of undertaking the two projects (ie Camel keeping versus cattle keeping). We also look at the optimal use of the environment in question by dynamizing cost-benefit analysis. In concluding this chapter, we also look at some of the major shortcomings of the study.

Chapter five is the last with conclusions arising from the empirical results, policy recommendations and possible areas of further research.

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter explores the theoretical and empirical literature on the utilization of natural resources and the consequences of their depletion. The last section gives an overview of the reviewed studies and the possible limitations of their approaches.

2.1 GENERAL LITERATURE

The problem of drought and desertification has received little attention in economic literature. Geographers and botanists have paid much attention to this problem. Socio-economic analyses are necessary in the design of policy because the most basic desertification control decisions by pastoralists are based on economic and social factors in addition to technical possibilities.

A drought is an environmental shortage of enough moisture to sustain established plant, animal or human life systems. It may be caused by a host of factors, the chief of which is often lack of sufficient precipitation and high transpiration. But other factors such as increased run-off due to overgrazing and poor vegetation cover, decreased cloud cover, dry hot winds which may accompany the reduced precipitation, lowered water tables and salinity are all factors which reduce the available soil water.

The above factors therefore indicate that availability of soil moisture in relation to the demands for water is what constitutes a drought. An off season crop, or variation in timing,

the sequence and regularity of precipitation for example might produce drought conditions. The choice of a high moisture requiring crop or increased plant, animal or human population might lead to the introduction of drought conditions in an area where there was none. Alternatively, judicious choice of plant and animal population, appropriate cropping sequences or complementing precipitation with any form of invitation might arrest drought conditions.

Desertification is the impoverishment of arid, semi-arid and some sub-humid ecosystems by the impact of man's activities. It is the process of change in these ecosystems that leads to reduced productivity of desirable plants, alterations in the bio-mass and in the diversity of life forms, accelerated soil degradation and increased hazards of human occupancy. Desertification is actually the result of land abuse. (United Nations conference on Desertification - 1977).

This study as a scientific inquiry however considers the impact of drought and desertification in the arid and semi-arid lands where three major land-uses predominate - pastoralism, wildlife and farming. In this respect, it is of great importance to discuss the relationship between changing land-use patterns, resource availability and ability of people to cope with drought in a particular environment. Therefore, explanation of the impact of drought upon pastoral population must be set in the context of the reduction in the availability of dry season grazing and water resources which has taken place in the years prior to the drought.

Natural resources economics is an important strand in environmental quality analysis as it basically evolves around human effects on biotic and abiotic resources. Resources for

the Future sponsored the definitive work on conservation economics for the pre-1970 period (Barnett and Morse,1963). Barnett and Morse examined contemporary views of ecology, economics, and philosophic naturalism on natural resources availability and discussed four models of economic scarcity:(1) Utopian, (2) Malthusian (3) Ricardian (4) their own complex model.They found that the real unit costs of extractive output, agricultural products and minerals fell significantly during the period 1870 - 1957 with the exception of forest product. From this price decline, they concluded that there need be little concern over natural resources scarcity in the foreseeable future although they admitted the potential for serious environmental pollution problems.

Their study was criticized for having focused only on the outcomes rather than the complex market process that affect the use of resources. Their measure of resource scarcity 'real unit cost' is not defined clearly(Smith,1979)because:

- It cannot explain economic responses and underlying causal factors thus its inadequate in fine tuning policies.
- As particular resources become scarce, their prices go up and other resources become economic substitutes.
- Price increase stimulates the search for new deposits of the original resource and encourages recycling and reuse.
- Lower grade sources are abundant and technological advances may decrease extractor and processing costs both for currently utilized deposits and such lower grade deposits.

However, their study was influential in establishing the conventional wisdom among US economists and policy makers until the early 1970s. This view of natural resource

availability is at odds with the view of classical economists and modern environmentalists. Much of the resource economics literature of the 70s involves revision and updates of the Barnett-Morse thesis.

Smith (1978) criticizes the Barnett-Morse scarcity index which assumes that relative costs determine exchange values and past trends will continue. Recognizing that there is no objective measure independent of demand, technology and preferences, he suggests three other scarcity indices: (1) Relative prices of natural resource goods; (2) Relative prices of natural resources as inputs; (3) Gross labour requirements per unit of extractive output.

Fisher (1977) rejects the unit cost measure used by Barnett and Morse because it does not reflect anticipated future scarcity relative to demand and it excludes environmental quality effects. A good measure should increase in the same direction and magnitudes as scarcity, yet real unit costs might not increase with depletion if there are no stock effects (increases in costs of extraction, processing and use) that result from the lower quality of the resource available.

The key issues dealt with in research on environmental degradation can be formulated in general terms as degradation of soils, vegetation, water regimes, atmosphere and other natural resources in which the biological and physical processes are accelerated as a result of human intervention. The overriding problems can also be postulated as conflicts arising from competition for resource utilization between the various production sectors (eg. agriculture, livestock, wildlife, human settlement etc.).

Such growth without development has meant the exploitation of human and natural resources for the primary benefit of outside interests. Many a previous effort to enhance

African agriculture have been far from success even as they have caused environmental damage to entire landscapes and displaced local production systems. To correct the ingrained problems of poverty and environmental degradation in Africa will not be easy. It will require a new approach to development one that is based on policies that sustain and expand the environmental resource base.

The term" sustainable development" has often been used by different people to mean different things that it has become, in the words of one critic, an intellectual oxymoron (Lele 1991 pp 608). The US Agency for International Development (USAID) tends to use it to mean a project can be sustained financially after foreign assistance has been terminated (Brown 1988 pp12). Most environmentalists use the phrase sustainable development to mean ecologically sustainable or environmentally sound (Tolba 1984).

If development is to succeed over the long term it must be for people and by the people. It is therefore important that any suggested strategies build on the issue that environmental issues should be considered from Developing countries viewpoint. As the need of economic development and an increasing population make intensive production necessary, existing production methods and local populations understanding of environmental realities and sources of valuable information which should be used to formulate a sustainable development strategy.

The part of economic theory relevant to the paper touches on Welfare theory. This part of economic theory basically looks at Consumers' Surplus; the excess of consumers' willingness to pay for a good or service over and above its market price, as a measure of the net welfare gain from a project.

The idea of measuring the net advantages of a capital investment project in terms of society's net utility gains originated with Dupuit's famous paper 'On the measurement of the utility of Public Works' [1844]. In his work, Dupuit pointed out that political economy has not yet defined in any precise manner the conditions which these (public) works must fulfil in order to be really useful. Dupuit introduced in his article the concept of consumers' surplus which has since played a crucial side in Welfare theory (see among others, Marshall,(1890) Pigou,(1947) Hicks,(1946) and Samuelson(1947).

Consumers' surplus theory suggested a way of measuring the social return to a capital project. The flow of services from the project, multiplied by their prices, merely defined the minimum social benefit. Since some purchasers would have been willing to pay more, they obtained something for nothing, an excess of utility which constituted consumers' surplus. This aspect of the definition of net social benefit is fundamental to Cost-Benefit Analysis, and is readily extended to cases where persons who are direct beneficiaries of a project obtain some 'overspill' benefit. They obtain some utility from a good or service for which they have not paid, a consumers' surplus in a context where the market price, to them is zero. It follows that the measurement of net social benefits requires the estimation of all the consumers' surplus to whomsoever they accrue. This link between surplus theory and the indirect third party losses and gains from capital projects was again not made until the 1950s. However, the idea of adding up all the benefits had achieved formal recognition in the US in the 1930s even if no guidance was given at that time about how benefits were to be measured.

During the postwar period, cost benefit analysis has become increasingly popular as a

meaningful evaluation technique for public projects. Cost-benefit analysis is originally a capital budgeting system primarily concerned with public projects. Cost-benefit analysis is essentially not a purely accounting system, but it is an evaluation method based on applied Welfare theory. It is a method to determine the net social surplus of public investment or of institutional decisions.

The Welfare-theoretical basis of cost benefit analysis is particularly reflected by the theory of willingness to pay and of consumers' surplus. The basic idea is that the utility of a certain good is at least equal to the price paid for it, so that a person buying a good against a certain price and attaching to this good a value greater than its price will derive a net profit. This implies that the worth or value of a good is determined by the willingness to pay of the buyer. Clearly, this willingness to pay depends on the demand curve (and hence on the individual indifference curve) of the buyer. Because a certain good is frequently bought against the same price by different buyers, a net profit will arise for those buyers whose willingness to pay exceeds the actual price of the good in question. This net profit is called the Consumers' Surplus and the relationship holds true for both public and private goods.

By aggregating for all elements of a certain good or plan, the expected consumers' surplus, the total net benefits (Benefits-Costs) can in principle be assessed. The (direct/indirect) benefits accrue from the total willingness to pay (of a new-good) or from the rise in total willingness to pay (of an extension of an existing good). The costs arise from the marginal costs of the production factors withdrawn from alternative uses (the so called opportunity costs). In general these costs are set equal to the price of the production factors (given the assumption of a neo-classical equilibrium theory).

If a choice has to be made among alternative goods (or public plans) in order to achieve allocative efficiency, the criterion of a maximum willingness to pay can be used. In this way, cost-benefit analysis can be used as a monetary evaluation method to assess the net social benefits of public projects or of institutional decisions. Clearly, right economic decisions can only be taken when the price system reflects the social revenues and sacrifices in an adequate manner.

By means of cost-benefit analysis, the multiplicity of dimensions of plan impacts are transformed into a common price denominator. Clearly, this tells us that the plan with the highest net benefit will rank as the most favourite plan.

On the other hand, there are also strong arguments against cost-benefit analysis as a project evaluation criterion principally considering its application a problem in the determination of consistent and reliable values of project outcomes.Cost-benefit analysis is essentially a social evaluation method, thus external effects have to be taken into account (Dasgupta and Pearce [1972]). These external effects imply in the framework of environmental damage that the source of the damage concerned can be identified (the interdependence condition). If the market mechanism does not provide an adequate price for environmental damage, a monetary amount (Shadow Price or social opportunity cost) has to be calculated which compensates all affected parties for the damage suffered so that the original Pareto market equilibrium is restored (the so-called Hicks-Kaldor compensation principle; see also Haveman and Weisbrod [1975]).

In addition to external effects, attention has to be paid to intangible effects (effects, which can only be measured either in quantitative terms but not in monetary terms or in

quantitative terms only e.g. human life, historic sites or natural beauty). It is clear that intangibles cannot be introduced directly into the traditional cost-benefit analysis (Coomber and Biswas [1972] and Mishan (1971]). A reasonable way of accounting for intangibles seems to be the use of a balance with a debit and a credit side in which all intangible project effects (both positive and negative) are represented in their own (quantitative or quantitative) dimensions as P.M. (ProMemonia) items.

Another element to be taken into account is the time period during which a certain plan provides benefits. Due to risk and uncertainty over a long time period, a time preference does exist so that the current value of a commodity is attached a higher preference than the same value after a number of years. The factor representing the social rate of time preference is called the social discount rate. A basic problem is the precise calculation of the social discount rate. According to Baumol (1969), the correct discount rate is the opportunity cost of capital in terms of the potential rate of return in alternative uses of the resources that could be utilized by the project at hand. This theoretical statement however does not offer a practical solution for an actual determination of the opportunity costs of capital, particularly because the latter variable shows many fluctuations throughout the economic system (Sandmo[1972]). In many practical studies, a value of discount rate varying between 7% and 12% is being used, but the theoretical foundation is in general rather weak (Bouma [1974]). Sometimes, the private rate of discount for capital is being used to assess the revenues which could be obtained in alternative uses. In general, the social discount rate is a function of the social time preference for the diverse plan impacts, so that it is not an unambiguous variable, but dependent on the social and political

preferences with regard to future development and expected plan impacts.

However, it is clear from the literature that cost-benefit analysis is not an easy application of welfare theory. Both in theoretical and in practical respect, several problems have to be overcome in order to obtain a meaningful and reliable evaluation method. The diverse applications of cost-benefit analysis have served to show that theory and practice are, often necessarily, divorced from one another. Further, the procedures followed in one application are not necessarily relevant in another application. Indeed, cost-benefit has become a generic term, covering a large range of evaluation procedures which frequently differ in what they include and omit as benefits and costs, and in the way outcomes are valued. There is also frequently little or no relationship between practical applications and the welfare theory which, one supposes, should undervalue the practice (Dasgupta and Pearce[1972]).

Even this brief list of the causes of dissent would be sufficient to deter many from taking a serious look at cost-benefit analysis. But it remains true that the alternatives to Cost benefit analysis are just as vulnerable to charges of arbitrariness, indeed often more so (Pearce [1971]). Cost-benefit analysis does at least make the attempt to refer to individuals' preferences and to place them on a comparable basis for measurement, consequently arises the need for empirical determination.

Empirical studies on the problems of environmental decay and its effects are very limited in number. This is partly due to the fact that the conventional framework of economic theory has been unable to integrate complex problems like pollution and resource depletion. Furthermore, a major part of economic theory is merely confined to the analysis

of logical choices and purely instrumental allocations of given scarce resources to given competing ends. Any discussion of human needs, requirements, norms and aspirations is avoided in as far as ends are regarded as given in a positive economic theory (Nijkamp[1977]). Another reason is that environmental economics is a relatively recent discipline (especially in Africa).

Environmental decay and the increasing interest in environmental problems has evoked the need of more adequate evaluation methods for assessing the value of ecological goods and ecosystems in the field of environmental management (Berry[1975]), Inhaber [1976], Penning-Rousell and Hardy[1973] and Wallace [1974]).

Evaluation of natural environments is increasingly required in order to weight alternative uses of natural environments against each other, particularly because environmental problems are going to be a major concern in physical planning. Edmunds and Letey [1973] attempted a comprehensive way to analyze the effects of human activities upon ecological and environmental variables by using an Environmental impact matrix. Elements of the matrix denote the quantitative effects of the activities on the environmental characteristics. They suggested the use of original or internal ranking scale to represent the relative order of magnitude of certain environmental effects. This matrix is a reliable tool to assess intangible environmental effects however, it requires a lot of detailed information and causal links may be more complex than indicated thus emerges an evaluation problem as there is no measuring rod for ecological assessments.

Ciriacy-Wantrup and Phillips [1970] proposed a monetary assessment of preserving the California tule elk. The monetary value (the social human benefits) which was mainly

based on the economic function of the elk population for hunters (e.g. via-hunting permits), was the result of a simple cost-benefit analysis. In this study, several other social and biological elements were considered as well but not transformed into monetary values thus creating a limited scope of the study. The authors exposed clearly the problems inherent in monetary valuations of wildlife.

The study carried out by Gosselink et al [1973] concentrated primarily on the value of tidal marshes but it has a more general scope. Resources have a variety of functions, for example, the value of marshland stems from identifiable commercial and recreational functions for which monetary values can in principle be determined and other potential functions evaluations. However, the basic problem which the study failed to tackle is whether such a functional component approach should not be extended to a more integral approach to a life support system thus rasing the issue as to whether the ecological function of the ecosystem concerned are evaluated or whether only the output to man is evaluated.

The non-monetary way of estimating the relative importance of environmental goods (natural areas, parks, animals etc) is to analyze the various functions of these goods for man (Bouma [1972], Hellwell [1971]. The use of a functional environmental profile, aggregating scores in environmental valuation does make sense for mutual comparison of natural areas make sense for mutual comparison of natural areas where all functions are defined consistently. However, these functions may have a considerable area of overlap and conflicting ideas. In this respect, how to use such environmental profiles in a broader framework of environmental analysis and environmental decision making becomes a problem. This calls for a monetary evaluation method like cost-benefit analysis as this method attempts

to transform all the numerical values of all functions into monetary terms.

However, cost-benefit analysis is criticized for not taking into account intangible effects whereas environmental costs and benefits are intangible. E.P.Odum [1971] suggested the use of environmental quality indicators. This is a scoring procedure used to obtain a total numerical value of the environmental goods concerned. Nijkamp [1975] suggested that the method can be used for comparison purposes in land-use planning and ecosystem planning. An application of this indicator is contained in an ecological valuation study of the South western part of the Netherlands[1972]. By means of a scoring procedure for each region, a total ecological value could be approximated. Other applications are found in Livingston[1975] and Malcolm and MacDonald[1975]

2.2 LITERATURE ON PASTORALISM

The works of Kayongo-Male(1980), Kroeber(1948), Spencer (1973) and Fratkin(1979) gives us the following general assumption that adaptive responses constitute situationally a typical sort of behaviour in the sense that they stand out in exaggerated form in times of economic hardship. The review also reveals that pastoralists possess a repertoire of adaptive strategies which they call into action during drought and famine. These responses are guided by a detailed knowledge of the physical and social environment and the kind of survival resources they may offer in times of need.

The literature reveals that in the past, several types of social relationships used to be exploited for survival in times of economic hardship - Kinsmen and affiliates within the pastoral communities themselves, reciprocal partnerships, symbiotic relationships with

neighbouring agricultural or pastoral communities. These could be termed as adaptive responses. Adaptive responses can be defined generally as the whole range of behaviours that are regarded as a typical and aimed at enduring the effects of drought, particularly famine. They are rational behaviours aimed at eliciting desired results in terms of generative subsistence and survival resources, namely food. We can therefore conclude that the ultimate purpose of the exploitation of social relationships was to gain access to economic opportunities which then enabled the famished nomads to obtain additional food supplies to top up their household reserves.

Over the recent years, a colossal human tragedy has unravelled the Sahelian belt of Africa. This is a vast swath of arid an semi-arid land running from one side of the continent to the other, from Senegal and Mauritania in West Africa through Mali, Ghana, Nigeria, Upper Volta, Niger, Chad, Sudan to Ethiopia and Somalia on the Horn, including parts of Kenya.The basic problem is the encroachment of the desert as a result of replacement of fertile by arid land. It is commonly estimated that some 10 million people are currently facing starvation as a result. It is argued that misallocation of resources produced by iterations of private property rights, exacerbated by well-meaning but disastrous governmental measures and the UN advice on the promotion of Agricultural productivity are to blame for the present situation.

Riesman (1978) noted that among the Fulani of Upper Volta, the pastoralists settled near the wells and overgrazed the area - the practice ultimately resulting in the desertification of the area and its abandonment. Results were similar for a World bank project in Tanzania in the 1950s, with 20 - 30 surface water schemes, 15 - 20 pipeline schemes and 25 - 30

boreholes (IBRD 1961) . UNESCO (1977) described similar occurrences in the Senegal and across the continent in Somalia and swift (1976) found the same. Cruz de Carvalho (1971) found that the scheme to improve watering sites resulted in an increase in land claims so that Ovambo nomadic pastoralists of South West Angola, lost both watering points and grazing land and that ecological deterioration later caused loss of grazing capacity.

In the case of Kenya, to overcome overuse of land resources and to reduce soil erosion to manageable levels, Ole Sadera (1986) notes that pastoralists were organized, ethnically or traditionally into large, organized areas with physical boundaries. Water and dipping facilities were provided and each family was allotted a livestock quota, which they were not to exceed. However, due to changes in climatic conditions, the pastoralists continued to move out of the schemes and consequently these schemes only existed by name. Some of the ethic groups appreciated the services provided by the scheme as the dipping facilities reduced deaths of the herd. As a result livestock numbers increased considerably beyond the capacity of the scheme. Many refused to sell the surplus and preferred to leave the scheme.

Curtailing grazing is another way which was thought would improve the land and halt the destructive effect grazing and the most obvious way to do this is to initiate a stock reduction program. Baker (1967) discussed some of the difficulties among the Karamojong and briefly reviewing destocking programs in Tanzania and Rwanda - Burundi as well as in the Karamoja concluded that destocking expresses a real issue in unreal terms, as bulk of the karamoja were not willing to reduce their stock numbers.

It is important to note that stock reduction schemes do not work because they operate

on fiat creating resentment and antagonism among a traditionally independent people, as they cannot be equitably applied within the local social structure and because even if they are temporarily successful, the numbers of animals will rapidly return to the previous level unless there is continuous close policing.

In Kenya, block system was conceived as early as 1970s in a bid to control grazing among the Samburu and the Pokot. The pastoralists are forced to use them successively so that each block has a period of fallow in which the grass is rejuvenated. Grazing block development projects, although technically viable, lacked grassroots support from the pastoralists. They viewed themselves as beneficiaries rather than as participants. Hence as soon as the donors pulled out, the envisaged operations of the projects have not been sustainable. Spencer (1973) has given an eloquent description of the failure as:

- Quarantine measures and security along trek routes affected sales, and therefore the anticipated offtake was not realized.
- Block development was not accomplished in all the stipulated areas. This uneven development resulted in an influx of nomads and their livestock to the more developed blocks, especially during drought. In some cases the geology of the areas was not properly studied, hence some dams never accumulated water. Therefore planned grazing patterns could not be enforced.
- The pastoralists were not fully involved in the initial project planning. Traditional rangelands use and herding practices were not incorporated in project design.

Disease control as a major form of animal improvement has often met with acceptance by pastoralists and has often led to dramatic increases in the number of animals.

This has led to decreased mortality which exacerbates problems of overgrazing. Riesman (1978) reported this for the Fulani who,according to Van Raay (1975) readily accepted this program leading to cattle overpopulation that worsened the 1968-1974 drought in the sahel. Bernard (1972) reported similar results among the Meru of Kenya and Deshler (1964) among the Dodos of Uganda.

The Kenyan government officials and external agents wanted somehow to change the character of the pastoralists to make them into something more like farmers or town-people. There has been an urgent desire to eradicate pastoralism and this sentiment is reflected in some government reports (Development plans and sessional papers) which say that the government must transform the pastoralists attitude towards cattle. Other sentiments and institutions of a pastoral people include:efforts to prohibit Maasai from buying cattle and from congregating in military age-sets (Jacobs 1973), creating communal cattle ownership among the pastoralists(Mccaulay 1976), decreasing nomadism among the Somali to increase meat and milk productivity, efforts to break Samburu age-sets (Spencer 1973) and banning traditional oaths and use of stock as payment of fines among the Meru of Kenya (Bernard 1972). In only few cases is there any record of success and where such success, it generally had unfortunate consequences.

Odegi-Awuondo's (1983) study among the Turkana explains the importance of camel among these people. Odegi asserts that the acquisition of the camel was a landmark in the Turkana technological innovation and a crucial factor in the pastoral production system. The adoption of the camel became popular and widespread among the Turkana who regarded it as a species of a cow which was extremely adapted to the desert-like conditions fed on the vast

unutilized thorny vegetation and was more resistant to diseases than other animals. More than anything else, the camel provided a dependable source of subsistence yielding many times more milk than a cow, remaining much longer in milk production and producing milk of higher nutritional value than that of other domestic stock. Odegi further argues that the camel is the hardiest domestic stock in the arid lands. It will withstand the worst drought that wipes out cattle goats sheep and donkeys and is more resistant to diseases.

Schmidt-Nielsen(1964) argued that camels have the ability to withstand the effects of heat stress better than other domestic animals as their large bodies create a greater surface area for sweating and convection. Camels he says can continue eating even when it is very hot and their huge plate like heavily padded feet are less damaging to the soil structure.

2.3 LAND DEGRADATION AND DESERTIFICATION

The explanation of the problem of land degradation is one of the crucial problems in which the existing literature in the Eastern and Southern African region and indeed in the rest of subsaharan Africa appears to be highly deficient.

There is a growing body of general literature on the problem of land degradation and especially desertification. UNEP has recently published a world desertification bibliography (UNEP[1991]). However with specific regard to Africa, the only comprehensive bibliographic documentation on environmental degradation or desertification was compiled a decade ago by Leng [1982]. There is currently no comprehensive bibliography on land degradation or desertification in the Eastern /Southern African region. Nor are adequate studies of these problems. While a few studies - Tanzania, Zambia and Botswana - have

benefited from fairly comprehensive studies of certain aspects of the problem, the majority of countries in Eastern/Southern African region have not.

Although a distinction can be made between the terms land degradation and desertification, for the purposes of this review, we will use both terms interchangeably. The term desertification is a fairly recent addition to scientific vocabulary, designating a process of ecological degradation in arid and semiarid lands by which the productivity of the land is lost or substantially diminished (Tolba[1979]). UNEP'S current definition of desertification is "land degradation in arid, semiarid and dry subhumid areas resulting mainly from adverse human impact" (UNEP[1992]). The term was used for the first time by Aubreville [1949], but it has been widely adapted and applied only during and after the 1968 to 1973 drought disaster in the Sahelian region of Subsaharan Africa.

The tragic events in the Sahel of Africa gained attention not only of the media all over the world but also of scientists who have carried out large numbers of scientific investigations of the phenomenon. The problem of ecological degradation was soon perceived as a serious threat to the world and in response in 1977 the UN convened a conference on desertification in Nairobi Kenya. For this meeting scientific knowledge of the problem was gathered and reviewed. At the conference various papers and documents were presented and discussed and a Plan of Action to Combat Desertification was adopted (PACD).

It was agreed that there was little evidence to support the view that desertification results from a long term climatic change. Instead mans' destructive activities, his bad management of land resources through overcultivation, overgrazing deforestation, wood

cutting were recognized as the main causal elements of desertification. Consequently a solution to the problem was expected mainly to come from an improved and ecologically adapted management of water soil vegetation (Rapp and Hellder 1979). But inspite of the rather optimistic estimations that bulk of scientific knowledge and technological means necessary for combating desertification and developing the resources of arid lands are available (Tolba 1979), the practical results so far have been poor. This unsatisfactory situation must be accounted for. Could it be that the knowledge of the problem and the solution derived from it are still inadequate?

This is the view held by Darkoh (1989) with regard to the southern African region. Similar views have been expressed by Baker(1981) on Kenya. We have noted that in recent research on the discussion of desertification or land degradation there has been the tendency to attribute these effects simplistically or mechanistically to either physical factors such as soil erosion, sedimentation and alkalinization and human factors such as overcultivation overgrazing poor irrigation practices and deforestation. While these factors are real and indeed do give rise to desertification the tendency has been to simply accept them per se and not to question the historical socio-economic and institutional factors that are behind them. Often such propulsive factors are ignored (Darkoh 1989).

Baker (1981) launches a scathing attack on what he calls the conventional or technocratic approach. In his opinion this approach is totally misconceived since it treats the environmental issue as the problem and seeks a technical solution thereby excluding the socio-economic system as a causal element. Thus the conventional approach is regarded as inadequate because it places environment over the people. It identifies secondary and

dependent phenomenon as basic or fundamental problems and therefore mainly tackles symptoms. Mismanagement in Baker's view is not the principal cause of desertification but the manifestation of more fundamental problems inherent in the structure of the society for example political, social and economic inequalities.

Baker proposes an alternative approach in which the issue of environmental degradation is conceived as part of a dynamic historical process. The focal question of the analysis should be, "What brought about the human behaviour which in turn initiated or accentuated the physical process". Explanations for environmental malaise must therefore be sought in the political economy of the societies in question. In his view the phenomenon of land degradation is not a physical but societal problem, only the symptoms are physical. An environmental management approach which concentrates on technical solutions does not address the root cause of the problem.

A real solution presupposes a socio-economic framework offering real alternatives to those degrading the environment. Elements of Baker's position can also be found in Darkoh (1980). Other recent works which have articulated this view point on a global basis are Blaikie (1989,1985) and Blaikie and Brookfield (1987).These studies pursue a chain of explanation from the on site symptoms of land degradation via land use practices to land users the agrarian society the state and the world economy. As Blaikie (1989) points out there are theoretical advantages in this approach but only problems of relating it to practical policy because the more radical the deep seated explanation of degradation becomes the more difficult it is to formulate a policy.

2.4 DESERTIFICATION PROCESSES

The problem of desertification is a serious threat to the welfare of mankind. Although degradation of the land has always characterized man's systematic use of it, the process has accelerated in recent decades, precisely at a time when population growth and the rising expectations began to demand enormous increases in food production. It is estimated that between 50,000 and 70,000 square kilometres of useful land are going out of production every year, and the most important cause of this appalling loss is desertification. The problem is one of overwhelming urgency. As land suffers degradation, the costs of reclaiming it, modest at first, rise steeply until a threshold is passed beyond which reclamation becomes economically impractical.

There are five main processes of Desertification: vegetation degradation, water erosion, wind erosion, salinization and soil compaction.Overgrazing by pastoralists reduces the productivity of the rangelands that the pastoralists-livestock must utilize and increases the soil erosion hazard, thereby lowering the profitability of the livestock enterprise.

Two sets of data are needed for a cost-benefit analysis. The first set consists of implementing a damage control programme over the project-s lifetime. The second set consists of estimated costs of on-site and off-site damages expected to be incurred over the same time period. The monetary estimates of the avoided on-site and off-site damages from adopting the programme then become the benefits of the analysis. Cost-benefit analyses have been made in many countries for projects dealing with water erosion (Bishop 1989, Gupta et al 1973, Holmberg 1990, Veloz et al 1985) and salinization (Leslie and Anderson 1988, Anderson and Kleinmann 1978; Miller et al 1986) of irrigated land. Relatively few have done

for rangelands degradation (Bishop 1989) and probably none of wind erosion control and erosion control and reduction of soil compaction in dryland. There has been little fieldwork done to establish the extent of these losses in Kenya, probably reflecting the difficulties that would be involved in collecting data on animal deaths and establishing the other economic losses at the national level.

TABLE 1: DAMAGES CAUSED BY DESERTIFICATION

DESERTIFICATION PROCESS	ON-SITE DAMAGE	OFF-SITE DAMAGE
1 Vegetation degradation from Erosion	Forage loss Soil Productivity Reduction	Air Pollution Sedimentation
2 Water Erosion	Nutrient Removal Long Term Loss Soil productivity Washing out of crops Gully Formation	Water Quantity Degradation Siltation of Reservoirs, navigation channels and ditches Sediment deposited on fields Downstream flooding grounds Eutrophication of water bodies
3 Wind erosion	Nutrient Removal Long-term loss in soil productivity Sand blasting of plants Burial of crops Blowing out of crops	Air Pollution Sediments deposited On railroads, roads ETC, Respiratory Diseases of human/livestock Abrasion of machinery Reduced visibility Mental Stress

Table 1 (Desertification Control Bulletin, 1992) lists some of the kinds of on-site and off-site damage that are associated with each land degradation process. Off-site damage for water and wind erosion tends to be greater on-site damage (Clark et al 1985; Huszan and Piper, 1986; Piper 1989). The opposite is generally the case for vegetation degradation, salinization, and

soil compaction in drylands.

TABLE 2: FACTORS INVOLVED IN ESTIMATING CONTROL FOR DIFFERENT LAND DEGRADATION PROCESSES

LAND DEGRADATION PROCESS	TIME PERIOD FOR CONTROL MEASURE	CONTROL MEASURES
1. Rangelands degradation • mean annual rainfall < 250 mm	20 - 30 years 10 - 20 years	Reduce grazing pressure, seedling, Fencing, wells, Controlling herding, bush control, rotation grazing
2. Water Erosion	5 - 10 years	Terraces, strip cropping contour tillage, minimum tillage
3. Wind Erosion	1 - 20 years	Grass barriers, trees and shrub barriers, strip cropping, tillage, minimum tillage, Mulches.
4. Salinization • Irrigated land • Dryland seepage	3 - 10 years 5 - 10 years	Drainage,leaching, Water management, amendments, Land levelling. Deep-rooted plants, tile drainage, interceptor, drains
5. Soil Compaction	1 - 5 years	Tillage management, crop rotation, deep ploughing.

Table 2 (Desertification Control Bulletin,1992) lists the degradation control practices and their time frame for each land degradation process. There are large differences in the cost of different control measures and the time period over which they must be maintained

2.5 REQUIREMENTS FOR ANALYSIS

The major task in approaching a cost-benefit analysis requires that you choose the representative area for the degradation process. For the sample area, the cost-benefit analysis

should:

(1) Identify the Control Practices

Conservation practices should be selected that maximize economic efficiency. Not all degraded land can be reclaimed economically. Some of it is irreversibly degraded while some is only marginally suitable for crop production and pastoralism. It is futile to try to control all degradation. Choices must be made. We need to set degradation tolerance criteria for deciding at what point to institute control measures; then select the most efficient control practices for the area in consideration for rangelands, salinized lands and wind eroded land.

(2) Assess Environmental Changes

It is necessary to estimate on-site environmental changes in the flow of goods and services and changes in the condition of the environment with and without control practices, then do the same for the off-site impacts. Every type of land degradation imposes changes on the national resources and alters the flow of goods and services. It is important to compare environmental changes according to whether conservation methods are practised or not since conservation practices usually do not totally stop degradation. Estimates should be made for the on-site impacts as well as off-site impacts so that both social and financial analyses can be presented. This step involves:

a) Identifying different kinds of on-site and off-site damage.Identifying the environmental changes caused by the degradation and how much the changes can be slowed by the control practices.

c) Identifying the relationship between the environmental changes and on-site and off-site damage.

(3) Estimate the Benefits and Costs

Benefits and costs of specific conservation programmes should be calculated from the environmental changes and financial data. This step translates the estimated on-site damage, off-site damage and costs of conservation practices into monetary terms. The costs of some damage can be calculated in terms of market prices while the cost of some of the other damage is more difficult to price or the market prices are distorted, requiring that estimated prices be used. Such prices frequently take the form of imputed or shadow prices.

Social Costs:- In addition to on-site impacts, off-site environmental impacts both tangible and intangible are difficult to estimate because many off-site effects are not well documented and the connections between effects and land degradation are not well understood. Therefore the majority of the cost-benefit analysis limit the scope of study to the financial analysis. However, just because the off-site impact is difficult to quantify does not make it less important. Presenting the social analysis alongside with the financial analysis will help decision makers identify the key constraints of the control programme and indicate the type and size of government subsidy required for effective implementation.

(4) Provide Sensitivity Tests

A description of the overall capability of the analysis to represent accurately a natural system should be provided. The impact of the crucial assumption made in estimating the costs and benefits should also be assessed. This includes looking at:

a) How representative the assessment is in relation to the real system especially the accuracy of the specific assumptions that are made when calculating the extent of

environmental damage (ie. the rate #of degradation with and without conservation practice, rainfall, population, reception of the programme).

b) Sensitivity to input errors and their respective impact on final estimates (eg.. discount rate, the type of conservation practices adapted, the stability of prices of marketable goods, the estimated prices for non-marketable goods).

(5) Aggregating Sample area analyses

Results of the sample area analysis should be consolidated into one summary for the economy.

2.6 LITERATURE OVERVIEW

Environmental modifications that affect the abiotic base are even more difficult to contend with. If the basic geological and soil conditions are adversely affected, replacement by perhaps more primitive biotic communities might occur eventually, but the restoration of the original biological environment will not be possible in anything like a time span that is meaningful for human societies.

The problem of the optimal rate of resource depletion has been extensively studied by economists: first perhaps by Gray (1914);elegantly using the calculus variation, by Hotelling (1931); with special reference to a mineral deposit by Scott(1967), among others; and most recently from a pure theoretical point of view that extends Hotelling's are several including Gordon(1967), Cummings and Brut(1969), Peterson (1973) and Solow(1974). However, the resource may have another value realized only if it is not extracted. Extraction then is irreversible in two senses:- It gives rise to a user cost, the forgone future extractive output and also to a loss (in perpetuity)in value from undisturbed environments.

Most of the studies reviewed have not considered a scientific approach to the environmental problem of drought and desertification. In this respect there is a need to focus on the social net benefits of investing in a particular land use pattern as well as its repercussions on the environment. Both theoretical and empirical insights into the problems of desertification in the region should help policy and planning make headway in the solution of arid lands conservation problems.

This study will pay particular attention to the conversion of a certain land use undertaking into another. As regards the arid and semi-arid regions of Kenya which are threatened by the desert encroachment,we intend to study the economic rationale of converting land from cattle keeping to camel rearing as an alternative land use program although in actual fact the two land modes are not mutually exclusive.In this respect a social cost benefit analysis will be adopted.

Social cost benefit analysis is an evaluation method based on applied welfare theory. This analysis transforms all impacts of a decision into monetary units in order to make alternative plans mutually comparable in terms of net benefits.

An impact analysis is a prerequisite for the use of a cost-benefit analysis. Impact analysis is a systematic determination of all physical technical and social effects of alternative plans without transforming these effects into monetary dimension.

By means of an impact analysis the interwoveness between sets of regions and sectors can be described in a formal way. The impact of institutional decisions on the state of a socio-economic, physical system and ecological system can be represented.

CHAPTER THREE: METHODOLOGY

3.1 INTRODUCTION

This chapter will consider an analytical framework for more adequate inclusion of dynamic factors to the environmental problem of drought and desertification. In this respect the dynamic aspects of production consumption and investment should be given much light. The methodology employed will therefore review key aspects of the analytical framework appropriate for discussing optimal resource use.

Economists have always been concerned with resource use, though the precise focus of their interest has varied. Classical economists saw natural resources as determinants of national wealth and of economic growth rates and differences in resource endowments as explanations of interregional income differentials. They were thus focusing on the general equilibrium aspects of resource use.

Depletion and its management were first analyzed by Gray (1914) and in a still classic piece by Hotelling (1931). The boom in resource economics in the 1970s and 1980s developed the depletion theme further. The macro and general equilibrium aspects of resource use were developed separately, and were poorly integrated with the resource depletion literature.

Recently, interest in resource use has been stimulated by the connection between resource use and environmental issues (Dasgupta 1982b). Resource use generates waste and pollution. One of the most complex interactions here is between the use of fossil fuels and

the emission of carbon dioxide with its potential greenhouse effect. The depletion of one of the few really exhaustible resources has a potentially major environmental impact.

Hotelling's 1931 article is still interesting and insightful that I cannot resist quoting his opening sentence:

"Contemplation of the world's disappearing supplies of minerals, forests, and other exhaustible assets has led to demands for regulation of their exploitation. The feeling that these products are not too cheap for the good of future generations, that they are being selfishly exploited at too rapid a rate, and that in consequence of their excessive cheapness, they are being produced and consumed wastefully has given rise to the conservation movement".

His paper contains a fully vigorous analysis of the pure depletion problem and constitutes the earliest applications of dynamic optimization in economics. In addition to the treatment of the pure depletion case, Hotelling offers interesting formulations of various cases of imperfect competition, noting features that were only rediscovered many years into the 1970s literature on market structure and depletion.

3.2 DYNAMIC COST-BENEFIT APPROACH

In this section we present a model of the irreversible investment in a resource development project on a natural environment. A particular project is selected and evaluated, then compared with the values of the alternative project in this environment. This is what we have referred to as the standard cost benefit format. These results are obtained by optimal control theory. This is a technique for finding the solution to certain dynamic optimization problems in economics. In our study we dynamize cost-benefit analysis through optimal control by considering the case of the Government seeking the time path of investment that maximizes its value, the stream of discounted net benefits.

The approach is modelled after the works of Dorfman (1969) who applied optimal control theory to various economic problems of consumption, production, and investment. Nijkamp (1976) applied this theorem to a problem of environmental design by looking at the Dollard - Water project in Netherlands. We shall however adopt Nijkamp's (1976) approach to our problem of desertification control in alternative land uses.

A cost-benefit approach applied to an environmental project is what we use. The particular project concerns the arid and semi region development program in the arid lands of Kenya where a friction between development efforts in the field of water resources, Livestock development and environmental preservation become apparent.

In this approach, we have two alternative land-use programs. We can therefore denote the number of alternative plans as (i).

Each plan (i) has a series of impacts Zji (j = 1 .....J); these impacts may include:

- Environmental repercussions
- Loss of grazing land areas
- Regional investment multiplier effects
- Improved quality of other areas.

Clearly, impact elements are determined by the location of plan so that these elements are in fact provided with spatial co-ordinates.

We assume that the impacts (Zji) can be defined as land use variables viz. the size of an area earmarked for a certain type of land use. By representing the plan impacts as land use variables, the following additivity condition should be satisfied

$$\sum Z_{ji} = Z_i$$

Where Zi = known size of the area related to plan (i). Clearly both the present and the future land-use pattern should comply with these additivity conditions.

However, there remains of course the difficult empirical problem of determination of Zi, the camel development project to be compared with the cattle keeping alternative. There is no general method of doing this but rather the selected project will be evaluated and knowledge of the benefit functions in the actual case suggests the scale of the project to be evaluated.

We assume that the decision concerning the future development of camel pastoralism are taken on the basis of the criterion of a maximum total Present Value of net Social benefits from the area in question.

This is the assumption used in cost-benefit analysis in deciding the viability of a project (case applies for both public and private projects).

Warnke et al (1973) divides the social benefits into Direct, Indirect and intangible benefits. Direct benefits are defined as those accruing from the direct output of new investment. Indirect benefits are defined as other monetary benefits attributable to the investments. Intangible benefits are benefits not subject to monetary quantification.

The cost are composed of direct capital outlays for constructing the project (i.e. cost of transforming land use patterns), the factor supply and overhead expenses, the opportunity costs and the social cost of undertaking the project at hand.

Another assumption is that each type of land use affects the environmental benefits of the region concerned. These benefits are intangible, they have to be measured by means of a

certain ecological quality indicator.

Total benefits are composed of monetary benefits and intangible benefits.

By specifying trade-offs (or relative weights) W_1 and W_2 for monetary and intangible benefits, the following decision criterion may be formulated:

$$Max\ w = \int_0^T [w_1 B^1_{i(t)} - I_{i(t)} + w_2 B^2_{i(t)}]\,\delta\ e^{-\rho t}\ dt$$

Subject to

$$\sum \delta_i = 1$$

$$\delta_i = (0,1)$$

Where

$B^1_{i(t)}$ the expected net monetary social benefits of plan (i) at time period (t)

$I_{i(t)}$ is the total investments costs at time (t) to transform the area in question from its initial state to the new state of plan(i).

$B^2_{i(t)}$ reflects the net environmental benefits (defined in terms of ecological quality) accruing from the conversion of the area into the new state.

T is the lifespan of the project.

ρ is the discount rate

δ is a (0,1) programming variable.

Land use policy, infrastructural design and environmental design is in general an

irreversible dynamic process (For example a road once constructed is hard to transform into agricultural land). The extent of the transformation process depends mainly on the total amount of investments Ii(t).

Assuming a constant marginal capital - output ratio, for these investments, the following differential equation for land use development can be specified.

$$Z(ji) = K_{ji} I_i$$

where

$$Z_{ji} = \frac{dZ_{ji}}{dt} = K_{ji} I_i$$

Where a dot represents a time derivative and Kji reflects a marginal project effectiveness coefficient.

The irreversibility constraint implies

$$I_i \geq 0$$

On the basis of the foregoing assumptions, the following dynamic cost-benefit model can be constructed, written as the following Pontryagin optimal control model (cf. Pontryagon et al.[1962]).

$$Max\ w = \int_0^T [w_1 B^1_{(t)} - I_{(t)} + w_2 B^2_{(t)}]\, e^{-\rho t} dt$$

Subject to

$$Z_j = K_j I_{(t)}$$

$I \geq 0$ The irreversability constraint- represents the dynamic constraint on development and the restriction on reversibility.

A development project may involve the use of an exhaustable resource and may be capable of operation over an indefinitly long period. Loss good land of the original enviroment could, however, be regarded as irreversible. In this respect land use services of the enviroment tend to enter directly the utility functions of consumers with no intervening production technology. Where there are percieved differences between this enviroment and others, as in general there will be, perfect substitution is not possible, and loss of a particular may matter, at least to some.

If there exists some interval of time over which projects benefits are decreasing relative to some related benefits so that the instantaneous optimal scale of development is decreasing, then the net present value of the project, the natural enviroment, will be maximized by stopping investiment at some point before the start of the interval, i.e, while it is still profitable to expand development. The sacrifice of some near term gains is a consequence of the restriction on reversibility, required to avoid greater future losses from

too much development.

$$(Z_j)_{i=0} = Z_{j0}$$

; where Z_{j0} represents the initial state of the system - Indicates that the state of the system, as indicated by the level of development, Z is known at the beginning of the planning period.

This model is a generalization of a model for environmental preservation developed by Fisher et al [1972a, 1972b] and Nijkamp and Verhage [1976] (a first version of this model for dynamic investment decisions was originally developed by Arrow [1968a], and Arrow and Kurz [1970]).

On the basis of the model a set of empirical results for optimal land use design can be derived.

The model being an optimal control model is hard to solve simultaneously so that a definite conclusion as to the optimality of one of the (i) projects can be achieved most efficiently by calculating the continuous variant of this model for each plan separately. By means of a mutual comparison of results, a choice in favour of one project can be made.

. Cost-benefit analysis is an important aid to the most optimal decision making by means of which the most efficient of several alternatives strategies can be selected. This analysis may be helpful in identifying and formulating preferences and objectives for making public policy decisions since an extensive impact analysis may make decision makers aware of (unpriced) hidden consequences of their actions.

Important gaps in the knowledge of public decision makers may also exist in the stage of problem formulation because sometimes problems are defined in a rather vague or fuzzy

way. A systematic impact analysis and evaluation method of all kind of actions may lead to a more sharply defined problem by the decision maker. This is even more important because policy issues and decisions are usually shaped by the interaction over time and space of individuals and groups with different attitudes, skills information and influence (Owen 1975).

Cost benefit analysis may therefore provide a conceptual structure and a set of techniques for relating means and ends, for assessing the cost components associated with each cause of action and for comparing possible outcomes.

3.3 DATA TYPE AND SOURCE

The study makes use of secondary data. The data covers the time period (1980 to 1990). This is the period during which various studies were undertaken as regards the arid lands of Kenya and the threat to the enviroment as a result of desertification came into light. Since the study is using a cost-benefit analysis to environmental design projects, the following information is taken into consideration.

It is clear that each human interference in a natural environment has diverse effects like socio-economic, physical and ecological impacts. As set in the preceding sections, the application of cost-benefit analysis requires an identification of all relevant plans as well as impact analysis of all plan outcomes.

As regards the study-area(The arid lands of Kenya covering basically the Eastern and Northern regions), two alternative plans for this area are distinguished

1) Camel project; implying that camels should be introduced into the area

2) Cattle project; implying that cattle should be maintained in the area.

For each plan, the following types of effects are distinguished:-

i) Ecological impacts:- Loss of good grazing land, transformation of a dry unbearable land to a bearable one, removal of a unique vegetation, increased soil erosion, drought.

ii) Physical impacts:- Shifts in recreational and agricultural and use, improvement of infrastructure

iii) Socio-economic impacts;- Change in output, employment and income effects, indirect production changes.

We note that the physical and socio-economic impacts can in principle be translated into monetary amounts. In this respect, we need to get data on:-

- Costs of technical constraints
- Environmental management costs
- Benefits from improved grazing land
- Revenues of change in products
- Infrastructural benefits
- Regional Multiplier effects (for production and income)
- Income effects from the products
- Indirect multiplier effects from the use in animal products.

After carrying out a detailed assessment of all monetary repercussions of these effects, the results obtained are tabled as:-

MONETARY IMPACTS OF ALTERNATIVE PLANS FOR THE STUDY AREA

IMPACT	NET BENEFITS	
	PLAN 1	PLAN 2
Physical		
Socio-economic		
Total net benefits		

The results should be based on planning horizon of 10 years and a social discount rate of 10%.As was indicated in the literature review that many practical studies in cost -benefit analysis use a value of discount rate varying between 7% and 12% we shall use a social discount rate of 10%.The social discount rate is a function of the social time preference for the diverse plan impacts.

We need information on environmental benefits of the study area which is rather difficult to quantify. We therefore measure these benefits by means of a certain Ecological Quality Indicator.

By using the scoring procedure we obtain a total numerical value for the environmental benefits. If the transformed score is denoted by qj*(j=1.....J) total value (V) of the environmental benefits concerned is given as

$$V = \sum q_j^*$$

From this, we can calculate our indicator as a weighted average of all q*js

We need information on the investment costs and thus the data should include:

- Pre production expenses
- Land
- Plant and equipment
- Start-up expenses
- Contingencies
- Working capital
- Material costs
- Utility costs
- Overhead costs.

The major source of data is obtained from FAO production year books, Ministry of Agriculture/Livestock statistics, Desertification Control bulletins, UNEP (Environmental data set) publications, Economic Surveys (various issues) Statistical Abstracts (various issues) and any other sources.

CHAPTER FOUR: FINDINGS AND DISCUSSIONS

4.1 INTRODUCTION

Desertification is one of the most serious resource management problems facing the world today (World Resources Institute, 1990). It is a global issue that manifests itself and must be attacked at the local and national level (Kassas et. al 1991). However most governments have failed to give adequate policy attention and funds to control the degradation. One of the major reasons seems to be that economic costs of land degradation and the benefits of controlling it have not been well presented and understood by policy-makers.

No country on earth has unlimited resources, every society is forced to make decisions about the best use of its resources. Cost-benefit analysis of desertification control is useful in improving the economic efficiency of resource allocation since it can identify the underlying causes and significance of degradation and the alternative responses that may be made by land managers and policy-makers. Decisions on allocating limited resources rarely can be made solely on the basis of cost-benefit assessment. Other factors (eg., social, cultural, political) invariably need to be considered. Nevertheless, the analysis provides decision-makers with organized and summarized information in the environmental effects of desertification.

Evaluating the costs and benefits of government programmes for desertification control is difficult, at best. The difficulty increases proportionally with the size of the area

in consideration, be it a farm, a watershed, a river-basin or a nation. In spite of the limitations, cost-benefit analysis at the national level can summarize information on the likely magnitude of the economic effects of environmental changes in the nation and the costs of options to minimize these adverse impacts.

This chapter attempts a quantitative assessment of financial damages and losses to the cattle farmers in the dryland region of Kenya. The estimated values are then compared to the costs of desertification control by the alternative land use method (camel keeping). The analysis is just indicative. Fine estimations are hampered due to inadequate field information and the spatial and temporal impact of drought and desertification on the livestock economy in various regions of Kenya. Secondly, there is the problem of lack of reliable benchmark data from which to gauge the impact.

This paper analysises a model hypothetical herd of 2000 animals. The size is arbitrarily chosen and the herd is maintained in an area where desertification is high in the absence of control.The herd size though arbitrarily chosen represents the maximum number of cows served by a cattle dip as well as the maximum number of camels a herder can posses. However, studies by UNESCO in Tanzania give a figure of 3000 animals as the number served by one cattle dip.The animals are kept by smallholders potentially for both beef and milk production. We start from a situation where no desertification control measure is undertaken and trace the production losses that would be alleviated and the increase in animal productivity likely to occur when efficient desertification control is instituted. The benefits derived in this way are then compared to the costs incurred by the farmers in desertification control mainly in the form of direct capital outlays (ie. costs of transforming

land use patterns), the factor supply and overhead expenses, the opportunity costs and the social costs of undertaking the project at hand. Since most of the benefits of desertification control accrue in the future, the capital budgeting principles are applied, involving discounting future benefits and costs to get the present values. Discounting takes into account, the time value of money. For discounting future costs and benefits, we select an discount rate of 15% as representing the rate of return farmers would expect from investing in livestock activities.

4.2 RESULTS AND DISCUSSION

Without a cost-benefit analysis, it is difficult to assess the scale and scope of the degradation problem or to adopt proper control measures at the national level. Once these rough estimates have been made, further improvements will be possible through the collection of more precise information and the refinement of estimating techniques. Cost-benefit analysis thus holds great promise for improving environmental quality management for the economy.

4.2.1 PRIVATE PROFITABILITY

At this stage it is essential to reiterate once again that the estimates indicate only the order of the magnitudes involved in the quantitative analysis of costs and benefits of desertification control in an area threatened by the desert spread. The estimates reflect the assumptions stated and the herd projections that have been made. Consequently, the discussion will be concerned mainly with relative rather than with the absolute values.

The herd projections and calculations for the results are presented in the appendix. The following are the estimated present value of costs and benefits of desertification control to the pastoral people in the arid and semi arid lands, per animal in the 2000 animal model herd, discounted at 15%, over a ten year period.

TABLE 4.1. DISCOUNTED BENEFITS AND COSTS OF CAMEL REARING

(i) Benefits

Milk output	Shs. 30630.00
Alleviated Mortality	Shs. 486.20
Enviromental Benefits	Shs. 9.50
Total Benefits	Shs. 3555.70

(ii)Costs

Cost of Drugs and Medicine	Shs. 183.30
Dry matter intake	Shs. 901.30
Management	Shs. 150.80
Enviromental costs	Shs. 3.50
Total Costs	Shs. 1238.80
Net Benefits	Shs. 2316.80

TABLE 4.2. DISCOUNTED BENEFITS AND COSTS OF CATTLE REARING

(i) Benefits

Milk output	shs.1882.50
Environmental Benefits	Shs. 3.00
Total Benefits	Shs.1885.50

(ii) Costs

Cost of Drugs and medicine	Shs. 157.35
Dry matter intake	Shs. 175.05
Management	Shs. 137.80
Environmental costs	Shs. 10.00
Total costs	Shs. 480.20
Net Benefits	Shs. 1405.20

	PLAN 1	PLAN 2
Net Benefits (Average per animal in initial herd)	1405.30	2316.80

Based on these results, it is quite evident that high returns accrue to pastoralist from efficient and effective desertification control through changing land use pattern from a cattle based economy to a camel based economy. However, we notice that the costs of camel keeping are higher than that of cattle keeping but the magnitude of the benefits resulting from introduction of camels is far much higher. The camel is much more efficient than a cow in converting vegetation into milk although it consumes more dry matter. Studies in northern Kenya show that the camel is more than four times more efficient than cattle in converting its food to human food. The implications of this findings for the future of pastoral economies in semi and arid lands cannot be underestimated.

It is of importance to note that once camel herds reach an optimum size that ensures economic security and satisfies socio-cultural needs, control would be necessary maintain that levels. Camels, too can become environmentally deleterious in excessive numbers.

In the analysis, financial profitability of desertification control to the pastoralists should not be interpreted as the role indicator of the ability and willingness of these people to undertake desertification control. The method of control involves cash expenditures before the benefits from desertification control are realised. Therefore, desertification control is likely to be crucially influenced by the relative availability of cash by the pastoralists in different season. It may also be hampered by labour bottlenecks in the peak seasons of planting and harvesting in the high potential areas of the country and the level of education

and environmental awareness of the people to shift their land use practices by considering the social vales attached to particular animals. In such circumstances, the pastoralists farmers are likely to consider the relative profitability of different organisations and public enterprises in allocating the scarce economic resources.

Moreover, the pastoral farmers perceived benefits of desertification control may not coincide with the mathematical calculation that have been made. The major factors influencing their perceived benefits include risk and risk aversion in their behaviour, widespread externalities in desertification control and ignorance. We therefore advocate government intervention to help reduce the risk from livestock keeping in a desert prone area, to internalise externalities and provide services and general information on the expected costs and benefits of desertification control.

4.2.2 SOCIAL PROFITABILITY

In appraising a desertification control project from the society's point of view, two major adjustments are required:-

(i) Identification of all the costs and benefits of desertification control through land use alternatives to the economy. In this case we shall consider the costs the pastoral farmers do not incur and are not incorporated in the previous analysis. Basically, we shall consider the free services offered by the government to the pastoral farmers in these area.

(ii) Adjustment relates to the price parameters that are used due to various imperfections in the market mechanism, particularly in the LDCs, market of inputs and the value of output from a project. The market failures may arise from the existence of monopolistic and

monopsonistic markets, government taxes and subsidies, government regulations, externalities and economics of scale. There is a need to correct the market prices for the distortions so that they reflect the social values. The adjusted prices are referred to as "accounting prices" or "shadow" prices. The shadow prices may also be used to reflect the government objectives and social dogmas.

The UNIDO and the OECD approaches are used for adjusting these prices. The UNIDO approach uses the prevailing market prices as the benchmark for the adjustment so that they reflect the social benefits and costs and the national policy objectives. The principal for the valuation of a project's output derive from classical utility theory and considers the willingness of the purchaser to pay for the output. When the output is imported, it is then valued in terms of the opportunity value of the saved foreign exchange. If exported, it is valued in terms of the earned foreign exchange. Inputs in the UNIDO approach are valued in terms of the opportunity cost of the resources that go into the project. If an input is imported or it is a potential export, its value is measured by the sacrifice of the foreign exchange that is used.

The OECD approach values goods and services in terms of their border prices (what they are worth at the International borders of the country concerned). The numeraire in the approach is the foreign exchange as the method relies on the world price as a reflection of the true opportunity cost of an input and value of an output of a project. The goods and services are put to two categories : Tradables and non-tradables. The tradables are those that can be imported or exported at the margin whereas the non tradables cannot be traded for various reasons such as high transport costs - This category includes electricity, construction

work, domestic transport etc. Non tradables are generally valued in terms of cost of goods and services which towards their production. By repeating this process, it is possible to express the value of these goods in terms of traded goods and labour. Labour, like in the UNIDO approach is valued in terms of its opportunity value in alternative employment The two approaches in social appraisal give essentially similar results (Dasgupta 1972).

In a desertification control project, several prices would require adjustment from the existing prices. Probably the most crucial are the prices of meat and milk which are determined institutionally rather than through the market prices and mainly handled by monopsonistic marketing agencies. Other crucial adjustment prices are the cost of labour, pesticides, construction materials. This paper, due to various constraints noted earlier is unable to undertake its own adjustments. Nevertheless, it is unlikely that these adjustments are large enough to offset the favourable benefit-cost ratios noted in the previous section and may instead boost the social profitability of a desertification control project.

The following are the results of a social cost benefit analysis of the project.

(I) CAMEL KEEPING - DISCOUNTED COSTS AND BENEFITS

Benefits		
Milk output	Shs.	37006.70
Alleviated Mortality	Shs	577.40
Enviromental Benefits	Shs.	9.50
Total Benefits	Shs.	37593.60
(ii) Costs		
Cost of Drugs	Shs.	46.50
Mustering labour	Shs.	71.80
Management costs	Shs.	35.80
Dry matter intake	Shs.	719.80
Enviromental	Shs.	3.50
Total costs	Shs.	877.40
Net benefits	Shs.	36716.20

CATTLE KEEPING - DISCOUNTED COSTS AND BENEFITS

(i) Benefits		
Milk output	Shs.	2132.15
Enviromental Benefits	Shs.	3.00
Total Benefits	Shs.	2135.15
(ii) Costs		
Cost of Drugs	Shs.	16.85
Mustering labour	Shs.	71.80
Management costs	Shs.	25.80
Dry matter intake	Shs.	197.10
Enviromental costs	Shs.	10.00
Total costs	Shs.	321.55
Net Benefits	Shs.	1813.60

The net benefits for both plans are positive. However, social evaluation of the two projects reveal higher benefits accruing to camel and cattle keeping as compared to the economic evaluation but the benefits of camel keeping as an alternative land-use programme are much higher (i.e. approximately 20 times more). We can therefore conclude that it is socially profitable to change the land-use pattern in this region from cattle rearing to camel rearing. We therefore reach the same conclusion as that reached when we carried out our

economic evaluation.

4.2.3 OPTIMAL USE OF THE ENVIRONMENT

Restoration of degraded land has some associated problems but there are two important considerations that require attention. One involves the time during which the adverse consequences of a decision must be suffered the other involves the fidelity of the reproduction or restoration, and perhaps more importantly, its acceptability. If the environmental modifications results in the elimination of essential habitat for a given species, restoration is impossible or at least incomplete without the fauna dependent on the original plant associations. But, even if the survival of a species is not the issue, restoration is not a simple remedy for redressing the impact of an inappropriate decision that the disturbed the original ecological system.

A planner is assumed to maximize the present value of net social returns from use of the environment, the project site. The decision or control variable at his disposal is the amount of investment (in changing land-use patterns) to be made at each point in time. In this respect, our planning problem can now be stated as:

$$Max\ w = \int_0^T [w_1 B_t^1 - I_t + w_2 B_t^2]\, e^{-\rho t} dt$$

For each plan therefore, the present value can be calculated as follows: Note that the calculations for the results are presented in appendix XVI

PLAN 1: CATTLE KEEPING

$$Max\ w = \int_0^{10} [5667780 - 740027]\, e^{-\rho t} dt$$

$$= \frac{4927752.4(1 - e^{-1})}{0.10} = 49277524(1 - 0.3679)$$

$$= 31149336$$

Average per animal in initial herd : 15574.67

PLAN 2: CAMEL KEEPING

$$Max\ w = \int_0^{10} [173553852.0 - 2614987.7]\, e^{-\rho t} dt$$

$$= \frac{14738864(1 - e^{-1})}{0.10} = 147388640(1 - 0.3679)$$

$$= 93164359$$

Average per animal in initial herd : 46582.18

We have seen that where benefits from cattle rearing in an arid environment are less over time relative to benefits from camel rearing, the instantaneous optimum level of cattle rearing as a land-use undertaking is also decreasing. By mutual comparison of the results

obtained above, a choice in favour of camel keeping as environmentally sound and economical viable is taken. One question that a planner seeking to maximize the value of the environment's resources would ask is "whether to invest in a project which is currently profitable but will not be in the future?" If the decision criteria is deemed, in terms of this question, then it would be more profitable to invest in a camel project than a cattle project.

As explained in the preceeding sections, environmental modifications that affect the abiotic base are even more difficult to contend with. If the basic geological and soil conditions are adversely affected, replacement by perhaps more primitive biotic communities might occur eventually, but restoration of the original biological environment will not be possible in anything like a time span that meaningful for human societies.

However, we have seen that land is a scarce good and the issue of land being abundant has become more or less a myth. Therefore, environmentally sound projects should be seen as important and most favourable so as to save the world from any further destruction.

4.3 ASSUMPTIONS AND INTERPRETATIONS

At the same time, one must have modest expectations. There are three principal reasons for this. First, economic valuation relies critically on understanding and measuring the physical, chemical and biological effects of degradation activities.

Second, available conceptual and empirical methods for placing monetary value on non-market goods and sources are quite imperfect. For example, it is difficult to put a value on human life and damage to human health. There are also aspects of environmental quality

and natural systems that are important to society but that cannot be readily valued in economic terms.

Third, as has been stressed earlier, many assumptions must be made in cost-benefit evaluation. The nature and validity of these assumptions influence the accuracy of the evaluation results. In addition to assumptions related to input and output prices, time frame for the analysis, discount rate and the relation of degradation rate to short term and long term productivity losses, separation of the effect of natural processes of degradation from human-induced degradation is also crucial. For example, droughts are responsible for major losses of forage production on rangelands. Grazing pressure will exercerbate the drought effect but not all the loss of productivity on rangelands is human induced. Determining how much degradation is due to natural forces and how much human can lead to different conclusions on the severity of the human impact. There is no simple solution to this problem. An arbitrary judgement must be made.

One important assumption is normally overlooked; that the project can be carried out in such a fashion that it achieves its stated goals. The possibility of failure is not considered. Only one global scale evaluation of the costs and benefits of land degradation has been attempted. A very simplified cost-benefit analysis was based on the status of desertification in the 100 countries containing drylands (Dregne and Chou 1992). While it provides an overall assessment of global degradation problems, the results have questionable significance for policy-making. The principal reason is that the reliability of the estimate of the global degradation level is low. Another reason is that any control of land degradation damage at the global level requires coordination among different countries. Since priorities and

constraints differ from country to country, it is difficult to implement control programmes on such grand scale.

In terms of policy making, cost-benefit analysis at the national level seems to serve the purpose better. However, a global estimate of the on-site damage caused by land degradation can provide summarised information on the status and severity of the degradation problem for world leaders and global institutions.

4.4 LIMITATIONS OF THE STUDY

This study has a number of weaknesses. First and foremost, the use of secondary data on livestock population and products is not adequate as sources report this data with some considerable degree of variation.

Using the cost-benefit analysis, it becomes difficult to assess in an accurate manner all direct and indirect impacts of a plan over a large number of periods. Information on plan impacts actually determines the outcomes of the a cost-benefit analysis. Cost-benefit analysis being an instrument for measuring social efficiency of a plan should look into the problems of distribution of benefits over diverse groups and the effects on the existing income.

CHAPTER FIVE: SUMMARY AND CONCLUSIONS

5:1 HALTING DESERTIFICATION

The surest and perhaps only way to halt desertification is to stabilize human population growth and reduce livestock herd sizes. It is very unlikely that these desirable objectives can be achieved as long as pastoralists depend primarily on cattle. The history of the spread of camels has shown that their southward movement was not due to climatic change alone. It is a history that chronicles what an economy based on cattle and small stock can do to the possible high human population growth. When the range is in good condition and rainfall is plentiful, there is copious milk, meat and blood to feed a growing population. When the grazing deteriorated, the people simply moved on. Woodlands are destroyed by tree-felling and by burning each year to regenerate the grass that the cattle need. A forest is transformed into a Savannah, and the Savannah into a treeless plain. Trampling and overgrazing finish off the ground cover. Wind blows dust into the atmosphere, a degraded land reflects the sun's rays back into the sky, heating the dust. There is little moisture to evaporate into the air from such a land, and when humid air moves into this dry region from elsewhere it is very difficult for rain clouds to form.Precipitation decreases over time, lakes and streams dry up, and a desert is created. Man has created it, and he has actually modified the climate himself. The notion that land is merely a passive factor in climatic change, reacting helplessly to the vagaries of rain and temperature, can no longer be accepted. Conditions of land surface are interactive with variables determining climate and changes in the land can cause micro-climatic changes, with as yet unknown effects at the macro level.

Near the end of the desertification process, when the rains become more erratic and unpredictable and cattle begin to die from drought, the camel makes an appearance. The camel can resist drought, allowing life to continue. When the drought ends, the cattle herds rebuild themselves, humans reproduce to replace those who died and the cycle begins anew. Over centuries of these cycles desert so desolate results that no cattle at all can survive, except in favoured spots. We are left with shifting sands and rocky plains of the Sahara, the Sinai and the Thar Desert of India. These areas supported abundant life 10,000 years ago, and it was not global climatic change alone that degraded these lands. The process of desertification was greatly assisted by man and his animals, and it is still happening today in Northern Kenya and other parts of Africa.It would be interesting to see what would happen if cattle,sheep and goats would be reduced in Northern Kenya substantially, to be replaced by fewer numbers of camels. If managed well, there would be no loss of food production and the land and its wildlife would benefit considerably. Bringing camels into an area before the desert is created might just well halt the desertification process, if it is integrated with an overall programme of education and training to teach the pastoralists care and management of camels and good land use methods. Camel breeding stations, centres where cattle and smallstock could be traded for camels, a marketing scheme with incentives to trade and an efficient system to supply milk and beef to towns could all lead to a healthier people and environment. It is not realistic to expect pastoralists to give up cattle entirely, they are too important culturally, but the herds could be greatly reduced if attitudes of the people can be changed through education and if the incentives are there.It would be a long, slow process, as societies need time to develop new ways of organising labour and for adapting their

institutions and beliefs to a modified economy. Camels are not easy animals to live with, which is the main reason why people do not adopt them until forced to by environmental circumstances,but a desert is not easy to live in either. If camel can help to halt the spread of deserts then they can be the animals of the future rather than the ones of the past. The people who want camels should be given help to obtain them - that alone might be worth more to improve the life of pastoralists than many expensive socially disruptive development projects. The pastoralists, at least would appreciate the camels more than an irrigated field of cotton. In the long term, so would land.

5.2 SOCIAL AND ECONOMIC PROFITABILITY OF CAMEL PASTORALISM AS A DESERTIFICATION CONTROL PROJECT

During the rainy season when pasturage is good, the camel will give an average of about 10 litres of milk a day; a cow will produces than five litres. In the dry season the cow will practically dry up while the camel will continue throughout to give from two to five litres a day of milk - about what a cow will give at the best of times. What all this means is that the camel will consistently provide a substantial quantity of milk for human consumption over the course of the year; while the cow's milk production is relatively small and highly variable.Because of the very low producing capacity of the cow during dry seasoons, and the poor resistance to drought, the cattle patoralist tries to have the largest head he can.There is no thought of culling of unproductive animals to take pressure off the pasture; that unproductive animal might survive the next drought and then be used to trade for grain or some calves to rebuild the herd. With everyone trying to maximise his herd the limited

rangeland inevitably suffers .The feeding habits of cattle and small stock are also much more destructive than those of camels as they feed almost entirely on grass, as long as it is available and also eat the green leaves of shrubs and herbs in the understory. Camels on the other hand have a wide diet, they do not overgraze any type of vegetation thus lessening pressure on vegetation levels. The camels too have a dispersed movement pattern which also reduces the effects of trampling, though with their soft, flat hoofless feet little damage is caused any way.

Another environmental plus for the camel is the type of settlement pattern it permits for people. The more dispersed settlements and livestock are, the less the land is affected by tree and bush cutting for fuelwood, stock enclosures, e.t.c, and by livestock grazing and trampling.Camels are famous for long periods without drinking and they can carry water long distances to settlements for human needs. Camel pastoralists can therefore live in areas where there is good pasture and no water.In northern Kenya and most other semi-arid and arid areas, rain falls unpredictably in patches over the landscape. It is rain that spins plants to grow so the pastoralists must be ready to go where the rain has fallen. Mobility is therefore essential. If a settlement stays in one area too long, overgrazing results and the people create a surrounding circle of uprooted bushes and grotesque trees with lopped off limbs. It is a very great effort for cattle pastoralists to move but camels people can pack everything on the backs of their beasts and be on the move with 24 hours notice. Cattle pastoralists burn bush, forest and Savannah to create grasslands because cattle depend on grass. Camel pastoralists do not need to burn bush because camels do very well inbush environment. Fire has undoubtedly done more to modify the earth's terrestrial habitats than any other single factor

and most fires are anthropogenic. The long term effects of repeated burning in lowland areas can have disastrous consequences, however. Rainfall tends to be much more unreliable in areas below approximately 1200m in East Africa and once protective bush has been burned off a prolonged drought can result in severe erosion and environment degradation.

The camel is also the only domestic animal that has demonstrated its ability to control human population growth. If livestock are the primary source of food, and if they regulate the creation of new families by their availability, then without outside economic inputs human population cannot grow faster than the head. Cattle herds can increase up to 15 per cent a year under ideal conditions. Normally however, over the long term a head will grow at a 3.4 per cent annual rate (Dahl and Hjort 1976). Small stock herds grow at an annual rate of 30 and 40 per cent. A camel herd usually grows at an average of only 1.5 per cent a year, and 5 per cent growth would be considered extremely good by most pastoralists. Because of the slow growth of camel herds,societies dependent on their practice many different types of social controls to regulate marriage and birth.

5.3 TOWARDS SUSTAINABLE DEVELOPMENT OF ARID LANDS NATURAL RESOURCES

It is undeniable that arable production in the drylands carries with it crop failure risks and dangers of land degradation. The arid lands real potential lies in livestock production and wildlife management. In the past, efforts have been misdirected to the point of almost completely ignoring the pastoral sector, the richest, resilient and most diversified resource base.

Since the main determinant of human welfare in the drier parts of the arid lands(Turkana,Wajir,Garissa and Mandera) is the performance of the pastoral economy, development effort should be directed to enhance lifestock development. Development planners should aim at understanding the traditional risk avoidance strategies of the pastoralists and attempt through introduction of broader knowledge and improved technologies to reduce risks without attempting drastic changes.

Implementation of appropriate risk-reducing and risk-spreading measures in the arid lands should in the short term achieve higher levels of production and greater food security so that in the long term,the knowledge and experience gained will be incoporated into new risk-spreading strategies. A new environmental balance should then be achieved, at a higher production rate, supporting the growing population with less risk of livestock failure and land degradation ultimately leading to higher economic benefits.

Proper land use depends on proper land uses. The basic cause of the kenya arid lands environmental woes is man's lack of ecological sensitivity (Darkoh,1980). There is a need to educate local people, a need to develop a population which is aware of and concerned about the solution of current arid and semi arid land problems and the prevention of new ones. The need to develop the technological potential of the local people cannot be overemphasized.

Probably the best development efforts are those that rely less on money than on the latent abilities and resources of the people they intend to help.Despite the efforts made over the last decade or so, the standard of living of the population in the arid and semi arid lands continue to lag behind than in the high potential areas of kenya. The enviromental situation

in the arid lands is worsening. The depletion of resource base due to over exploitation following basic landuse conflicts and well meaning development action on the part of the government and donor agencies are contributing to the worsening environmental and human conditions in the arid and semi lands. In the recent years there has been a flow of statements recognizing the nature of the environmental crisis in the ASAL. However, there is a distinction between political pronouncements and institutional responses. It is essential that any future initiatives are backed by real expressions of political will.

REFERENCES

Adeliff M., (1987). *Sustainable development: Exploring the Contradictions*, New York, Methuen

Ahmed Yusuf J., (1982). *Analyzing the Options*, United Nations Government Programme, UNEP Studies, 5, Nairobi, Kenya

Aldington J.J. and Wilson F.A. (1968). The marketing of Beef in Kenya, *University of Nairobi, Institute of Development Studies, Occasional Paper* No. 3

Areyard, J.M., (1988). Land Degradation: Changing Attitudes - Why? *Journal of Soil Erosion in Mali*, Environment Working Paper No. 21, Environment Department, The World Bank, Washington DC, USA. pp 71

Aronson, D.R. (1978). Review of the Economics of Pastoralism by Z.A. Konczacki, in *Nomadic People*, 4 pp. 3 - 7

Arrow K.J. (1968a) 'Optimal Capital Policy with Irreversible Investment' in *Value, Capital and growth* J.N. Welfe ed. Chicago: Aldine-atherton.

Arrow K.J. (1968b.). 'Application of Control Theory to Economic growth in *Lectures in Applied mathematics* Vol. 12, Mathematics of the Decision Sciences - Part 2 (Providence, R.F. American mathematical society

Arrow J.K. and M.Kurz(1970). Optimal Growth with irreversible investment in a Ramsay model, *Econometrica*, vol. 38. No. 2 331-344.

Baker P.R. (1967). Environmental Influences on Cattle Marketing in Karamoja. Kampala. Uganda. Makerere University, Department of Geography, Occassional Paper 5.

Baker P.R. (1975). 'Development and Pastoral People of Karamoja, North-Eastern Uganda: An Example of the Treatment of Symptoms, Theodore Monod (ed.), *Pastoralism in Tropical Africa*, London: O.U.P.

Baker R., (1981). Land degradation in Kenya: *Economic or Social crisis?*, Development Studies Discussion Paper No. 82, Norwich School of development Studies, University of East Anglia

Barnet H.J. and Morse, Chandler (1963). *Scarcity and Growth: The economics of National Resource Availability*, Baltimore: Johns Hopkins Press

Baumol W.J. (1969). On the Discount rate for Public projects, The analysis and Evaluation of Public Expenditures The PPB system-Vol 1, Govt. Printing Office. Washington pp. 489-503.

Benard, F.E (1972). East of Mount Kenya: Meru agriculture in transition. Munich, Germany, Weltforum Verlag

Bishop, J. and Cicchetti, C., (1975). Some Institutional and Conceptual Thoughts on the measurement of Indirect and Intangible Benefits and Costs, *'Cost benefit Analysis and Water Pollution Policy* (H.M. Peskin and E.P. Seskin eds), The Urban Institute, Washington D.C., pp. 105-126.

Blaikie P., (1989). Explanation and Policy in land Degradation and rehabilitation for

Developing Countries, in *Land Degradation and Rehabilitation*, Vol. 1, No. 1 pp. 23-37

Blaikie P., (1985). *Political Economy of Soil Erosion in Developing Countries*, London, Longman.

Blau F., (1964). Exchange and Power in Social Life, N.Y:, J.Wiley

Bojo, J, (1989). Case Study: Benefit-cost Analysis of Soil Conservation in Maphutseng, Lesotho, in John A. Dixon, David E. James and Paul B. Sherman (editors). *The Economies of Dryland Management*, Earthscan Publications Ltd. London, UK pp. 251 - 285

Brooks, K.N., H.M. Gregersen, E.R. Berglund and M. Tayna, (1982). Economic Evaluation of Watershed Projects - An Overview Methodology and Application, *Water Resources Bulletin* 18 (2) pp. 245 -250

Brown Janet, W., (1988). *Poverty and Environment Degradation: Basic Concerns for US Cooperation with Developing Countries*, Washington DC., USA, World Resources Institute.

Burt, Oscar R., (1981). Farm Level Economics of Soil Conservation in the Palouse Area of the Northwest, *American Journal of Agricultural Economics* 63, pp. 83 - 92

Cassanelli, L.V., (1981). Drought and Famine in Somalia: Pastoral Strategies through the-twentieth century, paper presented to the Seminar on Food Production Systems and Environmental Rehabilitation in Somalia, The National Academy of Science, Washington, D.C., 4th-5th June.

Ciriacy - Wantrup. S.V. and W.E. Phillips, 'Conservation of the California Tule Elk: A socio-economic study of a survival problem' Biological conservation vol 3 no.1. pp. 23-32.

Clark, Edwin H., Jennifer A., Havakamp and William Chapman, (1985). *Eroding Soils: The Off-farm Impacts*, The Conservation Foundation, Washington DC, USA, 1985

Coase R.H. (1960). The Problem of social Cost, *Journal of Law and Economics*, vol. 3 p.1

Coomber N.H. and A.K. Biswas (1972). *Evaluation of Environmental Intangibles*, Geneva Press, Bronxville.

Cruz de Carvalho (1971). Traditional and modern patterns of cattle raising in South western Angola: Critical evaluation of change from Pastoralism to ranching. Paper presented at the 14th Annual meeting of African studies Association, Denver, Colorado usa

Cummings, Ronald and Burt, O.R. (1969). The Economics of Production from national Resources: Note *American Economic Review* vol. 59 No.5

Dahl G. and A. Hjort (1976). Having Anthropology. University of Herds Stockholm. Studies in Social Anthropology.

Dahl G. (1979). Suffering Grass, Stockholm Studies in Social Anthropology, University of Stockholm.

Daniel, S., (1987). Camel Vs. Cattle Pastoralism: Stopping desert Spread, *Desertification Control Bulletin*, 14, pp 15 - 22

Darkoh, M.B.K., (1980). *Man and Desertification in Tropical Africa* Dar es Salaam University Press, Dar es Salaam.

_____ (1989). *Combating Desertification in Southern African region: An Updated Regional assessment,* Nairobi and Moscow, UNEP/USSR Centre for International Projects.

Dasgupta A.K. and D.W. Pearce, (1972). *Cost-benefit analysis,* Theory and practice, Macmillan, London.

Dasgupta p. (1972). A Comparative Analysis of the UNIDO Guidelines and the OECD manual. Bull Oxford University... University Institute of Economic Statistics; vol. 34 No.1 pp.33

Deshler, W.W. (1964). The Dodos: a cattle keeping tribe in East Africa. In Thomas, R.S et Patern D.J ed Focus on geographic Activity: a collection of Original Studies, New York, USA, Mc Graw-Hill

Dorfman, Robert (1969). 'An Economic Interpretation of Optimal Control theory' *American Economic Review* vol. 59 No. 5

Dregne H. E. and Nan-Ting Chou, (1992). Global Desertification Dimensions and Costs, in H.E. Dregne (editor), *Desertification and Restoration of Arid Lands*, Texas Tech University, Lubbock, Texas, pp. 249-282

Dupuit J., (1844). De la mesure d I' Utilite des Travanx Publics,' Annales des Ponts et Chaussies, serie 8, no. 2 (English translation by R.H. Banback, 'On the measurement of the Utility of Public works,' International Economic Papers, no.2, 1952 pp. 83-110).

Fisher, A.C. J.V. Krutilla and Cicchetti, C.J., (1972a). The Economics of Environmental reservation: 'A theoretical and Empirical Analysis.' *American Economic Review* vol. 62, pp 605-619.

Erwin, Christine A. and David E. Erwin, (1982). Factors Affecting the Use of Soil onservation Practises: Hypotheses, Evidence, and Policy Implications, *Land Economics* 58, pp. 277-92

Erwin, David E. and Michael . Dicks, (1988). Cropland Diversion for Conservation and Environmental Improvement: An Economic Welfare Analysis, *Land Economics* 64(3), pp. 256-268

FAO, (1987). *Agriculture: Toward 2000*, Rome, UN Food and Agricultural Organisation.

Field G. (1979). *Preliminary Report on the Ecology and Management of Camels, Sheep and goats in Northern Kenya*, IPAL Technical Report E -1a, Nairobi, UNESCO.

Fisher A.E. (1972b). Alternative uses of Natural Environments: The economics of Environmental modification, Natural Environments: Studies in Theoretical and applied analysis (J.V. Krutilla eds) John Hopkins Press Baltimore pp. 18-53.

Fratkin, E., (1979). A comparison of the role of the prophets in Samburu and Maasai warfare. Fukuj and Turton (eds), *Warfare among East African Herders*, Osaka.

Gosselink J.G., E.P. Odum and R.M. Pope, (1973). 'The value of the Tidal Marsh; Marine Science Department. Louisiana State University. Baton Rouge.

Good D.A. (1971). 'Cost-benefit and cost Effectiveness analysis: Their application to Urban Public Services and Facilities Discussion paper no. 47. Regional Science Research Institute Philadelphia.

Gordon R.L. (1967). 'A reinterpretation of the Pure theory of Exhaustion, *Journal of Political Economy* Vol. 75 No. 3

Gordon S.H., (1954). The Economic Theory of a Common Property resource: The Fishery, *The Journal of Political Economy,* April-Section I, II, III. University of Chicago Press.

Gray, L.C. (1914). Rent Under the Assumption of Exhaustibility, *Quarterly Journal of Economy,* vol. 75 No. 3

Gufu O. (1982). Environmental Education for Nomadic Pastoralists. Paper Presented at UNESCO - IPAL Orientation seminar, November, 1982, Nairobi.

Gupta S.B.L.,R. Prasad and R.K. Randay, (1973). An Economic Evaluation of Soil Conservation Measures in Varanasi District, VP, *Indian Journal of Agricultural Economics* 28(4) pp 205-211

Haveman R.H. and B.A. Weisbrod (1975). The concept of Benefits in cost-benefit analysis: with emphasis on *Water pollution control activities, Cost-benefit and Water Pollution Policy* (H.M.Peskin and E.P. Seskin eds). The Urban Institute, Washington D.C. pp. 37-66.

Helliwell, D.R., (1967). The Amenity of Trees and Woodlands, *The Arboricultural Association Journal* vol. 1 no. 5 pp. 128-131.

_____, (1969). 'Valuation of Wildlife resources,'*Regional Studies* vol. 3 no. 1, pp 41-47.

_____, (1971a). A methodology for the assessment of Priorities and values in Nature conservations Merlewood Research and Development paper no. 28.

_____, (1974). The value of vegetation for conservation, *Journal of Environmental Management* vol 2 no. 1 pp. 51-78.

Hellwell, D.R. (1979b).' Changes in Flora and Fauna Associated with the Afforestation of a Scottish Moor - An evaluation,' Merlewood Research and Development paper no. 29.

_____, (1973). "AN Examination of the Effects of size and Isolation on the Wildlife Conservation value of Wooded sites," Merlewood Research and Development paper no. 49.

Hicks J.R., (1946). Value and Capital 2nd edition. Oxford: Oxford University press.

Holmberg G., (1990). An Economic Evaluation of Soil in Kitui District, Kenya, in John A. Dixon, David E. James and Paul B. Sherman(Editors), *Dryland management Case Studies,* Earthscan Publications Ltd., London pp.56-71

Homans, G.C. (1961). *Social Behaviour, Its Elementary Forms,* NY:Harcourt, Brace and World.

Hooper, M.D. (1970). 'Critique of D.R. Helliwell: valuation of Wildlife Resources.' *Regional Studies* vol. 4, no. 2 pp 127-128.

Horowitz, M.M. (1981). Research in Pastoral Studies: An Agenda for the 1980s in *The Future of Pastoral peoples* , ed J.G. Galaty et al, Ottawa, IDRC

Hotelling, Harold (1931). The economics of Exhaustible resources, *Journal of Political Economy,* vol. 39 No. 2

Huszan, Paul C., and Steven L. Piper. (1986). Estimating the Off-site Costs of A Wind Erosion in New Mexico, *Journal of Soil and Water Conservation* 41(6) pp. 414-416

Inhaber H. (1976). *Environmental indices*, Wiley, New York

IUCN, (1980). *World Conservation Strategy: Living Resources conservation for Sustainable Development*, Gland, Switzerland, International Union for the Conservation of

National and Natural Resources United Nations Evironmental Programme and Wildlife Fund.

Jacobs, P., J. Gardner and D. Munro, (1987). Sustainable and Equitable Development: An Emerging P radigm, in (Jacobs et al) *Conservation With Equity: Strategies for Sustainable Development*, Cambridge, International Union for the Conservation of Native and national resources pp. 191 - 207.

Jacobs A.H (1973). Land and contemporary politics among the Maasai of East Africa. New Orleans, USA, American Anthropological Association.

Kassas, M.Y., J. Ahmad and B. Rozanov, (1991). Desertification and Drought: An Ecological and Economic Analysis, *Desertification Control Bulletin* 20, pp. 19-29

Kayongo-Male, D(1980). *Current Anthropology*, vol.21, no.1, p.37.

Kim, Sung-Hoon and John A. Dixon, (1986). Economic Valuation of Environmental Quality Aspects of Upland Agricultural Projects in Korea, in John A. Dixon and Maynard M. Hufschmidt (editors) *Economic Valuation Techniques for the Environment*: A Case Study Work Book, The John Hopkins University Press, Baltimore pp 63-82

Lele S., (1991). Sustainable Development: A central Review, in *World Development*, Blaikie P., 1985, Vol. 19, No. 6 pp. 607-621

Leng G., (1982). *Desertification: A Bibliography with Regional Emphasis on Africa*, Bremer Bertrage Zur Geographic und Raumplanning Heft 4, Universitet Bremen.

Lewis J.G. (1977). Report of a Short-term Consultancy on the Grazing Ecosystem in the Mt. Kulal region, Northern Kenya. IPAL Technical report E-3, Nairobi, UNESCO.

Little, I.D.M. and Mirlees, J.A. (1969). *Social Costs-Benefit Analysis*, OECD Development centre, Paris.

Livingston, R.C. (1975). Comprehensive Indicator: Quality of Life, *Regional Environmental Management* (L.E Coates and P.A Bonner eds.) Wiley, New York pp 155-172

Lusigi W. (1981). *Combating Desertification and Rehabilitating Degraded Production Systems in Northern Kenya*, IPAL Technical report A-4, Nairobi, UNESCO.

Manners I.R. and M.W. Mikesell (eds) (1974). *Perspectives on Environment*, Association of American geographers (Commission on College Geography) Washington.

Marglin S.A. (1967). *Public Investment Criteria*, Albn & .Urwin London

Marshall A., (1890). Principles of Economics. London: Macmillan and Co.

McCauley,E.H. (1976). Lessons from a survey of successful experiences in assisting the small livestock producer. In Food and Agriculture Organisation (FAO), World Animal Review,17,Rome,Italy,FAO

McConnel, Kenneth E., (1983). An economic Model of Soil Conservation, *American Journal of Agricultural Economics*, 65 pp. 83-89

McHarg I.L. (1969). *Design with Nature*, Natural History Press, New York.

Mckean R.N., (1972). The use of shadows prices, Cost-benefit analysis (R Layard eds), Penguin, London pp 119-139.

McKiernan, (1990). Preserving the Wisdom of the Ages, in *Garden*, Vol. 14, No. 4 , pp. 10-16 .

Migot - Adhola, S.E. and P. Little (1981). Evolution of Policy Towards the Development of Pastoral Areas in Kenya, in the *Future of Pastoral Peoples*, ed J.G. Galaty et al. Ottawa, IDRC

Ministry of Agriculture (MOA), Yields, Costs and Prices, Government Printer, Nairobi - Various issues.

Miranowski, John A., (1984). Impacts of Productivity Loss on Crop Production and 'management in a Dynamic Economic Model, American *Journal of Agricultural Economics* 66, pp 61-71

Mishan E.J. (1971). *Cost-benefit Analysis*, Allen & Urwin London.

Mitchell, Kent J., John C. Brach and Earl R. Swanson, (1980). Costs and Benefits of Terraces for erosion Control, *Journal of Soil and Water Conservation* 35, pp. 233-236

Nijkamp P., (1976). 'Economics-Ecologic Evaluation of Natural Environments' Environmental Economics, vol. 1, Theories (P.Nijkamp ed.) Martinus Nijhoff, The Hague pp. 1-16.

Nijkamp P and C Verhage, (1976). 'Cost-Benefit Analysis and Optimal control theory for environmental Decisions: A case study of the Dollard Estuary, ' Environment, Regional Science and interregional Modelling (M. Chattegji and P. Van Rompey eds. Springer Verlag, Berlin, pp 74-110.

Nijkamp P. (1977). Theory and Application of Environmental Economics, *Studies in Regional Science and Urban Economics*, Vol. 1 (Ake Anderson, Walter Isard (eds) North-Holland

Publishing Company - Amsterdam.

O'Riorda T. (1985). Future Direction in Environmental Policy in Journal of Environment and Planning Blaikie P. (1985). Vol 7 pp 143 1446

Odegi-Awuondo, C.,(1982). Wildlife conservation and decline of pastoralist in Ke, *African Journal of Sociology* Vol II No.2.pp.74

Odegi-Awuondo, C., (1983). Drought and Famine in Turkana Some human problem and suggested solutions, *The Kenyan Geographer*, Vol.5 pp.175-182.

Odegi-Awuondo, C., (1990). Life in the Balance: Ecological sociology of Turkana nomads, Nairobi, Kenya, Act Press Africa Centre for Technology Studies.

Odum E.P. and H.T. Odum, (1972). Natural Areas as Necessary components of Man's total environment; *Transactions of the North American Wildlife and National Resources Conference* vol. 37 pp 178-189.

Odum E.P. (1971). *Fundamentals of Ecology*,4 Saunders, Philadelphia.

Paylore P and Mabbi J.A.(eds) (1980). *Desertification World Bibliography Update* 1976-1980 Tucson, Arizona, University of Arizona, Office of Arid Studies.

Penning - Rowsell E.C. and D.I. Hardy (1973). Landscape evaluation and Planning Policy: *Regional Studies* vol. 7 pp 153-160.

Perberdy J.R. (1970). *Animal Production 1970 - 80 and beyond* - Ministry of Agriculture, Government Printer, Nairobi.

Pigou A.C. (1946). *The Economics of Welfare*, 4th edition, Macmillan and co., London.

Piper, Steven (1989). Measuring the Particulate Pollution damage from Wind Erosion in the United States. *Journal of Soil and Water Conservation* 44(1) pp.70-75

Plumwood V. and R. Rontley, (1982). World Rain Forest Destruction: The Social Factors in *The Ecologist*, Vol. 12 No. 1.

Pontryagin L.S. et al (1962). *The Mathematical Theory of Optimal Processes*, New York: Intersource

Prato, Anthony A. (1985). Private and Public Value of Controlling Soil Erosion With Conservation Tillage, in American Society of Agricultural Engineers (Editor), *Erosion and Soil Productivity*, ASAE Publications 8 - 85, St. Joseph, Michigan, USA, pp. 227-231

Pratt D.J. and M.D. Gwynne (1977). *Rangeland Management and Ecology in East Africa*, London, Hodder and Stonghton

Putman, John and Klaus, Alt., (1987). Erosion Control: How Does It Change Farm Income? *Journal of Soil and Water Conservation* (42) pp. 65-67

Rapp A and Hellden, U. (1979). Research in Environmental Monitoring for Land Use in Planning in African Drylands, in *Rapporter och Noticer* 42, Lund, Lunds Universitets Naturgegrafika Institution

Rees S.H. (1954). National resources Allocation, *Economics and Policy*. Methuen, London, New York.

Ribaudo, Marc, (1986). Reducing Soil Erosion Offsite Benefits, Agricultural Economic Report No. 561, Natural Resource Economics Division, Economic Research Source,

Riesman, P. (1978). The Fulani in a development context: the relevance of cultural traditions for coping with change and crisis. Washington, D.C.,USA, Report written under Agency for International Development Contrast.

Rosenberry, Paul, Russell Kintson and Lacy harmon, (1980). Predicting the Effects of Soil Depletion From Erosion, *Journal of Soil and Water Conservation*, 351 pp 131-134

Samuelson P.A., (1947). Foundations of Economic Analysis. Cambridge, Mass.: Harvard University Press

Sandmo A. (1972). Discount Rates for Public Investment under uncertainity, International Economic Review vol. 13 no. 2 pp 287-302.

Schneider, H.K. (1981). Livestock as food and money, in *The Future of Pastoral Peoples*, ed. J.G. Galaty et al Ottawa IDRC.

Scott, M.F.G., McArthur J.D. and Newberry D.M.G. (1976). Project Appraisal in Practise: the Little Mirlees Method Applied to Kenya. H.E.H., London

Scott Anthony, (1967). The Theory of the mine Under Conditions of Certainty in *Extractive and Resources and Taxation*, Maron Geoffrey, ed. Madison, Wisconsin: University of Wisconsin Press

Simpson, M.C. (1973). Alternative strategies in Range Land development in Kenya. The University of Leeds. Rural Development study No. 2

Solow R.M. (1974). The Economics of Resources or Resources of Economics, *American Economic Review* vol. 64 no. 2

Sorokin, P. (1975). Hunger as a Factor in Human Affairs, Gainesville: University of Florida Press.

Sorokin,P. (1942). *Man and Society in Calamity*, NY: Dutton.

Spencer P. (1973). *Nomads in Alliance London*, Oxford University Press

Spooner B. , and H.S Mann (eds) (1982). Desertification and Development: Dryland Ecology, in *Social Perspective*, New York Academic Press.

Stiles D.N. Vanishing Grass: Samburu camel Herders *Swara* 6 v

Stobbs T. (1967). Management of the Small East African Zebu in Relationship to Milk Yield. *East African Journal for Agriculture* vol. 32 No. 3

Sunkel O., (1987). Beyond the World Conservation Strategy: Integrating Development and he Environment in Latin America and in Caribbean, in (P. Jacobs et al) *Conservation with Equity: Strategies for sustainable development*, Cambridge, International Union for the Conservation of national and Natural Resources pp. 35-54

Swift, J. (1976). Some consequences for the Somali nomad pastoral economy of the development of livestock trading. Paper presented at Collegue Internationale: Le Pastoralisme Nomade: Production,Pastorale et Societe- 1-3 Dec.1976

Tolba M.K. (1984b). *Sustainable development in a Developing Economy*, Address to the International Institute, Lagos Nigeria, UNEP, Nairobi, Kenya.

Tolba M.K. (1979). What Would be Done to Combat Desertification, in Bishay A. and W.G. McGinnies(eds) *Advances in Desert and Arid Lands Technology and development*, vol. 1, Chur, London, New York, Harwood Academic Publishers.

Tolba M.K. (1984a). *The Premises for building a Sustainable Society* - Address to the World Commission on Environment and development, UNEP, Nairobi, Kenya.

Torry W.I. (1973). *Substitute Ecology Among the Gabra Nomads of the Kenya/Ethiopia frontier*, Ann Arbor. University Microfilms

UNEP, (1992). Status of Desertification and Implementation of the United Nations Plan of Action to Combat desertification, UNEP/GCSS III/3, Nairobi, Kenya.

UNEP, (1991). *World desertification Bibliography*, UNEP and OALS

UNIDO (1972). Guidelines for Project Evaluation , United nations, New York

USAID (1980). The Workshop on Pastoralism and African Livestock Development A.I.D. Program Evaluation Report No. 4

Walker, David J., (1982). A Damage Function to Evaluate Erosion Control Economies, *American Journal of Agricultural Economics* , 64 pp. 690-698.

Wallace B.C., (1974). Landscape Evaluation and the Essex Cost. *Regional Studies*, vol. 8 pp 299-305.

Wandera, G.J., (1983). Livestock diseases in ASAL,*The Kenyan Geographer*, vol.5.

Warnke D.W., N.C. Terre and A.P. Ameiss (1973) . 'A methodology for Determining Public Investment Criteria,' Socio-Economic Planning Sciences vol. 7, pp 317-326.

Warren, A. and J.K. Maizels (1977). Ecological Change and Desertification. U.N. Conference on desertification Paper No. A/CONF. 77/7 Nairobi.

Welfe J.N. (eds), (1977). Cost-benefit and cost-effectiveness, Allen & Urwin, London.

World Commission on Environment and Development, (1987). Our Common future, Oxford university Press, New York.

APPENDICES

APPENDIX I

COMPARISON OF VALUES OF CAMELS AND CATTLE PASTROLISM

	CAMELS	CATTLE
Annual Milk Production for human use, one cow litres	1,300 (1) - 2,500 (2) mean 1,900	112 - 420 (2) mean 300
Lactat ion period (weeks)	47 - 72 (1),(2)	16 - 60 (2),(3)
Head of 100, annual produce (4)		
Milk (Kg.)	24,820	6,615
Blood (Kg.)	356	480
Meat (Kg.)	676	980
Total Protein (Kg.)	1,100	100
Total Energy (Kcal.)	18,730,000	7,882,500
Dry matter intake per day (Kg. / head) per year	1.0 (1) 365.00 *	0.75 (3) 2,73.75 *
Typical herd annual growth (rate%)	1.5 (4)	3.4 (4)
Maximum herd annual growth (rate %)	7.5 (4)	15.0 (5),(6)
Herd size necesarry to maintain an average family (6 people)	28	64
Diet	Trees and shrubs (7) 70%	Grasss (3) 80%
Mobility	High (8)	Moderate (5), (9)
Trampling effects	Light (8)	Heavy (3), (5)
Pastoralist degree of polygyny	Low (5), (8)	High (5), (9)
Human population growth	Low (10), (11)	High (5), (10)

Sources: (1) Field, 1979; (2) Pratt and Gwynne, 1977; (3) Lewis, 1977; (4) Dahl and Hjort, 1976; (5)Spencer, 1973; (6) Schneder, 1981; (7) Field, 1976; (8) Torry, 1973; (9) Gulliver, 1955; (10) Sobania, 1979; (11) Rany, 1976.

APPENDIX II

HERD SIZE AND COMPOSITION

Year		1	2	3	4 .	5	6	7	8	9	10
(1) Cattle Total	2000										
Annual growth Rate (3.4%) (a)											
Calf mortality (30%) (b)											
Total	2000										
Initial herd size		2000	1448	1048	759	549	398	288	209	151	109
Additional		68	49	36	26	19	13	10	7	5	4
Total		2068	1497	1048	784	568	411	2948	216	156	113
Deaths		(620)	(449)	(325)	(235)	(170)	(123)	(89)	(65)	(47)	(34)
Total Herd	2000	1448	1048	795	549	398	288	209	151	109	79
(II) Camel Total	2000										
Annual growth rate (1.5%) (a)											
Calf mortality rate (5%) (b)											
Total	2000 (C)										
Initial Herd size		2000	1928	1859	1793	1729	1667	1607	1549	1493	1439
Addittion		30	29	28	27	26	25	24	23	22	22
Total		2030	1957	1887	1820	1775	1692	1631	1572	1515	1461
Deaths		(102)	(98)	(94)	(91)	(88)	(85)	(82)	(79)	(76)	(76)
Total Herd		2000 (c)	1928	1793	1729	1667	1607	1549	1493	1439	1388

NOTES

- This is based on the information on the comparison of values of camel and cattle pastoralism in appendix (i)
- We apply a calf mortality rate of 30% in a desrtification region and the rates reduced to 5% following effecient desrtifica control without the introdiction of camels
- This is the initial herd composition; although arbitraryly chosen, represents the maximum number of animals servered at waterhole.

Source: Author's own computation.

APPENDIX III

(3) COMPUTATION OF BENEFITS (I)

	No. of Camels in Milk	Milk Ouput at 1,900 litres (1) per animal and Shs. 3.75 (2) per litre	Discount Factor at 15%	Present Value of Benefits
0.	2000		1.000	
1.	1928	13,737,000	0.0870	11,951,190
2.	1859	13,245,375	0.756	10,013,503
3.	1793	12,775,125	0.658	8,406,032.2
4.	1729	12,319,125	0.572	7,046,539.5
5.	1667	11,877,375	0.497	5,903,055.3
6.	1607	114,494,875	0.432	4,946,346
7.	1549	11,036,625	0.376	4,149,771
8.	1493	10,637,625	0.327	3,478,503.3
9.	1439	10,252,875	0.284	2,911,816.5
10.	1388	98,895,000	0.248	24,525,996
			Total present value	61,259,351
			Averag per animal in initial herd	30,630

NOTES.

1. A Camel can produce 1,900 litres of milk for human consumption a year (the average for the range given in Appendix I

   The cow will produce about 300 litres for human consumption a year under the same conditions.

2. Milk is valued at the KCC price which generally acts as the floor price that farmers get. This price was at shs. 3.75 per litre in 1989 (Statistical Abstract 1989 - Price to Produce for wholemilk.

4. COMPUTATION OF BENEFITS (II)

	No. of Cows in milk	MIlk Output at 1,900 Litres (1) per animal and Shs. 3.75 (2) per litre	Discount Factior at 15%	Present Value of Benefits
0.	2000		1.000	
1.	1448	1,629,000	0.870	1,417,230
2.	1048	1,179,000	0.756	891,324
3.	759	853,875	0.648	553,311
4.	549	617,625	0.572	353,281.5
5.	398	447,750	0.467	209,099.25
6.	288	324,000	0.464	139,968
7.	209	235,125	0.376	88,407
8.	151	169,875	0.327	55,549.125
9.	109	122,625	0.284	34,825.5
10.	79	88,875	0.248	22,041
			Total present Value	3,765,036.3
			Average per animal in intial herd	1,882.5

APPENDIX V

(5) ALLEVIATING MORTALITY LOSSES

EAR	NO. OF CATTLE LOST	NO. OF CAMELS LOST	DIFFERENCE	VALUE OF ANIMAL AT A LIVE WEIGHT OF 27.35 (3) PER ANNUAL AND A WEIGHT OF 36 KG (4)	PRESENT VALUE AT 15% DISCOUNT RATE
	620	102	518	5,100,022.88	443,719.83
	449	98	351	345,594.6	261,269.51
	325	94	231	227,442.6	149,657.51
	235	91	144	141,782.4	81,099.532
	170	88	82	80,737.2	40,126.388
	123	85	32	37,414.8	16,163.193
	89	82	7	6,892.2	2,591.4672
	65	79	-14	-13,784.4	-4,507.4988
	47	76	-29	-28,553.4	-8,109.1656
	34	73	-39	-38,399.4	-9,523.0512
			Total Present Value	972,487.45	
			Average per animal in initial herd	486.24	

TES

the absence of readily available information of the relative quantities of meat of different ities delivered to KMC, we calculate a simple arithmetic mean of the following prices t the mean price we use in our analysis.

	(PRICE PER KG.)
GAQ	31.85
FAQ	30.85
3rd	26.85
4th	20.35

stical Abstract (1991)

rgusson (1971) used the weight of A fully grown animal of 227 Kg. Perberdy estimates an rage of 60 Kg. We shall however adopt a more conservative estimate of Aldington (1968) 36 Kg.

COMPUTATION OF COSTS OF CAMEL KEEPING

APPENDIX VI

	0	1	2	3	4	5	6	7	8	9	10
1) Camel Drugs and Medicine (individual spends sh. 9.88 on drugs per animal)											
Camel Herd	2000	1928	1859	1793	1729	1667	1607	1549	1493	1439	1388
Cost of Drugs and Medicine		19048.64	18366.92	17714.84	17082.52	16469.96	15877.16	15304.12	14750.84	14217.32	13713.44
Present value @ 15% discount rate.Total PV [84946.3]		16572.316	13885.391	11656.364	9771.2014	8185.5701	6858.933	15754.9331	4823.5246	4037.7188	3400.9311
Mustering labour 400 herdsmen engaed for 1/3 man day per week at an average of shs. 6.75 per manday		46800	46800	46800	46800	46800	46800	46800	46800	46800	46800
Total Present value [281676.84]											
Average per animal [183.3] in initial herd.											
2) Dry Matter intake											
DM of 365.0kg per year at a price of 0.38/- per kg.		267413.6	257843.3	248689.1	239812.3	231212.9	222890.9	214846.3	207079.1	199589.3	19251.6
Present value @ 15% discount rate		232649.83	194929.53	163637.42	137172.63	114912.819	6288.868	80782.208	67714.865	56683.361	47743.868
Total PV [1802515.2]											
verage per animal [901.258											
3) Management of camels											
Initial Costs	500006										
Salvage value 20% recovered											
Attendant receiving 315/- p.m.		3780	3780	3780	3780	3780	3780	3780	3780	3780	3780
Labour requirements		46800	46800	46800	46800	46800	46800	46800	46800	46800	46800
Total cash flow	50.000	50000	50580	50580	50580	50580	50580	50580	50580	50580	49580
Present value at 15% discount rate	50,000	44004.6	38238.48	32775.84	28931.86	23620.86	21850.56	19018.08	16539.66	14364.72	12295.84
Total PV [301640.4]											
Average per animal [150.82]											

Notes

1. Price used by F.M. Mwega (1980) as the cost of Acaricides from the MOA estimates.
2. Labour is valued at the 1977 legislated minimum wage rate of 6.75 per day.
3. Figure obtained from the table on companion of values of camel and cattle pastoralism in appendix (I)
4. We calculate the simple arithmetic mean of the cost per kg of dry matter as given by Newbery (1972)

	Parity	Grain	Germ	Greenchop	cents/kg.
cost/kg Dry matter (Export Parity) =	37.9	38.3		17.9	

5. This is equivalent to a 'farm clerk' who earns the legislated minimum wage of 315 per month.
6. This is the estimated amount got from the intergrated project in Arid Lands (IPAL) -Technical Report Number A-6.

APPENDIX VII

COMPUTATION OF COSTS OF CATTLE KEEPING

	0	1	2	3	4	5	6	7	8	9	10
1) Livestock Drugs and Medicine (individual spends sh. 9.88[1] on drugs per animal)											
Camel Herd (Totals)	2000	1448	1048	759	549	398	288	209	151	109	79
Cost of Drugs and Medicine		14306.24	10354.24	7498.92	5424.12	3932.24	2845.44	2064.92	1491.88	1076.92	780.52
Present value @ 15% discount rate.Total PV [33065.4]		12446.43	7827.81	4859.30	3102.60	1836.35	1229.23	776.41	487.85	305.85	193.57
Mustering labour 400 herdsmen engaed for 1/3 man day per week at an average of shs. 6.75 per manday		46800	46800	46800	46800	46800	46800	46800	46800	46800	46800
Total Present value@ 15% [281676.84]											
Average per animal [157.37] in initial herd.											
2) Dry Matter intake											
DM of 237.7[3]kg per year at a price of shs. 0.38[4] per kg.		150600.68	108998.28	78940.554	57099.294	41394.388	29953.728	21737.254	15704.906	11336.654	8216.474
Present value @ 15% discount rate		131022.5	82402.699	51942.884	32660.796	20573.01	12940.01	8173.2075	5135.5042	3219.6097	2037.6855
Total PV [350107.85]											
verage per animal [175.054]											
3) Construction and maintenance of stock enclosures											
Capital Costs	25.000										
Salvage value 20% recovered											(50000)
Attendant receiving 315/- p.m.		3780	3780	3780	3780	3780	3780	3780	3780	3780	3780
Labour requirements		46800	46800	46800	46800	46800	46800	46800	46800	46800	46800
Total cash flow	25.000	50580	50580	50580	50580	50580	50580	50580	50580	50580	45580
Present value at 15%	25,000	44004.6	38238.48	32775.84	28931.86	23620.86	21850.56	19018.08	16539.66	14364.72	11303.84
Total PV [275648.4]											
Average per animal in initial herd [137.82]											

APPENDIX VIII

(1) SOCIAL COST / BENEFITS ANALYSIS

YEAR	ADJUSTING FACTOR	MILK OUTPUT FROM CAMEL	DISCOUNT FACTOR 10%	PRESENT VALUE
0.	1.00 (1)		1.000	
1.		13,737,000	0.909	12,486,933
2.		13,245,375	0.826	10,940,679
3.		12,775,125	0.751	9,594,118.8
4.		12,319,125	0.683	8,413,962.3
5.		11,877,375	0.621	7,375,849.8
6.		11,449,815	0.564	6,457,129.5
7.		11,036,625	0.513	5,661,788.6
8.		10,637,625	0.467	49,647,770.8
9.		10,252,875	0.424	4,347,219
10.		9,889,500	0.381	37,647,899.5
			Total present value	74,013,347
			Averag per animal in initial herd	37,006.7

APPENDIX IX

(2)

YEAR	ADJUSTING FACTOR	MILK OUTPUT FROM CATTLE	DISCOUNT FACTOR 10%	PRESENT VALUE
0.	1.00 (1)		1.000	
1.		1,629,000	0.909	1,480,761
2.		1,179,000	0.826	973,854
3.		853,875	0.751	641,260.12
4.		617,625	0.683	421,873.87
5.		447,750	0.621	278,052.75
6.		32,400	0.564	182,736
7.		235,125	0.513	120,619
8.		169,875	0.467	79,331.625
9.		122,625	0.424	51,993
10.		88,875	0.381	38,619.375
		Total present value		4,264,306.8
		Average per animal in initial herd		2,132.15

APPENDIX X

(3) ALLEVIATED MORTALITY LOSS

YEAR	ADJUSTING FACTOR	VALUE OF ANIMAL AT LIVEWEIGHT OF 27.35 AND WEIGHT OF 36KG	DISCOUNT FACTOR 10%	PRESENT VALUE
0.	1.08 (1)		1.000	
1.		510,022.8	0.909	500,699
2.		345,594.6	0.826	308,298
3.		227,442.6	0.751	184,474
4.		141,782.4	0.683	104,584.36
5.		80,737.2	0.621	54,148.825
6.		37,414.8	0.564	22,790.102
7.		6,892.2	0.513	3,818.5544
8.		-13,784.4	0.467	-6,952.2999
9.		-28,553.4	0.424	-13,075.172
10.		-38,399.4	0.381	-15,800.584
			Total present value	1,154,753.6
			Average per animal in initial herd	577.38

APPENDIX XI

SOCIAL COSTS.

Construction and Management Costs	Adjustment factor	Cost
		Vr (0)
Cattle	0.80 (1)	20,000
Camel		40,000
Cost of land		20,000 (2)
Mustering Labour	0.50 (1)	23,400 for each year
Attendant		1,890 for each year

(i)

YEAR	ADJUSTING FACTOR	COST OF DRUGS FOR CAMELS	DISCOUNT FACTOR 10%	PRESENT VALUE	COST OF DRUGS FOR CATTLE	PRESENT VALUE AT 10% DR
0.	0.9 (1)		1.000			
1.		19,048.64	0.909	15,583.691	14,306.24	11,703.934
2.		18,366.92	0.826	13,653.967	10,345.24	7,697.3419
3.		17,714.84	0.751	11,973.459	7,498.92	5,068.52
4.		17,082.52	0.683	10,500.625	5,424.12	3,334.2065
5.		16,469.96	0.621	9,205.0605	3,932.24	2,197.7289
6.		15,877.16	0.564	8,059.2463	2,845.44	1,444.3452
7.		15,304.12	0.513	7,065.9121	2,064.92	953.37351
8.		14,750.84	0.4647	6,199.7779	1,491.88	627.03716
9.		14,217.32	0.424	6,028.1436	1,076.92	410.95267
10.		13,713.44	0.381	4,702.3385	780.52	267.462
			Total Present Value	92,972.18		33,704.898
			Average per animal in the initial herd	46.49		16.85

NOTES.

1. The paper is unable to take it's own adjustments due to various constraints. Nevertheless, it is unlikely that the adjustments are large enoug to offset results. Scott et al (1976) have estimated accounting prices for a wide range of products in Kenya using the Little and Mirlees method. Some of their estimates of the ratio of accounting prices to market in rural areas are used in the analysis.

2. The cost of land is arbitrarily selected at Sh. 20,000. The same cost was also used by F.M. Mwega in his study on the Economic damages and losses by Ticks and Tick borne diseases

APPENDIX XII

(2)

YEAR	ADJUSTING FACTOR	COST OF MUSTERING LABOUR	DISCOUNT FACTOR 10%	PRESENT VALUE	COST OF ATTENDANT	PRESENT VALUE AT 10% DR
0.	0.50		1.000			
1.		23,400	0.909	21,270.6	1890	1,718.01
2.		23,400	0.826	19,328.4	1890	1,561.14
3.		23,400	0.751	17,573.4	1890	1,419.39
4.		23,400	0.683	15,982.2	1890	1,290.87
5.		23,400	0.621	14,531.4	1890	1,173.69
6.		23,400	0.564	13,197.6	1890	1,065.96
7.		23,400	0.513	12,004.2	1890	965.57
8.		23,400	0.4647	10,927.8	1890	882.63
9.		23,400	0.424	9,921.6	1890	801.36
10.		23,400	0.381	8,915.4	1890	720.09
	Total Present Value			143,652.6	For Camel 11,602.71 +60,000.00	For Cow 11,602.71 +40,000.00
	Average per animal in the initial herd			71.83	35.80	25.80

APPENDIX XIII

(3)

YEAR	ADJUSTING FACTOR	COST OF DRY MATTER INTAKE FOR CAMEL	DISCOUNT FACTOR 10%	PRESENT VALUE AT 10% DR	COST OF DRY MATTER INTAKE FOR CATLE	PRESENT VALUE AT 10% DR
0.	1.00		1.000			
1.		267,413.6	0.909	234,078.96	150,600.68	136,896.02
2.		257,843.3	0.826	212,978.56	108,998.28	90,032.579
3.		248,689.1	0.751	186,765.51	78,940.554	59,248.36
4.		239,812.3	0.683	163,791.80	57,099.294	38,998.82
5.		231,212.9	0.621	143,583.21	41,394.388	25,705.915
6.		222,890.9	0.564	125,710.47	29,953.728	16,893.903
7.		214,846.3	0.513	110,316.15	21,737.254	11,151.211
8.		207,079.1	0.4647	95,463.465	15,704.906	7,239.96
9.		199,589.3	0.424	84,625.86	11,336.654	4,806.74
10.		192,515.6	0.381	73,348.44	8,216.474	3,130.48
	Total Present Value			143,956.4		394,139.98
	Average per animal in the initial herd			719.78		197.07

APPENDIX XIV

Our Environmental benefits resulting from desertification control can be estimated as follows:

ENVIRONMENTAL IMPACT	CAMEL J1 *	COW J 2 *
a. Possibility of plant regeneration	High (10)	Low (2.5)
b. Mobility	High (10)	Low (2.5)
c. Population Control	High (10)	Low (2.5)
d. Improved Organic matter/ soil	High (10)	Moderate (2.5)
e. Reduced burning of grassland and woodlands	Moderate (5) Moderate (5)	Low (2.5) Low (2.5)
f. Visibility disease of humans and livestock	High (10)	Low (2.5)
g. Reduced air polution resulting from wind erosion	High (10)	Low (2.5)
h. Genetic diversity of flora and fauna	High (10)	Low (2.5)
i. Resource management	High (10)	Low (2.5)

Environmental benefits of camel Keeping = $\sum j\ 1\ *$ = 95
Environmental Quantity indicator = 95/10 = 9.5

Environmental Benefits of cattle Keeping = $\sum j\ 2\ *$ = 30
Environmental Quantity indicator = 30/10 = 3

APPENDIX XV

These costs and benefits can be classified quantitatively as being either high, moderate or low. We shall use the following scoring procedure in our analysis:

High	10
Moderate	5
Low	2.5

We can therefore estimate our environmental costs resulting from desertification as follows:

ENVIRONMENTAL IMPACT	CAMELS	COWS
a. Overexploitation of woody plant's	Low (2.5)	High (10)
b. Creation of localised barren lands	Moderate (5)	High (10)
c. Trees and shrubs cut down for		
* Making stock enclosures	Low (2.5)	High (10)
* Cooking fires	Moderate (2.5)	High (10)
* Houses	Low (2.5)	High (10)
d. Destruction of vegetation	Moderate (2.5)	High (10)
e. Trampling effects	Light (2.5)	Heavy (10)
f. Soil loss	Moderate (5)	High (10)
g. Forage loss	Moderate (5)	High (10)
h. Reduction in soil productivity	Moderate (5)	High (10)
i. Population pressure	Low (2.5)	High (10)
j. Overgazing	Low (2.5)	High (10)

Environmental benefits of camel Keeping = $\sum q1 * = 42.5$
Environmental Quantity indicator = 42.5/12 = 3.54

Environmental Benefits of cattle Keeping = $\sum q2 * = 120$
Environmental Quantity indicator = 120/12 = 10

APPENDIX XVI

OPTIMAL USE OF THE ENVIRONMENT (II)

CATTLE

(I) COSTS

Management	Sh.	20,000
Land	Sh.	20,000
Medicine/drugs	Sh.	49,475.40
Mustering Labour	Sh.	117,000
Cost of attendant	Sh.	9,450
Dry Matter Intake	Sh.	523,982.20
Environmental	Sh.	120

(ii) BENEFITS

Milk output	Sh.	5,667,750
Environmental	Sh.	30

(i) COSTS

Management	Sh.	40,000
Land	Sh.	20,000
Medicine/Drugs	Sh.	146,602.80
Mustering Labour	sh.	117,000
Cost of attendant	Sh.	9,450
Dry Matter Intake	Sh.	2,281,892.40
Environmental	Sh.	42.50

(ii) BENEFITS

Milk Output	Sh.	117,220.500
Alleviated mortality	Sh.	5,631,706.80
Environmental	Sh.	95.0