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COMPREHENSIVE PLANNING OF
NATURAL RESOURCES:
PRESENT SITUATION AND
FACTORS TO CONSIDER
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ABSTRACT

Problems of the ecology, conservation, management and utilisation of a nation's renewable natural resources deserve a high priority in scientific, social and economic planning. Using examples from Kenya and other parts of Eastern Africa, the value of various renewable natural resources is described as well as the threats to which they are subject.

The importance of a coordinated approach to scientific research, management of the environment and national policy making is stressed. Planning should start with comprehensive land use surveys. National parks and reserves are also important, not only because they constitute wise land use in themselves, but because they provide a basis for comparison with regions which have been modified by man. These national parks and reserves should be located according to ecological criteria in order to create a network of representative ecosystems, biomes and habitats.

The most basic factor causing environmental stress is the rapid growth of the human population. In Eastern Africa, this leads to stress on marginal grasslands by overstocking and inappropriate cultivation. It is suggested that wild animals could provide more protein for human diets without causing the same stress to the environment as domestic species. The importance of assuring continued genetic diversity is also emphasised.

An even more serious consequence of the accelerating population growth is the increasing destruction of the remaining forests, particularly on mountains and hilly slopes, because forests are a key element as retainers of watersheds for vast areas and of soil stability.

Finally, it is suggested that developing countries should formulate scientifically-based conservation, management and utilisation plans for all renewable natural resources, taking into account the importance of the vegetation cover for the maintenance of the water regime, the productivity of soils and the habitat requirements of wild animals, with particular attention to the control of bush fires in rangelands and forests, clearing for cultivation, forest destruction and control of livestock numbers.

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The grim truth is that there has never in human history been any ecologically based long-term land use planning. Regardless of whether there have been serious pressures on the lands and waters or not, the utilisation of our most valuable resources has usually constituted environmental failure. This sad situation is quite clear from the testimonies of the lands and waters themselves in both so-called developing and developed countries. Whatever region or climatic areas one focusses upon in tropical, temperate or subarctic parts of the world, the evidence of unwise land use is overwhelming.

Therefore, in the interest of national prosperity and human progress in the various countries of the world many reasons make it imperative that problems concerning the ecology, conservation, management and utilisation of a nation's renewable natural resources deserve to be accorded high levels of priority in terms of economic, social and scientific planning. In subtropical and tropical countries with fast-growing populations, the nutritional needs alone provide sufficient justification for national efforts to improve the **efficiency** and increase the productivity of various forms of land without causing long-term deterioration. Yet, over the last century in general and in the last two decades in particular, there has been in most countries an ecologically unwise exploitation of renewable natural resources and a far-reaching destruction on an increasing scale of water, soil, vegetation and wild animal populations. Should this environmental degradation continue for another decade without energetic and efficient measures to stop it, there is little hope for the future of quite a number of nations.

Obviously progress - agricultural, industrial, scientific and educational - is the only road to prosperity. However, progress does not mean going ahead using methods and applying policies which have not taken ecological realities into account. Elementary ecological knowledge and conservation principles must be an integral part of all development planning and decision making at the same level as social and economic considerations, in order to avoid the process of gradual environmental decline leading to a point of no return.

The situation just described is global in scope, but also holds true for Africa. Can management and legislation be the answer to water and land use problems? It certainly can, provided it is ecologically sound, effective and implemented with a long-term perspective. It also needs a firm political will to implement what is ecologically necessary.

However, all attempts to plan and manage the renewable natural resources are futile as long as the human population growth is not under control. This is the basic conservation problem of Africa on which all other serious conservation problems depend.

THE PRESENT SITUATION IN KENYA AS AN EXAMPLE

In 1972 the Government of Kenya published its National Report to the United Nations on the Human Environment, presented to the U.N. Conference on the Human Environment. It consisted of a review and assessment of present environmental problems in Kenya. This basic document on the status of the natural resources in Kenya received much attention and respect from those governments and international organisations involved in the preparation of and participation in the U.N. Conference. The Report gives a firm background for future action.

The population of Kenya is totally dependent for its existence on the fertility of the land, that is water and soil. Four-fifths of Kenya consists of arid, low-yielding lands. Only 12 per cent of the land area gets adequate rainfall for intensive farming with a further 6 per cent of land getting marginal rainfall. Yet, 90 per cent of the 12 million population live in rural areas of the country and 75 per cent obtain their livelihood from the land. Seen against these facts, the increasing and accelerating rate of growth of the total population, 3.3 per cent in 1969 (one of the highest in the world), obviously has far reaching and serious implications for the environment and, therefore, ultimately for man.

Consequently, Kenya, like most other tropical and subtropical countries, is facing a problem of fundamental importance for the future of the country, namely the conservation, management and utilisation of the renewable natural resources from which the human population derives its subsistence.

In other words, it is essential to ensure the management of these resources and to avoid as far as possible the destructive environmental effects of the ever greater pressure on them caused by population increases. Yet, every day serious damage on an increasing scale is undermining the capital of renewable natural resources and reducing their utilisation potential.

Certain areas are already irreparably damaged, while in others the carrying capacity of the soil has been exceeded and degradation is accelerating. It is evident that certain of the renewable natural resources are deteriorating mainly as a result of unwise land-use practices which have been going on for a long time, and in addition new forms of environmental danger have recently become apparent, namely the pollution of the air, water and soil often through the use of toxic chemical biocides **which** on an accelerating scale are accumulating in the environment and in all living organisms, including man.

OTHER COUNTRIES

Of the other twelve African countries which are covered by this Seminar, the following ones show a roughly parallel situation to the one prevailing in Kenya: Sudan, Tanzania, Zambia, Malawi, Botswana and Swaziland. Somalia, Ethiopia and Lesotho are facing an even more serious environmental situation due to far-reaching erosion caused by man and livestock. Madagascar is also entangled in dramatic consequences of unwise land use, but owing to its peculiar ecological setting as an isolated subcontinent, it has problems of its own. Mauritius is in a somewhat similar situation, but due to the single culture which covers almost the whole island it has very specific environmental problems. Uganda, blessed by a relatively high rainfall, has so far escaped many of the destructive forces which are **affecting** all the other countries dealt with here.

However, whatever the ecological situation is in the various countries, they all need to plan the conservation, management and utilisation of their natural resources in a comprehensive way in order to avoid an unwise exploitation which might be profitable during the first years but in the long term have adverse effects.

USEFULNESS OF AND THREATS TO RENEWABLE NATURAL RESOURCES AS A BACKGROUND TO ENVIRONMENTAL PLANNING

Marine and Brackish Water Resources

Tidal estuaries and brackish water habitats produce environmental conditions that vary greatly from one area to another, depending on tides and freshwater outflows, temperature and salinity, bottoms and vegetation, and so on. Mangrove growths represent a very special environment, particularly below the water surface where the tangle of mangrove roots creates a peculiar underwater world with an extraordinary gathering of marine and freshwater animals. Usually estuaries and mangrove forests are regarded as unproductive wastelands, suitable for dumping industrial and urban wastes. The contrary is true.

Estuaries are often among the world's most fertile areas.

Coastal shallow waters and estuarine wetlands are often subjected to physical alterations besides being heavily polluted. Draining, dredging, filling and waste dumping of such coastal waters and lands are often highly uneconomic and can greatly reduce or entirely eliminate the food base for many or even all organisms in such wetlands, with negative repercussions also to human economic interests.

Coral reefs are in many ways an asset. They are important economically because the productivity of their organisms is high and contributes to several food chains in the ocean. Their fishery value is high, both directly and indirectly, for they provide food, shelter and spawning sites for marine life. In addition, they have mineral and recreational values.

Dynamiting for fishing and the trade in corals and shells as curios for visiting tourists have grown to such dimensions that it is now a threat to the living species and entire coral reefs. Some beaches, littorals and reefs have been virtually cleaned by collectors for commercial purposes and are now like lifeless submarine deserts.

Another threat to coral reefs is the unnatural accumulating sedimentation in the sea carried by rivers as a result of soil erosion from river banks and surrounding lands within the water basins. This erosion is in its turn due to unwise land use. It is an example of how man-made soil erosion in the interior of a country causes serious environmental damage in the sea affecting the productivity of marine fish and economically important tourist attractions.

The coastal waters are being polluted by oil discharged from ships accidentally or deliberately, as well as from industrial sites on land. The fines which have been imposed have little effect as a deterrent.

Deep ocean fishing by factory ships of several countries threatens populations of economically important marine fish living off-shore, for example marlin and tuna.

Freshwater Resources

Environmental deterioration of terrestrial resources affects freshwater resources, but it also works the other way around: misuse of water causes degradation of other resources. These problems merit attention. This is particularly true for Africa where freshwater resources are limited relative to area and population.

It is of great importance in conserving water resources that the soil-holding quality of the vegetation is not removed. Yet, this is just what is happening over wide areas of Africa. The results are that the soil erodes from slopes and river banks choking water courses, silting reservoirs, marshes and lakes and altering such marine habitats as estuaries, lagoons and coral reefs. Moreover, the amounts of water run-off, percolation, storage and slow distribution are no longer regulated in a rational way when the soil structure and vegetation deteriorate or are removed; this may lead to the collapse of productive landscapes. There are many examples of how such man-induced disturbances of watersheds, which formerly produced permanent and stable water flows, have changed them to irregular water courses characterised either by seasonal flash-floods and long periods of aridity or by dryness throughout the year. As a mobile resource, the availability of water rapidly affects the ecology of large regions. If it is polluted or contaminated or eliminated, the damage is quickly spread over wide areas. Therefore, the management of fresh-water ecosystems is of fundamental importance for the maintenance of aquatic quality, on which so many other resources depend.

Several lakes have no outlets and function as closed or internal drainage basins. Such lakes are often very productive and have a rich fauna. Many of them are alkaline. If toxic chemicals are used in industry and agriculture within such closed water systems, their residues inevitably end up in the lakes where they and other pollutants then steadily accumulate. This is, for example, the case in Lake Nakuru, one of Kenya's prime tourist assets.

Water development projects in the arid regions are not always of long-term benefit to a country, as too often such projects result in overstocking, which in turn often destroys large areas of grassland and converts previously productive areas into deserts. Such calamities can be avoided provided ecological factors are seriously considered at the planning stage. In particular, bore-holes or other types of artificial water supply can have very serious environmental consequences. Often far more and greater improvements in water supply can be achieved by proper management of soil, vegetation and livestock than through expensive construction of elaborate storage structures for water.

In regions where overgrazing already exists and in which no control can be exercised over the numbers or distribution of grazing domestic animals, water development should not be attempted. Under such circumstances, development of new water points in areas that previously had not

been used due to lack of water only leads to their overgrazing and deterioration. Where previously they would have supplied at least some grazing during the wet season without too much damage, this possibility could be eliminated by encouraging overgrazing during the dry season. Experience in many areas has shown that water development in such circumstances can at best provide temporary relief while livestock and human population increases to the capacity of the newly available range. Following this, however, the problems that were once confined to one area will have spread to an entire region. Thus, water development without control over stocking and without previous ecological research is another name for spreading deserts more rapidly.

Groundwater is a resource of very high value. The use of fertilisers has in many areas of the world, particularly in Sudan, affected the quality of the groundwater. It can be assumed that the same kind of pollution occurs in agricultural areas of other countries, and it is known that groundwater supplies in Kenya have been contaminated with chlorides, sulphides or fluorides.

Many kinds of water pollution exist in Africa and are tending to increase. Bacteriologic and helminthic pollution is widespread. Bilharzia is present in some areas and is especially associated with irrigation schemes. Silt pollution is increasing with forest destruction and cultivation on unsuitably steep slopes, affecting the potability of water, industrial use of water and fisheries. However, the main source of water pollution, apart from unnatural sedimentation and persistent pesticides, is due to dumping of industrial waste, and can have especially devastating effects in closed freshwater ecosystems.

At present river and lake pollution in Africa is more important than air pollution.

Besides water pollution, dam construction has also destroyed or altered the ecological role of rivers. The River Tana in Kenya is an example where the construction of dams for hydro-electric power is affecting not only the migration of freshwater fish but also that of partly marine fish of economic importance, for example eels. Construction of artificial fish passes could have provided the means for these fish to move freely, thus conserving a renewable resource of high value. Moreover, dams also prevent the downstream fertilisation effects of natural flooding on the soils in river valleys causing a decrease of productivity not only in seasonal wetlands such as flood plains and marshes but also in lakes and rivers and surrounding lands. In addition dams are only temporarily effective,

because they silt up and lose their retentive capacity. Later on floods recur, often with much more damaging effects than natural ones.

There are other adverse effects of irrigation besides the spread of bilharzia. Soil fertility is not always enhanced by irrigation. On the contrary, in the long term irrigation schemes in arid or semi-arid regions often prove to be detrimental. The high evaporation rate keeps salts in the soil. Irrigation tends to redissolve the salts and deposit them again as a crystal crust on the surface. Salinity increases and can make previously fertile areas useless.

Drainage of wetlands is another example of artificial intervention in ecosystems which does not always lead to desirable and planned results. Wetlands are often highly productive of protein and often maintain the water regime of a region, accumulating water during excess periods and distributing it during dry periods. Drainage of a wetland can affect the groundwater level in an area much larger than the wetland itself.

When discussing water as a resource, it is necessary to visualise that it is one element in a complex watershed system also involving air, land, vegetation and animals. The water circulation from clouds to land and back to the atmosphere is complex system of transpiration, evaporation and precipitation partly determined by the character of the drainage basin. These interrelationships dramatise the complexity of the environment and the impossibility of considering water as a separate, independent element.

Soil Resources

Africa's resources of fertile soils are under relentless pressure from people wanting more land for cultivation and higher yields. This is not only a social and political problem, but chiefly an ecological one because at the same time other renewable resources are under such pressure that their ability to maintain and produce soils is upset or destroyed. For example, unwise removal of the forest cover on mountains releases an accelerating erosion that can reach tremendous proportions. Solid matter including fertile soils and nutrients removed by water erosion in montane areas runs into hundreds of millions of tons. Much of the transport of sediment by river from the mountains to the sea is a natural phenomenon and has occurred long before man, but at the present time a high proportion of the sediment is due to man-made erosion. The intensity of this erosion is seen in the muddiness of the majority of the rivers.

The interactions between soil and vegetation and the rate of nutrient turnover from soil to plants and back to soil through decaying organisms are of vital importance for the maintenance of soil fertility. Moreover, the vegetation not only maintains the soil, it also protects it against wind and water erosion. In Africa, misuse of rangelands and forest through cultivation or overgrazing by livestock has caused accelerated erosion and serious losses of productive soils. Once lost, it takes very long periods to restore the soil, the vegetation and the productivity of the land.

The main factors behind soil erosion are destructive land use, the increase of unproductive and land-destroying livestock and the pressure of human population growth. These factors often negate anti-erosion measures to such a degree that soil erosion accelerates despite efforts to combat it. The prospects for long-term productivity in such eroded areas are not bright.

Soil erosion poses the greatest problem in cultivated zones where the rainfall pattern is seasonal, where monthly precipitation is about equal to or less than evapo-transpiration potentials and where rain falls as intense showers, which is frequently the case in Africa. The cultivation of short cycle crops on such soils is often accompanied by very rapid erosion. Soil losses are particularly catastrophic if the first rains falling on ploughed and seeded slopes are intense downpours. In addition, the spread of pastoralism into areas of steep topography brings further danger of erosion, since overgrazed and trampled slopes are particularly vulnerable to soil losses. There are examples in all regions of Africa of widespread, increasing erosion due to unwise land use through pastoralism and subsistence farming.

The degree of soil pollution is, in general, not known due to lack of monitoring. That soils must receive considerable pollution by organochlorine pesticides is indicated by the study of a river system in Kenya where all sampling was done at low flow thus indicating that the high residues found were most likely the result of groundwater flow.

However, there are further kinds of soil pollution other than through biocides, industrial waste and airborne fallout of radioactive materials. There is also soil pollution through biological disease agents. Pathogenic micro-organisms excreted by man are retransmitted to man by direct contact with contaminated soil. Hence, the chain in such cases is man-soil-man or man-soil-vegetation-man. Animals can also enter in the contamination chain: animals-soil-(vegetation)-man.

This sort of pollution is of vital importance to public health and is checked chiefly by sanitary control and preventive measures.

In Africa, man-made erosion is the gravest danger to which the soil is exposed. The ultimate goal of soil restoration and conservation is to put the complex biological processes of soil maintenance and soil formation back to work as they functioned before the decline. This is necessarily a long-term task.

Plant Resources

As stated in previous sections, the plant cover protects and partly creates the soil. The forests accumulate and distribute water. Without vegetation a region cannot function in a productive way. In addition, the vegetation is the sole means of converting solar energy, minerals and moisture into forms which sustain life. In other words, the vegetation determines, in relationship with sunlight, water and soil, the basic pattern of the environment.

A considerable part of Eastern Africa receives less than 500 mm of annual rainfall, and the country consists of semi-arid and arid lands. These low-yielding rangelands are chiefly marginal and not suitable for either cultivation or animal husbandry, but they have a very high protein productivity when utilised by the indigenous herbivores which have evolved in these arid habitats and to which they are **admirably** well adapted.

Unfortunately, some of these rangelands are, through mismanagement, deteriorating on an accelerating scale. Productive grazing lands turn to semi-desert or desert through overcultivation, misuse of fire, overgrazing and overtrampling. This destruction of the protective savanna vegetation is followed by loss of soil through erosion and the elimination of the normal water cycles. All these factors reinforce each other in a vicious circle which leads eventually to the collapse of an otherwise productive landscape.

Also forests disappear rapidly. For example, at present only less than 3 per cent of the land area of Kenya is covered by forests. The main economic value of the remaining indigenous forests in Eastern Africa is certainly their ecological role as accumulators and regulators of water resources, as maintainers of environmental health, as retainers of watersheds and soil stability and as producers of protein resources in the form of wild animals. Yet, these forest resources are being depleted very rapidly, not only on almost all the hills and mountains but also in the lowlands. There are many recent examples of how rapidly the forests disappear on mountain slopes as a result of settlements of squatters and pastoralists, which mean burning, grazing, browsing and trampling forests to death.

In Kenya, over the period 1964-1970, an average of 6000 ha. has been converted annually to agricultural settlement as a result of official redesignation of forest reserves. The conversion rate is also high in areas outside gazetted forest reserve, but no precise information is available. Most areas being converted are climax communities in the form of high forest. This is bad economy.

Wood cutting for domestic fuel is a serious problem in many areas, particularly in arid and semi-arid regions. The woodlands at the fringe of arid lands disappear very rapidly and give way to desert. Charcoal-burning on an industrial scale and for export also contributes to a rapid disappearance of savanna woodlands.

The plant uptake of toxic chemicals is an environmental danger associated with modern farming. Its occurrence has to be monitored as long as toxic chemicals are used in agriculture and forests.

Wild Animal Resources

Wild animal resources are of great economic importance for protein and hide production and commercial tourism, besides being of pronounced cultural, educational and scientific value. Moreover, wild animals play an important role in all habitats by contributing in many ways to the well-being of the landscape: to the maintenance and dispersal of vegetation and the control of both plant and animal populations. Conservation, management and wise utilisation of these animal resources are difficult problems, but it is even more difficult to reorientate people from their traditional land use and cultural habits. Therefore, conservation of wild animal resources in Africa must necessarily be concerned with people as well as with wildlife.

The destruction of the natural vegetation of grasslands and forests referred to above is followed by the disappearance of wild animals, and this productive resource is being replaced over wide areas by less productive forms of land use which, moreover, in contrast to the indigenous animals, clearly contribute to the deterioration of the landscape.

Poaching is often considered to be the gravest danger to the African mammals, but cultivation has done far more damage to wild animals because it alters or destroys habitats, in other words it removes the basis of existence for most mammals.

The wild animals have evolved on the grasslands and in the forests and are usually in balance with the vegetation, the climate, the water resources

and the soil. Therefore, this complex of resources is often a much more productive unit on a sustained yield basis than lands utilised by livestock; particularly on marginal lands.

Each area of grassland or forest has a carrying capacity beyond which it cannot be utilised by animals or man without causing damage, deterioration and decreased productivity. In undisturbed areas inhabited by natural populations, various mechanisms regulate the animal numbers in relation to the environment so that they remain within the habitat's carrying capacity. In areas altered by man and used by him or his domestic livestock, overexploitation often results, causing the habitat to deteriorate.

When the carrying capacity of various rangelands is studied in the light of human failure to plan, use and manage them properly, one may question whether livestock has any place at all on arid rangelands. With few exceptions the available data and experience seem to indicate that in the long run cattle, goats and sheep are uneconomic in arid and semi-arid regions, inevitably producing such serious damage to vegetation and soil as to ruin the landscape. Where wild animal populations are still allowed to utilise comparable arid lands, animals and landscape both flourish, producing a sustained high yield. Even though figures on carrying capacities from various areas of Africa have to be taken as approximations, they definitely indicate that wild habitats used by wild mammals reach tremendous biomass values and remain within the carrying capacity of the land. Just the opposite situation prevails for most land utilised by domestic livestock. Despite the fact that the biomass of livestock is considerably lower than that of wild mammals, the domestic animals appear in virtually every case to exceed the carrying capacity of the land.

Therefore, whether it involves wildlife management or animal husbandry or both, it is essential to adjust animal populations to the carrying capacity of the habitat or the pasture. A high production of proteins and hides from wild mammals can be consistently maintained on lands which would deteriorate under other forms of use. Africa is exceptionally well stocked with a wide range of highly productive wild herbivores, but this potential has so far not been rationally utilised.

Although I have chiefly dealt with the role of wildlife as a protein resource, it proves to be of high economic value in other ways as well. Tourism and recreation are in Africa largely dependent on wild animals, which in this respect are utilised in the form of national parks and nature reserves.

Wildlife management includes restoring, protecting, conserving and maintaining animal populations. All these stages require successful cooperation with the environment, a long-term, ecologically based policy and synchronisation with other kinds of land use within and outside the area involved. No such management can ever be successful if it is not based on ecological research.

THE PLANNING OF NATURAL RESOURCES USE

The previous section has reviewed some of the conservation and resource use problems in Eastern Africa as a background to the present environmental situation. The rapid development and the rapidly increasing human population in Africa have during a relatively short time produced dramatic changes and new kinds of interactions with the environment. In fact, the relations between man and his environment are now changing so fast that productive resources are seriously endangered and this process will also hamper a well-balanced development.

Can an accelerating development be achieved without environmental disruption? It certainly can, if the political will is firm to avoid unnecessary damage to renewable natural resources by maintaining environmental quality as an integral part of the development process. Such a development programme will be costly at the initial stage, but will pay off in the long run.

Since all the renewable natural resources are interacting, solutions to environmental problems connected with these resources require an integrated approach. Likewise, land use planning and a land use policy must necessarily be based on the totality of renewable natural resources as a whole unit consisting of interrelated resources. In the past, planning, policies, management and utilisation of renewable natural resources have almost exclusively been organised along sectoral lines because ecological considerations were mostly absent.

An ecologically based, integrated management approach to the planning of renewable natural resources in Africa would exploit the potential of these associated resources and insure their maximum productivity on a sustained yield basis.

Therefore, an important part of the development planning process should be a clear-cut national policy on water and land use, including the fullest integration of air, water, soil, wild vegetational and wild animal resources into the overall planning and utilisation of a nation's resources.

Such an integration must, of course, be based on the real economic and ecological values and potentials of these renewable natural resources in comparison with other resources (agriculture, animal husbandry, exploitation of mineral resources, etc.) and their effects on the environment. In addition, other land uses, such as human settlement, tourism, industrial development and so forth, must also be considered in this context.

By taking account of the numerous potentialities of a given area or region or ecosystem and of the various options for development and high productivity on a sustained yield basis in relation to the foreseen needs of the nation, such a policy would ensure a rational use of a country's natural resources, based on a multiple use concept and leading to the best economic results of land utilisation and the safeguard of the fertility and functioning of the ecosystem.

Obviously such a policy must be based on an adequate knowledge of the potential of a nation's natural resources and their interrelated functioning. Such knowledge can only be obtained through geological and ecological surveys of the land leading to the compilation of land capability maps of each region. This material would be the basis for interdisciplinary planning of various forms of land use in each country or region.

Since renewable natural resources are dynamic and changing, particularly when utilised by man, such ecological surveys covering the whole of a country have to be undertaken at regular intervals in order to provide governments with necessary background data for a continuous planning process.

An ecosystem approach to the conservation, management and utilisation of natural resources requires basic data on all environmental factors affecting these resources such as physical, chemical and biotic forces. They all interact with one another.

Land Use Surveys as a Part of Comprehensive Planning

A thorough understanding of the interrelationship between ecosystems and different types of environmental utilisation is essential for planning.

Before trying to review the tricky subject of land use effects on an ecosystem or vice versa I would like to stress the limitation of current knowledge. We still have a long way to go to overcome the fragmentation of our understanding of tropical ecosystems, whether natural or managed, and of all the organisms which are interacting in these ecosystems. This is not an easy task, because in our time man-made changes accelerate in almost every

climatic-biotic zone creating drastic alterations to renewable natural resources supporting life. This situation complicates the study and management of ecosystems as well as any land use planning. However, there is no time to waste, so we must take action using the knowledge presently available.

The aim of conservation measures should be to maintain the high productivity of an area or to restore an area in order to regain its ecological potential and diversity. It is also necessary to recognise and foresee the needs of future generations.

Restoration of areas which have been ruined by man can only be successful if the remedial action traces back step by step the ecological processes in the natural cycle which at earlier stages had been upset by man. In such restoration schemes technological options may be available to effect a cure in cooperation with the environment.

Policy, research, conservation and management are essential for the wise utilisation of renewable natural resources. All these components are dependent upon each other. Research data must be available prior to policy formulation. When the land use objectives of an area or a region have been determined, monitoring and research must go on in various fields as a basis for management. But management may also set priorities for research. Finally, both research and management may induce policy revisions.

Ecological land surveys are fundamental to planning development and optimal utilisation of renewable natural resources. They are also important tools for land use knowledge and should be compulsory in the national interests before any development plan is decided upon. This is especially true for already productive regions where it must be certain that habitat manipulation does not lead to undesirable effects due to lack of understanding of climate-water-soil-plant-animal relationships.

Ecological land and water surveys necessarily involve team work. A specialist group, ideally, should include a climatologist, a geomorphologist, a geographer, an aerial photographer, a pedologist, a hydrologist, a limnologist, a plant ecologist and an animal ecologist. It is useful also for such integrated surveys to have sociologists and anthropologists (ethnologists) on the team, because local peoples' habits and knowledge of the environment are based on generations of experience and are often very accurate. Interdisciplinary land surveys have been made with important results in a number of countries. The value of such integrated surveys has been particularly well

demonstrated in Australia and New Guinea, where the Commonwealth Scientific and Industrial Research Organisation (C.S.I.R.O.) has developed techniques for this sort of extensive regional survey.

To be significant, land use surveys have to be concerned with whole ecosystems. Extensive ecological land surveys are particularly valuable for those concerned with plant and animal population management. Surveys of single factors, soil or vegetation alone, are certainly useful, but the results are of limited value and can be highly misleading as a basis for management decisions at ecosystem level. It is, for instance, dangerous to base recommendations for future land use on the vegetation that happened to be on a rangeland when the survey was made. In fact, surveys of single components of the environment are not truly ecological in character. Ecological surveys must involve the entire environment or, at least, all renewable resources - air, water, soil, vegetation and animals. Man is included in the last category.

Of elementary importance, both for determining policy and drawing up plans for long-term research, is to know the past history of the area concerned and to what extent it has been influenced by human impact. Each land or water system is the product of a long history of landscape formation. Without facts about the historic background of a present ecological setting, there is a risk of making serious mistakes in both research and management, as well as in establishing a policy, because factors determining the prevailing situation are not understood.

The basic question behind each land use survey is the ecological potential of the region concerned. It can be expressed in many ways. For management purposes, whatever the final goal of a land development plan, the biological productivity of a given area, as a part of the energy flowing through the ecosystem, gives a firm basis of practical information. Amongst many data emerging from ecological land surveys is the carrying capacity of an area. It gives a measure of the number of individuals of any domestic or natural plant or animal species which the area concerned can support. However, it must be borne in mind that the carrying capacity is not fixed. It varies in many ways in interaction with several environmental factors and is of course greatly influenced by human action.

The information expected from any land use survey, besides the ecological potential of an area, would include also the ecological feasibility of planned land use. When this is determined, other questions such as the social feasibility or economic viability of a project can be answered.

The place of nature conservation in land use planning is obvious. One of the most important conclusions of a landmark conservation conference on "Conservation of Nature and Natural Resources in Modern African States" (Arusha, 1961) was that a study of habitats emphasises the basic principle that, no matter to what use land is put, its maintenance is dependent upon as close as possible continuous plant cover, since that cover is the obvious and simplest mechanism for taking in Africa's chief energy resource - sunlight. In fact, the maintenance of a permanent vegetal cover in order to absorb as much light as possible must form the basis for land use development.

A useful and desirable end product of a land use survey is a land capability map. Such a map is based not only on physical factors of the environment (topography, geology, climate, water regime, soils, vegetation, fauna, human population density) but also on social factors and other features of human activities including land use history. Obviously aerial photographs are particularly useful as a basis for land capability maps. In fact, the cost of modern land surveys can be considerably reduced by interpreting from aerial photographs. All interpretation of data from a land use survey with or without aerial photographs can only be made through integrated interdisciplinary methods, even in cases where the objective is to survey a single factor of the environment.

At the present time with increasing human populations and decreasing natural resources, the need for ecological land surveys is particularly strong. Man is no longer in the position to exploit the environment by working against it. He must cooperate with the environment in order to survive. Only ecological land use surveys at ecosystem level will enable man to understand how to use the environment to his benefit and the benefit of the environment.

National parks and equivalent reserves are essential components in any system of land use surveys and land use planning, not only because they constitute a wise land use in the form of recreation, education and research, but also as sample areas for comparison with regions which have been modified by man.

The important role of national parks and equivalent reserves in the fields of international conservation, research, education and recreation as well as national economy and development is becoming increasingly recognised in many countries on all continents and by international organisations which are not directly involved in conservation activities. So far, however,

national parks have been primarily regarded as national assets. The traditional way to select areas as national parks has been based mainly on special features such as spectacular landscape scenery, or rare and interesting geological sites, vegetation and/or fauna. In fact, the areas of many national parks have been chosen to preserve natural curiosities. Also areas where historical events have taken place have in certain countries been set aside as national parks. It is not wrong to use such criteria as national values for selection of national parks, but they emphasise single features rather than the natural scene as a whole (habitats, biomes, ecosystems) and such a limited approach may in the long run be dangerous, because it might lead to unexpected surprises and the disappearance of what one wanted to preserve.

Today we cannot afford any longer to base our actions concerning nature on emotional romanticism. We have to face ecological realities and they are, due to ourselves, very serious.

One may ask whether present and future conflicts over land use, due to population and economic pressures or political aspirations, can be reconciled with the idea of having large areas set aside for national parks. The latter are often regarded as unproductive. This is a wrong view. It is indeed as vital to preserve habitats and ecosystems as it is to set aside areas for other human needs. This is just the essence of ecological planning on a continental scale.

Some people foresee a dim future for national parks in countries which are at present suffering from heavy overexploitation of natural resources due to ecological ignorance and overpopulation. These people do not seem to have learned from past and present mistakes. These mistakes will certainly be an important background when it comes to sound ecological planning and the formulation of long-term land use objectives.

Hitherto the selection of sites for national parks in various countries has been a rather disparate process. The motivations have varied greatly from country to country but usually they have had one common denominator, namely that the area set aside as a national park did not constitute at the time an economic sacrifice. Therefore most national parks of today are located on marginal lands or in remote and inaccessible areas or on what was considered wastelands. Fortunately, many of these areas harbour a rich animal life and at the present time function as refuges for many endangered species.

The idea of selecting areas for a national park system, based on ecological criteria at the national level, in order to create a network of

representative ecosystems in each country is emphasised by the African Convention on the Conservation of Nature and Natural Resources signed by the African Heads of State in 1968. Its Article X on Conservation Areas stipulates the following:

1. The Contracting States shall maintain and extend where appropriate within their territory and where applicable in their territorial water, the Conservation areas existing at the time of entry into force of the present convention and, preferably within the framework of land-use planning programmes, assess the necessity of establishing additional conservation areas in order to:
 - (i) protect those ecosystems which are most representative of and particularly those which are in any respect peculiar to their territories,
 - (ii) ensure conservation of all species and more particularly of those listed or may be listed in the annex to this convention;
2. The Contracting States shall establish where necessary, around the borders of conservation areas, zones within which the competent authorities shall control activities detrimental to the protected natural resources.

The obligations in the African Convention will lead to a fair representation of all kinds of ecosystems in each African country and hence also on the African continent. This is an example for other continents to follow because it is now high time that the national parks and equivalent reserves of the world should represent the different continental and oceanic ecosystems and major biomes. In their approach to national park systems and criteria for selection of areas for reserves, the world's nations must now go beyond national boundaries to create a representative global network of national parks which will give humanity a complete pattern of various natural ecosystems and major biomes.

The African Convention obliges the Contracting States to ensure that conservation and management of natural reserves are treated as an integral part of national or regional development plans.

Environmental management problems are as varied and as changing as the habitats themselves. They depend on various kinds of land use and on human population pressure. Basically, the role of renewable resource management is to keep the areas concerned optimally diversified and in harmony with the environment in order to respond to the needs of man. A sound management policy also requires some basic conservation concepts, including ecological and biological considerations and a respect for native plants and animals, which should always have priority over exotic species. The development and application of management measures to obtain the greatest sustained public benefit from wildlife, or any other natural resource,

should never be allowed to go so far as to threaten a species or subspecies with extinction.

Modern management of the environment must function by foreseeing **the tremendous** future human pressure on habitats, biomes and ecosystems. A great deal can be learned from the numerous human mistakes and cases of land misuse during past centuries in order to reduce as far as possible man's detrimental impact on the environment. Much of the damage done to biomes and ecosystems during past centuries is irreparable. Nevertheless, management measures should include environmental restoration designed to put back the natural interactions that lead to fertility in a healthy landscape.

The ecosystem dimension is important in all environmental management. It is desirable to avoid conflicts between natural ecosystem processes and human control and utilisation of ecosystems or parts of them. Simplification of ecosystems and uniformity of vegetation are the results of monocultures. These may initially be profitable, but in the long run they often lead to degradation and loss of stability. Accelerating human population growth is an increasingly important factor influencing ecosystems negatively. It is imperative that this relationship is not overlooked in human ecosystems management and planning of renewable natural resources at national or regional levels.

Ecosystem management is necessarily an ecologically-based exercise. It is the antithesis of unplanned exploitation, which so far in a reckless manner has characterised man's 'development' of the environment. An ecologically based and well explained land use policy will help the citizens of a country understand in a balanced way their role in the world as a part of the environment. **If they appreciate this, they will also understand why renewable natural resources should be managed so that nothing irreplaceable is destroyed.**

Land Use Conflicts

Many types of land use in Eastern Africa are detrimental to the environment and in this way also to human society. Examples of such conflicts are manifold. Here only one example will be given but it is representative for wide areas of the continent and has high priority for remedial action. It is the desertification in arid and semi-arid regions. In Sudan, Ethiopia, Somalia, Kenya and Tanzania man-made deserts have been created or are being created. Mountainous Lesotho has similar problems. Even in dryer parts of Madagascar warning signs are visible. The main factor behind this process is unwise human land use through **overgrazing** by goats and cattle, deforestation,

cultivation practices, uncontrolled fires and in some areas total removal of vegetation by digging up roots. Climatic factors, such as drought periods, cannot alone induce the same environmental changes. In northern Somalia, for example, it has taken less than 100 years to alter a flourishing woodland savanna of parklike character with rich grasses under the trees and forest-clad mountain slopes and plateaus to a desert-like landscape ruin. Where formerly this area produced food and shelter for elephant, black rhinoceros, wild ass, large antelopes such as Swayne's hartebeest, oryx, greater and lesser kudus, gerenuk and beira, three species of gazelle, lion, leopard and cheetah, today only a fraction of this fauna remains.

Although it is politically and socially difficult to stop the present land use practices in Somalia and in other arid or semi-arid regions, it is an ecological and economic imperative for the survival of man in these areas to do so. The number of livestock has to be drastically reduced in order to correspond to the carrying capacity of the land.

Brown (1971) discusses the basic relationship between the dietetic needs of pastoral people, the number of stock they must keep to supply these needs and the productive capacity of the environment. There is a basic minimum number of cattle required to support a human family. Where rising human populations become too great to permit each family to maintain this necessary minimum herd, damage to the environment through overstocking becomes inevitable. The prevalent overgrazing situation in many areas reflects human over-population.

The prevalent land use in arid and semi-arid areas is grazing by livestock in a nomadic pattern directed by the seasonal availability of water and forage.

On properly managed rangelands in arid and semi-arid regions, the effect of rain is wholly beneficial. On overgrazed rangelands, however, rain causes erosion, which not only permanently lowers the carrying capacity of land utilised by domestic and wild animals, but also destroys the natural watering places by choking them with silt and by increasing the rate of runoff. Therefore, proper water and soil conservation is a vital necessity if arid lands are to maintain their resources.

To sink bore-holes and build dams in order to increase the water supply or to provide water-points in places where no permanent surface water exists are only short-term solutions which do not solve environmental problems, but usually aggravate them by encouraging animals and people to remain in an

area longer than the pastures can maintain them without serious deterioration. Therefore, artificial water supplies usually create more long-term environmental problems than they solve.

There are planned and ongoing projects for the settlement of nomads in Africa. Is this the right solution? The way of life of nomads in arid and semi-arid areas is in fact an ecologically sound use of poor rangelands as long as the livestock does not exceed the carrying capacity of the area. Today there is hardly any area in arid and semi-arid Africa where the land is not overstocked resulting in environmental deterioration.

Agriculture on arid and semi-arid lands can have the same devastating effect on the soil resources.

Pastoral nomadism in its original state came very close to the productive and fruitful coexistence of vegetation and wild animals in habitats unspoiled by man. This is particularly the case on the arid and semi-arid lands of Africa, which I refer to as marginal lands. (They are marginal in the sense of being unsuitable either for agriculture or for livestock.) There, the wild grazing animals changed pastures regularly and did not destroy the vegetation. Nomadic livestock did the same but began to overgraze the rangeland when they became too numerous.

This means that pastoral nomadism of the past was a form of rational land utilisation, although less productive of animal proteins than the wild herbivores also on marginal lands. Not before livestock increased to such a number that there was no possibility for the grazed vegetation to recover, despite nomadism, was there any serious detriment to the habitat. Ever since, deterioration has gone on preparing the ground for desertification.

The important ecological lesson is that livestock raising on marginal lands is bound up with movement, if habitat is to be conserved, and has to be adjusted to the carrying capacity of land used in rotation. Nevertheless livestock grazing is far inferior to the protein productivity of wild grazing animals which, in addition, do not destroy the environment despite the fact that they represent a much higher biomass than livestock.

At least half of Africa's land area is marginal or submarginal for crop production. (Ledges 1964) About 90 per cent of Africa's lowland savannas are also marginal for domestic livestock production due to low or erratic rainfall. Most of these grasslands are extremely vulnerable to overgrazing and overtrampling, particularly during dry spells. In the tropics, natural populations of wild ungulates seldom overgraze, while livestock almost always

does so. Moreover, water needs, diseases and other environmental obstacles constitute further limitations on livestock production.

The African human diet is in many parts of the continent deficient in animal protein. Domestic animals cannot satisfy the protein needs of the continent's people for the reason that they are not generally adapted to the tropical environment and so destroy its productivity. The wild animals are not exposed to these environmental limitations. On the contrary, they are a product of the same environment. Thus the utilisation of wild animals as a food resource is the best and most rational use of African marginal lands, both for economic and ecological reasons. The results of experience all over tropical Africa clearly indicate that a new approach to land use planning, management and utilisation based on wild animals is necessary. Of Africa's total area, about 40 per cent is occupied by savannas. About 37 per cent is infested with tsetse flies, which transmit trypanosomiasis (nagana or sleeping sickness) to livestock, while wild animals are immune. This factor alone emphasises the usefulness of wild animals in comparison with domestic stock.

It has been claimed that the nomads' way of life has kept them "in a state of pronounced under-development". This is true, but it has to be added that it is primarily due to the fact that nomads are in reality overdeveloping the lands they utilise by unwise overgrazing leading to desertification. It is highly doubtful that the settlement of the nomads in agriculture will provide them with a more rewarding way of life or will increase their contribution to the national economy, if the intention is that this settlement has to take place in the same areas which at present are utilised by African nomads. Or is the idea to settle the nomads in areas which are already developed for agriculture? Then there will be other conflicts.

An assessment of the ecological potential of marginal lands utilised by nomads should point out what kind of land use on a sustained yield basis would be most justified from ecological, economic and social points of view.

Whatever the result of such a survey would be, the first step in a land use plan for the present marginal areas used by nomads must be a restoration programme giving the water, soil and vegetation a chance to recover.

It must be borne in mind that arid and semi-arid grazing lands such as desert shrubs and semi-desert grasslands (in the sense of being climax habitats under present climatic conditions), both in lowland and high plateau areas and regardless of whether they are located on flatlands, rolling plains

or mountain slopes, are highly vulnerable to cultivation and animal husbandry.

In planning marginal lands on an ecological basis it is not enough to analyse water, soil, vegetation and the fauna as separate entities. Although all these elements operate in their own way, they are dependent on each other and form one ecosystem. Fire is also often an important factor. The ecological background is very complex. This is one of the reasons why marginal lands break down when occupied by monospecific combinations of species, e.g. goats, cattle and men.

The conclusion is that it would be ecologically and economically more realistic to utilise the natural productivity of marginal lands rather than to develop them for agriculture in order to settle the nomads.

Besides the increasing human and livestock population, one of the main factors behind the present misuse of rangelands in Africa is the common view that land must be made available freely at nominal cost for grazing of livestock. This gives no incentive to proper commercial ranching and economic land use, but leads to the treatment of land as free to be used destructively and without personal responsibility and planning for the future.

PLANNING OF GENETIC RESOURCES

Genetic resources are too frequently completely forgotten in the planning and development of natural resources.

The population of the world is expected to double in size by the year 2000, but our planet's land area on which to grow food can be expanded only by the gradual addition of poorer lands, while the lands already under cultivation are deteriorating due to overutilisation and other unwise land use. The fertility of crops and the productivity of both wild and domestic animal resources are therefore increasingly vital. Genetic diversity is essential to fertility and to the health of plants and animals at population level.

These facts were recognized by UNEP's Governing Council at its meeting in Nairobi in March 1974, and it was felt that the preservation of genetic diversity should be one of UNEP's most important objectives and priority areas.

The genetic diversity of the African fauna is a precious resource, of which many future dividends are still unknown. It is extremely unwise to exterminate such resources.

Examples of the tremendous genetic diversity of animal species in Africa are Lakes Nyasa, Victoria and Tanganyika. Each of them contains more species of fish than any other lake in the world: 244, 208 and 193 species respectively. However, even more remarkable is the high degree of endemism shown by cichlid fishes (Cichlidae). Of 202 cichlids in Lake Nyasa, 198 are endemic; in Lake Victoria there are 164 (of 170) and in Lake Tanganyika all 126 species of cichlids are endemic. Other examples are Lake Edward with 19 endemic cichlids out of 28, and Lake Kivu with 8 out of 9. These figures explain better than words the tremendous adaptive radiation and speciation which have taken place in these lakes. In some cases, as with Lakes Edward and Kivu, these processes have been rapid, while in the other lakes the species have evolved over a long period of time. This is clear from the number of endemic genera in Lake Tanganyika: not less than 42, while there are 20 in Lake Nyasa, 4 in Lake Victoria, 1 in Lake Edward and none in Lake Kivu.

The significance of these figures is that the African lakes are exceptional store houses of genetic diversity. Many terrestrial habitats show the same phenomenon without producing such spectacular figures as the lakes mentioned.

ENVIRONMENT AND DEVELOPMENT

Can the development of natural resources in Africa be achieved without environmental disruption? It certainly can, if the political will is firm to avoid unnecessary damage to renewable natural resources by maintaining their productivity on a sustained yield basis as an integral part of the development process. Moreover, development in Africa must in many areas be initiated with restoration schemes. Such development programmes may be costly at the initial stage, but will pay off in the long run.

The environmental threat to the developing countries of Africa comes actually from their current misuse of the resources of water, soil, vegetation and wildlife. The developing countries are in reality using up their renewable natural resources before the development process has accelerated or even begun. This dramatic situation is being caused by the population increase and lack of control of how the land is used. It is a terrific challenge for a nation, because it undermines its potential for development. This situation emphasises the necessity of comprehensive planning, including ecological-socio-economic considerations, for a rational utilisation of natural resources.

Let us hope that in the recommendations emerging from this Seminar we can achieve a positive effect by drawing attention to an existing and accepted document, namely the African Convention on Conservation of Nature and Natural Resources, signed by the African Heads of State in 1968, because it constitutes a firm basis upon which developing countries can formulate a long-term, ecologically based policy for conservation, management and utilisation of renewable natural resources.

I would like to suggest that this Seminar recommend that governments in developing countries should formulate policies, within the framework of total environmental planning, which would establish scientifically-based conservation, management and utilisation plans for all renewable natural resources taking into account the importance of the vegetation cover for the maintenance of the water regime, the productivity of soils and the habitat requirements of wild animals, with particular attention to the control of bush fires in rangelands and forest, clearing for cultivation, forest destruction and control of livestock numbers.

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