DEVELOPMENT AND THE ENVIRONMENT IN AFRICA

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INTRODUCTION

By

William Mares and Liberty Mhlanga

If there is one thing that capitalist, socialist, liberal, conservative, rich man, poor man agreed upon in the last two hundred years, it was that the best of all possible economic worlds is one of unlimited expansion. Millions of people have been killed in efforts to prove that one system of ownership and distribution is better than another, but no one questioned the notion that growth per se was an unalloyed good.

Thus, as Ignacy Sachs writes, "Only a profound sense of uneasiness can explain why the theme of zero growth should have so captured the public imagination and why it should have been taken up by public opinion within so short a time, despite the fact that it represents a complete reversal of (the economic thinking) of the last two centuries...."

The sources of this malaise are manifold; they lie beneath the Persian Gulf, in the thin soil of much of the world, in the choking air of the world's metropoli, in climatic pressures and in the intractibility of the human species.

What we are concerned with are the failings of the so-called development process. Regardless of what happens with the notion of zero economic growth, it is abundantly clear that the poor countries continue to experience more than their share of misery. Is there any way out?

Despite the universal currency of the term 'development', the fact is that as a concept and a discipline, development economics is less than thirty years old.[1]

As the governments of Western Europe put their economies back into order after World War II, and as industrialised countries in general shifted to peacetime economies, the consensus among economists was that poor countries would be helped to develop by the very fact that the rich nations kept running and expanding at more or less full stream. Both colonies and independent states would benefit from a sort of 'trickle-down' effect. By the mid-fifties, just as de-colonisation began to speed up and the economies of the industrialised nations were back in gear, it become evident to those who worried about such things that the trickle was simply not sufficient. The poor countries were so poor that they did not even have the boots, let alone the bootstraps with which to pull themselves up.

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1. We draw heavily on the paper by Barbara Ward, "Half Full or Half Empty: Our Planet", Adlai Stevenson Institute, 1974.

Most of them had been sources of primary products for their former masters, the prices for which were totally out of their control. They lacked the infrastructure of public facilities, education, trained manpower to function as viable governments and economies.

Meanwhile, the onset of the cold war set the scene for the next stage of development. Both blocs attempted to win friends and influence governments by pouring large amounts of aid, grants and outright gifts into the underdeveloped countries. In its most selfless light, the theory was stated by W.W. Rostow in his Stages of Economic Growth. The aid would help build a platform from which the recipient nation could 'take off' into the sunlit uplands of self-sustaining material well-being.

Swarms of aid officials, technologists and economists spread out over the globe like locusts, testing this theory, that procedure. They talked about product cartels, import substitution, leading sectors, rapid industrialisation and new towns. Roads, dams, power stations were built. Health and sanitation projects covered the underdeveloped world.

The gross national products of these countries did grow, sometimes as much as five or six per cent per year. But their populations also grew, alarmingly. Mortality rates plummeted while birth rates remained high. It was found that the smallest population growth rate among the less developed countries, about 2 per cent, was twice the growth rate of the population of Europe in the nineteenth century, when that continent become heavily industrialised. It was a vicious cycle.

> Rapid population growth tended to reduce the proportion of current production which could be allocated to investment in new capital equipment.... What happens in many low-income countries is a dualistic trend toward a significant intensive development in a small segment of the economy, where conspicuous advances are made in productivity and incomes, while the major part of the labor force remains trapped in activities with low productivity and a rising number of totally or partially unemployed persons.[2]

Finally, as Lady Jackson writes, "the whole Atlantic transition to the technological order was cushioned by a vast 'bonanza' of free inputs secured by migration to all the planet's remaining supply of temperate land."

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2. Frank Lorimer in The Population Dilemma, Philip Hauser, editor, Englewood Cliffs, N.J., Prentice-Hall, 1963, p. 178.

All of these somber thoughts spelled disillusionment for donors and recipients alike.

Concern for the 'quality of life', the pollution of surroundings in the developed world, the disappearance of animal species, the disfigurement and defiling of urban and rural areas alike, had been the thin cry of conservationists for some time. Few had heard and fewer heeded their warnings about possible irreparable damage being done to nature by the headlong rush to produce and consume more and more goods. In the late-sixties more and more people in the developed world had their consciences and senses pricked by Rachael Carson, Stewart Udall, Barry Commoner and David Brower. They began asking if economic development has to proceed in ways which befouled the air, destroyed the land and which, in the image of one writer, saw the United States sending a man to the moon while standing knee-deep in garbage.

For the most part, these cries of anguish issued from the well-fed and the comfortable. But there was no question that over the world hung a pall of doubt about where the limits of health, consumption and productivity lay. It was this malaise which led to the United Nations Conference on the Human Environment in Stockholm in 1972. From the time of his appointment as Secretary General of the Conference, Maurice Strong had his work cut out for him. He had to balance the blocs, regional as well as ideological. He had to tend to the needs of the small as well as the great powers. Most importantly, he had to mediate between the rich nations and the poor nations. And if there was one topic on which blood nearly flowed, it was the overall emphasis, the sense of the conference.

"Mea culpa, mea culpa" cried the developed countries. The Japanese delegation spoke as follows:

> The world thinks we have done splendidly in the past twelve years. They talk of our success in growing by 15% a year. They put us at the top of the growth league in gross national product. But come and look at the consequences. We no longer see Fujiyama more than twice a year through the polluted smog. We have to take oxygen to downtown Tokyo if we want to carry through a full day's business. Our fish are so full of mercury that we have to cut back on our favorite dishes. This is not a society in which people are going to want to live.[3]

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3. From Barbara Ward, "Half Full or Half Empty: Our Planet", Adlai Stevenson Institute, 1974.

"Selfish and pernicious notions these", said the representatives of many underdeveloped countries. "You have robbed us of our products; you have the best farmland in the world; you have per capita incomes ten to twenty times as large as ours and now you want us to cut back on our growth to help you out? No way!"

Thirty-three African countries participated in the Stockholm Conference and fifteen submitted national reports on their own 'states of the environment'. A group of African environmental experts meeting in Dakar prior to Stockholm, noted that, "They (the experts) warn the African countries against the so-called dilemma; stagnation ('no growth') or continuation of the present ruinous system of exploitation of natural resources." On the contrary, the African environmentalists considered that in their present situation, the safeguarding and improvement of the environment must be made an integral part of their general development policy. This policy must not only be based on their aim of achieving harmonious growth and on their own specific values, particularly their cultural values, but must also be derived both from an economic and social analysis, including social costs, and from ecological research, within the framework of a model specifically designed to serve the interests of Africa's populations.

In consequence, they felt there should be no conflict in African countries between Development and Environment.

It was the African delegations at Stockholm who took the lead in broadening the definition of the basic term 'environment'. They asked rhetorically why "poverty was not pollution", and if people were dying on the land, was that not "spoiling the environment"? They demanded and obtained a major concession from the developed countries that a distinction be made between primary and secondary environmental problems. In the first category were issues of health, sanitation, shelter and nutrition. In the second were processes like industrial pollution, soil erosion, deforestation and wildlife preservation.

Watching the vehemence with which the (mostly Western) non-governmental organisations pleaded their cases at Stockholm, the delegates from the underdeveloped countries could not be blamed for seeing little difference between concern for the environment and the conservation movement, which to them seemed to hold animals more dear than people. Secondly, they found it difficult to sympathise with much of the breast-beating over pollution. "Give us your industry and we'll worry about the pollution," said one delegate.

It is a great tribute to the talents, patience and empathy of Maurice Strong that the Conference did not break apart over this issue. And it was doubtless with that continuing tension in mind that the delegates decided to base the newly created United Nations Environment Programme in Nairobi, Kenya. This was the first time that a major U.N. agency was located outside the developed world.

Some delegates from the developed countries complained that the all-encompassing definition of the environment would dilute the whole issue to the point of meaninglessness. Yet, in fact, it was really a confirmation of biologist Garrett Hardin's aphorism that "You cannot merely do one thing," on any geographical scale - local, national or global. Gone forever were the halcyon days for economists and the rest of us when we could define away 'externalities' like air, water and landscape. From the beginning of the Industrial Revolution until the present, the cost of producing goods was only what the manufacturer could not avoid paying.[4] The popular cry now is that "the polluters must pay". In many countries, the governments are the polluters. Regardless of who is responsible for the most pollution, the fact remains that environmental damage will be most severe in those areas already desperately poor.

Nowhere is this more apparent than in Africa.

We cannot pretend to offer a comprehensive description of the African environment. Instead we would like to make a few salient points.

Some of Africa's major problems stem from her very geography. About 60 per cent of the continent is arid or semi-arid. In fact, writes Professor William Hance, over 90 per cent of the continent "may be said to suffer from one or another climatic disability". One sees a water situation "of plenty where it cannot be used and of paucity where it is most needed".

Needless to say, a primary aim of development has been to redistribute some of the water to make maximum use of it. In their wakes many of the dam and irrigation projects brought a host of ecological problems. For engineers, the job is to build a dam at the lowest possible cost. A dam is a vast but 'neat' enterprise. It may be primarily for hydo-electric power, or for irrigation or for fishing or all three. The point is that until very recently, all such monster projects were seen as turnkey operations. This was the approach taken in constructing the huge Kariba Dam on the Zambezi River in the mid-fifties.

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4. Barbara Ward and Rene Dubos, Only One Earth, Middlesex, Penguin Books, 1972.

In both planning and construction, scant attention was paid to either the people, the animals or the flora of the region. Once the 2,000 square mile lake was formed, millions of animals simply drowned while the people had to stand back and watch. In the Gwembi Valley where the lake was to form lived over 50,000 Tonga tribesmen. Very little effort was made to provide alternative housing or a livelihood for them, even though the authorities knew all of these people would be displaced by the rising waters. At the last minute, they had to be resettled by force.

Once the dam was built and Lake Kariba had reached its maximum size, it was assumed that a prosperous fishing industry would develop. In fact, there occurred a cancer-like growth of waterweed which choked the shore and made net fishing impossible. The weed putrified the area to such an extent that it killed many fish.

The great irony about water in Africa is that it provides life and harbors potential death at the same time. Using the latest techniques of storage and distribution, it is both a blessing and a curse. Irrigation systems so vital for cash and food crops in water-starved areas become the major carriers of enteric bacterial infections, diarrhea, cercarial dermatitis, guinea worm, polio and possibly histoplasmosis. They also provide suitable breeding places for insect vectors of malaria, filariasis, dengue, encephalitis and schistosomiasis (bilharziasis).

Schistosomiasis affects more than 200,000,000 people in the world and over 40,000,000 in Africa. It has been called "the last great scourge" partly because its medical control has so far eluded scientists and its physical control is prohibitively expensive. It doesn't kill so much as it weakens. As John Weir wrote in the World Health Organisation Chronicle,

> It is a tragic irony that in many parts of the world the vast irrigation schemes constructed with the aim of improving the standard of living have had the effect of undermining the health of the areas they serve. The network of canals designed to carry water to arid territories have proved ideally suited for carrying bilharziasis - and sometimes other diseases - to the inhabitants. Still more important is the fact that before the introduction of perennial irrigation, bilharziasis was unknown in many of these areas. For this reason, bilharziasis has been termed a "man-made" disease.[5]

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5. Quoted in Milton and Farvar, The Careless Technology, Garden City, N.Y., The Natural History Press, 1972.

Like the rest of the developing world, Africa is experiencing an enormous rural to urban migration. The causes are numerous and complex; it no longer suffices to call it the attraction of the bright lights. There are jobs in the cities. There is a progression of migration from farm to village to city. More and more people are attempting to live on less and less land with the same agricultural techniques. The cities may in fact offer only ephemeral attractions; they may assuage only part of the hunger for meaning and self-respect; they may be dens of iniquity; they may offer disease and crime. Yet in many countries, anything is better than the countryside.

The problems of the cities are getting out of hand. The cities in Africa are growing at two to four times the rate of the population at large. Squatter settlements proliferate around the centres. The governments are sometimes too poor to provide adequate basic services and the result is like a chain reaction collision on a highway - more and more people ramming into those already stalled or wrecked.

Despite the rising tide of rural to urban migration throughout the continent, something like 80 per cent of Africa's population still lives on the land. The relative percentages may change, but the absolute numbers of people and animals pressing upon the same amount of land continue to rise. An outer limit of soil productivity may have already been reached in large areas. The unchecked and increasing population pressure cannot but have the most profound and disruptive effects on the standards of living in these already poor countries. As Professor Otieno writes:

> In Kenya, 25,000 tons of charcoal are exported yearly and rain-water catchments are being denuded. Here, forests cover only 3% of the total land area and the authorities realize that elimination of forests leads to costly changes in river regimes which are often irreversible. Conversion of bushland to grassland by itinerant charcoal burners creates environmental degradations and conversion of forest land to agricultural land under political pressure is a force the government cannot ignore ....

Vast and expanding tracts of land around urban centres are beginning to resemble the mange on a dog as the trees are cut down for fuel.

When one sees how difficult it is for a rich, powerful nation like the Soviet Union to control its agriculture, it is not hard to see why so many underdeveloped countries have paid no more than lip-service to rural problems and have concentrated on industry and the cities.

In their headlong and desperate rush to develop, many poor countries have fallen prey to the idea of "one-shot technological fixes". This dam,

that chemical, this steel plant, that technique will by itself solve all the clammering, clustering problems of food, power, employment. They have been encouraged in this belief by Western 'experts'.

The tragic conditions of the Sahelian Zone are at least partly man-made. Into a tier of basically pastoral countries where the nomads have over millennia learned to wrench existence from an uncompromising environment, marched platoons of aid officials with THE answer - bore well holes by the thousands. This, combined with the wide-spread increase in health care, and the unusually large amount of rain for a few years, set the scene for the catastrophic effects of periodic drought. (It is still too early to say whether there has been a fundamental shift in climatic patterns in that area.) Development schemes are drawn up by economists, politicians and agricultural scientists, not the ecologists and nomads. The latter have required tens of generations to develop ways of interacting with that harsh environment. Forcing them suddenly to settle, to change from a previous life, upset cultures based upon the absolute right and need for movement. The nomadic adaptation made it possible to utilise lands unsuitable for most agricultural pursuits and at the same time provided surplus animal products for sedentary populations. Nomadic pastoralism in its proper place (which is in those marginal lands of the world) can be an efficient form of land use.[6]

What they forgot in building all these wells was that water without food is as surely death as no water at all. Animals and people crowded around the watering places trample larger and larger areas in circumference, wreaking the same havoc as the bidonville inhabitants in burgeoning cities.

Garrett Hardin's justifiably famous essay, "The Tragedy of the Commons" was remarkably prescient of this African tragedy, and we would like to quote it at length.

> The tragedy of the commons develops in this way. Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the numbers of both man and beast well below the carrying capacity of the land. Finally, however, comes the day of reckoning, that is, the day when the long-desired goal of social stability becomes a reality. At this point, the inherent logic of the commons remorselessly generates tragedy.

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6. F. Fraser Darling and Mary A. Farvar, "Economic Consequences of Sedentarization of Nomads", in The Careless Technology, pp. 671-82.

As a rational being, each herdsman seeks to maximize his gain. Explicitly or implicitly, more or less consciously, he asks, 'What is the utility to me of adding one more animal to my herd?' This utility has one negative and one positive component.

1) The positive component is a function of the increment of one animal. Since the herdsman receives all the proceeds from the sale of the additional animal, the positive utility is nearly +1.

2) The negative component is a function of the additional overgrazing created by one more animal. Since, however, the effects of overgrazing are shared by all the herdsmen, the negative utility for any particular decision-making herdsman is only a fraction of -1.

> Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another .... But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein lies the tragedy. Each man is locked into a system that compels him to increase his herd without limit - in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a common brings ruin to all.'

As Hardin himself points out, the tragedy of the commons is not limited to agricultural situations. It can be applied to cities, or developed areas. The sudden realisation that the world's resources are finite and that we are threatened by increasing competition for these resources has sent waves of dismay through the chancellories of the Third World. During the October War of 1975, some countries broke relations with Israel for the simple reason that they thought they would get some kind of economic benefit. In fact, they did not.

The quadrupling of oil prices alone has come close to devastating some economies. Will the developing countries therefore be more willing than before to become 'pollution havens' to take on industry which has been banned in developed countries?

For better or worse, many underdeveloped countries are being forced into a mode of life which at its most charitable means 'self-reliance'. The developed world is in disarray, economic nationalism is gaining currency and adherents. It is impossible to imagine that the developed countries have the will and desire to shift the huge amounts of capital which would be required to even make a dent in the underdeveloped countries' economies. From now on, development may have to be largely internalised. There must

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7. In Science, 162 December 13, 1968, pp. 1243-48. U.S. copyright 1968 by the American Association for the Advancement of Science.

be a significant rethinking of the potentials for labour-intensive, capital-deficient projects. Or, to put it differently, more attention will have to be paid to human capital.

Governments are huge, powerful, lumbering beasts. They don't move backward very easily. All African governments are committed to development. Many of the development projects will either fail or fall short of expectations unless and until the men and women who make the decisions about them become sensitive to and knowledgeable about the environmental and ecological aspects of development. It is abdundantly clear that for a biologist, expertise gained in one area or climate, for example, is almost worthless in another climatic region. And obviously there is a brutally wide range of expertise required - planning, engineering, ecology, botony, anthropology, climatology, limnology, chemistry, entomology, medicine, etc.

Few countries in Africa have experts in all these fields and the ones they have are spread thin. In many cases, hard pressed governments have been forced to rely on foreign-trained experts who have neither the knowledge nor the background to deal with the problems they were hired to solve. Still another problem has grown out of what Barry Commoner calls the 'reductionist view'. That is one in which the 'problem' is broken down into its component parts each of which is tackled separately. It is born of the American tradition of maximum specialisation. The soil experts say one thing, the cattle experts another, the hydrologist a third. They never get together. In fact, they are each intimately involved in the same overall problem.

Still another problem bedeviling the underdeveloped countries is the lack of basic research geared to or located in these areas. (One research facility which is an exception to this generalisation is discussed in Dr. Odhiambo's paper.) In addition, most African scientists themselves have been trained outside Africa. As one indication of the gap which exists, it has been pointed out that there is probably more data on the soil, climate and hydrology of one California agricultural county than there is on most entire African countries.

The most telling and critical lack in those countries bent upon development is trained manpower. Few developing countries have officials within their civil services who can ask the right questions about development projects. Officials responsible for projects all too frequently think only of the 'positive' results. From the mistakes of the past we are painfully aware that "we can never do merely one thing".

Will a bilharzia epidemic do more damage than the presumed agricultural benefits of a dam?

Will greater uniformity of crops actually be better for the people and the land?

Will the loss of silt behind a dam demand an unacceptable amount of chemical fertiliser in compensation?

Is sedentarisation of nomads the best usage of people and pasture?

One path out of the Slough of Despond has been suggested by Professor Sachs and has been taken up by the United Nations Environment Programme. (See his paper in this report). He defines eco-development as a "style of development which in each eco-region calls for specific solutions to the particular problems of the region in the light of cultural as well as ecological data and long-term as well as intermediate-term needs.". The style of development he describes goes beyond the alleged universalist solutions, the one-shot technological fixes, the uniformity of cropping, the inappropriate technologies. It is a type of development with local answers to local problems.

Our seminar was designed as a pilot project to help fill a manpower gap. We used an analogy from soil science where in order for large quantities of fertiliser to be absorbed by plants, metallic trace elements are required. In the same way, large sums of money can be used to advantage by a community only if there is an efficient mechanism through which it can be channeled. We ought therefore to sensitise a small number of middle and upper-echelon officials to problems of the environment. Our objectives were three:

1. To help the participants become aware of their individual and common problems; to give them an ecological perspective, so to speak, by demonstrating to them the centrality of environmental issues to successful development efforts.
2. To give them a body of information about African environmental problems and ways in which they may obtain further information and advice.
3. To establish a cadre of officials in each country who can play an effective role in reviewing development plans from an environmentalist's point of view. A corollary of this is that each of the participants will realise that there are men in the other countries who are up against the same problems, and this may lead to exchanges of information.

Nascent field that it is, the study of the environment is also subject to that double bane of all fields of inquiry - the information explosion. The first danger is inundation, to be drowned by the sheer volume of data. The second is obsolescence. And a third difficulty for the less developed countries is isolation - being out of touch with the sources of information. The United Nations Environment Programme has made a great advance in creating the International Referral Service (I.R.S.). This agency is designed to assist those governments, organisations and individuals who have specific environmental problems communicate with others who are working on the same or similar issues. In a very modest way, we hoped that this seminar would be the basis for an informal regional I.R.S.

The papers which follow provided the basis for discussion during the seminar. The aim was to provide basic information which would put all the delegates on a more or less even footing when the time came to discuss the two case studies, one a ficticious country named Kuumba, and the other the area around the town and lake of Nakuru in Kenya, which the delegates were able to visit.

In the case of Kuumba, the delegates were divided into small groups which functioned as planning agencies and came up with recommendations about the course of development Kuumba should take. In the Nakuru case, initially the role-playing technique was tried, with each participant taking the part of a town manager, a park warden and so forth. The participants moved on from this role-playing situation, and made a number of recommendations on how the complex of forces and influences at work in the unique situation at Nakuru could best be handled.

AFRICA AND THE ENVIRONMENTAL CHALLENGE

By
Nicholas C. Otieno, Chief, Natural Resources,
Economic Commission
for Africa

INTRODUCTION

The African continent presents a gigantic question mark which embodies a complex environmental mosaic riddled with so many imponderables that our efforts to find solutions to these questions - leave alone understand them - fall far short of what the African masses expect from us. At the centre of the African riddle lies the frightening realisation that we are almost totally ignorant about the behaviour of the many-faceted variables that make the African environment what it is at present; nor are we in a position to predict how these will behave in future.

All we know is that the result of Africa's environmental variables is the oppressive poverty that permeates African society and renders the masses helpless, thereby losing their identity and self-respect. In the words of Adlai Stevenson, "A hungry man is not a free man". If this statement is accorded the seriousness it deserves, then the African individual who spends the day wondering where his next meal will come from, the one who goes to a miserable bed with half empty stomach, he whose very existence is stalked by periodic famines which often plague the land, or the farmer who never earns enough from his crops to feed his starving children - this man has yet to know and experience what it means to be free.

The African wants to escape from an environment characterised by grinding poverty, high mortality rates, rural and urban squalor, the scourge of endemic diseases, malnutrition and all other environmental insults which have rendered his lot that of hopelessness and utter despair from his cradle to his early grave. This same brutal environment is undergoing far-reaching changes and modifications at break-neck speeds; and the African must accommodate himself to the changes at far greater speeds if irreversible disasters are to be avoided.

This short paper attempts to focus on this environmental scenario by providing an outline of how the African's efforts to grapple with the elements and to improve his lot have altered his environment either for good or for ill. Topics such as climate, use of water resources (above-ground and under-ground), utilisation of flora and fauna, agricultural

practices, educational methodologies, urban-rural problems, energy, minerals, transport and industrialisation are given brief treatments so as to bring out some of the environmental challenges which Africa faces today.

CLIMATIC FACTORS AND WATER RESOURCES

The African continent lies astride the equator and extends as far north as 35° latitude, and as far south as 35° latitude. This placement determines the position, direction and regularity of the continent's atmospheric circulation; the frequency, intensity and distribution of rainfall precipitation; as well as the circulation of oceanic waters around her shores. With respect to the atmospheric regime, the tropical convection currents regularly ascend and descend in specific ways and affect the continent's climate locally, whereas other air streams reach Africa after emanating from various parts of the globe; and whatever environmental changes take place in their places of origin would be experienced in such a way as to affect Africa either for good or for ill. The amount of rainfall, its frequency and intensity, which varies both regionally and seasonally in Africa, determines the quantity of surface waters, river regimes and the rate of recharge of the underground water resources of the continent.

By virtue of its global position straddling the equator, Africa has distinct high pressure belts on the tropics - north and south of the equator - and an equatorial low pressure belt lying more or less along the equator. This situation would remain static and seasonal changes rendered less variable were it not for the revolution of the earth around the sun which makes these pressure belts oscillate northwards or southwards, relative to the equator, with the apparent position of the sun during the year. The tropical high pressure belts lie approximately along the 30° parallel, north and south, and are characterised by descending and divergent dry air currents throughout the year; while the equatorial low pressure belt lies along the equator and is characterised by ascending air masses. The pressure of these two high pressure belts separated by the equatorial low explains the presence of the regular easterly winds which occur in the African low latitudes; and it is the oscillation of the high and low pressure belts over Africa and her neighbourhood that normally causes the seasonal variations of temperature and rainfall precipitation and explains the spatial distribution of ecological zones in Africa.

Between 10°N and 10°S latitudes, Africa has a typical tropical climate of high temperatures and heavy monsoon rains. Elsewhere, temperatures and rainfall are moderated by altitude so that about one-third of the continent receives over 40 inches of rain per year while another third gets less than 10 inches. In the immediate north, east and south of the tropical equatorial belt, climate is often harsh, and rain varies from year to year as most of the annual precipitation falls during the north-east monsoons which are in themselves variable. West Africa and the Congo basin are well watered by the south-west monsoons. Rainfall variability and reliability thus fluctuate as one crosses the continent from west to east and as one moves north or south of the equator.

Large areas of Africa receive seasonal and unreliable rainfall and are subject to serious water shortages for man, animal and plant. This situation is further aggravated by the fact that the amount of incoming radiation is large, temperatures are high and the potential for evaporation from open surface waters is high over most of the continent as compared with rainfall. It is estimated that 42 per cent of Africa is extremely arid: 42 per cent has rainfall of between 250 and 500 mm, 42 per cent has from 500 to 1500 mm of rain, whereas 16 per cent has rainfall above 1500 mm. A few countries will be mentioned to illustrate the environmental problems created by shortage of water.

In Somalia, water supplies are so extremely short that the demand for reliable, perennial sources of water for human and animal consumption is serious.

In Kenya, 491,000 square kilometres (80 per cent of the country) receives between 200 mm and 750 mm of erratic rainfall with the result that semi-desert and arid areas occupy more than half the country in the north, north-east and southern parts.

Sudan has an area of about 1 million square miles half of which is desert or semi-desert with moisture index varying between negative values of -40 and -60. In this area, the harnessing of available water resources and their conservation for consumption constitutes the main problem facing many development projects. The area north of 12° latitude in the Sudan is described as a thirst zone where the quantity of water needed in the dry season is 21 billion gallons of which only 40 per cent is available, and where only 5 litres are available per person per day compared to W.H.O. estimates of 20 litres per person per day. Life here is one perpetual grim struggle to find enough water to keep man, his crops and beasts alive.

Most of Central and Southern Africa is a semi-arid area of low and erratic rainfall and where evaportranspiration is extremely high.

In Lesotho, large areas suffer from frequent droughts leading to serious fluctuations in agricultural production and insufficient supplies of water for human consumption in several towns. In Madagascar, the southern part of the country is semi-arid, water is short and agricultural efficiency extremely low.

The situation outlined for a few countries reveals the grim environmental hazards which several African countries face with respect to availability of water. Its shortage often leads to famines which disrupt social and economic lives - often leading to death. Little is known about the hydrographic regimes and rainfall patterns so that African countries are unable to plan on rational use of available water - both surface and underground.

Surface Water Resources

The continent possesses massive bodies of water that could be used for development. Lakes Victoria, Albert, Kivu, Malawi, George, Edward, Rudolf, Baringo, Magadi, Manyara, Nakuru and Chad form an important resource. Where they are shared by a number of countries, their maximum utilisation to environmental advantage can be realised through international co-operation.

In addition to the lakes, there are over 50 river basins in Africa which are shared by two or more countries. The total area of these international river basins covers approximately 40 per cent of the total African area and provides scope for in increased exploitation of the water resources for fishing, transport, irrigation and production of hydro-electric power. For such activities, inter-African cooperation is an essential condition for the rational exploitation of water resources.

With respect to Nile waters, agreements started in the nineteenth century during the colonial era aimed at facilitating irrigation in Egypt and the Sudan. It is known that Egypt required 62,000 million cubic metres per year in 1971 to irrigate perennially 3.16 million hectares, and will ultimately require 77,820 million cubic metres to irrigate 4.1 million hectares annually. The Sudan requires about 26,800 million cubic metres for irrigation annually. Irrigable land in the Kenyan part of the Nile basin is an area of 52,212 acres that requires over 296 million cubic metres of water annually. The total quantity required for Uganda within the Nile basin is 1.5 million cubic metres. Even without considering Tanzania's requirements, there is already a shortage of 17,000 million

cubic metres of water per year for the riparian states, and cooperation in the utilisation of the Nile's waters is essential.

A major step in achieving collaboration between Nile basin states took place in 1967 when Tanzania, Uganda, Egypt and the Sudan started a hydrometeorological survey of the basins of Lakes Victoria, Kyoga and Albert. It is hoped that data from this survey will increase the knowledge of the natural hydrologic phenomena of the Nile catchment areas before complex systems of flow regulation of the Nile are set up.

The Niger basin covers more than 1 million square kilometres and is shared by nine countries in West Africa. Due to the river's economic importance, experts from riparian states held a number of meetings between 1960 and 1963 aimed at pooling results of their hydrological studies of the river. In 1964, they established the Niger River Basin Commission with headquarters in Niamey. This Commission deals with all aspects concerned with irrigation and navigation along the river. Such co-operation enables the countries to plan for flood control in the Niger basin as well as coordinating joint development programmes.

The Senegal river basin cover 333,800 square kilometres and is shared by four states which formed the Senegal Basin Commission in 1963. The body is charged with the task of promotion and coordination of technical studies for the joint exploitation of natural resources of the basin including such activities as irrigation, river transport, power production and distribution, and mining.

The Chad basin covers an area varying between 13,000 and 23,000 square kilometres, depending on the season, and is shared by four countries. It is the largest closed river basin in the world with Lake Chad lying at its lowest level and receiving waters from the Logone and Chari river systems. The lake has fresh water suitable for irrigation in a semi-arid zone inhabited by nomadic stock breeders who are normally short of water.

In 1964, the four riparian states formed the Chad Basin Commission through the signing of a convention which obliged members to abstain from carrying out any works in the basin which would have a marked effect on the surface and groundwater flow without adequate notice and prior consultation. Further agreements are contemplated in areas such as customs duties, transit arrangements, border control, communications, transport, land and water conservation.

Environmental Problems of Man-made Lakes

Man-made lakes have appeared in the African scene as an important source of surface waters. The creators of these lakes have often had noble ambitions and lofty goals to improve the quality of the physical and social environments of the citizens by producing electricity, raising of additional food through irrigation, increasing fish production and improving navigation.

Lakes Nasser, Kariba, Kainji, Volta and Kossou are the main ones to be considered here. In creating these lakes, there has been a tendency to give an over-riding disproportionate emphasis to more material aspects of growth, human considerations have often been overlooked and human beings seen only as instruments of production rather than as free entities for whose welfare and cultural advance the increased production is intended. At Kariba, 50,000 Tonga tribesmen were moved without plan and it took them two years to clear sufficient land to meet their subsistence needs and government had to step in with relief to avert famine and misery. In High Aswan, 100,000 people were relocated without plan and the World Food Programme had to rush in famine relief to the Nubians. In Ghana, 80,000 people were moved, but one year after relocation, the government's ambitious agricultural programme was successful in only 1 out of the 52 planned communities - and the World Food Programme again had to step in with relief.

Ecological disturbances associated with man-made lakes include increase in the incidence of bilharziasis in Egypt, Sudan and Ghana, disturbance of the micro-climate, possibilities of earthquakes, emergence of aquatic weeds which hinder transport and alter the environment for biological production in the lake and probable accumulation of silt behind the dams.

Underground Water Resources

Underground water resources have not yet been fully exploited except for a few local and regional areas. In the Maghreb, untapped resources include the underground flow to the sea through fractured zones of coastal limestone, freshwater submarine springs, water-bearing dunar sands and certain deep aquifers which call for expensive drilling operations. In this area over 20 per cent of underground water resources are being exploited. In other areas, cities such as Dakar, Abidjan, Tunis, Mogadishu, Lome, Mombasa, Nairobi and Lusaka depend on ground water for their supplies.

Africa's attempts to exploit underground water resources are hampered by a number of intractable problems. The economic and social importance of groundwater is often disregarded because the source is not visible. Shortage of qualified personnel and finance hinders research and exploitation. The number of groundwater engineers and geologists in Africa - most of whom are expatriates - about equals the number in Rumania. In addition, drilling rigs are often in poor working condition: due to lack of spare parts. Institutional and legal problems also hinder the work of exploiting underground water. Services in charge of prospecting for underground water are not always adequately integrated with governmental administrative structure and are either scattered in several ministries not sufficiently related to geologic or hydraulic services, or they are entirely isolated. Some countries have neither legislation nor the means to enforce measures which would ensure rational development and protection of essential groundwater resources.

FORESTS AND ANIMALS IN THE AFRICAN ENVIRONMENT

The rich forest resources of Africa are being exploited at such high rates that environmental distortions are already being felt in most African countries. In most of sub-Saharan Africa, population growth has led to increasing demand for land and led to conflicts in land use between man and wild animals so that areas inhabited by the latter have continued to shrink. Use of timber for charcoal burning is leading to serious land deterioration. These situations are illustrated by the following:-

In Kenya, 25,000 tons of charcoal are exported yearly and rain-water catchments are being denuded. Here, forests cover only 3 per cent of the total land area and the authorities realise that elimination of forests leads to costly changes in river regimes which are often irreversible. Conversion of bushland to grassland by itinerant charcoal burners creates environmental degradations, and conversion of forest land to agricultural land under political pressure is a force the government cannot ignore. Efforts at reafforestation by planting exotic trees have led to a multiplication of pathogenic organisms. Periodic fires during the dry season often destroy vast tracts of forest land.

In Tanzania, frequent fires during the dry season kill trees and seriously alter soil structure. Shifting cultivation in semi-arid areas coupled with over-stocking lead to destruction of forests. The country has embarked on reafforestation programmes in Kilimanjaro and Usambara catchment areas and has passed legislation against burning.

Zambia's shifting cultivation known as the "Chitemene" system in the north-west leads to serious deforestation and erosion. Charcoal burning adds to this destruction, and the government has plans to plant 100,000 acres with forest by 1990.

Swaziland was once richly endowed with a wide variety of flora and fauna, but the impact of human settlements during this century has made enormous inroads into the indigenous wild life. Reafforestation programmes have been set up.

In Congo (Brazzaville) forestry is the main rural activity and provided 50 per cent of the country's exports in 1969, but at present rates of exploitation, forestry resources might be depleted within 60 years.

In Cameroon, 700,000 tons of wood are felled yearly and exported in the form of logs, sawn timber and plywood.

In Nigeria, forests cover 139,000 square miles of which 36,104 are gazetted as forest reserve. Timber logging is a major industry, but it is feared that the resource might be depleted due to improper logging operations and illegal logging and felling. Afforestation programmes have been started.

In Ghana, timber comes from the high forest zones in the south western parts of the country and 50 to 60 million cubic feet of timber are cut annually. In non-controlled areas agricultural expansion has led to serious forest destruction, but in reserved areas the government is working on some kind of sustained production basis.

In Liberia, preservation, protection and maintenance of 9 million acres of high forest is of primary concern to the authorities. But forest exploitation is expanding rapidly through logging concessions which have been granted during the past few years - and logging operations in Liberia have been given a stimulus by the depletion of hard woods in neighbouring Ivory Coast.

These few examples illustrate the situation prevailing in most African countries. The problem of cut-and-burn shifting agriculture and periodic fires totally destroys vast forests in Africa. Charcoal burning to supply fuel for urban centres is another menace - as is overstocking. Concessions to foreign logging firms in several countries are such that the loggers are encouraged to practise a 'cut and quit' policy which is already depleting hard wood forest resources which take as long as 60 years

to regenerate. Pressure for expanding agricultural requirements poses a dilemma since governments are politically committed to provide land for their ever-increasing populations. These are some of the serious environmental challenges in the management of forest resources in Africa.

Animal Resources

The fate of the valuable hardwood forests is matched by that of the unique animals which are hunted, killed and poached with such ferocity and barbarity that they are threatened with the fate of the classical dodo. A few random examples will suffice to illustrate the plight of these animals. In the Sudan, the valuable gazelle has been heavily poached and is all but eliminated from the plains east of the Blue Nile. The ostrich is being killed at the rate of 1,000 birds per year and is vanishing in the northern provinces. The crocodile is almost depleted. Leopards have almost been wiped out from the Red Sea Hills and the previous equilibrium of prey and predator between leopard and baboon has been disturbed to such an extent as to lead to baboon population explosion to the discomfiture of the farmer. The legendary Ivory Coast has very few of these animals left. The rhinoceros is in danger of extinction in many areas. The paradox with respect to poachers is highlighted by Indira Gandhi when she says, "unless we are in a position to provide employment and purchasing power for the daily necessities of the tribal people and those who live in or around our jungles, we cannot prevent them from combing the forest for food, and livelihood, from poaching and from despoiling the vegetation."

National Parks and Game Reserves

The above forebodings have led several countries to establish sanctuaries and parks where animals and plants can live unmolested in the hope that they will be preserved for posterity. The establishment of these parks recognises the fact that human hunger for beauty and for natural things is a reality; and it is possible that the wild animals may provide the much needed protein for local population.

Tanzania has established 13 games reserves - some of which are world famous - where the Game Department employs game scouts to prevent poaching. Lack of adequate funds and enough trained manpower including inadequate public awareness of the importance of wild life all act as bottlenecks in implementing effective conservation measures.

In Swaziland, the buffalo, elephant, rhinoceros, giraffe and lion which used to roam the country disappeared long ago. Now two game reserves have been established and a trust Commission created to administer national parks.

Uganda has established some great national parks which are world famous; while neighbouring Kenya pursues a vigorous policy for the conservation of natural resources. National parks of Kenya cover some 25,000 square kilometres or 4 per cent of the total land area. Legislation has been introduced aimed at utilising these resources without serious environmental disruption. Problems have arisen in imbalances created by increase in the number of elephants in the Tsavo National Park - mainly due to lack of understanding of the population dynamics of these animals. There is increasing pressure on the habitat from thousands of visitors whose numbers double every four years and tend to urbanise the wild areas to the extent where conflicts of objectives arise.

Botswana has established six national parks; while in Zaire the authorities are vigorously expanding their game reserves after they realised that elephants which were estimated at 100,000 in 1960 had almost been depleted five years later. Education of the masses to respect wild animals is a difficult problem in the country.

In Cameroon, certain species of wild animals like the gorilla, chimpanzee and the ostrich were found dwindling and their killing has been prohibited. The government has established several national parks but finds poachers so numerous the country is barely able to keep up with them.

Nigeria is concerned with the destruction of wild animals on a large scale and has passed legislation and created reserves where hunting is prohibited. Chad, Niger and Senegal have also established game reserves as the main method of preserving their wild animals.

It is with these unsettling facts in mind that African countries should sign and help to enforce both the O.A.U. convention on protection of wild life and the convention on trade in endangered species signed in Washington, D.C. in 1973. Both of these, however, will only be effective if the consumer countries introduce and enforce stringent measures against the importation of animal trophies.

Tourism

Africa's 'unspoilt' nature and her fantastic game attract all types of visitors from the rest of the world. Receipts from tourism rose 15 per cent to US$390 million in 1970. Tourism arrivals rose by 14 per cent in 1970 compared with the world rate of 9 per cent.

The main problems stifling further growth of tourism include costs of getting to Africa, inadequacy of infrastructure and shortage of hotel accommodation. But several environmental considerations arise. As the visitor pressure increases, the impact of the tourist becomes so accentuated that in some cases delicate habitats have been destroyed. Added to this, the tourist himself becomes disillusioned with the overcrowding from which he was trying to escape.

In Kenya, tourism is the most rapidly expanding industry and is second to agriculture in foreign exchange earnings. The number of 338,777 visitors in 1970 was estimated to rise to 400,000 in 1971, bringing a gross income of £18 million which would rise to £50 million in 1975. The government is encouraging the development of game lodges in parks and reserves to the tune of 500 new beds and the development of infrastructure including new tourist attractions in mountains, beaches and archaeological sites so as to reduce visitor pressure on national parks.

In Tanzania, government policy on tourism comprises sustained efforts to publicise Tanzania, an increase in the number of hotel rooms especially near game parks, and placing the industry in the hands of Tanzanians. The aim is to increase the number of visitors to 120,000 during the 1973/74 period, as compared to 72,300 in 1969/70. New lodges are being opened in Ngorongoro, Arusha and Serengeti, a new hotel is being constructed in Arusha and an international airport has opened in Kilimanjaro.

Nigeria is just beginning to develop tourism by the formation of the Nigerian Tourist Association. National parks are being developed and the number of visitors was 100,000 in 1971.

Sierra Leone plans to improve the tourist industry by setting up game parks, sports facilities, better accommodation in the provinces and improvements in transport and communication. Ghana intends to spend vast sums of money in developing tourism.

Swaziland opened a casino in 1966 which attracts up to 100,000 tourists from South Africa yearly. Lesotho, which has beautiful mountain scenery and a pleasant climate, was only able to attract 50,000 tourists from South Africa in 1971.

In Ethiopia, the number of visitors is small in comparison to available bed-space. Some 36,000 people visited the country during 1968/1969 but still the hotels operated with low occupancy rates.

The above examples illustrate that the continent has vast tourist potential and shows that tourism can play an important part in the continent's economy. The main question that arises is "Who gets most of the money from the tourist industry in any one country?"

AGRICULTURAL ENVIRONMENT

Basically, it can be said that agricultural progress in Africa is lagging behind industry in the adoption of modern production techniques and of economic institutional arrangements required for vigorous increase of productivity. This lag, in turn, retards industrial progress because a large part of the rural population is not generating sufficient purchasing power to create the demand needed for absorbing the growing industrial output - which, in turn, leads to idle capacity in many factories.

In most countries, the traditional farming sector is characterised by fragmented farm holdings - decreasing in size as a result of population pressure - situated in remote and sparsely populated areas having poor transport and marketing facilities. The farmer is normally uneducated. The inadequacy or non-existence of storage, distribution and marketing facilities discourages the progressive farmer from producing more than his family needs. Prices fluctuate and even the governmental price stabilisation policies of marketing boards are often so unsatisfactory that they make farming an unattractive proposition and lead to an exodus to the towns and the depletion of agricultural labour from the rural areas.

The traditional farmer can hardly be pursuaded to modernise. He needs local facilities for moving goods into and out of his locality, for getting modern inputs available in time, for grading, storing, processing and selling. He needs research and extension services to demonstrate modern techniques and adapt them to local conditions. He needs credit and marketing services at favourable terms under well managed cooperatives. Above all, he needs a rural social environment that encourages the development of his managerial capacities and civic responsibilities. Land tenure conditions must be so improved as to provide security and managerial freedom, give protection against high rents, etc.

A further problem in the agricultural environment relates to those countries which depend on a single crop economy. The situation becomes more complex where a number of countries produce the same agricultural commodity for sale in world markets. Both situations lead to disastrous consequences to the economies of the countries concerned whenever world prices drop. Added to this, a single crop is often exposed to destruction by physical disasters, pests and diseases. It is therefore important for

African countries to cooperate in order to diversify their agricultural production and to plan a strategy for selling their goods in world markets despite failures of UNCTAD. They should aim at processing their own agricultural products and selling finished goods as one sure way of escaping from the stranglehold of unstable prices for primary products in world markets.

The unreliable rainfall in many parts of Africa - already referred to - is a serious constraint and leads to disastrous crop failures followed by famines which necessitate importation of food at great cost. In the case of livestock, production is hindered both by the shortage of water in arid and semi-arid areas and by the presence of many diseases disseminated by anthropod vectors. The presence of foot and mouth disease and anthrax has led European countries to prohibit import of meat, etc. from Africa on sanitary grounds.

Corrective Measures

Despite the many environmental hazards to agricultural production, several African countries are making efforts to introduce measures to improve the life of the rural farmers. These include the introduction of rural settlement schemes e.g. Ujama Villages; operation feed yourself (Ghana); campaign for freedom from thirst (Sudan). In addition, efforts are being made to improve land tenure and to make the farmer more secure; to introduce hybrid seeds, fertilisers and pesticides. Above all, African countries realise that their only hope of success is the training of agriculturists and extension workers who will go out into the countryside and work hand in hand with the uneducated farmer.

FISHERIES

In the African environment plagued by deficiency diseases arising from protein shortage, many dieticians have advocated more extensive and intensive exploitation of fish resources as an alternative source of protein. This desire has not been fulfilled due to lack of precise knowledge of fishery resources, both marine and fresh-water, and by the poor methods of fishing used by small-scale African fishermen.

With respect to marine fisheries, the vast majority of fish off the west, north and east African coasts are landed by foreign trawlers - Russians, Poles, Norwegians, Japanese, etc; and certain fish are all sent to Europe and America. Many operators illegally stray into African waters and process fish to export to Europe to feed pets. Overfishing in African

waters is already a serious issue and it is likely that the big operators will cause permanent damage by overfishing.

Sierra Leone imports one-third of its local fish consumption.

Tunisia has 1,300 kilometres of coastline but produces only 30,000 tons of fish for domestic consumption. Sardine fishery resources of the Mediterranean are reported to have dropped seriously off the Egyptian coast as a result of the ecological effects of the High Aswan Dam. In Nigeria, development of marine fisheries is reported to be affected by the narrowness of the continental shelf and may be further affected by development of off-shore oil drilling. Ghana is importing fish for local consumption while her off-shore fisheries are being exploited by foreigners. The same applies to Ivory Coast. In Kenya, marine fishing contributed 8,000 tons of fish for local consumption in 1970, but pollution by oil and use of explosives are a danger to local fish stocks.

With respect of fresh-water fisheries, Africa has large lakes and rivers which contain large quantities of delicious fish. The problem is lack of knowledge about fish populations in the lakes and rivers, lack of transportation of fish especially during the muddy season when fish from a lake cannot reach even ten miles inland, and poor fishing techniques as well as inadequate infrastructure.

In Lake Victoria, fish catches increased from 23,000 tons in 1965 to 34,000 tons in 1970 on the Kenya side alone. Fluctuating lake levels during various periods have tended to reduce catches. In 1958, total catch from the lake was 70,418 tons valued at £4,364,000. Lake Tanganyika could produce 100,000 metric tons of fish annually while Lake Kivu has a potential production of 600 to 800 metric tons of fish annually despite the presence of methane and hydrogen sulphide.

Lake Albert produced 13,900 tons of fish in 1955 and its potential is unknown. In Chad, about 100,000 tons of fish are caught annually from the Chari and Logone rivers.

From this short outline, it is evident that Africa has plenty of fish which could be used to supplement the protein-deficient diets of the continent's populations. Research, the introduction of new fishing methods and the training of local fishermen are pre-requisites. In the marine areas, Africa will need to invest large sums of money to buy modern trawlers which would match those of the foreigners. In addition, stringent measures will have to be introduced and enforced to stop over-fishing by foreign trawlers.

THE NOMAD IN THE AFRICAN ENVIRONMENT

Most African countries having nomadic populations face environmental problems peculiar to this form of existence. Movements of nomadic tribal groups across national frontiers give rise to political, social and health problems in the countries concerned. These nomads represent an important economic potential and could significantly contribute to economic and social improvements in their countries, but they have not had opportunities to benefit from the advantages of modern techniques and scientific progress in their respective countries. Several countries have not even succeeded in linking the development plans of nomadic regions with their national development plans.

In the Sudano/Sahelian Zone and in most of East and Central Africa, nomads are basically pastoralists who move with their livestock at the dictates of environmental changes. I will refer here to Eastern Africa only, due to the length to which this paper must be limited.

Somalia is described as a nation of pastoral nomads, forced by their harsh environment to move constantly with their flocks in search of water. The nomads despise agricultural farming, and their modes of livelihood and social institutions are tightly adjusted to the scant resources of their environment. Many pastoralists move many miles yearly from water point to water point, but there appears to be a shortage of livestock to satisfy the needs of families. Lack of sufficient water leads to the death of many animals during drought. There are no organised marketing facilities, erosion is serious due to overgrazing and health and transport facilities are lacking. The Somali Government considers sedentarisation of the nomads as a long-term objective which would only be achieved by improving the living conditions of nomads through education and training, development of improved stock breeding techniques, the creation of public health services adapted to the nomadic way of life and by the improvement of watering facilities.

In Kenya, it is estimated that there are about 1.5 million nomads in the arid and semi-arid areas who own 50 per cent of the nation's flocks and herds. These pastoral areas are an asset in that during years of normal rain, they meet their own subsistence requirements and provide most of the meat for the urban population, but they become a liability during drought years when government spends vast resources for famine relief.

The Masai now have accepted formal land tenure and need to improve their herds through the purchase of better bulls, use of artificial insemination and the culling of unproductive cows. Efforts are being made to convert subsistence pastoralism into an economy of commercial production through

advice, persuasion and demonstration without resorting to compulsion. New water supplies are being installed, dipping tanks constructed and improved bulls introduced. Among the nomadic tribes around Lake Rudolf, local nomads have been taught fishing. Canoes, nets and lines were purchased and catches increased from 2,000 tons of fish in 1968 to 5,000 tons in 1972, some of which is exported to Uganda and Zaire.

In South and Central Africa, the Dobe Bushmen of Botswana and the Eastern Hadza of north central Tanzania both live in semi-arid woodland savannah unfavourable for subsistence agriculture. In these marginal areas where agriculturalists often suffer from famines, the hunters and gatherers have adapted themselves to their environments and are comparatively better off.

This is why any projects aimed at sedentarising the nomads and changing their way of life is not necessarily the best solution to nomadic environmental problems. Flexible programmes must be initiated if ecological imbalances are to be avoided. In fact, although the nomads and their practices are blamed for expansion of the desert in Africa, there are other continental changes which are responsible for rainfall fluctuation and the resulting desert advancement in Africa.

EDUCATION IN THE AFRICAN ENVIRONMENT

The solution of Africa's environmental problems will depend on her own educated manpower. What kind of animal is he? He has been shaped by several variables. The advent of colonialism introduced religious missions from different denominations and countries who established schools and strived to convert Africans to their brand of religion. In these institutions, unquestioning acceptance of dogma and doctrine was the rule. Inquiry, curiosity, creativity and innovation were discouraged. Education was used as a powerful tool for the status quo and the furtherance of economic and other interests of the colonisers, such as belittling the African heritage and depriving the African of his dignity and pride. He developed neurotic inferiority complexes and remained for the rest of his life a slave to the environment designed for him.

African education, even after independence, continues to depend on the services of foreign teachers who use transplanted curricula and text books. They use systems from their own countries which they know best. The quality of these foreign teachers varies widely and often leaves a lot to be desired. In lower levels, it is necessary to employ many unqualified teachers who have to learn on the job. Over-crowded classrooms and lack

R⟶M and T⟶M, effects on the environment of methods of utilisation of the resources and of the production techniques employed;

Y⟶M, impact on the environment of the methods of consumption of products;

P⟶M, impact of human settlements on the environment;

M⟶R, degradation of natural resources due to abuses;

M⟶Y, conditioning of production through the quality of the environment; and

M⟶P, environment as a component of the quality of life.

Figure 2 does not, of course, set out to do anything more than point out the relevant relationships which, over and above the traditional factors used in planning, must be taken into consideration within the framework of a strategy aimed at making development compatible with the management of the environment. At best, these diagrams have a heuristic value and will have to be modified in every concrete case. Likewise it would be impossible to indicate once and for all the operational variables for such a strategy. On the other hand, it is possible to identify the critical levels at which action will take place. We distinguish six such levels, a brief description of which is given below:-

1. The consumption structure, which, in turn, depends on the distribution of incomes and on the totality of values recognised by the society in question;

2. The socio-political regime and, more particularly, its manner of dealing with social changes; in market economies, the rule is to let enterprises internalise profits and externalise costs, while in socialist or mixed economies, the state may, in theory, change this rule of the game;

3. The techniques employed, where a distinction has to be drawn between, on the one hand, the adding of anti-pollution measures to the escalation of production and the resulting nuisances and, on the other hand, the introduction of techniques which are not destructive of the environment, i.e. where the environment factor has been internalised;

4. The methods of utilisation of natural resources and energy, analysed from the viewpoint of wastage of rare resources, possible recycling of waste products, and even of controlling the obsolescence rates of certain durable goods and equipment with a view to reducing the utilisation of rare resources incorporated in them;

5. Land occupation systems, since the same types of production and activities lead to very different effects depending on their localisation; and

6. Lastly, the size, rate of growth and distribution of the population, it being understood that population size alone cannot serve as an indicator of its pressure on natural resources; by reason of their high per capita consumption, the few hundred million inhabitants of the rich countries exercise more pressure than the thousands of millions of inhabitants of the Third World.

In view of the complexity of the subject and of the many ways in which the relevant operational variables can be fitted together, there can, of course, be no question of proposing a single development strategy. And so we come back once more to the search for future alternatives.

The foregoing general considerations have led to the formulation of the concept of eco-development. This concept aims at defining a style of development particularly suited to the rural regions of the Third World, though this does not mean that it cannot be extended to include towns, as we shall see in the case of New Bombay.

Its main features or guidelines are as follows:-

1. In each eco-region, efforts are made to develop those of its resources which are specifically needed for the satisfaction of the basic needs of the population in regard to food, housing, health and education, these needs being defined realistically and independently so as to avoid the undesirable effects of copying the consumption style of the rich countries.

2. As man himself is the most valuable resource, eco-development must above all contribute to his fulfilment. Employment, security, the quality of human relations, respect for the diversity of cultures - or, if one prefers, the development of a satisfactory social eco-system - are all part of this concept. A certain symmetry is discernible between the potential contribution of ecology and social anthropology to planning.

3. The identification, exploitation and management of natural resources is conducted from the standpoint of a forward-looking solidarity with future generations. Depredation is strictly prohibited and the exhaustion of certain non-renewable resources - which is inevitable in the long term - is mitigated by the dual approach of avoiding wastage and making the greatest possible use of renewable resources which, if they are correctly used, should not be exhausted ever.

4. The negative impact of human activities on the human environment is reduced by resorting to procedures and forms of organising production which make it possible to take advantage of complementarities of all kinds and to use waste for productive purposes.

5. In tropical and sub-tropical regions in particular, but everywhere else as well, eco-development relies on the natural capacity of the region for photosynthesis in all its forms. Since guideline number 1, as applied to energy, tends to attach great importance to the use of local energy sources and to give preference to means of transport other than the private car, one result should be a reduction in the consumption of energy from commercial sources (and in particular hydrocarbons).

6. Eco-development implies a particular technical style, since the above guidelines cannot in most cases be applied without the development of appropriate techniques. There are two comments to be made here.

The development of eco-techniques will play a very important role in eco-development strategies for the obvious reason that it is at this level that compatability can be achieved between various objectives - economic, social and ecological - since technical change would appear to be the principal multi-dimensional variable in planning.

But it would be wrong to assimilate eco-development merely to a technological style. It calls for certain social organisation procedures and a new education system.

7. The institutional framework for eco-development cannot be defined in the abstract without regard to the specific features of each case, any more than can the new forms of rural institutions proposed by the World Bank for achieving some success at last in the attack on absolute poverty in rural areas and for exploiting the potential of the impoverished masses of the Third World by providing the small peasant with production equipment and techniques suited to his economic and ecological conditions.

We can however state three basic principles.

Eco-development calls for the establishment of a horizontal authority which is capable of looking beyond the interests of particular sectors, is concerned by all the facets of development and is able constantly to control the complementarity of the different activities undertaken.

Such an authority cannot be efficient without the effective participation of the populations concerned in the realisation of eco-development strategies. This participation is essential for the definition and harmonisation of actual needs, for the identification of the productive potential of the eco-system and for the organisation of the collective effort to develop it.

Lastly, it is essential to ensure that the results of eco-development are not impaired by any plundering of the populations concerned by intermediaries acting as contacts between the local communities and the national or international market.

These principles can be applied without too much difficulty in areas of the Third World where agrarian reform has been undertaken, and also in every case where the community structures have remained in being.

8. One necessary complement for the machinery of planning and management is preparatory education. This argument applies a posteriori in the case of eco-development, where it is essential also to make people aware of the dimension of the environment and the ecological aspects of development. Lastly, as we have already said, it is essential to internalise this dimension and thus to change the system of values and predominant attitudes to nature or, on the contrary, to preserve and strengthen the respect for nature which is still a characteristic of certain cultures. This result may be obtained either by formal or environmental education. The Chinese experience is very instructive in this connexion. The eco-techniques developed in China do not differ appreciably from those which other peasant societies have known and practised; but what is new is the education which precedes and accompanies their application, and determines their scope.

In brief, eco-development is a style of development which in each eco-region calls for specific solutions to the particular problems of the region in the light of cultural as well as ecological data and long-term as well as immediate needs. Accordingly it operates with criteria of progress which are related to each particular case, and adaptation to the environment, as postulated by the anthropologists, plays an important part. Without denying the importance of exchanges - and we shall revert to this matter later - it tries to react against the predominant fashion of allegedly universalist solutions and panacea-type formulas. Instead of placing too much emphasis on external aid, it relies on the capabilities of human societies to identify their problems and devise their own original solutions to them, though drawing on the experience of others. It rejects passive transfers and the spirit of imitation, and gives pride of place to self-reliance. It avoids the pitfalls of extreme ecologism and suggests on the contrary that a creative effort to benefit from the margin of freedom offered by the environment is always possible, however great the climatic and natural constraints may be. This is amply borne out by the differences

between cultures and human achievements in comparable natural environments. But success depends on a knowledge of the environment and on the will to create a lasting balance between man and nature. The setbacks and disasters in which certain societies have foundered offer equally eloquent evidence of the high price which has to be paid for inability to organise the relationships between man and nature.

With the assistance of some examples taken from the fields of production, food, housing, energy, industrialisation of renewable natural resources, conservation of resources and organisation of social services, we now propose to illustrate the scope of application of eco-development strategies, with special reference to eco-techniques.

FOOD

The 'green revolution', at least in its first phase, is based on a universalist and diffusionist philosophy of development which places too much emphasis on the virtues of transfers of technology and the widespread use of certain 'miracle' varieties of wheat and rice. We are unable here to examine the complex and controversial subject of its results, and we shall therefore merely mention that many critical analyses insist that there are limits to its applicability, since it assumes that the problem of irrigation is solved and it also calls for extensive industrial inputs. In addition, it has contributed to an increasing social polarisation and an even more inequitable distribution of income in the countryside. Lastly, it involves ecological risk both because of the reduction of genetic variety and because of the extension of single-crop farming which is more vulnerable to epidemic disease than mixed farming.

Is it necessary to conclude from this that cultural borrowings and 'modern' agriculture should be ruled out? Though certain champions of so-called biological agriculture may not agree with us, we reject this conclusion. The mere list of the plants originating from America which are now being cultivated by the rest of the world is enough to demonstrate the absurdity of such an approach, quite apart from the fact that the abandonment of chemical fertilisers and insecticides would lead immediately to a decline in production with very serious consequences. Nevertheless, it is possible to take a stand against the views incorporated in the 'green revolution', and to stress the specific potentialities of each eco-region in regard to food production.

This leads us to draw attention, first of all, to the importance of ethnological research in order to take advantage - if only as a point of departure - of local people's knowledge of their natural environment, that

'practical science' of primitive peoples and peasants whose richness and accuracy are constantly surprising anthropologists and ethnobotanists.

The striking diversity of types of agriculture and cultural habits in the world may be analysed from the standpoint either of their adaptation to natural eco-systems or of the transformation of these systems. A classic study by Clifford Geertz draws a comparison between the irrigated terraces of Java - veritable aquaria fashioned by man for rice cultivation - and nomadic agriculture practised on patches of burnt soil which constitutes an imitation of the tropical forest. These are two extreme cases in many respects: the degree of artificiality, and supportable population densities (that of the rice fields is as much as 2,000 inhabitants per square kilometer): they are also two cases of felicitous adaptation to very different sets of ecological conditions. They reflect two very different orientations for agronomic research, the one relating to highly labour-intensive methods of production involving massive populations living in a small area, the other pointing to the development of mixed farming based on the chacras of the Amazonian Indians and the gardens of the indigenous population of Polynesia. In the view of several experts, the apparent disorder of the latter conceals a profound rationality.

In general, we have insufficient knowledge about agriculture in humid tropical areas; and priority should therefore be given to eco-techniques applicable in this area, on which the development of Amazonia will to a large extent depend. This in itself is a highly controversial theme. Should Amazonia be developed or should it, on the contrary, be kept as a reserve, as certain people advocate?

In view of the programmes already undertaken and the existence of mineral wealth in this region, this question is rhetorical, particularly since the argument that the Amazonian forest is one of the 'lungs of the world' producing oxygen is scientifically unsound. The only real problem is how this development will be effected (and what is to be done with the last of the Indians). Will the development be effected by traditional techniques which involve cutting down the forest in an attempt to transform it into artificial pampas and open fields - which is quite impossible - or, on the contrary, will it be effected by eco-techniques which respect the forest but turn it to greater profit? The results will depend on this basic choice and the ability to create in Amazonia a new plant life civilization. Can it be that the pessimism of Betty Meggers is due perhaps to the fact that she does not believe in the second possibility, while the optimism evident in the last writings of Gourou reflects

precisely a genuine act of faith in human creativity in planning?

Whichever be the case, it will of course be necessary, here as everywhere else, to make use of methods which are already known and belong within the range of classical solutions, even though they may not have been adequately used hitherto. By way of example, we may mention the use of cassava or stripped sugar cane as fodder. But the bulk of the effort must be based on new approaches, of which we shall mention only a few.

First of all, forest-farming, which the Anglo-Saxons describe as three-dimensional forestry, uses the forest as a source of industrial materials and also of animal fodder and human foodstuffs. A glance back to the European Middle Ages will show that forests were long used as "a cattle fodder yard of unequalled quality", in the words of a Burgundy chronicler of the fourteenth century, quite apart from the role which they have long played as a source of energy. For a long time past, Germans have spoken of the Nahrwald - the forest as a source of fodder - whose value is calculated in terms of the number of pigs it can feed. The same evidence is provided by the study of certain primitive societies. One example is the astonishing case of the inhabitants of Ukara Island on Lake Victoria in Tanzania, which has a dense population of livestock breeders whose animals are kept in yards and fed on a mixture of leaves from specially planted trees and from aquatic plants. This opens up prospects of research on trees which can produce human foodstuffs, either directly of indirectly through producing fodder. This research is regarded as essential for the future of agriculture in humid tropical areas, since tree cover seems to be the best cover for the soil in these regions. We may note in passing that forest rehabilitation will call for a change in some ideas profoundly rooted in European civilisation, which has grown accustomed to regard forest-clearing as synonymous with economic progress. The rational management of the fauna and the taming of certain species may, in certain conditions, constitute a counterpart and a valuable extension of forest-farming.

Next we turn to aquaculture or the 'blue revolution' (as opposed to the 'green revolution') in all its aspects: the cultivation of aquatic plants and the breeding of fish and animals in fresh water, lagoons and the sea instead of a continuous fish-kill. There are abundant examples of this, starting with the familiar case of fish breeding in pools, where a judicious combination of cultivation practices and fertilisation produces very high yields with eco-techniques which require practically no capital

investment. Mention may also be made of the possibilities of breeding milk-fish in brackish-water lagoons. From certain lagoons fertilised by sewers in Indonesia it is possible to obtain a yield of 5,000 kg/ha/year. In Taiwan, fish breeding with fertilisers produces yields of 2,000 kg/ha/year; and it has been calculated that in South East Asia 350,000 square kilometers of water are suitable for breeding milk-fish. If they were put to use, they could produce 70 million tons of fish at the Taiwan productivity rate, or the equivalent of the world fish catch. One more difficult but also promising field is the taming of certain species of aquatic mammals which feed on plants. The most notable example might be the sea-cow, which unfortunately is almost entirely extinct. In tropical regions where the soil is ill-suited for the creation of meadows, aquatic plants offer great possibilities as fodder for buffaloes and other animals.

Going on a step further, we come to the production of proteins from leaves of various kinds, including weeds. Under certain conditions, the plants infesting certain lakes could likewise become a raw material for the extraction of proteins, and eutrophication could be prevented in this way.

It goes without saying that biological pest control methods, and also genetic research on local species which might be exploited, both naturally come within the framework of an eco-development strategy.

Most of our examples have been taken from the humid tropical zones. The problem is quite different for the arid and semi-arid zones, though it is possible to imagine eco-development strategies for these areas as well. Recent studies have pointed to the possibility of developing plants which are particularly suitable for photo-synthesis in areas where there is a lot of sunshine, high temperatures and little water. It is true that the development of deserts may call for eco-techniques with a high capital-intensiveness, but capital is not lacking in the petroleum producing countries. A Japanese research project which was originally undertaken with a view to desulphuring the petroleum of the Persian Gulf points to the use of asphalt injected beneath the surface of the desert to prepare certain areas for the hydropinic cultivation of plants which are genetically suited to the brackish waters existing in the region. It is essential to mention also the political importance of studies of this kind, as a possible contribution to solving the Middle East conflict by developing the resources of the desert. The national aspirations of the Palestinians and Israelis could be satisfied more easily if the ecology of the region were changed; and the 'Great Petroleum Scare' and

the consequent sharp rise in prices have made it possible to envisage a machinery for financing such an enterprise through a small surtax on petroleum, long-term loans advanced by the petroleum producing countries and the conversion of the military aid provided to the two opposing camps into a desert development fund.

HOUSING

Every year, the housing shortage on the world scale increases by some 4 to 5 million units in urban areas alone. The situation in the country-side is far from being satisfactory. And yet, paradoxically, this is a field in which over the centuries human societies have created dwellings of varying types according to the locality and culture, and well adapted to the eco-system and the climate, but in which misunderstood modernity has led to such ravages that it has become necessary over recent years to re-invent 'eco-dwellings' reflecting a high degree of ingenuity in the choice of materials, the use of solar and wind energy, water re-cycling, etc. Housing comes within the framework of eco-development under three closely linked aspects:

1. The use of building materials of local origin, which are abundant and cheap, ranging from bamboo to mud; this is a problem which has been studied in some detail, but much remains to be done in practice, starting with the rejection of an alien system of values according to which an aluminium roof or a steel and cement house imported at great expense is regarded as a symbol of modernity even in the bush;

2. The adaptation of the dwelling itself to ecological conditions; as we have already stated, this is the field par excellence for the cultural creativity of man, in which it is necessary to take a deliberate step backwards to re-examine traditional housing and possibly draw inspiration from it. A rigid attitude of reverence for tradition is, of course, undesirable; but architects should pay more attention to anthropology and move beyond the false universalism with which their discipline is at present tainted; and

3. Lastly, the integration of ecology and anthropology with urbanistic thinking and with the elaboration of structural plans for towns and all other human settlements; this is by far the most difficult task and the one which has so far been least studied. Hence the importance of the pioneering efforts made by the creators of the New Bombay plan. This city of two million inhabitants is to be built with a minimal allocation of resources for housing proper, since the housing is to be provided by self-construction on very small plots; but a very elaborate plan for the occupation of the ground--

(which has been made possible by prior purchase of land by the authorities) and rapid collective transport by railway will together provide the inhabitants with living and working conditions which will be very reasonable compared with those in other towns in India.

ENERGY

The debate on the importance of non-classical sources of energy is highly charged and we have no intention here of taking a position on this controversial subject. It is enough merely to state that the recent increase in petroleum prices has already upset many hard-and-fast ideas. We shall not say anything of the possible solutions to the problem of large-scale energy production but, in the context of eco-development strategies, we must refer to the importance which might be attached to the elimination of the energy waste which occurs so often in the consumption style of the industrialised societies, and to the possible contribution which might be made - in the case of domestic energy uses and small production units - by solar energy (for example for pumps, kitchen stoves and water heaters), wind energy (for the local production of electricity), small dams and even the production of methane from organic sources. These various procedures are justifiable in the conditions of isolation which exist in many rural regions; and they also have the advantage that they can be applied on an even more reduced scale, for example on a single farm. The possibilities of using geothermal energy should, of course, also be carefully assessed where they exist.

INDUSTRIALISATION OF RENEWABLE RESOURCES

One way of combating the possible shortage of certain non-renewable resources might be to restore pride of place to the 'plant life civilisations' which are so well described by P. Gourou and whose importance is so evident in Far Eastern cultures. We do not advocate a pure and simple return to the past as do the partisans of the so-called intermediary and 'soft' techniques, but would rather propose some detailed research on the possible use of plant life as an industrial raw material, both for building materials and for chemical products. The rise in petroleum prices makes this all the more necessary, and it increases the urgency of devising techniques for the rational management and exploitation of tropical forests and water bodies. We believe that a special place should be reserved for 'mixed techniques' - i.e. transforming the qualities of a product by highly technical processing, as the terminal stage in an otherwise traditional production procedure which offers plenty of employment. All forms of processing and impregnating timber and plant fibres, based on the latest advances in modern

chemistry and offering new outlets for certain products of tropical forests and agriculture, provide a good illustration of this concept.

CONSERVATION OF NATURAL RESOURCES

As we have already indicated in regard to the definition of eco-development, the maintenance of natural resources in the name of a forward-looking solidarity with future generations is an integral part of this strategy. It seems that it is also an excellent field for human investment, since many soil and water conservation activities, reforestation, etc. are suitable for the use of highly labour-intensive techniques. Also, as spare labour is often available, at least outside the season of major agricultural activity, it is possible to envisage natural resources conservation programmes which would not to any large extent diminish the capacity of a country to undertake other development enterprises. This is one opportunity which should not be missed, as the example of China eloquently demonstrates.

SOCIAL SERVICES

If, as has been suggested, the social environment is to be considered as part of the global environment concept, as meaning the total habitat of man, an eco-development strategy must naturally include forms and techniques for providing social, educational and cultural services which are adapted to the specific conditions existing in the rural areas of the Third World and also call for as little capital as possible. Many recent studies and the experience of a number of countries prove that such techniques already exist at the level of para-medicine and rural education. In these conditions, Third World countries should be encouraged to attach much more importance to these activities than they are given in the industrialised countries, since the possibilities for developing these services - like any others - are best at the time when social workers' salaries are still low. In other words, the poor countries have a comparative advantage in creating many social services which also offer employment possibilities that are more valuable to society than the traditional tertiary sector (domestic services and small business). Paradoxically, it is the countries of the Third World which have the best chance of creating genuine welfare states.

The concept of eco-development is intended to be operational. It constitutes a guideline for action (or, if one prefers, a philosophy of development) whose value can be judged only in the light of practice. Is it merely a return to the illusions of community development? Not necessarily so since, by comparison with the community development schemes

for the rural areas of the Third World, it is richer in two aspects: first, there is the critical reflection on the failure of those schemes and accordingly the desire to do better, particularly at the institutional level, and secondly there is the link with natural and social ecology which is revolutionising the habits of thought of the developers.

The application of the concept does, however, require a sustained research effort accompanied by pilot activities subject to critical review, so that permanent feedbacks are established between practice and action-oriented research.

In particular, it is essential to promote the collaboration and circulation of information on eco-development experiments as identified and described by anthropologists, historians and human geographers, and also on eco-techniques developed and applied by different indigenous peasant cultures and, to an increasing extent, by certain research laboratories. The purpose of this will be three-fold: to inspire the imagination of research workers and persons responsible for regional planning, to assist in the training of eco-developers and, occasionally, to suggest experiments in adaptation, particularly between similar eco-zones. This will require a vast programme of comparative and interdisciplinary research and voyages in space and time, undertaken through a network of scientific collaboration in which our colleagues of the Third World will have primary responsibility, since encouragement must be given above all to exchanges within the Third World, on a South-South axis, by insisting on co-operation between eco-regions which are similar but situated in areas geographically distant from one another.

On the basis of these exchanges, supported by specific case studies, it would be possible to define points of interest to serve as foci for the collaboration of biologists, technologists and planners - three professions which have in the past had too little contact with one another. Their exchanges would lead to the formulation of research priorities on eco-techniques and organisational forms of eco-development.

Without waiting for the results of all these exchanges, it is possible even now to undertake certain pilot activities, designed to show that regional or micro-regional development strategies would be improved if they were oriented in the direction of eco-development. The elaboration of eco-development 'scripts' would make it possible, in a first stage, to take stock of actual knowledge - or gaps in knowlege - on this matter, to test the participatory and unified approach to planning

and to train eco-developers. In a second stage, it is conceivable that the eco-development concept will simply be assimilated by the regional planners and will thus be generally used to contribute to the indentification of development styles appropriate to each specific case; and, in the long-term, the internalised environment as a permanent dimension in the field of vision of the planner is destined to vanish as a specific field of action.

It would seem that, as a result of the Stockholm Conference, conditions now exist for the above suggestions to be put into effect without delay by the United Nations Environment Progamme.

CASE STUDY: KUUMBA, A FICTIONAL COUNTRY

Kuumba is a fictional country and any resemblance to any other country living or dead is purely coincidental. As with any hypothetical model, certain assumptions will have to be made as you deal with it. We have tried to construct it in such a way that some of the problems you face day to day in your countries may be reflected in the problems faced by Kuumbans.

It should always be remembered that Kuumba is only a device for making explicit the fundamental connections between environmental and developmental concerns. For the protection of the environment is one of the bases for development.

In an artifical study such as this, we cannot expect to include all of the facts and assumptions which a real planner faces. This lack is part of the exercise. Every government and every development planner must make decisions based upon incomplete information. In Kuumba you will do the same. Two major development schemes and their results to date will be presented for your discussion and recommendations. There are two basic questions underlying both cases.

(a) What was done that should not have been done?
(b) What should we do now; given the means at hand and the economic, social, political and technological contraints?

Implicit in these specific questions are some more general developmental issues:

1. What is the best use of the resources available?
2. How does an undeveloped country develop?
3. What is the balance between public and private economic interests?
4. How do you achieve the greatest good for the greatest number?
5. How do you formulate an integrated national development scheme?
6. What is the role of public planning?

We hope in this exercise to take advantage of the complementarity of development and the environment. They need not and should not be in conflict.

Finally, we would be fools, even in a hypothetical game, not to recognise the primacy of politics. We hope, however, to make this fact itself an assumption or at least to soft pedal its influence on the discussions. With all of the other information provided here, there should be plenty of materials for discussion.

BRIEF DESCRIPTION OF KUUMBA

a. Gained independence in 1963.

b. The nation is a single-party democracy, with a unicameral legislature. It has a military establishment of some 20,000 men. The president, a former army general, took power in 1966 and was elected in 1970 to a four-year term.

c. Principal ministries are as follows: Finance and Planning; Agriculture; Defence; Commerce and Industry; Posts/Communications; Natural Resources; Tourism and Wildlife; Public Works; Housing; Labour; Foreign Affairs; Health, Education and Welfare; Treasury. In addition, the president has a small 'kitchen cabinet' of special advisers, confidants and ministers without portfolio.

d. Kuumba's foreign relations have been unusually quiescent during the 11 years of independence.

e. Population - 5.2 million (1974 estimate); rate of increase - 3.3% per annum.

f. Total Area - 36,324 square miles.

1) Southern Region	954,000 people	10,376 square miles	
2) Central "	2,875,000 "	13,714 "	"
3) Northern "	1,411,000 "	12,234 "	"

g. Minerals - Bauxite (50% alumina), estimated recoverable reserves: 20,000,000 tons.

h. Main towns Ngamula 120,000
Lwazi 22,000
Nata 25,000

Cities

Although Kuumba is still predominantly rural, there is besides the agglomeration of people in the three main cities, a score of small towns which have sprung up in various parts of the country, but especially in the Central Region. The latest crude estimate of Kuumbans in towns over 2,000 is about 300,000.

Balance of Payments (U.S.$ millions) (All money figures will be in US$.)

	'68	'69	'70	'71	'72	'73
Imports	60.1	65.2	75.1	80.6	93.9	107.4
Exports	50.2	52.3	63.1	77.3	86.1	78.2
	-9.2	-12.9	-11.4	-3.3	-7.8	- 29.2
Foreign Exch. Reserves Total	22.8	22.5	30.7	31.6	25.2	22.1

Main Exports (U.S.$ millions)

	'68	'69	'70	'71	'72	'73
Tobacco	15.6	18.9	24.9	34.5	43.1	47.5
Tea	14.4	14.1	16.2	18.0	20.2	21.9
Groundnuts	6.9	8.4	6.3	7.5	8.9	10.1
Cotton	1.8	2.4	3.9	3.6	4.2	4.9
Maize	4.5	3.3	-	-	-	-

Imports (1973) (U.S.$ millions)

Grain	3.9
Processed Foods	4.6
Machinery	13.5
Petroleum products: fuel, lube oil, petrochemicals, heating oil and lubricants	20.6
Vehicles	11.2
Cloth	2.7
Paper products	3.5
Chemicals (other than petrochemicals), fertilisers, etc	11.2
Steel, metal goods	14.6
Construction materials	8.2
Other	11.3
	107.4

Gross Domestic Product (U.S.$ millions)

	1967	1968	1969	1970	1971	1972
Monetary	170.6	191.2	225.4	245.4	263.5	270.1
Non-monetary	137.3	142.2	147.0	159.0	166.5	171.3
Total G.D.P.at factor cost	307.9	333.4	372.4	404.4	430.0	441.4

Budget	U.S.$ millions	
Education and Welfare		24.3
Finance and Planning		7.7
Commerce and Industry		8.3
Housing		10.5
Labour		5.5
Foreign Affairs		5.4
Health		4.1
Natural Resources		6.2
Public Works		8.2
Post/Communications		3.5
Agriculture		10.9
Defense		11.1
Tourism/Wildlife		3.6
Transportation		6.7
Home Office		8.2
Public Debt/Charges/Redemptions		13.3
Pensions		4.3
Interior		9.3
Development Fund & Expenditure		25.2
		176.3
Ordinary Revenue/inc.appropriations-in-aid		147.6
Development Funds received		30.7
		178.3

The basic food of Kuumbans is ugali, sometimes with vegetables or meat. In the rural areas there are more vegetables, garden and wild, available. Cabbage, lettuce, carrots, rape spinanch, etc. are also grown. The city diet among the many men especially is buns, Cokes, and perhaps ugali. In the Northern Region, maize crops have failed and there are growing shortages. The Central Planning Commission acknowledges that the path to development is not simply one of going hell-bent for industrialisation. In the first place, the country has no significant resources for that goal except its abundant hydroelectric power potential and its bauxite. At the same time, the Commission believes that some major efforts towards expanding those resources and building light industries for import substitution will help to save scarce foreign exchange.

To this end, the planners have encouraged government to use various fiscal incentives such as tax allowances, tariff protection and licensing arrangements to establish small industrial concerns. These include bottling plants, companies to make bicycle parts, paints, textiles, metal processing and pulp mills. A distillery and brewery were among the early arrivals. This plan will be pursued in the future.

Needless to say, the recent explosion of petroleum prices has had a devastating effect on budgeted figures in all sectors of the economy. The government is still trying to sort through wreckage of its projected figures.

The agricultural sector will probably continue to dominate the economy in a real sense for the foreseeable future. The government paid lip service to the needs of the rural areas for the first years of independence, but only within the past five to six years has government begun to take the small farmers seriously. The larger farms, the estates, have been able to manage pretty well by themselves. Kuumba has targeted a G.D.P. of $650 million by the end of the decade, a growth of nearly fifty percent.

Flue-cured tobacco was introduced into Kuumba's Central Region in the early 1920s. Not until after independence were Africans able to join the business. Those who have begun have opted for the less capital-intensive dark-fired variety.

Tea growing was also begun by the Europeans in the 1900s. By the time of independence, Africans had about a thousand acres of small holdings. Estate owners continue to be Kuumba's major tea producers. Three quarters of the 60,000,000 pounds annual output are grown on estates.

Groundnuts are the principal cash crop, after tobacco, grown by small holder farmers. There is some potential for expansion of this crop since the Kuumba groundnuts are of high quality and are favoured by confectioners. There is virtually no domestic consumption. The industrial heart of the country is in Ngamula, the capital city. This has occured partly by accident, partly by design. Whatever the cause, the effect is a concentration of people and jobs unlike anywhere else in the country. As in most developing countries, job applicants far outstrip jobs. Consequently, there is a growing number of young men, scratching out a precarious existence shining shoes, selling newspapers, willing to take almost any work however temporary. The population of Ngamula is growing at about 6% per year and the municipal government cannot begin to cope with the increased demand on its services.

Kuumba's development in the rest of this decade will be based upon the completion of the Msilisi Dam. This ambitious programme on the Juluka River is intended to produce power for industrial expansion in Ngamula and for several pilot agricultural projects designed to show the way towards more efficient and productive techniques. Except for the game reserves, there are no completely unsettled areas in the country. Government has decided to create several demonstration projects.

Although there are some 550,000 cattle and almost 600,000 sheep and goats, government has done little to develop a systematic plan of animal husbandry. It has been content to let the farmers and squatters use as much land as they want to graze their animals. The result has been that in enclosed spaces the animals have tended to eat and trample most vegetation into extinction. In larger pastures or freer areas, the results have not been dissimilar, for the animals have grazed indiscriminately.

In the Northern Region, where most of the cattle-herding occurs, the grazing capacity of the land varies between five and twenty acres per cow. This also happens to be the major area for nomads in Kuumba. Naturally, accurate statistics are impossible to obtain, but some estimates number them at around 20,000. Their coming and going, especially in the Northwest, has raised problems for the Ministry of Wildlife which wants to establish another game park in that region.

Sheep and goats are calculated to graze one sixth as much as cattle. The nomads do not choose freely which animals they raise - they follow custom. And the custom is to possess as many cattle or goats or sheep as possible, no matter what their condition. The herdsmen see no reason to change their practice of securing the maximum number of cattle.

Kuumba will spend in the next two years $26.2 million on the development of its infrastructure; this consists of $10.5 million on transportation, $8.2 million on water supplies, sanitation, power, posts and telecommunications and $7.5 million on roads and bridges. A further $10.5 million will be spent on other agricultural activities in the areas without specialised projects.

A more detailed treatment of the **NATA LAND DEVELOPMENT PROJECT** will be given in Appendix 2.

The N.L.D.P. will be associated with a 100,000-head cattle ranch. The ranch will be 100,000 acres. It is assumed that the stubble from the maize, cotton seed and peanut by-products will be used to feed the cattle and that this system will easily enable stocking one animal per acre when both rangeland and arable land products are used for stockfeed.

The increased use of fertiliser and chemical spraying from 1967 to 1969 seems to have corresponded with an increase in the yield of maize, but after 1969, there was no maize yield increase. In fact it decreased. (See sampling of statistics in Appendix 4)

In most rural areas, the pattern of emigration is similar to that in many parts of Africa. Land tenure and succession patterns militate against more than one son receiving enough land to make a living from it. In addition, some of the land is so poor that people simply cannot survive, even when they want to remain in the countryside. So movement to the cities is not merely a question of being attracted by the 'bright lights'. Government has done little or nothing to stop this movement, probably because, short of Draconian laws and enforcement, there is little that it could do .

There are about 150 estates, each larger than 200 acres, in the Central Region. Some of the business people, expatriates and government officials who own these estates live in town and use the estates for their families' recreation. There are small holder farm owners who have taken to ploughing small acreages (2 acres) of corn, cotton, tobacco, tea and coffee. Most of these farmers do not use tractors and other modern techniques of ploughing and land clearing. What the government has tried to do instead is develop some agricultural schemes which will encourage farmers to stay in the countryside. One of these is at Nata. See Appendix 2.

TOURISM .

Having observed the impact of **tourism** on the economies of countries such as Kenya, Tanzania and Uganda, Kuumba has taken first tentative steps to build a tourist industry. Despite its land-locked location, Kuumba has several potential tourist attractions.

a. Game - Most major game animals (zebra, gazelle, hippo, impala, giraffe, lion, leopard, wildbeest, hartebeest and even some rare greater kudu) are found here.

b. Water - several sizeable bodies of unspoilt water remain.

c. Scenery - the highlands contain both a good climate and an impressive variety of vistas, including several water falls. The problem is transportation to these places.

Government commissioned a study which came back with the following observations:

1. The road system is deficient;
2. There are no game lodges; and
3. Package tours are needed.

(For further discussion, see Appendix 2.)

APPENDIX 1: THE PHYSICAL STRUCTURE OF KUUMBA

The three physical regions of Kuumba are geographically determined.

Lake Harambee - 9,375 square miles - is the dominant physical feature. Bestriding it are two 8,000 foot high plateaux. Flowing from the plateaux into Lake Harambee are four main rivers. These rivers are tributaries which cut deep gullies of up to 40 feet into the plateaux. This area has suffered the most severe erosion in the country. No one has calculated how much soil has been washed into Lake Harambee.

Kuumba gets most of its rain from the south-east trade winds. East of Lake Harambee, the Mude plateau receives up to 70 inches. The lake itself averages 35 inches. On the Western side, the Kwela plateau receives as much as 55 inches. Westward from there, the rain decreases to about 30 inches. Going northward from the Lake, there is a similar steady decline in precipitation so that at the Northern border of the country, rainfall in the semi-desert is both scant and spotty, averaging less than 15 inches.

The central and Northern regions are both characterised by gently sloping topography. The division between these regions is one of rainfall rather than topography.

Soil in the plateaux region is of the red sandy type with a mixture of pebbles, rocks and stones. In many places the top soil is less than four inches deep. In the other two regions, the soil is mainly sandy loam, but along the Julaka river it is of the alluvial clay loam variety. The Northern region is a mixture of savanna and semi-desert.

Of Kuumba's total area of 36,324 square miles, a quarter is Lake Harambee and another 8,000 square miles is too mountainous, too swampy or too dry for agriculture of any sort. About 500 square miles consist of national forestry land, with rare and native stands of timber.

Then there is one major national park of some 500 square miles. The park contains all of the major game animals except elephant. In addition, it has a large number of the rare greater kudu. This park is the principle tourist attraction in the country at the present time.

APPENDIX 2: LAND DEVELOPMENT SCHEME

As part of its second five year plan, the government of Kuumba launched a new agricultural scheme of some 20,000 acres in the northern part of the Nata region, in an area which had been a forest and game reserve under the colonial regime and during the first five years of independence.

This area had been almost a private hunting block for the colonial administration. Then after independence, it had become a game and forest preserve. This was the reason for its relatively undamaged state.

Q1. As a basis for determining fertiliser use, do you use a general or specific soil survey for both crop and region?

The region is a mixture of forests and savanna. Its altitude averages about 3500 ft. Several tributaries of the Julaka River flow through the district. Rainfall is erratic, ranging from 20 to 40 inches. The soil is a sandy loam, with a depth averaging 14 inches. Soil scientists estimate the land to have an average fertility for most subsistence crops. What makes it attractive for this project is that it has not been farmed for over 80 years, and thus has not suffered the damage from erosion and over-grazing experienced in many of Kuumba's rural areas.

Q.2 In devising the proper mix between agricultural and industrial development, is there such a bias in favour of the latter that public attitudes will have to be changed i.e. to give the rural areas a better image?

Government clearly meant for this to be a demonstration project. (In fact the Minister of Agriculture staked his reputation on its success.) The public announcement was full of phrases such as "self-sufficiency", "freedom from hunger", and "no rural surrender to the cities". Government wanted to kill two birds with one stone, that is it had two audiences in mind; the rest of the country and the people in the lands surrounding the site of the scheme. The hope was that farmers would want to practice more scientific methods of cultivation once they saw the results in the target area.

Q.3 What are the environmental, social and economic bases for resettlement? Is eco-development a viable strategy here?

Into 10,000 acres, therefore government moved 500 families, averaging 10 members each. Each family received 5 acres free and clear and they were allowed to purchase the other 5 acres over a 10 year period. In addition, the new settlers were given access to the common land for grazing. Government, wishing to avoid some of the problems of over-grazing evidenced elsewhere, prohibited the farmers from owning cattle but allowed them to bring up to 10 goats or sheep. It had been determined that the carrying capacity of the land was about 5 sheep or goats to the acre.

Q.4 How do you "re-train" people raised in one traditional livelihood so that they can lead productive, satisfying lives in another?

The settlers were a mixture of subsistence fishermen and farmers who had been displaced by the construction of the Kwela Falls dam. They were of a different tribe from the people in the surrounding area. Because of controversy concerning government supplied housing in an earlier development scheme, the settlers here were allowed to construct their own homes from whatever materials they could find in the forest.

Q.5 How important is the distinction between the physical and the chemical characteristics of a soil? Is eco-development a viable alternative to semi-mechanised agriculture?

Government agronomists calculated that each family would be able to grow enough maize, upland rice, groundnuts, beans and sorgum, together with domestic animals, to feed themselves, while devoting the major part of their labour to cash crops such as cotton, tobacco, tea and coffee. No restrictions on crop proportions were placed upon the farmers. Since maize had been the staple food in Kuumba since time immemorial, it was not surprising that the first rows were planted in maize.

Q.6 What are the guidelines for deciding the appropriate technologies for any development scheme?

To assist the farmers further, government provided tractors the first year to break the ground. Fertilisers and insecticides were also provided at extremely favourable rates, allowing farmers to defer payment until their first crop was in. However, the agricultural agents assigned to the project were unfamiliar with the type of soil in the area. In fact, they were much more expert in fertiliser application than in the physical characteristics of soils.

Q.7 Some experts claim that small-holder agriculture does less environmental damage than large estates? Is this true and if so why?

Rough as some of these arrangements were, the contrast with traditional methods was still great. Outside the demonstration area, the farmers were using pangas, grubhoes, local seed and no fertiliser except burnt vegetation. Only about one year in five saw a surplus which might be marketed. Essentially the farmers were subsistence agriculturalists. The average yield per acre in a good year, was about 3 bags of maize (one bag = 200 pounds) . The result was that farmers spent just about all their time and land raising maize just to feed themselves.

Q.8 Are there specific types of soils which are particularly erosion prone? What are the environmental implications of clearing trees from large tracts of land, especially for firewood, and what are the feasible substitutes for charcoal in rural areas?

As has been mentioned, prior to the opening of this settlement, the surrounding land was under increasing pressure from both men and animals. Poaching was widely practiced despite the stiff sentences meted out to those caught. Sheet and gully erosion were rampant. The land was overgrazed. Most of the trees in the area surrounding the settlement scheme had been cut down for firewood to sell in the cities. In response to the complaints of their tribesmen and constituents, several local chiefs and politicians petitioned government in the early stages to halt this 'elitist' project, to give to the people who needed it most, the locals, the use of this choice land. They objected strenuously to 'foreigners' owning land in their midst. Government representatives listened politely but did nothing. There were scattered reports of incidents between the new and old settlers.

Q.9 Can such government planned development if properly monitored be an answer to the 'pollution of poverty'?

From the agricultural standpoint, however, the first years were very good for the new farmers. Those who had farmed before welcomed the chance to work virgin land. Some of the fishermen could not adjust, and they sat in their huts and sulked. Others learned quickly, especially when they saw maize yields triple what they had been under traditional methods.

Q.10 Is African technology advanced enough to justify the use of biological insect controls?

Logically, it seemed to the farmers that the same agricultural techniques which had been so successful with maize ought to work with cotton, tobacco, coffee and tea. So they used a great deal of fertiliser for

these crops as well. They had known the insects which prey on coffee plants, and they wanted once and for all to get rid of them. Similarly they reasoned that if 200 pounds of fertiliser increased yields by 200 per cent, then 400 pounds would increase it by 4 times.

As was noted above, rainfall is erratic, so that in some years there is 35 inches and farmers are tempted to raise upland rice. In fact, this was attempted a couple of years ago. But there are dry years too. To give the farmers further from the river more reliable sources of water, government has drilled a number of bore holes. These, however, do not provide much more water than is used for domestic needs.

On the local tributaries of the Julaka River, the Corps of Engineers has constructed a few minor earth dams. These storage areas provide the basis on which the farmers, again with government aid, have laid out some irrigation canals. As a result, they can irrigate at least one crop all year long.

All in all, the project seems to be a success. In any case, the Minister of Agriculture proclaims it as such and begins making elaborate plans for similar projects in other areas of the country.

Q.11 Quite bluntly, what should be the balance between the needs of the animals in a game park and the subsistence needs of the local populations?

However, the increase in crop yields did not continue after the first two years, and the Minister of Wildlife for one was dismayed by the project. It had been his intention to expand the game preserve area into a full-fledged national park. While the country already had one national park, containing most of the common animals sought by tourists, this area had several rare species and during the eighty years in which they had remained largely unmolested the animals had achieved a satisfactory balance with the land. The target area was only a small portion of the game reserve. However, it happened to lie directly astride one of the main migration routes taken by some of the larger mammals to obtain dry season water. Further north there was much less water. The influx of settlers, equipment and plows effectively blocked the animals' passage.

The Ministry of Wildlife made a half-hearted attempt to create a park out of the bisected land, but it was no use. Squatters and semi-nomadic tribesmen had moved into the northern area and, given the local opposition to the Nata scheme, there was no hope of any other government ministry removing some of these people. In vain the Ministry presented statistics showing that the tourist potential of the park was on the order of $5 million annually. In vain it decried the loss of valuable species to the poachers' guns and spears. In vain it warned that the wild animals had achieved a precarious balance with the land, and that domestic animals would do irreparable damage and tip the balance towards destruction.

And in just a few years, one of these dire predictions was fulfilled. Despite heroic efforts by game wardens, hundreds of gazelle, oryx, bushbuck and zebra were killed. In fairness to the tribesmen, they were hungry. They did not kill for the sake of killing. They simply did not believe in going hungry when they could eat.

Government officials did not say so, but it was apparent that they believed the future wellbeing of the people would come more from their ability to raise enough food than from relying on the tourist dollars which would derive from the game viewing in this particular area. The Minister of Wildlife declared that one large game park is not enough. But the Minister of Agriculture stated that, "Feeding people is more important than feeding animals."

Near the river, a routine medical examination of school children revealed that a number of them were passing blood in their urine.

In the farming areas, the exciting increases in crop yields after the first applications of fertiliser and insecticides led to a rapid conversion of some of the common lands to these crops. Forested lands and hillsides were cleared and planted regardless of the type of soil,

slope or contour. A land rush ensued in which the project people and even some outside people hurried to exploit the unused lands. Moreover, the people from outside took the opportunity to cut down many trees for fuel.

Q.12 What are the inherent dangers in a single crop system as opposed to diversified crops?

In the fifth year the weather proved its fickleness. The area experienced two storms which in two days dropped ten inches of rain on the upland district. By this time, great swaths of land had been cleared. There was little vegetation to hold the soil, and thousands upon thousands of tons of silt filled the streams.

A further problem emerged when fish in the streams began dying mysteriously. It was discovered that their bodies contained quantities of a lethal posticide called Dieldrin. A newsman covering the story suggested that there might be some connection between the Dieldrin and the deaths. This brought immediate and outraged responses from the Minister of Agriculture and from the head of the fishermen's co-operative. The former said there was nothing to link the two facts. The fishermen were frantic at the threat to their livelihood, and possibly their health. It was finally ascertained that the Dieldrin had come from the coffee plots, which had been sprayed heavily.

Incidentally, this particular coffee was a premium type. It had already established itself as one of the best. It brought the highest prices at auction and this was at a time when world coffee prices were at their peak. As a result, the director of the Coffee Marketing Board saw fit to join the debate, asserting this was no time to restrict coffee production. "Nothing has been proven," he said "These are neo-colonialist rumours. We can't afford to lose our markets by listening to petty fears. Don't look a gift horse in the mouth."

APPENDIX 3: CASE STUDY OF THE KWELA FALLS DAM ON THE JULAKA RIVER

Q.1 Is there an energy development alternative to massive hydro-electric projects?

1a. Is it advantageous to postpone the exploitation of mineral (non-renewable) resources with the hope that they will be worth more in future?

During the colonial period, there was a great deal of talk about a large dam at Kwela Falls on the Julaka River. The narrow valley there seemed a good location for such a dam. The main purpose was to be the production of hydro-electric power. It had become known that commercial quantities of bauxite existed in Kuumba, and the dam would provide all the substantial power needs for converting the bauxite to aluminium.

Feasibility studies were encouraging but no actual construction was begun.

Independence brought the plans once more to the fore. Like many newly independent countries, Kuumba wanted to industrialise as quickly as possible. A policy of expanded exploitation of natural resources, such as bauxite, limestone, phosphorous and potential hydro-electric power, would be pursued with the hope of pulling along the lagging sectors of the economy.

Q.2 Is the introduction of environmentally non-polluting technology prohibitively expensive for the developing countries?

As bauxite requires substantial quantities of electricity to be converted into aluminium, this industry would be the largest consumer of electricity, using about 50 W out of the projected total output of 150 MW. In addition to the aluminium industry, various light industries were planned to take up a major portion of the remainder.

Q.3 Should a government encourage or force people from the rural areas to remain there, i.e. prohibit their migration to the cities?

Taking advantage of the sizeable limestone deposits, government built a cement plant. A 100,000 ton fertiliser plant followed.

Q.4 Is the concept of 'Metroville' THE answer to rural-urban migration in a country where the government had deliberately displaced rural communities and created industrial parks?

The political capital, Ngamula, also became the industrial centre. Government laid out a 5,000 acre industrial park and encouraged cotton ginneries, coffee hulleries, textile mills, food processing plants and other light industries to locate there.

This required installation of a 100,000 volt transmission line which would also become the first link in a national power grid.

Statistics of the Dam:

Height: 50 metres

Length: 200 metres

Cost: U.S.$ 50,000,000, financed by a loan from the World Bank

Resevoir Area: 200 square miles

Type: Rockfill

Annual Flow: 1,500,00,000 cubic meters.

The Kuumba government wished to fulfill several objectives by building the dam. Besides the production of power, secondary purposes were:

Q.5 What are the environmental bases for establishing a fishing industry?

1. The lake formed would, with improved techniques, provide some 30,000 tons of fish annually- 20,000 tons for domestic consumption and the remainder for export.

2. Among the 80,000 acres to be cultivated, 15,000 acres of alluvial soil were found suitable for a wide variety of crops. The planners estimated that the fertiliser production deriving from hydro-power would, by massive applications, more than compensate for the loss of land due to creation of the lake. As a corollary scheme, the government planned to take the estimated 6,000 people who had been living in the valley, and re-settle them either on the lake shore once it was filled or in other parts of the country. Resettlement means taking people away from the land where they are confident about what they will eat, even though it may be little.

Q.6 How does a government make rural living attractive?

3. Flood control would be improved along the Julaka River and its tributaries.

Q.7 What is the justification for investing so much money - about one third of the current budget - for the direct benefit of less than one twentieth of the population?

And so the dam was built. Engineers, economists, planners and politicians hailed it as the "Brightest jewel in Kuumba's economic crown", and "an example all Africa could emulate".

When the dam was completed in 1967, four years after independence, President Mware proclaimed it the "beginning of true economic independence".

At first all seemed to go according to plan. The lake filled swiftly, the generators functioned well. In six months, power was surging towards Ngamula.

On the lake, meanwhile, fishing was a bonanza. Fishermen could not recall such good takes. They didn't seem to mind moving back from the water each month or so. Government collection of salted fish was good. The only discordant notes were sounded by a few displaced farmers.

However, even as the lake was filling, fishermen noticed the rapid growth of one particular kind of green plant. It floated over large portions of the lake. At first they thought nothing of it - minor nuisance. As time went by the areas choked by this plant grew larger. The men had difficulty avoiding them. Their nets became clogged.

Also, once the lake was filled, the turbidity of the water initially thought to be caused by soil dissolving into the new lake did not go away completely, and the species of fish which were common on the Juluka River before the dam was built disappeared almost completely.

The Department of Fisheries provided fingerlings of several new fish species, in addition to the one which had existed in Lake Harambee. Together, these were to be the basis for both subsistence and commercial fishing. One species was the Mormyrid. Government officers knew that this fish was well-liked in West Africa, that it added a significant amount of protein to the diet and that commercial quantities had been taken in lakes in that area. Unfortunately, the Mormyrid did not become acceptable to the local population. The women in particular strongly disliked this fish which because of its elephant-like snout made them fearful that their children would develop the same countenances.

Reports filtered in about clashes between displaced people and existing settlers in the resettlement areas. Former fishermen did not take to farming and even the former farmers in some areas complained of the hard pan, the lack of water and the government-built block houses.

Q.8 Is bilharzia infestation an acceptable risk to run?

The first signs of schistosomiasis occured in Lawzi. School children reported infections. It proved extremely widespread, almost universal among the children of

fishermen. Anyone who used the lake for swimming or washing was likely to become infected.

The government health officer offered three possible solutions:

1. Move away from the water;
2. Use massive quantities of molluscides to kill the intermediate hosts of the schistosomes; and
3. Use chemotherapy on the infected individuals.

None of these suggestions was very attractive, because they were all either impracticable, too costly or too dangerous. So nothing was done.

The government realised that a substantial portion of the new land would not have the fertility of that inundated. In compensation, therefore, it brought in thousands upon thousands of tons of fertiliser from its new plant downstream and gave it to the farmers at practically no cost. No attempt was made to ascertain how much was needed, what kind of soil was there or what was the run-off rate.

Finally, the effluents from this same fertiliser plant were dumped, untreated and unfiltered, directly into the Juluka River.

On the basis of these facts accounts and assessments, you as members of a task force are empowered to study this project, decide what, if anything, went wrong and make recommendations for corrective action and for an alternative strategy of development starting at the same time as this project, i.e. what should Kuumba have done, and also what should it do now.

Q.9 What environmental standards in the developed countries act against the exports of developing countries?

Q.10. Where in the chain of cause and effect is the environmental impact the greatest?

Q.11 What kind of environmental impact would there be in bauxite production?

APPENDIX 4

Fertiliser Application in Kuumba's Central Region

By 50,000 farmers with 8 acres each (million lbs)

1964	65	66	67	68	69	70	71	72	73
30	30.5	31.2	32	45	60	60	61	62	62.4

Amount of Chemicals used to Spray Cotton and Maize (ounces per farmer)

1964	65	66	67	68	69	70	71	72	73
300	300.1	300	400	500	500	500	501	501	550

Total Yield of Maize in Million lbs. per Year

1964	65	66	67	68	69	70	71	72	73
600	600	600.1	600.1	900	1,100	1,000	900	850	830

Fish Caught in the Area in '000 lbs. per Year

1964	65	66	67	68	69	70	71	72	73
300	350	470	400	100	50	50	51	51	52

Reported Bilharzia Victims among Farm Families

1964	65	66	67	68	69	70	71	72	73
1,100	1,300	1,500	1,780	2,301	3,540	4,917	6,790	9,241	14,157

Volume of Sulphuric Acid and other Chemicals from Pulp Factory into River Water (in gallons)

1964	65	66	67	68	69	70	71	72	73
-	-	400	900	1,200	1,700	2,200	2,500	2,900	3,052

Effluents from Mining Operations in River Water (in tons) (trailings, earth etc.)

1964	65	66	67	68	69	70	71	72	73
100	300	600	800	1,100	1,400	2,000	3,000	3,500	4,300

Estimated Weight of Soil Run-off per Acre of Arable Land (in tons)

1964	65	66	67	68	69	70	71	72	73
1.9	2	2.7	4	5	5	6	6.5	6	6

Estimated Fertiliser Loss in the Whole Area through Leaching and Run-off (million lbs.)

1964	65	66	67	68	69	70	71	72	73
1	3.5	3.12	3.2	4.5	6.1	6.2	6.4	6.6	6.6

You constitute a planning body with direct access to the President.

Your job is to come up with a set of recommendations based upon.

1) The materials given for Kuumba.
2) The assumptions you agree upon as a group.

To arrive at an evaluation of:

(a) What was done;
(b) What should have been done;
(c) What should be done in future, i.e. should the past policies be pursued with modifications or should an alternative strategy be implemented? If the latter, what should it be?

RECOMMENDATIONS FOR KUUMBA: GROUP 1

Chairman: Dr. L. Mhlanga

Group Leader: Mr. M. Bahal

Rapporteur: Dr. L. Mureithi

Administrative Aspects

1. A national planning commission should be set up to evaluate all the country's potential viewed as a whole. This body should be able to give guidance as to where the various economic activities (fisheries, ranches, national parks, agriculture, industry, etc.) should be located.

2. A Bureau for Resource Assessment should be set up attached to the National Planning Commission.

3. Explicit policy statements should be made, for example, what priorities to attach to rural and urban areas. The chairman of the National Planning Commission should attend relevant cabinet meetings so as to be in a position to brief the Commission on government policy.

4. A body should be instituted with statutory powers to coordinate the various ministries in the implementation of projects. It should be interdisciplinary and interministerial. It should have a liaison officer to bring in people at local, regional and national levels.

Project Formulation and Implementation

1. Several pilot projects should be set up in a variety of locations thought to typlify several large areas. Only those that are shown to be successful should be replicated.

2. When projects are being formulated, the needs of the intended beneficiaries - the local people - should be considered and continuously monitored.

3. Serious consideration should be given to the locational aspects of projects. Every project should be set up in the 'best' location, both technically and economically, for that project.

Land-based Projects

1. The utilisation of land - be it for agriculture, national parks, etc. - should be made on the basis of maximising benefits or returns and real expert advice should be sought.

2. Selection of crops, domestic animals, crop mix or crop-animal mix should be done on the same basis as in (1).

3. Extension officers concerned with agriculture, fertilisers, etc. should be in continuous contact with farmers so as to efficiently direct expertise into farming.

4. The carrying capacity of land should be assessed carefully before determining the number of people per acre, livestock density and the kind of domestic animals recommended for a given eco-system.

5. A soil conservation programme for the whole area should be implemented. People should be educated concerning the benefits of afforestation, terracing etc. Though most people will continue to rely on wood for fuel for a long time, alternative sources of power should be explored and a reduction in tree cutting encouraged.

6. Application of chemicals on crops should be done in correct quantities, so as to minimise the hazards to other creatures in the environment.

Water-based Projects

1. There should be continuous monitoring of the situation or position of such projects. This would facilitate anticipation of any problems that might arise and expedite advice on corrective measures.

2. Research should be instituted as to whether water weeds (Salvania) should be utilised or destroyed. Do they have economic value (e.g. feeding pigs) or are they just a nuisance (fish killer or clogger of generator blades)?

3. Any water-borne disease eradication programme (e.g. schistosomiasis) should be done in such a way that other creatures in the eco-system are not harmed. Selectivity in elimination is called for.

RECOMMENDATIONS FOR KUUMBA: GROUP 2

Chairman: Dr. Nicholas Otieno

Group Leader: Mr. W.N. Mbote

Drafting Committee:-
Mr. Semugoma
Mr. Pintz

The following recommendations are offered as a basis for Kuumba's future development programme. It is felt that these recommendations are consistent with the proposed national goals, lessons learned from past development mistakes, and eco-development.

Agricultural Policy

1. Future emphasis should be on attaining domestic self-sufficiency in food crops.
2. A major programme of livestock development should be undertaken. Particular attention should be given to rural marketing institutions.
3. Maximum use should be made of animal by-products, such as manure, and grain waste for animal feeds.
4. Future development projects should only be undertaken when specific soil surveys have been completed.

Resettlement Policy

1. Resettlement schemes should be preceeded by ethnic and occupational studies of the proposed settler and indigenous groups.
2. During the initial stage of a project the settlers should work for the government, and the scheme should become independent only after self-sufficiency has been established.

Water Policy

1. Emphasis in future development schemes should be on non-consumptive uses of water.
2. Comprehensive studies of aquatic ecology should preceed any new water development programme.
3. Wherever possible, water transport should be substituted for surface transport.

Socio-economic Policy

1. The ownership of the means of production should either be directly in the hands of government or heavily regulated for the benefit of the majority of the people.
2. Government development policy should be oriented toward low-income people.
3. Government should pay greater attention to the needs of the traditional sector and its transition to the modern sector.
4. Government economic policy should emphasise substitution for imported raw materials.

Mineral Policy

1. Extraction rates of mineral wealth should be roughly compatible with general social and economic growth.
2. The minerals industry should be localised at the earliest possible moment.
3. In-country processing of minerals should be encouraged.
4. All mineral projects should be designed so as to minimise polluting effluents.

Tourism/Wildlife Policy

1. Mass tourism, for example package tours, should be discouraged.
2. Tourist infra-structure should be kept at a minimum and tourism should be on a very exclusive/expensive basis in near-wilderness reserves.
3. Development projects should be sited on the periphery of game areas (where no other areas are suitable). They should be sited in such a way as to cause the least interference with natural patterns.

Health Policy

1. A massive health education programme should be undertaken in rural areas. This programme should stress sanitation, nutrition and should target health problems such as bilharzia.
2. The Kuumban government should provide rural health posts and clinics for preventive programmes.
3. A comprehensive public health inspection programme should be undertaken.

Rural Development Policy

1. Stress should be placed upon developing marketing facilities in the rural areas.
2. Wherever possible, urban amenities should be extended to the rural areas.
3. A programme should be undertaken to strengthen rural institutions with special emphasis on traditional rural values and the rural heritage.

Urban Policy

1. Low income housing schemes should be established near the job centres.
2. Minimal services (water/sewage) should be provided, together with access to indigenous building materials.
3. No elaborate building standards should be imposed.
4. Low income schemes should be primarily self-help.

Forest Policy

1. A major reforestation policy should be initiated as a means of generating both rural employment and providing a source of energy in the rural areas.
2. Where feasible, forest areas should be combined with other areas to provide varied eco-systems and habitats.

Fisheries Policy

1. Thorough ecological studies should preceed any fisheries programme.
2. Estimates of maximum off-take, surveys of dietary patterns and social attitudes in prospective markets, and a comprehensive infra-structure and processing study should be undertaken early in any fisheries development programme.

Education Policy

1. Education should be made relevant to the local needs of the people of Kuumba. In particular, conservation education and appropriate economic techniques (e.g. agricultural, mining, etc.) should be stressed.
2. There should be an equitable distribution of educational opportunities between rural and urban areas.

RECOMMENDATIONS FOR KUUMBA: GROUP 3

Chairman: Dr. Peter Mwanza

A PLAN FOR INTEGRATED SOCIO-ECONOMIC DEVELOPMENT

Preamble

The primary objective is to develop Kuumba in such a manner as to allow the country to prosper both socially and economically and with the minimum destruction to the environment. Given the primary objective, there are several mistakes which have been committed in the past which need to be avoided:

1. The policies of government were never really clear; particularly there was no definite ideological guidance from the state. This made public participation difficult as the people were generally very confused.
2. The style of administration seems to have been based more on coercive rather than educative principles (cf: policy on bilharzia). This has been entirely negative from the standpoint of social development.
3. The economy proper had declined and the country was becoming more and more dependent on imported goods and hence at the mercy of external economic systems. Internally, there was an alarming maldistribution of economic benefits (e.g. land), especially to the detriment of indigenous people.

In short, Kuumba seems simply to have adopted and perpetrated the colonial economic system inherited at independence.

The Plan

The first step towards any national planning is the collection of data. The following steps are to be recommended:

1. Government should commission a population and an economic census so that we can determine what size of population and what range of economic potential we are dealing with.
2. The economic census should quantify all the resources and include in its scope a geological survey to determine what other mineral potentials there are apart from bauxite.
3. Government should establish permanent data collecting institutions for the continuous appraisal of the economy.

Infrastructure: Development will require an efficient system of both physical and social infrastructural arrangements.

4. Government should improve existing roads.
5. Government should also improve water navigation so as to prevent too much reliance on road transportation.
6. Government should make use of the electrical power derived from the river among other things to electrify the rural areas generally.
7. Government should develop a more efficient marketing system especially for agricultural and livestock products based essentially on railroad development, should water transportation become for some reason impossible.

Agriculture: As this is primarily an agricultural country, our aim should be to keep the peasants on the land and hence allocation of budgetary provisions should clearly show this bias. Our specific task is to transform the agricultural economy from subsistence orientation to a cash economy.

8. Government should step up the production of maize, cotton, tobacco and such foodstuffs as are presently imported and which can be relatively easily produced and sold locally.

9. With the availability of the dam, irrigation projects should be started for the introduction of high protein foods.

10. Government should develop the livestock industry in the north with regard being paid to the socio-cultural factors obtaining there. The livestock industry should be based on a feedlot system with an average density of one animal per acre.

11. Government should use the opportunity presented by the dam, the lakes and the rivers to develop a strong fishing industry. But there should not be any further introduction of new varieties of fish until a detailed survey concerning the chemistry of biotics of water, their behavior at primary production and the nature of aquatic life existing in them has been made.

12. Government should start a programme of re-afforestation in the south which in turn will provide a basis for recreation and the development of paper and wood industries.

13. Government should sieze all undeveloped and underdeveloped farms and transfer them intact to the indigenous people. The organisational structure of these farms should be as far as possible based on cooperative principles.

Industry: Industrial development should in principle be decentralised so as to avoid maldistribution of the labour force and reduce rural-urban migration presently taking place.

14. Government should establish agriculturally based industries to deal with the processing of tobacco, coffee, tea, cotton, canned foods, paper and wood. These should be situated where the raw materials are to be found.

15. Government should shift the bauxite smelting industry to Msimbi from the region of the capital. The machinery and standards of production should take special account of the necessity to preserve the environment. Hence as far as possible 'clean' technology should be preferred.

16. Government should insure that these industrial undertakings are placed under some form of public control and management.

Tourism: The primary aim of the government must be to develop its rivers, forests and wildlife for the good of its own people. The emphasis on animals must therefore be changed to accommodate wider environmental and human concerns.

17. Government should improve existing game parks and make them easily accessible to the local population as well as visitors from overseas.

18. Government should also preserve historical monuments and other sites for the benefit of posterity.

Education: Education for development must be sensitive to local needs and conditions and be properly and efficiently structured.

19. Formal education should include as a pre-requisite a programme for literacy and numeracy as soon as possible. Free and compulsory education is therefore essential. In order to avoid a gap between youth education and adult responsibility, a programme of adult education must accompany the latter.

20. Government should introduce a comprehensive programme of technical education, build technical schools concentrating on acquisition of intermediate skills, and devise ways and means of keeping leavers in the rural areas where they are needed.

21. Government should train an efficient cadre of extension workers whose job it would be to teach and communicate technical and development information to all farmers without regard to status or level of progressiveness.

22. Government should encourage the development of self-help groups and organisations which can operate both as production units and channels of communication in the rural areas.

RECOMMENDATIONS FOR KUUMBA: GROUP 4

Group Leader: Guy Danjoux
Rapporteur: Miss Polak

After independence, the Government of Kuumba had to establish its objectives concerning industrialisation and agricultural development, based on exports.

Agriculture for local consumption had to take second place to export orientated production. The problems of the environment and of social consequences of the decisions taken have not been sufficiently considered.

We note the low expenditure in the budget on agriculture and health and the high figure on defence. As subsistence agriculture plays an important part in the country, more emphasis must be put on education and information. Diversification in agriculture is strongly recommended to remedy deficiencies in the diet of the people.

In view of the preceeding comments, in our opinion, the following mistakes were made:

1. The construction of the dam seems unjustified in view of the possibility of producing hydro-electric power cheaper and with less topographical damage from the falls at the outlet of the lake. The dam seems to have been the main influence on the whole country. All the ill effects seem to have been overlooked at the planning stage.
2. The concentration of light industries in the capital city without at the same time promoting some of these industries in the rural areas has been the wrong policy.
3. Soil conditions were not sufficiently investigated for the type of crops and techniques used. Also, the question of grazing land and the prevention of overgrazing has not been sufficiently studied.
4. The preservation of the soil on the plateau east and west of the lake for the use of future generations has been neglected.

Recommendations

1. Creation of medium-sized towns to serve as links between the three principle cities and the existing small settlements. These towns will be self-contained with light industries, health and education facilities and information centres for the needs of neighbouring settlements.

2. A rational land distribution for various uses supported by appropriate techniques, traditional and modern, with a special view to encourage subsistence crops and cattle raising, should be planned.

3. We consider it necessary to divide the 150 large estates at present not fully utilised among the small farmers with growing families, or to use them to benefit populations displaced by the construction of the dam.

4. A cooperative movement, grouping small farmers, is recommended for the following reasons:

a) better possibilities for technical assistance;
b) commercialisation of their products;
c) supply of agricultural input; and
d) possible establishment of small industries using local materials, agricultural products and waste.

5. Afforestation of certain areas should be undertaken and rational exploitation of existing forests. The benefits will be timber for building purposes, paper, chemical production and the use of greenery for cattle feeding.

6. Anti-erosion measure must be taken.

7. As an alternative to building the dam and to use funds allocated to the dam, we recommend the exploitation of the bauxite mines and refining into the finished product of aluminium, using electric power generated by the falls at the outlet of Lake Harambee. Anti-pollution measures must be accounted for.

8. The more rational use of the lake is recommended, including aquaculture, transportation, recreation and tourist development.

9. Housing and human settlements should be improved utilising local materials to the full in the rural areas, to prevent migration to larger towns. Better amenities such as transportation, community and health centres, primary schools, etc. should be provided.

10. Finally we would advocate more research to be undertaken into alternative (e.g. solar) sources of energy, biological insect control, better utilisation of industrial, human and animal waste and the cultivation of certain types of crops capable of surviving in semi-arid areas.

CASE STUDY: NAKURU, KENYA

RECOMMENDATIONS FOR NAKURU: GROUP 1

Chairman: Mr. Gachui
Rapporteur: Mr. Okoth-Ogendo

General Policy

What is required is a plan that would strike a balance between the requirements of the human environment and the Lake. This means that apart from the concerns of the National Parks we must incorporate into our plan the concerns of the municipality and the surrounding farming community.

Preliminary Recommendations: Despite the memo by the National Parks, it is fairly clear that we do not know enough about the entire environment, the Lake, the birds, the people, the industries and the farming systems around.

1. The Municipal Council, National Parks and the Ministry of Agriculture should together establish and maintain a research laboratory in Nakuru whose duty it would be to monitor information about the stability of Lake Nakuru and its chemistry; to analyse all the waste that is discharged by the various activities under ordinary and emergency conditions in and around the town; to isolate all the harmful from the harmless wastes; to determine how much of these are tolerable both to the human and animal environment; and to investigate what effects the special geographical conditions of the Nakuru area would have on future developments of the town and its environs.

Short-term Measures: The disposal of industrial waste presents a most immediate problem both to residential areas through which the sewage passes and the life on the Lake where the sewage ends.

2. The Municipal Council should treat industrial waste at plant sites to prevent seepage of toxic materials into the Lake. More especially, heavy mineral wastes should be removed before dumping them into the general sewage system.

3. The existing heavy industries should be connected so as to minimise the discharge of deleterious substances.

4. Better land use plans and practices should be devised for the surrounding agricultural communities which would minimise soil erosion around the Lake and consequently the escape of pesticides and fertilisers into the Lake. Further, such a plan should incorporate a buffer zone between farm land and the National Park such that agriculture is kept at a reasonable distance from the Lake.

Long-Term Measures

In the long run more fundamental action will be needed to ensure a more integrated development of the Nakuru environment.

5. The National Parks should invite a specialist to advise on the possibility of constructing underground cables within the Park so as to prevent death of birds through electrocution and also improve the scenery.

6. Environmental education should be introduced into the primary and secondary schools nearby as soon as possible.

7. Industrial concentration in Nakuru should be broken by the creation of satellite villages around the town.

8. Residential estates should be located where there is minimum possibility of pollution. The exact locations will, however, depend upon the location of other social amenities, e.g. schools, recreation grounds etc., but in any case no more developments should take place towards the Lake.

9. As soon as the data envisaged in Recommendation 1 is available, a comprehensive plan should be developed for the recycling of organic sewage into irrigation agriculture.

Administrative and Financial Measures

The responsibility for maintaining the health and stability of the Nakuru environment will primarily depend upon the collective action of the Municipal Council and the National Parks.

10. The Municipal Council should be actively incorporated into Parks administration and vice-versa, and the Parks Warden especially should be a member of one of the Council Committees.

11. The Parks Department, the industrial community and possibly UNEP should contribute towards the maintaining of environmental information and planning and the construction of anti-pollution works by the Council.

12. The national and local authorities should have greater say in industrial location. Further, in making such decisions greater emphasis should be given to the overall need to preserve the environment.

13. Government should establish a strong national body with sub-branches all over the country whose duty it would be to formulate, coordinate and implement common environmental standards and legislation in the country. This body should be located within the President's office.

RECOMMENDATIONS FOR NAKURU: GROUP 2

Chairman: Dr. J. Okedi
Rapporteur: Dr. L. Mureithi

We offer some recommendations on four broad headings: industrial and human wastes, agricultural practices, game park conservation and financial and administrative arrangements.

Industrial and Human Wastes

1. A number of industries have already been set up and it would be very expensive to dismantle and take them elsewhere. It would not be wise to relocate those industries with hazardous effluents outside the Lake catchment area because this would just transfer the problem from one area to another. It is recommended, therefore, that rigid standards be set and enforced as to the tolerable level of pollution, both water- and air-borne.

2. Waste from the present industries should be purified before finding access to the Lake.

3. The cleansing ponds (sewage and oxidation lagoons) must be made to work efficiently. Since they tend to be stenchy, particularly the first three, they should be located away from human habitation, besides being away from the Lake.

4. There is a need to remove any poisonous deposits from the sediments in oxidation lagoons and the Lake basin.

5. Run-off from the city due to roofs and tarmac can flush petrol, oil and grease deposits. The municipality should institute a by-law forbidding garage owners and other users of oil from discharging this in the open and instead require them to burn it.

6. Any new industries with effluents dangerous to wild life should be placed outside the area and purification measures undertaken there.

7. We note the presence of vegetable gardens below the refuse dump. Copper, lead and zinc are easily picked up by those plants and lead poisoning is a real danger there. We recommend that the dump be removed or/and growing vegetables be stopped forthwith. The dump should be located in a hole OUTSIDE the catchment area.

8. To avoid inundation of the town by air-borne industrial wastes, the dump should be located on the hill to the north-west of the town.

9. At present only one-third of the population in Nakuru are connected to the sewage system. The other two-thirds use pit latrines. While seepage and percolation could purify the water, it all depends on the soil type. If clay, not much percolation is possible and overflow in rainy season is a real possibility. It is recommended that pit latrines should be planned according to the nature of the soil.

Agricultural Practices

10. Currently, cultivation is done up to the banks of Njoro River, thus raising turpidity in the water which raises sedimentation in Lake Nakuru and spreads havoc among the Lake-area fauna and flora. We need to create a buffer zone between agricultural land and the National Park and also between the National Park and the town.

11. Chemicals and fertilisers used can be flushed into the lake. It is important that the quantities be kept to the minimum required so as to minimise detrimental effects on the environment.

12. Soil erosion is a widespread phenomenon in the area. This should be arrested by two measures. First, cultivation of cereal crops (maize and wheat) should be discouraged in favour of sisal and cattle ranching. Second, intensive soil conservation measures should be popularised.

13. Further settlement in the area should be discouraged. If possible, those already settled there should be relocated.

Game Park Conservation

Lake Nakuru is a small and shallow lake which sometimes dries up, thus affecting the animal and plant cycle. It is supplied by small rivers and has no outlet except evaporation; thus it is essentially a soda lake so that land animals do not use it directly for drinking. Some fish have been introduced and are doing well.

To preserve the game park we recommend:-

14. Roads and houses should be kept to the bare minimum consistent with viewing of wild life.

15. Lake Elmenteita forms an ecological unit with Lake Nakuru in the sense that flamingoes and other birds migrate between the two. These birds must be protected even while in Lake Elmenteita. Any interference with the migratory cycle should be opposed. We note that Lake Elmenteita is on private property (Lord Delamere's Estate) and for preservation statutorily should be brought under Government control.

16. We note also that since Lake Natron in Tanzania is a migratory sanctuary for flamingoes and other birds found in Lake Nakuru, inter-state cooperation is necessary for a meaningful preservation strategy for these rare birds.

17. High tension powerlines kill birds in flight, not by electrocution but by injury on collision. If we tried fitting the wires with noise-making mechanisms, we are not sure whether the birds will hear the noise and avoid collision and we also cannot be sure that this will not introduce perpetual noise pollution. We recommend that the National Parks should launch a study into the mortality effects of power lines.

18. Some park animals, e.g. water buck, are reproducing rapidly due to lack of predators. A study should be undertaken to ascertain whether some of these animals should be 'harvested' for human consumption, or whether predator animals should be introduced in the Park in order to maintain an ecological balance.

Financial and Administrative Arrangements

19. The collection at the park gate amounts to some K.Shs 1.5 million and results in substantial monies net of operating costs. We recognise that the money spent in the area for food, petrol, lodging, etc. may exceed the gate taking at the park but these are invisible benefits to hoteliers, petrol station owners, etc. There should be visible direct additions to the area's welfare. We propose that the National Parks should earmark some of that money for social amenities and Harambee projects in Nakuru area.

20. Management of the Park should be entrusted to a joint board to coordinate various activities. On that board there should be representatives of agriculture, business, the municipality, the community and the National Parks.

21. A representative of the National Parks Department should sit in various Municipal Council committees in order to create a liaison between the two bodies.

22. Residents of Nakuru should be allowed to enjoy their facility by either (a) granting them free entrance to the Park or charging only a nominal fee (much less than the present K.shs 5/- for citizens), or (b) maintaining the fee but providing free transportation in the Park.

RECOMMENDATIONS FOR NAKURU: GROUP 3

Chairman: Mr. Chileshe
Rapporteur: Mr. Kabwegyere

Problem Isolation

1. There is a lack of interdisciplinary research.
2. There may have been some form of adaptation by the animal life in this area. An attempt to move to a pure stage may be deleterious.
3. The problem is to try and get a reasonable balance between the human needs, animals and the environment.
4. It was reported that there was an alternative to drain waste from Nakuru town, but the costs were prohibitive.
5. National interests may conflict or even contradict local interests. As a result of this a board representing the divers interests is needed.

Problem Areas

The following four problem areas were isolated:-

1. The Lake and wildlife,
2. Industrial activity,
3. Agricultural activity and
4. The human impact.

Recommendations

1. Preservation of the Lake and Wildlife

Remove the people from the Western part of the area to the Eastern part to allow more land for wildlife around the lake as planned. It should, however, be taken into account that Lake Elmenteita should not be affected as it is known to be the breeding area of the birds. If it should be found that Lake Elmenteita will be negatively affected, these people may be resettled elsewhere. Government should take into account the problems of human displacement with social and economic measures.

A study of the behaviour, breeding habits and numbers of the bird life should be commissioned in order to understand the ecological balance of the area.

2. Industrial Activity and Town Planning

In order to preserve the Lake and wildlife, industrial and town expansion should be divided away from the Lake.

The industrialists should use anti-pollution devices to reduce environmental hazards that often result from industrial activity.

The new dumping ground for industrial waste should be decided after a thorough geological study to avoid the filtration of these dangerous products into the Lake.

New residential estates should be sited to the north-east of the town.

The central government has the heavy responsibility of getting the land, and if need be seizing it, and providing the necessary infrastructure that is required for this planned change. Incentive schemes should be made available to those who have the heaviest human burden. The costs of effecting these changes should be apportioned on the basis of relative benefits, i.e. taking account of the local people, local government, central government and the international community.

3. Agricultural Activity

The slopes of Menengai Crater should be afforested to stop soil denudation.

The land near the Lake should be used for ranching instead of ordinary agriculture which tends to use high inputs of fertilisers that finally wash into the Lake.

All these measures are meant to reduce pollutants into the Lake. It is therefore suggested that constant checks of levels of pollution should be undertaken.

4. Human Impact

There should be continuous ecological studies which should include the impact of man on the National Park aimed at preserving harmony between animal life, humans and the environment.

The deleterious effects should be periodically corrected.

RECOMMENDATIONS FOR NAKURU: GROUP 4

Chairman: G. Danjoux

An area authority should be created (for the Lake Nakuru basin) to coordinate and unite the activities and to look for a compromise between the interests of the different communities: agricultural, industrial, tourist-orientated and preservationists.

Limnology

It would be interesting to know the exact concentration of salt in the Lake when it is at different levels. Even if the concentration of harmful chemicals is less in the Lake than it is in the main sewers, high enough traces are still found in the Lake. Research should be made to determine whether the concentration of chemicals entering the Lake could not cause a disruption in the cycle of flamingo droppings recycled to algae.

Agriculture

Soil erosion could be prevented by terracing. Natural manure should be used whenever possible instead of chemical fertiliser. Also chemical fertilisers and insecticides used must be carefully selected to choose those more easily broken down in the ecosystem. The group is against resettling of people and would prefer to see rather an intensive programme of improving agricultural methods, use of waste products from the dairy industries, irrigation, etc., so as to prevent an encroachment of agriculture on National Park land.

Industry

We suggest that industrial waste should be treated separately from domestic waste to a standard so high as to make it possible to recycle the effluent back to the industries, always excepting the use of this recycled water for consumption or any other purposes where it might prove unsuitable.

Domestic waste could be treated and used for irrigation.

A tax should be levied on industries graded according to the amount of effluent from each factory. The area authority which we have previously suggested should be responsible for the control of these operations.

The Town

The run-off from roofs could be collected and directed through pipes into the sewage system. The disposal of solid waste involves more than just moving it to another area away from the Lake. To avoid contamination of soil and underground water, incineration would be the best method.

The question of the new road has been discussed. Considering all the arguments for or against the road cutting across the northern part of the Park, we think that it would be more beneficial both to the Park and the people of Nakuru for the road to pass through the racecourse and enable the Park to be enlarged. The saving of £100,000 in this way could, in part, be used for various purposes to benefit the people of the town.

A land use survey of the town is necessary to assess its expansion on most suitable grounds away from the side of the Lake. The areas most appropriate for agriculture, recreation and tourism must be protected. To the north-west of the town seems the ideal site for expansion. This extension should be comprehensively planned to include all essential amenities.

To maintain an equilibrium between town, rural areas and the natural environment, every effort should be made to improve living conditions and create working possibilities (cottage industries, etc.) in the rural areas.

The Park

Excavations for road use should not be made in a National Park. Similar types of soil could probably be found in the surroundings for this purpose. The buffer zone around the Lake must be preserved at all cost for the benefit of wildlife.

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

By

Kai Curry-Lindahl,

United Nations Environment Programme

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 animal 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 fresh water 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 occured 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 have 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 occurance 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 knowlege 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 feaibility 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,

of reading material add to the confused state of education. The politician has committed himself to the rapid expansion of education to satisfy the intense popular demand without considering what kind of person this education should produce. Unsuitable curricula have produced unemployables who flock to the urban centres and are proving a nightmare to the politician. The prevailing educational system has become institutionalised, conservative and alienated from society's real problems. There are huge drop-out rates from most of the educational systems while some mythical educational standards are supposed to be maintained. The multi-lingual nature of many societies and non-existence of scripts in some languages have proved a serious constraint. Institutions of higher learning established on the advice of expatriates display an unbelievable conventionality of design and inspiration and remain alien institutions aping European and American models. Even African academics brought up under colonial systems continue with what was imparted to them under colonialism. The present dearth of scientists and technologists is directly attributable to the present educational system. Higher education in Africa can only get better orientation after national goals and objectives have been so defined as to enable the universities to be responsive to changes in the African situation and to the priorities which will best serve the African environment; and the infusion of indigenous pride and the greater awareness of the African tradition are prerequisites if Africans are to convert universities copied from the European and American traditions into true universities of Africa.

THE URBAN-RURAL ENVIRONMENT

The urban population of Africa is estimated to be growing at the rate of 8 per cent per annum and cities are doubling their population every 10 to 15 years. Total urban population it is estimated will have increased from 58 million in 1972 to 294 million by the year 2000. These continent-wide increases are caused mainly by migration of people from the countryside.

Larger cities grow faster, peri-urban slums are created; urban expansion imposes inescapable costs for public services and a general atmosphere of instability and alienation sets in. This immigration has been attributed in part to economic, social and psychological motivations. I attribute the migration largely to the inappropriate educational systems already described above. Whatever is the cause, it has led to serious shortage of housing in the cities, unemployment, proliferation of peri-urban slums, crime and delinquency with which the city planners are totally unable to cope. Services in the cities are stretched beyond their

elastic limit. Water supplies and sewerage facilities are found inadequate and rooms which were built for two people contain as many as ten or more people.

The acute as well as chronic aspects of social problems that result from rapid urbanisation are most discernible in the adjustment of migrants to urban living. The in-migrant from a relatively homogeneous origin is confronted with a bewildering and almost incomprehensible vastness and heterogeneity. He must adapt to new and unfamiliar ways of making a living. He is in a different setting often involving new kinds of housing, sanitation, traffic congestion, etc. He ends up by displaying personal disorganisation as the subjective aspect of social disorganisation.

Men are often more numerous than women with the resultant social disorganisation evident in most African cities. Tribal heterogeneity leads to serious stress during the process of readjustment.

The issues of rural exodus, unemployment and the proliferation of peri-urban slums are closely interrelated. They are all a product of the dualistic nature of African societies which are characterised by the depressed rural environments having islands of apparent opulence in the form of cities. Measures aimed at reducing the rural exodus have ranged from establishment of work camps for the unemployed, formation of collective farms and cooperatives, the creation of National Youth Service Corps, expansion of health, education, recreation and transportation facilities, establishment of rural industrial development projects, formation of Ujamaa villages, etc.

In the towns, National Housing Corporations have been formed, site-and-service schemes introduced to enable in-migrants to build houses of reasonable standards, but most of these only nibble at the problem.

It has been stated that since the urbanisation of man is a reality, the counter city should be of sufficient size with industries and amenities to act as a counter balance. These regional poles of growth - such as those being planned for nine towns in Tanzania - would take the strain off the primate cities and dam up some of the migratory flood moving towards them.

It must be realised, however, that environmental problems of the rural and urban areas are inter-related. It is the improvement of services in the rural areas, the provision of other poles of growth and the re-orientation of the educational system that might help to reduce the pressure on the beleaguered cities. Each city and each country has its own set of peculiar problems whose solutions will have to be worked out locally.

ENERGY IN THE AFRICAN ENVIRONMENT

The African continent is endowed with vast energy resources which have hardly been tapped. Her mighty rivers have falls which are ideally suited for the production of electricity. Vast reserves of hydro-carbons including oil bearing beds in northern, western and north-eastern Africa, including the shales of Central Africa, have still to be fully exploited. Large parts of the continent have abundant sunshine and are ideally placed to tap solar energy. Geothermal energy associated with the great rift valley in the eastern seaboard are just beginning to be investigated. Forests produce fuel wood which supplies local inhabitants with the energy they require for their daily use.

Industrialisation which is the one sure means for Africa to accelerate her economic and social development for the impoverished masses will only be possible by the use of her energy resources.

Electric energy was produced in Africa mainly from thermal engines to supply urban centres and the few industrial installations, but during the fifties and sixties a number of hydro-electric schemes were introduced, so that by 1964 hydro-electric power accounted for more than 60 per cent of the total production in the continent and production of electricity rose from 58,073 kWh in 1965 to 79,962 kWh in 1969. During the same period, average consumption of electric energy per inhabitant increased from 182 kWh to 227 kWh, a growth rate of 4.7 per cent per year.

Problems experienced include distribution of electricity over long distances, differences in voltage levels from country to country and the uneconomic nature of supplying electricity to widely scattered populations. With respect to the last item it is contended that governments should provide electricity as a social service from which no profit is to be expected because this would contribute to general increase in economic activity and social development from which each country would benefit. And the energy crisis facing Africa is the depletion of her wood resources on which over 90 per cent of the population depend.

TRANSPORT AND COMMUNICATIONS

The present environmental problems connected with transport and communications between Africans in an individual country and between African countries can be attributed to the partition of Africa among European countries during the nineteenth century. These powers saw to it that transport and communication were to facilitate administration of the territories and the transfer of raw materials from Africa to the processing industries of Europe. Roads and railways in any one country

were only disconnected extensions from sea ports to the hinterland which formed disconnected systems of the north-south transport and communication channels. Telecommunications and postal services followed the same pattern so that after independence, African countries found that not only were their nationals unable to communicate with each other within their borders, but also that it was impossible to communicate with their neighbours on a transcontinental basis without passing through Paris, Brussels or London. This communication gap still exists.

This situation could neither satisfy the internal development needs of the newly independent countries nor allow for national economic and political cooperation between them. They therefore established priorities: first to develop internal traffic routes into national networks capable of contributing to the opening up of the hinterland, and second to connect the national network with the transport and communications systems of neighbouring countries. The governments realise that railways, roads, waterways, airways and telecommunications are complementary systems making up the total communication system irrespective of overlap or competition since they all enhance the environment by ensuring maximum flow of people, goods and ideas.

With respect to telecommunications, the facilities available are a legacy of the past both with respect to international routes served and the equipment used. The total number of telephones in Africa in January 1970 was 3.14 million, constituting 1.2 per cent of the world total of 255.2 million. In a number of countries, inland trunk networks are poorly developed and little effort is made to coordinate the use of telecommunication channels. There is an increasing demand for telex, leased circuits and other services, but traffic growth is cramped due to high costs, limitation on hours of transmission and insufficiency of circuits.

With respect to intra-African telecommunication links, ITU statistics for 42 African countries show that in January 1968, almost half of intra-African telecommunications passed through Europe (380 out of 832) - and it was easier to get a telephone line to Europe than to one's own neighbouring country.

The railways have shown a similar colonial pattern of serving the hinterland route to the coastal town. Different gauges have made inter-country connections difficult. Cost of construction and maintenance have made their operations expensive. The roads have proved an even greater environmental obstacle than the railways. Most are unpaved and are dusty in the dry season and become impassable quagmires during the rains.

National airlines have been established mainly for prestige purposes and have not been operating economically.

Nevertheless, steps are being taken to rectify some of the above environmental drawbacks. Moves are afoot to establish an African telecommunications network; a grouping of services for the various airlines has been proposed; the trans-African highway, the trans-West African highway and the trans-Saharan highway are now likely to become a reality in the near future. It is hoped that these developments will enable Africa to communicate with herself more efficiently and in turn communicate with the rest of the world. The establishment of earth-satellite stations in various parts of Africa is a step in the right direction in this regard.

MINERALS AND INDUSTRIALISATION IN THE AFRICAN ENVIRONMENT

Africa is the major world producer of manganese (28 per cent), cobalt (70 per cent), industrial diamonds (98 per cent), gem diamonds (93 per cent), platinum (40 per cent), gold (70 per cent), tantalum (80 per cent), geranium (70 per cent), lithium (70 per cent) and radium (100 per cent). It contains 90 per cent of the world's reserves of chromite and is also a major producer of strategic metals like beryllium, uranium, caesium, corundium and graphite.

Africa's iron ore potential is estimated at 33,000 million long tons - twice as great as that of the United States. It has coal reserves to last over 300 years and large quantities of copper. The United States, for instance, imports large quantities of Africa's magnesium and 31 per cent of manganese used in the U.S. comes from Gabon. Africa provides Britain with 90 per cent of her antimony requirements, 82 per cent of cobalt, 80 per cent of manganese, 66 per cent of asbestos and 50 per cent of chrome ore. Japan depends on Africa for many minerals utilised in her industries.

The environmental challenge here revolves around the question as to what benefits Africa is receiving from her minerals in the international market and what contribution are proceeds from minerals making towards the improvement of life among Africa's impoverished masses.

It is known that Africa continues to sell raw materials cheaply from which the industrialised countries manufacture products which they then sell at high prices to the poor African countries. And, moreover, since African countries do not own the minerals they produce, it is the subsidiary foreign companies which sell the minerals to their parent companies and which determine the prices of the unprocessed products.

This means, in the final analysis, that there is a considerable net outflow of wealth from the poor African countries to the affluent industrialised world. Between 1951 and 1965, for example, the rich western nations injected US$16,000 million into Africa and Asia in terms of investment and aid. During the same period, US$26,000 million were sucked out in the form of profits, interest on loans and loan repayments from the same African and Asian countries and returned to the western countries, thereby creating a net outflow of US$10,000 million.

In Zambia, US$260 million of profits were taken out by foreign companies between 1953 and 1963. From Zaire, foreign firms exported raw materials valued at US$2.77 billion between 1945 and 1955.

The industrialised world is so dependent on continuous flow of Africa's minerals that they have not encouraged African countries to develop any mineral-based industries since this would reduce or even halt the flow of their lifeblood. At the same time, a warning note has been sounded that there will come a time when these resources are so exhausted and Africa will find herself with no resources left if she decides to follow the known patterns of industrial development. But due to her temporary deficiency in expertise and capital, she has to put up with high profits taken out and with intolerant and high-handed behaviour by expatriate minorities brought in to run the mines, often engandering frustration and jealousy among the local population.

The African governments are one day bound to express dissatisfaction with this industrialised power-host state relationship and demand readjustments despite pressures that may be exerted upon them by the industrialised world. For it is clear that Africa's constitutional sovereignty over her natural resources at present amounts to sovereign impotence because of lack of capital, the political pressure to which the exploitation of her minerals gives rise, and above all, the fixing of raw mineral prices in the world market by governments of other countries and by the pernicious interests of the multinational corporation monopolists.

Africa knows that she has almost everything needed for development and that she will ultimately develop without, or in spite of, outside assistance and involvement; and the notion will have to be accepted that Africa's minerals do not belong to those that find and extract them as at present, and that mining companies are members of a service industry extracting and processing minerals that are the property of the people of the country in which they are found. Formulae must be found to do away with tangled webs of royalties, export duties, depletion allowances and

special rates of depreciation. At the same time, decisive moves must be made to process Africa's minerals in Africa so that the mining industry can provide jobs for the millions of unemployed Africans, lead to the improvement of infrastructure both in the rural and the urban environment and produce the necessary revenues which would improve Africa's balance of payments and bring the continent out of the vortex of poverty which makes her rely on fictitious foreign aid and borrowing from which she appears doomed to be environmentally enslaved. This is a serious challenge.

Industrialisation in the African Environment

Efforts at industrialisation in African countries are beset by many intractable problems. Imports of goods and services, mainly the expensive machines and skills needed to increase productivity are as high as they are in the developed countries. Markets at home remain limited by local poverty or by the extreme smallness of African states. Furthermore, industrialisation based upon the local manufacture of formerly imported goods is relatively inefficient and relies overly on inappropriate, capital-intensive technology.

All these result in low use of capacity or in capacity far in excess of any foreseeable market. In other cases where capacity has been based on future market growth, interim output levels have been below capacity. Furthermore, inadequate quality control has often rendered the local product unsatisfactory for certain key uses. Higher prices for locally manufactured goods have been a hindrance in competition, while irrational pricing aimed at covering full costs at very low output levels results in pricing the local goods out of the market, encouraging imports and holding local capacity idle.

Stress laid on intermediate technology for industrialisation has had the effect of making Africa use only the second or third best instead of aiming at the latest technological innovations, and making her perpetually lag behind. Added to this, shortage of trained manpower - especially in the technical fields - is a serious bottleneck in Africa's efforts to industrialise rapidly. This has also led African countries to invite multinational corporations to establish industries and bring in their technological know-how to run these local industries.

The benefits which the host African countries derive from these set-ups are questionable since the foreign corporation insists on easy tax terms, transfer of profits, monopoly against other imported goods and capital intensive methods which do not have any effect on the serious unemployment problems facing African countries.

This leaves one with the impression that the degradation of human conditions in developing Africa, which must follow upon too low a rate of economic growth and social transformation, is likely to deepen in the seventies and grow to catastrophic proportions in the eighties. The conventional import substitution, aimed at replacing imports of consumer goods with domestic production behind high protective barriers while the exchange rate is kept overvalued, has raised difficult problems. The hoped-for transformation of African economies through import-substituting industries has not come about. An industrial structure has emerged which is dependent mostly on imported inputs, and domestically oriented for its market for which the spread effects are small. Thus inefficient industries have been established behind high protective barriers, producing inappropriate goods, employing capital-intensive techniques and operating on a sub-optimal scale, thus further raising unit costs.

However, in Africa today some countries are choosing the socialist path to industrialisation, others the capitalist or private path, and all experiencing degrees of success or failure.

POLLUTION IN THE AFRICAN ENVIRONMENT

Pollution is the qualitative alteration of any medium for the worse so that long established equilibria between life systems which the medium sustains are either adversely affected or even irreparably damaged.

Africa suffers from the following forms of pollution:
Moral and mental pollution rooted in history; sand and dust pollution; air pollution by smoke from forest fires; bacterial pollution of the air, chemical pollution of air and water especially in industrial/mining complexes; and soil and water pollution by biological agents.

Many examples can be cited in African countries to illustrate these.

CONCLUSION

The environmental challenge facing Africa can be summed up in three words : Pollution of poverty.

SOME SOIL AND RELATED PROBLEMS AFFECTING DEVELOPMENT

by

Peter M. Ahn,

Professor of Soil Science, University of Nairobi

GENERAL CONSIDERATIONS

Introduction

Soils and the Environment: In considering soils and soil problems in relation to the development of the environment we are concerned not only with the soil itself but also with such closely related aspects as the climate, the relief of the land and other factors. Soil greatly influences agricultural possibilities, but where irrigation water cannot be supplied economically it is, over much of tropical Africa, water which is probably a more important limiting factor than the soil itself. Thus before he can make recommendations the development planner needs to study climate, particularly rainfall amount, distribution and reliability, as well as soils and relief. As is considered further in the section on soils in relation to the physical environment, the characteristics of the soil are themselves closely related to the local climate, relief, geology and vegetation, so that in order to understand the nature of soils and their distribution it is necessary to adopt an ecological viewpoint, relating soils to the landscape of which they form part. Both in order to understand soil characteristics, therefore, and in order to plan rational development we have to look not only at the soil itself but also to all related aspects of the physical environment.

In this short paper on soil factors affecting development it is possible only to indicate very briefly some of the major aspects meriting attention, but examples of the more technical considerations that might arise are given in the appendices, which also contain some suggestions for further reading for those who wish to go more deeply into the topics touched on here.

Our Knowledge of Soils: Our knowledge of soils is in its infancy, since soil science is still a relatively young subject. In a later

section on problems posed by lack of knowledge, the extent to which lack of technical soil knowledge actually limits development is discussed. In general we may distinguish between our general knowledge of soil science, including our knowledge of the ways in which the soil makes available both water and nutrients to the plant, and our more specific knowledge of local areas, as shown by the availability of soil maps and related information. In addition to this body of scientific information - still very patchy and inadequate - we must neither forget nor underestimate the value of the knowledge of soils often acquired by the farmer. Farmers, both large-scale farmers and small-scale farmers using traditional methods, acquire an intimate local knowledge of soils and the ways of making practical use of them, and visiting scientists, development planners and other 'experts' should make every attempt to enlarge their own knowledge and experience by drawing upon that of the practical farmer. Even illiterate farmers often have an invaluable knowledge of local soil characteristics and an ability to recognise soil properties and capabilities. Conversely we should be aware of how soils affect what local farmers are doing. If equipped only with hand tools they often tend to prefer light, easily worked soils even if these are inherently less fertile then heavier ones, while some very heavy soils in Africa, the black cracking clays, are generally left uncultivated by the unmechanised local farmer not because they are infertile but because they are so hard when dry and so sticky when wet that he cannot cope with them with hand tools.

Economic Considerations Compared with Technical Ones: Agriculture is not the art - or science - of growing crops. Agriculture, apart from purely subsistence agriculture, is the art (or science) of growing crops for a profit. We have always to distinguish between what it is technically possible to grow in any particular area, given the local soils and climate and current technical knowledge, and what is economically profitable. There may, of course, be special situations where a government subsidises a crop or activity because it is willing to pay more than the normal price (e.g. to reduce imports, or just to keep farmers occupied and employed), but the fact remains that a farmer has to be able to sell at a price which is above his production costs. The study of the local soil and climate in relation to what crops can be technically produced is the first step. The second step is to try to calculate the economic viability of these crops. The agricultural economist has to try to predict both future costs and future demand and selling price.

To some extent it is technically possible to grow anything anywhere, provided that you are prepared to put in enough time and money to do so. Deserts can be irrigated, tropical crops can be grown in Europe in heated glasshouses and so on. Much more generally, and less spectacularly, commercial farmers can and do modify soil characteristics and local climates in order to increase the amounts and ranges of the crops grown. Whenever fertiliser is applied, the chemical characteristics of soils are being modified. Thus it becomes true that the more intensive the agriculture the less relatively important is the natural fertility of the soil. Thus we look at soil both in relation to what it is now, and in relation to the extent to which it can be improved. The simple farmer using shifting cultivating techniques relies on the natural fertility of the soil though even he improves on this by burning dead vegetation and adding ash, and by other methods.

In general we should distinguish between those chemical characteristics of the soil affecting productivity, and its physical characteristics. The chemical characteristics are usually capable of modification, at least temporarily, relatively easily and cheaply, as when a farmer puts on fertilisers. The physical characteristics of soils, that is their texture, structure and consistency, their depth, ease of working, water holding capacity and so on - characteristics which also greatly affect productivity - are much less easily modified. To improve poor drainage, or to try to modify structure and handling characteristics, is much more difficult and expensive usually than just correcting a nutrient deficiency by adding chemicals. Thus, for intensive, commercial agriculture involving considerable inputs, we may be more concerned with the physical properties of the soil than with the chemical properties since we assume that the fertility status of the soil will be corrected as necessary by the appropriate use of fertilisers, though naturally the cost of doing this will have to be taken into consideration.

Some people appear to imagine that the task of soil scientists and soil surveyors is to go out and to discover exceptionally productive soils, just as it is the task of certain geologists to find oil. Soil scientists and surveyors however see the task somewhat differently: soils have different characteristics and, depending on the current state of technical knowledge, different potentialities. Scientifically the task

is to study those characteristics and see what can be done with them. Some soils are more versatile than others, but it is unscientific and sometimes misleading to think about 'good' soils and 'poor' soils. A soil that is excellent for coconuts would be useless for cocoa, for example . It is better to think of many different soils having many different combinations of characteristics, and to find rational and profitable ways of using each soil. Just as in nature there is some vegetation associated with all soils except desert ones, so can almost all soils be used in some way if water is available. Nevertheless, it is still obviously appropriate where there are large areas of underdeveloped land to make a rapid reconnaissance of the whole area and then to select for more intensive study smaller areas which appear more immediately promising.

The Nature of Tropical Soils

To what extent do soils of the tropics differ from those of cooler regions? Most of the intensive work on soils so far has been on the soils of the temperate zones, particularly on those of North America and Europe. To what extent can the knowledge and experience of these soils be applied to other parts of the world? These are important fundamental questions, first because there are still many misconceptions about the nature of tropical soils, and secondly because we are all aware of schemes, including some very large and costly ones, which have collapsed spectacularly. These failures were caused, it appears, by insufficient knowledge of local soils and other factors, and because knowledge and techniques appropriate to the temperate zones have been applied uncritically to tropical areas.

Soil students at the University of Nairobi are warned at the beginning of their studies that most of the standard soil textbooks have been written by and for people working in the temperate areas of the world, and the information contained in them is not necessarily equally applicable to other areas. For example, in Europe and North America the soils under natural grassland have a higher humus content than the soils under forest, and are therefore usually more productive and fertile. In tropical Africa, the reverse is true. The savanna soils have less humus, and are often less productive, thanthe forest soils.

Essentially, tropical soils differ from temperate soils because the environment is different, and soils reflect their environment. Vegetation is different, and climate is different. The history of the landscape may also be different, for many temperate soils are developed in superficial deposits laid down during the last ice age, whereas many African soils are developed on very old land surfaces and therefore have a longer history of weathering and soil formation. But apart from these local variations due to geology and geomorphology, the broad zonal differences between temperate and tropical soils are those related to the influence of climate and vegetation. In a hot wet climate weathering is faster at higher temperatures. Weathering is thus most intense in hot, wet environments. By weathering we mean not only the initial weathering and softening of the parent rock, but the subsequent weathering and development of the whole soil profile. When this continues long enough, all the weatherable minerals in the soil profile are broken down, and a highly weathered tropical soil may then consist of little except resistant residues - clays, quartz, sand, and, usually, iron and aluminium oxides. These are the general characteristics, to varying extents, of the tropical soils grouped under the general term 'Latosols'. Such soils may have very low reserves of fertility apart from that in the organic matter, since as noted, all the minerals (such as feldspars, micas, hornblends, etc.) which might weather to release plant nutrients have already weathered and the sand fraction might then consist of only highly resistant minerals such as quartz, which is of no use to the plant. The reserves of fertility of such highly weathered soils would then reside in the organic matter they contain. Where humus levels are high they can be very productive, as when newly cleared from tropical forest, but when the humus has been lost by long cultivation and/or by erosion the soil may become relatively infertile, i.e. low in plant nutrients. However, as stressed above, for intensive commercial agriculture low fertility may be less of a problem than poor physical characteristics. The physical characteristics of many Latosols are generally good in as much as they have stable structures, and, though clay in texture, a good microstructure giving them good porosity and handling qualities. Thus, though many highly weathered tropical Latosols may not have much fertility apart from the reserves in the humus they do have favourable physical qualities which would lend themselves, where the relief and erosion hazard is not a difficulty, both to mechanised agriculture and to irrigation.

However, it is a misconception to think of all or most tropical soils as being of this type. It is a common mistake to generalise about tropical soils as though they were less varied and diverse than temperate soils. In fact, tropical soils are probably more varied than those of the temperate zone! Here in Kenya for example, there is a quite exceptional range and variety of soils, not only because of a varied geology (with a wide range of igneous, metamorphic and sedimentary rocks), but also because the relief has resulted in a range of climate and associated vegetation which must be as great as that of almost any country in the world. Similar situations occur in the Andean countries which have tropical lowlands but include high areas with cool climates. In Kenya we find soils developed under tropical conditions, both dry and wet, as well as the soils of the highlands developed under cooler conditions. The resultant range in soils is very great, and in fact the very highly weathered Latosols characteristic of some parts of the tropics are not important here.

Lateritisation: The word laterite has been used in such a wide variety of ways and contexts that it now has little precise meaning. Originally it was applied to sesquioxide rich soil material in India which was soft when cut out but subsequently hardened irreversibly, so that it could be used to make building blocks (later = brick). Recent microscope studies suggest that the hardening process in such soils involves the reorientation of the iron oxides in the material to form needle-like Goethite ($Fe_2O_3.H_2O$) crystals which bind together the soil mass and cause it to become hardened (indurated). More generally the word laterite has been applied to any gravelly or concretionary tropical soil (thus becoming synonymous with the word 'murram' as sometimes used in East Africa), and even to any red soil, whether gravelly or not and whether indurated or not. For these reasons the word 'laterite' is often best replaced by other more precise terms such as 'ironstone' or 'ironpan' for the very hard forms, and 'plinthite', soft or hard, for iron rich material, often mottled, which has hardened or appears to be capable of becoming hard.

Lateritisation on the other hand is generally understood as the process which causes some soils, or some soil horizons, to harden irreversibly. There are some sesquioxide (Fe_2O_3 and Al_2O_3) rich soil horizons, generally red and mottled, which, when exposed to the atmosphere,

harden irreversibly, i.e. become indurated. The horizons likely to harden are generally subsoils, and they might harden when they are exposed, as by topsoil removal due to erosion. Such cases, when they occur, are spectacular and the soil then becomes quite unproductive. However, precisely because these cases are spectacular, and because they interest soil workers and textbook writers from temperate zones in particular where such phenomena are not usually found (except in fossil form), there has been an unfortunate tendency to exaggerate their importance. As a result some people have got the impression that the soils of vast areas of the tropics are likely to harden irreversibly if carelessly cultivated and exposed. Such an impression is totally false. I doubt if even one per cent of the soils of the tropics are going to harden in this way, however misused. Many of the examples of ironpan and indurated horizons in soils, which in some areas limit soil depth, appear to have hardened some time ago. Cases of mottled hardening now are less common and extensive. As a phenomenon affecting agriculture therefore, current lateritisation is quite unimportant in very large areas of the tropics, even though fossil ironpan may be a limiting factor locally in some areas. The extent of actual or potential lateritisation constitutes one of the popular fallacies about tropical soils.

Desertification: The drying out of some areas of the tropics appears to be a consequence of climatic change and of rainfall becoming less, often associated with, and aggravated by, the clearing of natural vegetation so that less of the rain received gets into the soil and more is lost as run-off. When the natural vegetation is removed, water moves more quickly over the surface of the ground and less seeps into the soil. Increased run-off means less water entering the soil and becoming available to vegetation or crops, increased danger of soil erosion, and of flash floods as rivers quickly rise.

Some areas appear to be getting progressively less rain. The Sahara Desert appears to be expanding southwards, for example. In other cases, less rain locally appears to be associated with the clearing of forest vegetation so that less water is transpired back into the atmosphere. If forest is cleared in areas bordering savanna where annual burning is the rule, the annual burning of the newly cleared once-forest areas prevents the re-establishment of forest once the farm patches are abandoned and allowed to return to natural regrowth vegetation. In this way they change

from forest to savanna. Most African savannas are the result of the fact that the dry grass vegetation has been burnt off every year by man, probably over long periods. Burning of once forest areas prevents forest coming back in, even where the rainfall might be adequate in amount and distribution, and in this way the savanna spreads at the expense of the forest. Both desertification and the encroachment of savanna on the forest are factors locally important in Africa in modifying soils and agricultural possibilities.

Soils in Relation to the Physical Environment

Historically we may recall that early workers on soils, such as those in England where there is not a great range of climate but where the geology is very varied, were particularly impressed by the fact that soils changed markedly according to the parent rock or parent material. A soil over sandstone, for example, is very different from one developed over mud-stone or over limestone, and a soil over granite is very different from one developed over a basic igneous rock such as basalt. Today, even most laymen at all interested in soils are aware of, and have little difficulty in understanding, that soils vary considerably according to the local parent rock or other parent material (such as river alluvium).

The soil scientists, however, see that many other factors affect the ways soils develop and their characteristics. These factors they term 'soil forming factors' and we may think of a soil forming factor as any factor or set of factors responsible for causing differences between soils. If two soils differ, it is because at least one soil forming factor is different; conversely, two similar soils would be considered to have developed under similar conditions, i.e. under the influence of similar soil forming factors. These factors are mainly factors of the physical environment. In addition to (1) the parent rock or material, there are (2) the climate, (3) the local vegetation and soil fauna, (4) the local relief and (5) age, i.e. the length of time these environmental factors have been operating, since a pedologically young soil differs from an old or senile soil, so that time causes differences between soils even where the remaining soil forming factors are similar. In addition, in the case of all soils except virgin ones, a sixth soil forming factor has modified soils - man. Man changes a soil by burning

or clearing vegetation, and by grazing, cultivating and so on.

The effect of the influence of these soil forming factors is that soils are part of the natural environment and closely related to it. The pedologist would not expect to find the same soil under forest as under savanna, nor would he expect to find the same soil in a dry area as in a wetter one. These considerations explain why, in the example of Kenya referred to above, there is such a great variety of soils related to the variety in climate, relief and vegetation as well as geology. In order to understand the characteristics and distribution of soils we have therefore to adopt an ecological approach which seeks to study and understand soils in relation to their environment. We have already noted above that tropical soils differ from temperate zone soils because the environment, particularly the climate and vegetation, are different.

Soils in Relation to Agricultural Possibilities and to General Development Planning

We have to consider the very complex question of the extent of our present knowledge of soils and soil characteristics in relation to our knowledge of the needs of plants and crops, and the degree to which that knowledge of soils can or cannot help us in rational development planning.

Availability of Technical Soils Information: We may distinguish between our general knowledge of soils, including soil physics, soil chemistry, soil genesis and classification and soil microbiology, and our specific knowledge of soils of any particular country or area under consideration. Under general aspects one might include, to take examples in the field of soil chemistry and fertility, our general knowledge of the soil factors affecting the supply to the plant of nutrient elements. These general aspects would include, for example, study of the nitrogen cycle and factors governing the rate at which soil organic matter mineralises to release nitrogen and other elements; they would include studies on soil potassium and factors affecting its release from slowly available forms in the soil and its supply to the plant; they would include studies on soil factors affecting the supply of phosphorus to the plant and soil factors which affect the extent to which phosphate added as fertiliser is available to the crop or lost through being fixed by the soil as available forms. These general studies would point out general relationships which, though based on the study of soils in specific areas, are thought to be widely applicable. Excess magnesium in the soil, for example, inhibits the plant uptake of potassium, and vice versa. We believe that these

general relationships hold good to a considerable extent for soils wherever they are, and our knowledge of these general factors and relationships has expanded very greatly over the last 25 years and is probably now expanding faster than ever before.

Compared and contrasted with this general knowledge is our knowledge, or lack of knowledge, of specific areas. In much of Africa, for example, there are still no detailed soil maps. Systematic soil mapping was started by several African countries after the Second World War but in most of Africa only general, small-scale maps are available with little more than ad hoc detailed work on specific areas which may have been investigated more thoroughly in relation to specific problems or projects.

A further difficulty is that methods of work and systems of soil classification in different countries are not always the same. It may not be easy to correlate, for example, soils described, mapped and classified in English-speaking areas with those of French- or Portuguese-speaking areas which have adopted different systems of classification. However, attempts have been made by the S.P.I. and by F.A.O. to compare and synthesise general soil information and to produce, though only on a small scale, general soils maps for Africa.

Anybody interested in planning the agriculture of a specific area in Africa has really to do two things as regards soils: he has to obtain some knowledge of local soils, their characteristics and distribution, and he has to try to relate this local knowledge to the relevant aspects of the body of general soil knowledge available. He might for example locate acid peat soils in an area: he would then relate this to general information acquired elsewhere about the properties of acid peat soils and their reclamation. He would note, inter alia, that such soils are often short of a trace element, copper, so that he would be alerted to the likelihood of copper deficiencies occurring.

There are an almost infinite number of different soils (or soil series) in the world, but the pedologist's answer to this variety is the process known as soil correlation. Soil correlation seeks to compare

soils so as to group those which are for practical purposes similar, or similar in some relevant aspects. In this way knowledge acquired about a soil in one area can be usefully applied to a similar soil elsewhere. Without good soil correlation, soil science could hardly make much practical contribution to agriculture. Here in Kenya, for example, there are in the Nairobi area two very distinct and contrasting types of soil. There is the widespread red soil, the so-called Kikuyu friable clay. This is an excellent soil, one of the best soils in many ways that I have ever seen. It is deep, friable, easily worked, well drained, has a high moisture storage capacity and, if well supplied with organic matter, is generally fertile. It is a Latosol developed over intermediate and basic volcanic rocks and if we wanted to find out more about such a soil we would, in addition to examining the soil itself and its associated agriculture, obtain information about work on comparable volcanic soils in other parts of the world.

The second type of soil found in the Nairobi area is a complete contrast to the red soil. It is a black, heavy cracking clay, poorly drained and impermeable when wet, and very difficult to work and cultivate because it is extremely sticky when wet but very hard when dry. The marked differences in physical characteristics between these two soils are related to the fact that the clay mineral in the red soil is mostly kaolin, a non-expanding clay which is generally associated with good physical properties (particularly when, as in this case, it is bound into stable micro-aggregates by iron and aluminium oxides) whereas the clay minerals in the black soil include montmorillonite. Montmorillonite expands when wet and shrinks when dry, and soils containing this clay mineral crack severely on drying and have other unfavourable physical properties which make them difficult to cultivate. The black, cracking clays of the Nairobi area are however not an isolated phenomenon peculiar to that area. They are examples of a widespread group of soils known variously as Tropical Black Earths, Tropical Black Clays, Vertisols and other terms, which are found scattered throughout many parts of the tropics. Similar soils occur, for example, in West Africa (in Ghana and near lake Chad), in South Africa, in the West Indies, in parts of South America and in India, where they are known as 'Black Cotton Soils', since cotton is one of the crops grown on them there. In other areas they have been successfully cultivated for sugar-cane and rice, often with irrigation, and often with special measures to improve their naturally slow drainage. Thus, the point being emphasised here is that

anybody concerned with using and developing these soils in the Nairobi area should not work in isolation but should take care to examine the soils with a view to comparing them carefully with similar soils elsewhere. In that way he might find that he can adopt or adapt cultural techniques, and even crop varieties, that have been successfully used in other parts of the world where the soils are comparable.

A mention of the topic of soil correlation leads naturally to the question of the classification of soils and the value, to the planner, of soil classification.

Soil Classification and its Relevance to Development Planning: Why classify soils? If we know why we want to classify, then we are better able to select the type of classification appropriate to our needs.

There are many types of soil classification, some very general and seemingly relatively academic, others immediately practical. The general classifications adopted and often discussed at length by pedologists are classifications which try to relate the characteristics of a soil profile to the way the soil was formed, i.e. to soil genesis, and to soil groups which are thought to have similar characteristics because they were formed in a comparable way. Such general systems usually attempt to encompass all the world's soils, or all our present knowledge of them, and to classify them in such a way that any soil can be fitted into its appropriate Order, Family, Group, Sub-Group and so on. Such a general classification might be compared with the botanical classification of plants or the zoological classification of animals, in which every plant and animal can be fitted into its genus and species. Soils can never be classified in the same way as plants or animals because they vary in so many aspects and grade into each other often gradually so that some divisions have to be fairly arbitrary, but nevertheless such classifications have enabled soil scientists to correlate soils on a world scale and to focus attention on specific soil properties thought relevant to the classification and to the genesis of the soils. Such a general classification, by its very nature, does not seek directly or primarily to emphasise agricultural characteristics or value, though it may give such information on these. As a result there is also a need for other classifications, often less complex because they emphasise relatively few and more practical aspects, and often are specially adapted

to local needs and conditions. These practical, often local, classifications are in some cases more useful in relation to specific projects than the general classifications.

In classifying soils for a specific scheme or project the local climate and soil conditions often suggest a specific range of crops, and of soil criteria particularly relevant to assessing the value of soils for the crops in mind. If drainage is important, a map classifying soils according to drainage may be useful. If soil depth is limiting, a map showing soils grouped according to effective depth may be needed. In other cases soils may be usefully grouped and mapped according to texture, or to organic matter content, or to reaction (pH). For irrigation purposes the salt content of the soils may be particularly important. In the Gezira scheme in the Sudan, for example, a soil map showing salt content was found particularly useful in selecting soils for irrigation. These are specific examples of soil classification, albeit very simple ones, which can successfully help evaluate soils and help in selecting soils most suited to a particular use. There are also other more general simple practical schemes which have been widely used. One is the U.S. land capability classification (See Appendix 1.) which groups land into broad classes according to the degree of limitation; it emphasises mainly relief and gradient and hence erosion hazard, and is concerned primarily with classifying land for mechanised annual cultivation. Where other forms of land use are envisaged, such as the planting of perennial tree crops, it is less important to have nearly flat land and other criteria might be emphasised instead.

A comparable system of classification geared specifically to the value of land for irrigation purposes has been used by the U.S. Bureau of Land Classification. This classification is designed to be modified and adapted to local conditions, but generally divides land into six classes. Classes 1 to 4 are for soils suited to irrigation agriculture (class 1 land having the least limitations and class 4 land the most); class 5 is land not at present suitable for irrigation though capable of becoming so under some circumstances or if improved; class 6 land is not considered to be irrigable.

The criteria specially emphasised when land is considered for irrigation are (a) the soil texture, since very heavy, poorly drained soils and very sandy soils are both unsuitable, the first because water moves too slowly through them and the second because they store very

little water and might be excessively permeable; (b) the gradient of the land, which is important for furrow irrigation but less so for sprinkler irrigation; and (c) the presence, as mentioned above, of high levels of salts in the soil which might increase and become harmful during use.

A map of an area dividing land into irrigation classes might be useful in assessing the viability or otherwise of an irrigation scheme, but normally the user would want to know more than merely the class of the land, he would also want to know the specific properties which caused the land to be put into that class. Thus, normally what is needed is first a general soil map showing the extent and distribution of the different soils, accompanied by a report describing their physical and chemical properties, and secondly a map or set of maps (sometimes prepared as a series of overlays) showing specific properties or classifying land for a specific purpose. The second is derived from the first, but is no substitute for the basic map and associated information.

Some Soil Problems Affecting Development

The soil problems affecting agricultural development are too varied to allow for more than very cursory mention in a paper of this nature. There are problems simply of lack of sufficient knowledge. In other cases we know enough about specific areas to be able to outline and define specific problems and limiting factors. These problems are in many areas climatic. Problems raised by the soil itself are very varied indeed: such problems may include physical soil factors, soil chemical factors (low general fertility and in some cases toxicities) and the overall difficulty, often not fully appreciated by those without practical experience, that soils are often very patchy (heterogenous) and vary over short distances.

Problems Posed by Lack of Knowledge: In many parts of Africa there are no detailed soil maps available. Very small-scale maps covering large areas may not give sufficient information for planning purposes. In Kenya, for example, regional plans have been drawn up for all provinces in which an attempt has been made to gather together and interpret basic environmental information in relation to planned development, but in some cases the soils information is still sketchy and inadequate. For specific development schemes, further soil investigations and mapping

are often necessary before the viability or otherwise of the scheme can be assessed.

In addition to local soils information and maps, there are more general aspects of soil science where the present state of knowledge is inadequate and may thus limit development. The important fact is that for tropical lowland areas in particular we do not know to what extent traditional shifting agriculture, in which a period of cropping is followed by a period of fallow, can in practice be replaced by more continuous cultivation which reduces or eliminates the fallow period. The technical problems involved in continuous agriculture in the tropics appear to be very complex and to vary very much from place to place. Continuous rice cultivation and perennial tree crops (such as coffee, tea, rubber and oilpalm) form examples of perennial continuous agriculture, but it is much more difficult in many areas to cultivate annuals year after year. Some of the soil problems involved in moving from shifting cultivation to permanent cropping were outlined by the author recently at the Ibadan conference on shifting cultivation. Extracts from this paper are included here as Appendix 2. These extracts include the question of the extent to which fertiliser applications increase yields in areas of traditional shifting cultivation, and allow the cropping period to be lengthened and the fallow periods, which are at present such a prominent feature of much of agriculture in tropical Africa, to be shortened or even eliminated altogether. This Appendix therefore serves as an example of the type and range of technical problems encountered, and as an example of the ways in which our present technical knowledge might limit what can be carried out in the field of agriculture. The spectacular failure of such costly schemes as the East African groundnut scheme (partly because of inadequate prior knowledge of soil factors) forms a warning as to the dangers involved in attempting the rapid development of large areas without sufficient prior technical experience.

Climatic Problems: In tropical Africa the main problems associated with climate, apart from the lack of sufficient, long-term, reliable climatic data, are the problems associated with low and/or erratic rainfalls. It is one thing to have a low rainfall, and quite another to have a rainfall which is erratic, i.e. which varies so much from year to year that one can hardly predict in advance how much rain is going to be received. Much of the research work of E.A.A.F.R.O. (the East African Agriculture and Forestry Research Organisation) has in recent years been concerned with

the specific problems of low and erratic rainfalls, as summarised and commented on by Russell. (7) One important approach has been to apply statistical methods to work out rainfall probabilities. In this way it might be possible to say for example that statistically and area has so many inches of rain for so many months in four years out of five. This information has then to be related to the water needs of specific crops and crop varieties. Here again it was found that lack of knowledge is often a limiting factor because we know surprisingly little about exactly how much water many crops and crop varieties need at different stages of their growth. Experiments were initiated to measure water consumption accurately.

Once the likely rainfall is known (and for many areas it still is not known with accuracy) then the task is to select or to breed a crop adapted to that rainfall. If there is no irrigation and the crop relies entirely on the natural rainfall, then often it might be necessary to choose between a crop or variety which gives a safe but relatively low yield, and one which because it needs more water or has a longer growing period might fail in some years but which will give a higher yield in those years in which rainfall is adequate.

There is much that will undoubtedly be achieved by crop selection and breeding to open up areas of lower rainfall. The soil and climatic problems affecting development are not static, but subject to change as man's knowledge increases: what may be technically impossible today may be quite feasible in the near future. Thus the development planner has to keep constantly in touch with experts able to provide up-to-date guidance as to what is technically possible, and the mere fact that a scheme or development plan was found impracticable some years ago does not mean that it might not be profitable to reassess it afresh now in the light of technical developments.

Unfavourable Soil Characteristics: Apart from the frequent problem of lack of sufficient knowledge about the soil there are problems posed by known unfavourable soil characteristics and properties. Unfavourable soil properties might for convenience be considered under the general headings of (i) unfavourable physical properties; and (ii) unfavourable chemical properties, including low general fertility, soil reaction, soil salinity and other toxicities. In addition soil patchiness (soil heterogeneity), while not necessarily unfavourable in the same sense, is nevertheless a factor which sometimes makes both experimental work and

agricultural development more difficult than it might be if soils were more uniform, or uniform over larger areas.

Unfavourable physical soil properties refer to unfavourable soil texture, structure, porosity, permeability, etc., and also include excessive stoniness, shallowness and other aspects. Natural soils vary widely in texture. In many respects the most versatile soils are those of moderate, intermediate textures, including the various loams. Very light sandy soils and very heavy clay soils are often less versatile i.e. have a more restricted range of agricultural uses, but usually there is some profitable and practicable way of making use of soils of all textures. For irrigation work, however, texture is particularly important. (see Appendix 1.) Very porous sandy soils may be excessively permeable and store very little moisture, so that they may be wasteful of water and need more frequent irrigation than soils of heavier textures. Very heavy soils on the other hand may have very low permeabilities and be relatively difficult to irrigate for that reason, and may also be very sticky when wet and very hard when dry. These latter properties are aspects of soil consistency. A friable consistency is generally the most favourable for agriculture; where soils are very sticky when wet but very hard when dry, then special care must be given to cultivating them (ploughing them, harrowing them, etc.) at the optimum water content, i.e. when moist but neither too wet nor too dry.

In general it might be said that unfavourable physical properties are difficult to correct satisfactorily and often result in the operating costs being higher than they would otherwise be. In some cases soils are excessively shallow, rooting depth being limited by rock, by a layer of hard pan or ironstone or, for some crops, by the water table. Soil depth, texture and porosity in turn all influence the soil moisture characteristics, including the important question of how much water the soil can store and make available to the plant. The water storage capacity of soils is particularly important where water is a limiting factor; in an area of similar rainfall a soil with a relatively high water storage capacity might carry a different natural vegetation and also support a wider range of crops than another soil in the same area with a relatively low water storage capacity. The red soils which conference participants will have noticed in the Nairobi area, the Kikuyu friable clays, include among their excellent physical properties the fact that they have an unusually high available water storage capacity, often being as high as over two inches per foot of soil. Conversely a

particularly low moisture storage capacity would be regarded as an unfavourable physical soil property which, like most physical soil properties, might be difficult and/or expensive to correct.

Unfavourable soil chemical properties might include a generally very low fertility, but the fertility of the soil can generally be controlled or improved by the use of fertilisers, and most intensive agriculture no longer relies on the natural fertility of the soil alone but involves the use to varying degrees of fertilisers and soil amendments. Correcting the fertility status of the soil is thus mainly a matter of cost and economics in relation to the yield obtained and its value. More troublesome are some other possible unfavourable chemical properties such as salinities or other toxicities. Saline soils contain sufficient sodium to harm some plants and limit their growth; alkaline soils are those where plant growth is affected by excessive concentrations of salts of other elements. Such soils can usually be reclaimed, but the process may be too expensive to be economic. Soil salinity is something that is looked at particularly carefully when irrigation is likely, since the unwise use of irrigation water often results in salinity being increased.

Other possible unfavourable soil chemical properties concern the minor or trace elements (oligoelements) such as copper, boron, zinc and molybdenum. It is characteristic of most trace elements that the plant requires only very small amounts. If large amounts are present in the soil, then some trace elements are toxic. Thus, trace elements can limit agricultural development either because they are present in too small amounts, as for example in parts of Kenya where the soil does not contain enough copper, and in parts of Tanzania where low boron has been a problem, or because they are present in too large amounts and thus are toxic (i.e. poisonous) to plants. Sometimes an otherwise productive soil has been rendered agriculturally virtually useless by the absence of a trace element which can be supplied in the very small quantities required at negligible cost once the deficiency is diagnosed and known. This happened in the case of some unused Australian soils which were made productive simply by adding a pinch or two of molybdenum per acre, but such spectacular cases of improving soils at very little cost are rare.

Soil patchiness (heterogeneity) can itself be something of a problem affecting development, particularly if soil characteristics change markedly over very short distances. Soil workers have sometimes reported important variations, particularly in soil chemical properties, between

samples taken a few centimetres apart. Such patchiness makes analysis of the soil and also experimental work more difficult; it also affects the utilisation of the land. Planners often prefer areas where the soil is reasonably uniform over relatively large expanses.

Soil reaction, i.e. the pH (acidity or alkalinity) of the soil, is an important soil property affecting fertility since most plant nutrients are generally most easily available to the plant in soils which are neutral or slightly acid in reaction. Very acid soils and very alkaline soils usually suffer from specific problems. Reaction can be corrected and acid soils are often limed for this purpose, but expert advice is needed before doing this. In some cases plants actually prefer acid or alkaline soils: tea and pineapples, for example, are generally considered to grow best in acid soils and soils may be deliberately acidified for this reason. Such considerations reinforce the viewpoint already expressed that often what is a good soil for one crop is a bad soil for another, and that there is usually some rational way of using and developing most soils provided that there is enough water.

Soil erosion is sometimes a problem. Many people are, fortunately, now aware of its dangers and conscious of the need for control measures, though here too expert advice might be needed as to what has to be done. Soil erosion measures are now relatively well understood and it is mainly a question of applying them in time and of using the land in a sensible way. Soil erosion is particularly likely to be a problem where the rainfall comes in intense downpours, where slopes are steep and where the soil is not adequately protected by vegetation, but the texture and other properties of the soil also affect erodability. In Kenya legislation was passed enforcing the terracing of land above a certain degree of slope. In some areas wind erosion can also be a serious problem, and may be more insidious inasmuch as it may be less spectacular and therefore less easily noticed, at least at first, as compared with the gullies which may be caused when water collects and runs rapidly down a slope. In development planning the recommended land use will often be broadly influenced by the erosion hazard, so that only the flatter areas might be used for annual arable crops, with the steeper ones reserved for permanent pasture or tree crops.

APPENDIX I: LAND CAPABILITY CLASSIFICATIONS AND SOIL CLASSIFICATION FOR IRRIGATED AGRICULTURE

The following notes on land capability classification and on the classification of land for irrigation purposes are extracted from my book, West African Soils. (4)

Land Capability Classifications

There have been many attempts to classify soils according to their agricultural 'capability' and to make the classification simple enough to be understood by the layman and by the ordinary farmer. Such classifications are widely used in the U.S.A. in particular. The capability assessed is one which normally refers particularly to the dominant local type of land use (the U.S. land capability classification, for example, was constructed for areas where annual crops and mechanised agriculture are the rule). However, the simplification necessary to produce a scheme easily understood by everybody sometimes leads to the classification saying very little which is not rather obvious and over-simplified. Capability maps can be useful for planning purposes and have often drawn attention to the need for erosion control measures, but they are no substitute for more detailed work on soils.

Because the best known capability classifications were developed in areas of mechanised arable agriculture, they are not always easy to apply to rather different areas without the danger of being misleading. The usual method is to classify soils according to the severity of factors held to limit their use: the more severe the limiting factors, the narrower will be the range for which the soils are suited. Thus a Class I soil is a soil with very few or no limiting factors and is therefore the most versatile, but soils of Classes II to VIII suffer from progressively more severe limitations which narrow down their desirable and practicable range of use.

The land capability classification of the U.S. Soil Conservation Service, the best known and widest used of the U.S. capability classifications, places considerable emphasis on the liability of the land to suffer from accelerated erosion if cultivated. It therefore pays particular attention to slope gradients but it also considers natural soil productivity where this is a limiting factor, factors interfering with cultivation (such as stoniness) and climatic limitations. It should be emphasised that the normal practice is to adapt

the general class definitions to local conditions prevailing in particular areas, and that this adaptation makes the classification of more value in those areas. The eight broad classes are the following:

Classes 1 to 4:		soil suited to cultivation
	Class 1 -	no special practices needed
	Class 2 -	simple conservation methods necessary
	Class 3 -	intensive conservation practices necessary
	Class 4 -	suited for occasional or limited cultivation with intensive conservation practices.
Classes 5 to 7:		soils not suited to cultivation but suitable for permanent vegetation such as tree crops, forestry and pasture
	Class 5 -	no special restrictions or practices
	Class 6 -	moderate restrictions in use
	Class 7 -	severe restrictions in use.
Class 8		not suitable for cultivation, grazing or trees. Class 8 land is usually extremely rough or steep land, or extremely sandy areas or extremely wet or arid areas that may however have some value for wildlife or recreational purposes.

Soil Classification for Irrigated Agriculture

Soils are often classified specifically for irrigation agriculture, usually according to a system somewhat comparable to the land capability classifications outlined above. A system widely used is that of the U.S. Bureau of Land Classification, as outlined in their reclamation manual, or a modification of it to suit local conditions. This type of classification often divides land into six classes. Classes 1 to 4 are all suited to irrigated agriculture, with Class 1 land having the least limitations and Class 4 land the most. Class 5 land is that land which is not considered to be irrigable at present but which could become so under certain circumstances. It is therefore a 'holding' class in which land can be classified pending reclassification after the necessary engineering or other modifications have made it irrigable. Class 6 land is that land not considered to be irrigable.

For irrigation agriculture particular attention is given: (a) to the gradient of the land, for only flat or gently sloping land is normally considered irrigable; (b) to the texture, which is preferably

a loam, for very sandy and very clay soils are not particularly suited to irrigation, the first because they store so little water and have excessive permeability, the second because they are relatively impermeable and water moves very slowly through them; and (c) to the presence of high levels of salts, particularly sodium chloride, which might be increased to toxic levels during use.

It should be stressed that the definitions of the irrigation classes are normally suitably modified to suit local conditions. The following broad definitions of soils in Classes 1 to 4 may be found adaptable for general use in West Africa.

Class 1 soils are highly suitable to irrigated agriculture. They can produce sustained and relatively good yields at moderate cost. They are flat or nearly so and have little erosion hazard. The soils are deep, of medium to moderately fine texture, have a structure and porosity allowing easy penetration of roots, air and water, and combine good drainage with an adequate moisture-storage capacity. No farm drainage works are normally necessary. The soils are free of salt or other toxic substances, or can easily be reclaimed.

Class 2 soils are well suited to irrigation agriculture but somewhat more limited than Class 1 soils. They may be more expensive to prepare for irrigation than Class 1 soils, and be more costly to farm and require more supervision. The limiting factors may include one or more of the following: shallow depth, texture which is either too coarse or too heavy, low moisture-storage capacity or slow permeability because of heavy texture or subsoil compaction. These soils may require some expenditure on drainage or reclamation works.

Class 3 soils are those with a somewhat restricted suitability for irrigation agriculture because of more serious limitations than are present in Class 2 soils. They may require heavier investment in land preparation, more care during use, heavier levels of fertilisers and amendments or be restricted by heavy texture and slow drainage which can be corrected only partially and at high cost.

Class 4 soils are severely restricted in their irrigation possibilities: they may be suited only to special types of

land use, such as pasture, or require heavy investment in engineering and drainage works before they can be used. Factors which could put a soil into this class include very poor drainage because of heavy texture and unfavourable low position which subjects the soil to periodic flooding or a very high water table.

It will be noted that, as in the land capability classification, soils are placed in groups of decreasing suitability for irrigation but that the particular factors or combinations of factors responsible for the soil being placed in that class are somewhat varied. Irrigation suitability maps are very useful for planning purposes and for deciding whether an irrigation scheme warrants the investment involved, but the individual user will often want to know exactly why a soil has been placed in a certain class and not merely what class it is in. He may, for example, have two soils both placed in Class 3 but for quite different reasons, and intelligent use of these soils will require knowing more about their limiting factors than the mere fact that they are classified as Class 3. As in the case of land capability maps, the irrigation suitability classification is therefore no substitute for more detailed work or for a knowledge of the properties of each soil series concerned. To some extent the type of limitation involved is indicated by the practice of adding suffixes to the irrigation class. The usual suffixes are (SO)where soil characteristics are a limiting factor, (T) for areas limited by rough topography or too high gradients, (D) where the soils are limited by poor drainage, (R) where loose rocks occur within the plough layer and (C) where a climatic factor (other than low rainfall) is considered to limit the use of the soil for irrigated agriculture.

APPENDIX II: SOME TECHNICAL CONSIDERATIONS AFFECTING RESEARCH ON IMPROVEMENTS AND ALTERNATIVES TO SHIFTING CULTIVATION*

The main criticisms of shifting cultivation concern low yields and the generally short period of cropping in relation to fallow. Both the increasing of yields and the lengthening of the cropping period are obvious ways of raising overall productivity of the system, and both of these are influenced by a wide range of factors apart from soil factors. Another way of raising productivity concerns the fallow period which follows the cropping: how can the beneficial effects of the fallow be obtained in a shorter time, or by means other than natural fallows or, best of all, be eliminated altogether by a rotation which keeps the land constantly productive?

Just as the reasons for low yields are diverse, so the measures that need be taken to raise yields are varied and complex. The use of fertilisers can be effective only where soil fertility is the limiting factor and where the plant is genetically able to respond to an improved nutrient supply, but many other limiting factors, such as poor physical soil properties, water shortages, inadequate management in general (including weeding), poor husbandry methods (including wrong plant population densities and wrong time of planting), poor crop varieties, attacks by pests and diseases and so on, also limit yield, so that maximum yields can be obtained only when a very wide range of factors are all favourable.

The General Level of Management and Choice of Husbandry Methods

According to Russell (7) possibly the most important single factor responsible for low yields in tropical Africa is wrong time of planting - usually too late. This appears to be due partly to caution, partly to the fact that at planting time the farmer is simply too busy to cope with all that has to be done. Recently, for example, it has been shown that cotton yields in Uganda fall seriously if sowing takes place after the optimum date. (29)

Another widespread factor responsible for low yields is wrong planting densities, which are often too low. These factors plus management factors, such as timely weeding, could of themselves, if corrected, probably give more substantial yield increases than the use of fertilisers,

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* This Appendix is extracted from Ahn, 22.

particularly if fertilisers are used without attention to these factors as well.

Allan (23) investigated maize yields on small farms in Kenya with and without good husbandry, and with and without hybrid seed and fertilisers. He defined good husbandry (GH) as early planting at the start of the rains, a density of 36,000 plants per hectare and clean weeding up to tasselling time. Bad husbandry (BH) is described as planting four weeks late with a low population density of only 18,000 per hectare and only one late weeding. These two types of management were investigated both with local maize without fertiliser (LM, no F) and with hybrid maize and fertiliser (H + F). Average yields for the four combinations were as follows:

BH + LM, no F	:	19.2	quintals/hectare
BH + H + F	:	32.7	" "
GH + LM, no F	:	48.8	" "
GH + H + F	:	80.2	" "

The difference between good husbandry and bad husbandry, both using local maize without fertilisers, is associated with more than a doubling of yields and with an increase of 29.6 quintals per hectare. In contrast, if bad husbandry is used, the use of hybrid maize and fertilisers gives an increase of only 13.5 quintals per hectare, despite the extra investment in fertilisers. In circumstances examined by Allan therefore, correct time of planting, correct planting densities and better weeding together gave a much larger yield increase than did the use of hybrid maize and fertilisers without these improved husbandry practices. The yield increase associated with good husbandry as compared with bad husbandry was even greater when hybrid seed and fertilisers were used. The results also indicate that the use of fertilisers in this case was not very profitable unless accompanied by improved management too.

It will be noted that hybrid maize and fertilisers were tested together, not separately. In many situations, the local variety is well adapted to local conditions and resistant to local maladies, but is unresponsive to fertiliser application. In such cases it is little use applying fertiliser unless the crop variety is also improved, and little use planting a variety of higher potential yield unless the soil can meet the correspondingly higher demand for nutrients, though

F.A.O. fertiliser trials and demonstrations appear to indicate widespread fertiliser responses even where local varieties are used. (34 and 7)

In areas of low and/or erratic rainfall, much depends not only on selecting a suitable crop variety but on making sure that as much as possible of the rainfall gets into the soil and is then used by the crop.

Increasing the effective rainfall includes measures designed to keep the soil open and to reduce and slow down runoff. These measures include the use of mulches, contour ridging, basin listing and other measures which have been successfully demonstrated both in West Africa (37) and in East Africa (38), though not widly used as yet.

The Extent to which Fertiliser Applications Increase Yields and Prolong Cropping

A very considerable amount of information is now available on fertiliser responses in those areas of the world where shifting cultivation is widespread. In considering this information it is helpful to relate responses to the agricultural/ecological zone in which they occur, to see to what extent they form a consistent pattern related to the zone. It is also useful to distinguish between the evidence of fertiliser trials on experimental stations and the generally larger body of information relating to results on farmers' farms, such as those obtained in the numerous and widespread trials and demonstrations carried out by F.A.O.

In the final analysis, increased use of fertilisers depends not on whether or not they give an increase in yield but whether that yield increase is profitable. Russell (41) has pointed out that in most tropical areas fertilisers are more expensive than they are in the developed countries, while the crop produced is sold relatively cheaply, so that "much higher crop responses per unit of fertilizer nutrient are normally needed in the tropics if fertilizers are to be profitable". However, in a number of countries where shifting cultivation is practiced, governments now make fertilisers available at subsidised prices.

A number of authors have pointed out that in Africa broad differences exist between fertiliser responses in forest and in savanna areas. (42, 21, 44) [illegible] In savanna areas responses to nitrogen are very frequent and responses to phosphate frequent, but responses to potassium have been relatively uncommon even on soils which appear on analysis to be low in potassium. In forest

areas the position is somewhat different, since responses to phosphorus and potassium are relatively frequent, but responses to nitrogen do not generally occur except in long cultivated soils low in organic matter. Responses to individual nutrients are now considered in more detail, together with some examples of related topics requiring further research.

Nitrogen Responses and Green Manuring: Nitrogen responses are closely related to organic matter contents and are to a considerable degree predictable for this reason. They are frequent in savanna areas because these areas are generally low in humus, and there is also evidence that some natural grass fallows inhibit nitrification in the first year after clearing. In forest areas organic matter levels are often higher than in savanna areas and responses are less frequent except after several years of cultivation and on degraded soils. In a recent paper Ofori (43) for example, states that nitrogen failed to produce a response with cassava or maize when forest soils at Kumasi, Ghana were continuously hoe cultivated for nineteen years. Research has paid attention to:

Seasonal changes and flushes in nitrate production under natural conditions;

The type of fertiliser most appropriate including the acidifying effects of sulphate of ammonia; and

Symbiotic and non-symbiotic nitrogen fixation and the role of legumes in tropical agriculture.

Bartholomew (6) has summarised current knowledge of nitrogen in the humid tropics and has pointed out that relatively low yields, such as 600 - 1200 Kg/ha of maize, do not remove more than about 15 Kg/ha of nitrogen in the harvested grain. He believes that, taking into account the natural nitrogen supply, only small amounts of fertiliser may be necessary for long periods. Nevertheless, he considers that available nitrogen may be the chief limiting factor to higher yields in many important food-producing areas of the tropics, and, in order to achieve these higher yields more fertiliser nitrogen and/or the use of legumes will be necessary.

Russell (44) considers that sulphate of ammonia is suited to the tropics inasmuch as the nitrogen is held against leaching by the ammonium action and that the S contained is often beneficial, but nevertheless, because of the acidifying effects he makes "a strong plea that sulphate of ammonia should no longer be used as a standard nitrogen fertilizer ... except for the tea crop". Applied research on shifting cultivation improvement should therefore include consideration of other forms of nitrogen fertiliser such as the calcium ammonium

nitrate now fairly standard in Kenya for arable crops.

Nitrogen fixation is mainly by symbiotic bacteria, and these are associated with a fair number of plants other than members of the leguminosae(40) but it is important to remember that bacteria fix nitrogen only when other sources of supply are inadequate: nitrogen in the soil solution inhibits fixation, and adding nitrogen fertilisers may have this inhibitory effect even though nodules may form. (6)

A promising field of research in the tropics concerns blue-green algae, for although they are thought of mainly in connection with their nitrogen-fixing role in swamp rice cultivation they can tolerate a wide range of moisture conditions and can live in moist or even dry soils. They can obtain all their needs from air, water and mineral salts and can therefore colonise areas which other micro-organisms needing organic residues cannot.

Considerably more applied research is required on the use of legumes in areas of shifting cultivation, either mixed with other crops, as a rotation crop or as a form of fallow. During the growing period very little nitrogen escapes from the legumes to become available to associated crops: the N, becomes available when the plant dies and decomposes, and it is this that accounts for the increase in available N when leguminuous green manures are turned into the soil. However, the effect of the added N may be equivalent to only modest amounts of fertiliser nitrogen, so that the economics of green manuring need to be examined carefully.

Because of the mobility of nitrate nitrogen, leaching losses can be severe in high rainfall areas. The pattern of water movement in a soil may need to be studied in relation to the movement of nitrogen down to soil layers beyond the reach of the crop. Research on this topic is needed to formulate efficient N-fertiliser practices.

Although total nitrogen in the soil is simple to measure, tests for available nitrogen (NH_4 and NO_3) are made more difficult by the fact that these ions are present in the soil in small and fluctuating quantities. Seasonal variations in available nitrogen have been studied by Greenland (30) Birch (24 and 25) and others.

Greenland (31) has pointed out that the reason why nitrogen

tends to increase under natural grasslands is that the labile nitrate ion occurs only in very small amounts under such conditions, so that losses are kept very small and even modest additions of nitrogen to the soil-plant system result in a net increase. He also refers to recent methods which would assist with the detailed quantitative analysis of the nitrogen cycle under different management practices, mentioning the acetylene-ethylene method for measuring nitrogen fixation (33) and sensitive methods of gas chromatography to determine losses of nitrogen gas from the soil. (27 and 28)

Phosphorus Responses and Research on Phosphorus: Possibly more attention has been given to phosphorus in tropical soils than to any other nutrient. This attention reflects both the belief that phosphorus is frequently a major limiting factor and the relative complexity of the problems associated with the uptake of phosphorus from the soil, including phosphate fixation. Some aspects of current knowledge regarding phosphorus in soils of the humid tropics have recently been summarised by Olson and Engelstad. (6)

Phosphorus responses have been widespread, both in tropical forest and tropical savanna areas, and appear to be related to the intrinsic qualities of the soil, particularly to its phosphate fixing capacity. In the F.A.O. Freedom From Hunger fertiliser programme some response to applied phosphate was reported for slightly over 90 per cent of the very numerous trials reported (F.F.H.C. Fertilizer Programme, 1968), responses being particularly large for tubers (including yams) and vegetable crops. The following figures give average yield increases in trials in West Africa and South America:

West Africa:	Maize	(794 trials)	173 Kg/ha
	Yams	(377 trials)	895 Kg/ha
Northern South America:	Maize	(196 trials)	401 Kg/ha
	Potato	(53 trials)	2,762 Kg/ha

Phosphorus is relatively immobile in the soil, so that the root has to grow to the applied phosphate. This fact, and the well known ability of a range of tropical soils to fix applied phosphate in various ways (usually as aluminium and iron phosphate in the acid soils and calcium phosphates in alkaline ones) have contributed to the fairly low availability of applied phosphate fertilisers and suggest the need for increased fundamental and applied research on increasing the efficiency of phosphate fertilisers. Topics requiring further investigation include:

- the effects of granulation of phosphatic fertilisers in

reducing fixation and prolonging availability

- the possible effects of coating fertiliser granules to reduce fixation
- the use of local rock phosphate supplies on acid soils
- the use of a little lime on very acid soils (below pH 5.0) with high exchangeable aluminium
- special problems of soils with particularly high phosphorus fixation capacities (usually soils high in amorphous hydrated oxides of iron and aluminium)
- further investigations on methods of application, including depth of placement in different crops and soils and rates of application
- further investigation on the feasibility of predicting P responses by means of direct soil analysis and correlations both between different methods and between results and subsequent responses
- problems of seasonal variations (especially between wet and dry seasons) in test results
- the practical role of other diagnostic methods such as leaf analysis
- the use of added silicate to reduce fixation in soils with high iron and aluminium but low silicon
- possible harmful effects of P applications, e.g. depressing zinc, manganese or copper availability, especially in soils with a high pH
- assessing and improving the residual effects of phosphatic fertilisers.

Potassium: Potassium, in areas of shifting cultivation, is much less frequently a limiting factor than is nitrogen and phosphorus. In some cases this is because the soil parent material contains adequate potassium (as in parent materials containing potassium feldspar and the micas), or because potassium release from humus mineralisation is adequate. In many cases, such as soils of the West African savanna areas, both total and available K appears low when measured in the laboratory, and yet crops show little or no response to potassium fertilisers. This has been explained as being due to the fact that the crops involved are generally grasses (maize, sorghum, millet) which are relatively efficient extractors of potassium, and also to the fact that savanna soils which are sandy and low in organic matter have relatively low action exchange capacities. A low action exchange capacity means that even a small amount of exchangeable potassium can give a satisfactory potassium saturation percentage (exchangeable K/CEC), so that the small amount is nevertheless fairly easily

available to the plant. More recent work, however, including trails with yields at higher levels, has shown increasing numbers of examples of responses to potassium fertilisers in the savanna areas.

In the forest areas potassium responses are more frequent than in savanna areas, particularly with bulky starch-containing crops such as cassava, while K responses of coconut palms growing on sandy littorals have sometimes been particularly spectacular. Further research is required on potassium leaching losses (particularly the role of phosphate, sulphate and chloride anions in facilitating the removal of K and other cations), and on the release of non-exchangeable forms of potassium in the soil to replace the removal of the more readily available forms. Further work on determining readily available and slowly available forms of K in the soil in relation to CEC and other factors affecting uptake should make it easier to identify in the laboratory those soils deficient in this element. A useful summary of existing knowledge of potassium in soils of the humid tropics has recently been made by Boyer (6) who examines the various minimum levels of exchangeable potassium required by various crops as reported from different parts of the tropics. He divides crops into three groups according to whether their minimum exchangeable K requirement appears to be about 10 m.e. per 100 g, or less than this or more. He also examines exchangeable potassium needs in relation to total exchangeable bases (K should be at least about 2 per cent) and reviews work on various potassium "fertility scales". Boyer also discusses the important question of equilibria with other cations, particularly K/Mg and K/Ca ratios, and possible interactions between potassium and nitrogen, phosphorus and iron. This valuable summary of present knowledge indicates clearly that further work is needed on these topics, as well as on the problems of potassium leaching (referred to recently by Wild, 46), the problem of potassium fixation in certain soils and climates, and the fact that the commonly used potassium fertiliser (KCl) sometimes has a depressive action or lowers the quality of some crops.

Sulphur: Sulphur deficiencies are now known to be fairly widespread in some areas of shifting cultivation, particularly in savanna areas. This may be because the sulphur is lost during the annual burning.

The sulphur in soils is mostly organic, and closely tied to organic nitrogen. In wet areas sulphur may be lost by leaching.

Sulphur responses have been reported from Brazil (39), the Punjab of India (36), in East Africa (44) and in West Africa (41, 32 and 26). In many other areas deficiencies have probably been unwittingly made good by sulphur-containing fertilisers such as sulphate of ammonia and single super-phosphate. In Senegal, Tourte et alia (45) reported an average sulphur leaching loss from lysime studies of 10 Kg/ha. Olson and Engelstad (6) suggest that the required rate of S application could in some cases be as high as 20 Kg/ha and and state that provided that sulphur applications are not allowed to lower soil pH to levels which would result in excessive S and Mn plant uptake, moderate sulphur applications to non-acid soils in particular can be expected to have a beneficial effect on the availability of a wide range of nutrients.

Calcium, Magnesium and Liming: High soil acidity was formerly believed to be due to a high degree of hydrogen saturation of the exchange complex, but it is now known that in soils with a pH of 5.0 or less the predominant cation is exchangeable aluminium. This is due to the hydrolysis of aluminium and the production of hydrogen ions. Kamprath (6) has recently summarised current thinking on these topics and has discussed responses to liming based on neutralisation of exchangeable aluminium. This approach calls for the addition of lime, in relatively small amounts, only to very acid soils. Liming of moderately acid soils has met with very varied results so far, and is not likely to prove of widespread use. Some of the harmful effects of liming are related to the fact that all the trace elements except molybdenum are more available in acid soils than in neutral and alkaline soils, so that liming may induce trace element deficiencies.

One of the beneficial effects of adding lime to very acids soils high in exchangeable aluminium is that their phosphorus fixation capacity may be lowered.

Considerable further research is required on the importance of soil pH in the tropics, and on useful ways of measuring it. Research on liming rates should probably be based on determining amounts needed to neutralise only the exchangeable aluminium. Frequency of application will depend on leaching rates, and field studies are needed to ascertain these.

The main effects of low calcium and magnesium in soils are indirect, i.e. on soil pH, but in a few cases direct shortages of these elements have been reported.

Micronutrients: Under shifting cultivation, with adequate fallows, it was generally thought that micronutrient deficiencies are unimportant. Recently, far more cases of trace element deficiencies have been reported. This is partly because increased yields put greater strains on micronutrients in the soil and show up deficiencies which were not apparent with less intensive agriculture, and partly because more research has been carried out on these topics. Current knowledge of micronutrients in the humid tropics has recently been summarised by Drosdoff (6) who states that in Africa deficiencies of molybdenum, zinc and boron appear to be the most prevalent, but copper, manganese and iron deficiencies have occasionally been identified. Deficiencies reported in Malaysia are mostly of zinc and boron, while in the Campo Cerrado area of Brazil, where the highly weathered and leached soils are developed over very old sediments, dramatic responses have been obtained to trace element applications, particularly to zinc, boron and molybdenum.

It appears very likely that more research on trace elements will reveal further examples of deficiencies. These are generally least likely on younger, more fertile soils well supplied with organic matter, and most likely to occur in highly weathered or sandy soils, developed from old sediments, which are also low in humus.

Silicon: Silicon is not an essential plant element, but in many highly weathered tropical soils soluble silica may be relatively low and there is increasing evidence that added silicate can increase yields of certain grasses, particularly rice and sugarcane. In Japan large quantities are applied annually to the rice crop. In a review of recent work on this subject D'Hoore and Coulter (6) refer to reported responses of sorghum in Mauritius and millet in Rhodesia and conclude that there is considerable scope for research into the role and need for silica in tropical agriculture.

Fertiliser Responses in the Absence of other Improved Practices: The extent to which fertiliser applications alone can often increase yields on farmers' plots has been the subject of considerable discussion and sometimes disagreement. Those concerned with the recent widespread F.A.O. fertiliser trials in Africa have on occasion written enthusiastically of the very high proportion of cases in which responses have been obtained. Thus Hauck (34) states that:-

> The results obtained up up to now from several thousands of fertilizer trials indicate: after the effect of the fallow on the plant nutrient content of the soil has gone, it is

possible and economic to increase by relatively small quantities of fertilizers, not only the immediate yields but also, gradually the fertilizer level of the soil .... Fertilizers can become the main factor for the intensification of the cropping period and eventually for a complete abolishment of the shifting cultivation.

Richardson (in Russell, 44) wrote:

Fertilizers used alone can be far more widely effective on the farms of traditional small farmers than had formerly been thought .... For this reason we in F.A.O. regard fertilizers as "The spearhead of agricultural development".

Richardson went on to state that of 8,746 demonstrations and 2,250 trials in West Africa, all of them "showed positive responses" and of these 85 and 99 per cent respectively showed "positive economic returns to at least one treatment". Further details are given in Richardson. (7)

In contrast to this, and in direct reply to Richardson's views, Russell (44) quoting data supplied by Nye (some of it published in 20) stated that in Ghana alone nearly 1,200 trials were made before 1960 on peasant farms, nearly all with a 3 x 3 N and P unreplicated factorial design. Responses ranged from 4 to 42 per cent of mean yield, but many sites gave negative responses and Nye considered that the responses were profitable on considerably less than the 85 per cent of cases reported for the F.A.O. trials.

The F.A.O. trials have undoubtedly amassed a considerable amount of data, and further work on these lines should possibly be concerned with relating trial and demonstration results to soils and climates and analysing results in more detail than has been possible so far.

Research on Continuous Cultivation

Shifting cultivation is concerned mainly with arable food crops. Alternatives to shifting cultivation include systems of arable cropping which are more permanent, including long-term rotations, and also the greater use of permanent irrigated agriculture (particularly swamp rice) and of tree crops.

In an integrated landscape using different parts of a soil catena in different ways one can envisage permanent rice or bananas in valley bottoms, permanent tree crops on the more sloping ground, and arable

agriculture confined to areas of gentle gradient. A broader view, considering the various ecological zones of West Africa as an example, would perhaps emphasise that the very wet rain forest areas are generally not as well suited to arable crops as they are to tree crops such as oilpalm and rubber, so that rational land-use here would include tree crops on uplands and permanent rice or bananas in valley bottoms. In the less wet areas of the semi-deciduous forest zone a much greater range of crops, including cocoa, can be grown but there is still a strong case of preferring tree crops to annuals on the slopes. In the savanna areas where gradients are usually more gentle than in forest areas, there appears to be more possibility of introducing mechanised arable agriculture involving appropriate rotations.

Two alternatives to shifting cultivation thus already exist: these are swamp rice and other irrigated crops and permanent or semi-permanent tree crops. The third alternative, continuous arable cropping, or continuous cropping broken by grass, legumes, leys or planted fallows, is not yet a well tried workable alternative in most areas where shifting cultivation is practised, and the great variety of soils and climates in which shifting cultivation is found implies a large number of different local solutions to the problems raised.

Considerable experimental evidence is now available on long term rotation of crops and on the effects of leys, green manures and other ways of maintaining productivity. The initial emphasis in the savanna areas of Africa was on the use of farmyard manure or compost. The best known experiments, at Kano in Nigeria and at Serere in Uganda (Russell, 44), both relied on impractically heavy applications of FYM, but even with these applications yields at Kano fell off. Heathcote (35) concluded that organic manures applied over a period of years at Samaru, Northern Nigeria were effective because they corrected soil acidity and incipient potassium deficiency and provided trace elements, but claimed that "no evidence has yet been found to suggest that the addition of organic matter as such is of value". Farmyard manure has often been thought to have longer lasting effects than green manuring. Although green manuring and the introduction of grass/legume leys have proved valuable in some areas such as Zambia, it appears that it is mainly in relatively cool parts of the tropics that their effect is sufficiently long lasting to be worthwhile. In the lowland tropics the additional organic matter supplied by green manuring

is mineralised in a season or two, and the beneficial effects on the succeeding crop may correspond merely to those obtained by a small fertiliser application. All work on green manuring and the effects of leys designed to raise organic matter levels must be critically interpreted in relation to the climate, particularly temperature, and to the original organic matter level, as discussed by Nye and Greenland. (42) As suggested above, research also needs to tackle realistically the question of maintaining yields even with relatively low organic matter contents.

Although there is clearly increasing evidence of our ability to raise yields and to prolong cropping periods, it nevertheless remains true that in many areas where shifting cultivation is practised, particularly in the lowland tropics, there is as yet no economic system of continuous arable cultivation which has proved workable. Current work, some of it referred to in this paper, is undoubtedly bridging the gap between intermittent and continuous cultivation but a very great deal of fundamental and applied research remains to be done to close this gap in the way it has been closed in temperate regions.

BIBLIOGRAPHY

The available information on soils and related topics affecting development is, as would be expected, both very extensive and very scattered throughout a number of different types of publications. Further information exists which has not been published but which occurs in the files and records of agricultural research stations, government departments and private organisations concerned with agriculture, engineering, road building and so on.

The published information ranges from that found in general textbooks on soil science, climate, geography and allied subjects to that which appears in current scientific journals and the reports of research organisations.

The following suggestions for further reading are confined to a few recent books and periodicals dealing mainly with soil science, but most of them contain extensive further bibliographies or lists of references which will guide the reader if he wishes to go more deeply into the topics dealt with.

General textbooks on soil science have generally been written by and for workers in temperate zones, though there is an increasing tendency for some of them to pay more attention to tropical soils. General soil science textbooks include the following:

1. Buckman, H.O. and Brady, N.C. The Nature and Properties of Soils. Seventh Edition. New York, Macmillan, 1969.

2. Donahue, R.L., Shickluna, J.C. and Robertson, L.S. Soils: An Introduction to Soils and Plant Growth. Third Edition. New Jersey, Prentice-Hall, 1971.

3. Russell, E.W. Soil Conditions and Plant Growth. Ninth Edition. London, Longmans Green, 1961.

Of the above, the book by Russell is the most detailed and advanced, and the ninth edition has benefitted from the author's experience in East Africa as director of E.A.A.F.R.O.

The following publications deal more specifically with tropical soils:

4. Ahn, P.M. West African Soils. London, Oxford University Press, 1970.

5. Buringh, P. Introduction to the Study of Soils in Tropical and Subtropical Regions. Wageningen, Landbouwhogeschool, 1968.

6. U.S. National Academy of Sciences. Soils of the Humid Tropics. Washington, D.C., 1972.

7. Moss, R.D., ed. The Soil Resources of Tropical Africa. London, Cambridge University Press, 1968.

The following publications deal with more specific aspects of soil science, of soils and fertiliser use, and include the generalised soil map of Africa compiled by the C.T.C.A.

8. D'Hoore, J.L. Soil Map of Africa and Explanatory Monograph. Publication No. 93. Lagos, Commission for Technical Cooperation in Africa, 1964.

9. Dudal, R. Dark Clay Soils of Tropical and Subtropical Regions. Agricultural Development Paper No. 83. Rome, F.A.O., 1965.

10. F.A.O. and UNESCO. Soil Map of South America. World Resources Report No. 34. Rome, F.A.O.

11. Ignatieff, V. and Page, H.J., eds. Efficient Use of Fertilizers. Agriculture Study No. 43. Rome, F.A.O., 1958.

12. Indian Agricultural Research Institute. Proceedings: International Symposium on Soil Fertility Evaluation. New Delhi, 1971.

13. Milne, M.K. Annotated Bibliographies on Soil Fertility in West Africa. Commonwealth Agriculture Bureau, Farnham Royal, Bucks., England, 1968.

14. Nye, P.H. and Greenland, D.J. The Soil Under Shifting Cultivation. Technical Communication No. 51. Commonwealth Bureau of Soils, Farnham Royal, Bucks., England, 1960.

15. U.S. Department of Agriculture. Soil Survey Manual. Agriculture Handbook No. 18. Washington, D.C., U.S. Government Printing Office.

References 16 to 20 are to more general works on tropical agriculture.

16. Jameson, U.D., ed. Agriculture in Uganda. Second Edition. London, Oxford University Press, 1970.

17. Jurion, F. and Henry, J. Can Primitive Farming be Modernised? Brussels, I.N.E.A.C.

18. Philips, J.V.F. The Development of Agriculture and Forestry in the Tropics. Second Edition. London, Faber and Faber, 1966.

19. Webster, C.C. and Wilson, P.N. Agriculture in the Tropics. London, Longmans, 1966.

20. Wills, J.B., ed. Agriculture and Land-Use in Ghana. London, Oxford University Press.

There are numerous scientific publications dealing with soils, agriculture and related subjects which the interested reader will wish to consult in order to keep abreast of latest developments. These include: Soils and Fertilizers, The Journal of Soil Science, Soil Science, Soil Science Society of America Proceedings, Canadian Journal of Soil Science, African Soils (Sols africains), Plant and Soil, Experimental Agriculture, Nature, Ecology, Journal of Applied Ecology, Agronomie Tropicale and East African Agriculture and Forestry Journal. There are also many other local publications of value, such as the Ghana Journal of Agricultural Science and the West African Science Association Journal.

Extremely useful are the services of abstracting organisations which summarise articles on selected topics which have appeared in scientific publications. Mention must be made in particular of the Annotated Bibliographies issued by the Commonwealth Bureau of Soils, Harpenden, Herts. Latest titles in the list are given periodically in Soils and Fertilizers.

Further works referred to in this paper are as follows:

21. Ahn, P.M. "A Review of Fertilizer Responses in West Africa, with Special Reference to Food Crops." Legon Journal of Agriculture. 1 (1) 1968, pp. 16-23.

22. Ahn, P.M. Some Observations on Basic and Applied Research in Shifting Cultivation. Paper presented at the F.A.O./SIDA Regional Seminar in Shifting Cultivation and Soil Conservation held at Ibadan, Nigeria in July 1973.

23. Allan, A.Y., ed. Proceedings of the Third Eastern Africa Cereal Research Conference, Zambia/Malawi, March 1969.

24. Birch, H.F. "The Effect of Soil Drying on Humus Decomposition and Nitrogen Availability." Plant and Soil. 10 1958, pp. 9-31.

25. Birch, H.F. "Nitrification in Soils after Different Periods of Dryness." Plant and Soil. 12 1960, pp. 81-96.

26. Braud, M. "Sulphur Fertilization of Cotton in Tropical Africa." Sulphur Institute. 5 1969, pp. 3-5.

27. Burford, J.R. "Determination of N_2O, O_2 and CO_2 in Small Samples of Soil Gases." Journal of Chromatographic Science. 7 1969, pp. 760-762.

28. Burford, J.R. and Greenland, D.J. "Nitrous Oxide Evolution from Soils under Pasture." Proceedings of the Eleventh International Grassland Conference. 1 1970, pp. 458-461.

29. Davies, J.C. and Wheater, R.O. "Trials of Spraying and Cultural Practices on Cotton in Uganda. I: Agronomic and Spraying Implications." Experimental Agriculture. 9 1973, pp. 147-157.

30. Greenland, D.J. "Nitrate Fluctuations in Tropical Soils." Journal of Agricultural Science. 50 1968, pp. 82-92.

31. Greenland, D.J. The Maintenance of Shifting Cultivation Versus the Development of Continuous Management Systems. Paper presented at the I.I.T.A. Conference on traditional African Agricultural Systems and their Improvement, Ibadan, Nigeria, November, 1970.

32. Greenwood, M. "Fertilizer Trials with Groundnuts in Northern Nigeria." Empire Journal of Experimental Agriculture. 19 1951, pp. 225-241.

33. Hardy, R.W.F., Holstein, R.D., Jackson, E.K. and Burns, R.C. Plant Physiology. 43 1968, pp. 1185-1207.

34. Hauck, F.W. Soil Fertility and Shifting Cultivation. Paper presented at the F.A.O./DANIDA regional seminar on planning and organisation of fertilizer use, Nairobi, Kenya, December 1972.

35. Heathcote, R.G. "Soil Fertility under Continuous Cultivation in Northern Nigeria. 1: The Role of Organic Manures." Experimental Agriculture. 6 1970, pp. 229-238.

36. Kanwar, J.S. "Sulfur Deficiency a Key Factor in Indian Agriculture." Fertiliser News. 12 1967, pp. 9-13.

37. Lawes, D.A. "Rainfall Conservation and the Yield of Cotton in Northern Nigeria." Empire Journal of Experimental Agriculture. 29 (116) 1961, pp. 307-318.

38. Le Mare, P.H. Tie Ridging as a Means of Soil and Water Conservation and of Yield Improvement. Proceedings of the Second Inter-African Soils Conference, 1954. Vol. 1, p. 595.

39. McClung, A.G. and de Frietas, L.M.M. "Sulphur Deficiency in Soils from Brazilian Campos." Ecology. 40 1959, pp. 315-317.

40. Norris, D.O. "The Biology of Nitrogen Fixation." A Review of Nitrogen in the Tropics with Particular Reference to Pastures. Bulletin No. 46. Hurley, Commonwealth Bureau of Pastures and Field Crops, 1962.

41. Nye, P.H. "Studies on the Fertility of Gold Coast Soils, III: The Phosphate Status of the Soils." Empire Journal of Experimental Agriculture. 20 1952, pp. 47-55.

42. Nye, P.H. and Greenland, D.J. The Soil under Shifting Cultivation. Technical Communication No. 51. Commonwealth Bureau of Soils, Harpenden, 1960.

43. Ofori, C.S. "Decline in Fertility of a Tropical Ochrosol under Continuous Cultivation." Experimental Agriculture. 9 1973, pp. 15-22.

44. Russell, E.W. The Place of Fertilizers in the Food Crop Economy of Tropical Africa. Proceeding No. 101. Paper presented at a meeting of The Fertilizer Society, London, January 25, 1968.

45. Tourte, R., Vidal, P., Jaquinot, L., Fauche, J. and Nicow, R. "Bilan d'une rotation quadriennale sur sols de regeneration au Senegal." Agon Trop. 19 1964, pp. 1033-1072.

46. Wild, A. "The Potassium Status of Soils in the Savanna Zone of Nigeria." Experimental Agriculture. 7 1971, pp. 257-270.

AGRICULTURE AND WATER PROBLEMS: THE CASE OF THE VOLTA LAKE

By

Letitia E. Obeng, Director, Fresh Water Biology Research

Volta Project, Ghana

INTRODUCTION: WATER RESOURCES

In comparison with other continents, Africa has varied natural resources. There are luxuriant stretches of green, rare animals and precious minerals, but the distribution of these over the eleven million square mile area of the continent is painfully uneven and we find sharp contrasts in the availability, quantity and quality of essential resources crucial for development projects. This unfortunate state of affairs underlies most of the problems of developing Africa. And it is also particularly true of the distribution of water resources in Africa.

There are large African river systems: the Congo, Zambesi, Niger, Volta, Senegal, Webbe Shibeli, Juba and others have high flow rates. They all flow south of the huge Sahara desert, 3,500,000 million square miles, over a quarter of the size of the continent, which in common with other semi-arid areas has virtually no surface water resource. The mighty Nile rises in East Africa but flows north into the Mediterranean. These major African rivers alone constitute about 3 million miles of water. In addition there are also about 3,750,000 square miles of lakes and other land-bound water in the eastern section of the continent.

In the semi-arid west, Lake Chad precariously holds its own. But water resources appear nowhere to be near enough in quantity. Oddly, the pattern of water distribution somehow seems to assure abundant water where it can least be effectively used and very little where it is most needed so that it appears that parts of the continent are constantly short of water.

In the arid and semi-arid areas south of the Sahara, regular and adequate water supply is of vital importance especially for agricultural practices. Rainfall in these regions can be heavy but also of short duration so that its overall usefulness, in terms of annual rain hours, is ineffective for soil saturation. This is made worse where run-off is rapid after rain. Where normal rainfall reaches an annual mean of 20 inches the water problem mainly centres around requirements for domestic use and for watering stock.

In colonial Africa some attention was given to the problem of domestic water supply. The principal approach was the development of wells and bore holes. In some colonies considerable sums were sunk into this.

There are instances where a good part of the financial provision made for water supply went into making bore holes which were dug at £1.10 a foot. But there were also earth dams, as well as wells.

In some areas, nomad stock breeders on their own initiative excavated tanks, some up to 300 ft. by 70 ft. in dimension. They built water holes up to 60 ft. deep. All over East Africa during this period, many bore holes, dams and wells were constructed. The picture was pretty much the same in West Africa where rural water development schemes were initiated in Nigeria, Gold Coast and French West Africa. Particularly in areas of poor rainfall the schemes were most welcome.

With time however, dam construction has come to be a major form of water supply for domestic, industrial and agricultural use. Almost all the major African river systems have dams on them or on their principal tributaries. In addition to these, there are many more of varying sizes scattered all over the continent.

Large dams have been constructed for multi-purpose use. Their sheer size commands attention. At the same time, they have magnified the problems which normally accompany small dams. As they have brought benefits or misery, so they have been hailed or condemned.

In the following, I recount the story of the Volta Lake, currently the largest single artificial lake anywhere in the world which for almost ten years now has provided ample opportunity for a case study of large dams.

THE VOLTA LAKE

The Volta Lake covers almost 4 per cent of the total land surface of Ghana and the inundation displaced 70,000 people from their homes. As a complex development project it has provided a rare and useful opportunity for studying ecological changes which accompany lake creation and assessing the benefits as well as adverse impacts which are caused.

The Volta story is complex and it began long ago. In very early colonial Gold Coast, slave traders and smugglers could navigate the Volta from the Atlantic up to Ada. In the years which followed there was an assortment of activities on the river directed very often towards a northward movement with a view to subjugating the rebellious Ashanti. But navigation had been "difficult and had not proceeded beyond Kete Krachie where there were formidable cataracts".

Steamships travelled up to Ada and a prosperous trade flourished. Yet it was not until 1895 what Joseph Chamberlain, then Colonial Secretary, authorised an investigation into the siting of harbours on the coast that the Volta was seriously surveyed as a route to link the north and the south. Commander D. Pagen Jones, R.N., who had had previous experience with the Niger and other rivers, investigated the river and proposed overland monorails for the impassable rapids. A total cost of £50,000 was estimated for a project to open trade between the north and the south along the Volta River. This seemed uneconomical and London abandoned the project. Thereafter, there were a number of bold attempts to travel the Volta. They include a hair-raising account of the adventures of the dauntless Miss Mary Gaunt.

But it was Albert Kitson, the head of the Geological Survey Department, who after reporting on deposits of bauxite later in 1915 decribed the narrow gorge at Ajena as an ideal place for a dam. He estimated that 2.5 miles downstream where the gorge measured 200 yards wide and 60-90 ft. deep and the volume of water was 1,634 cu. ft. sec., by raising the water height through the construction of a 100 ft. dam it would be possible to generate 180,000 horse power or 134 kilowatts of electricity. There would be ample power to process bauxite deposits of some 4 million tons from the Kwahu plateau. A complex project which involved rails for moving the bauxite as well as a smelter was considered.

Years later in 1924, Kitson prepared a proposal for a Volta hydro-electric scheme with a dam near Akosombo. He also recommended another dam to be built on the Black Volta at Bui. The project received varying degrees of attention during the following years. Duncan Rose made further technical studies.

In 1946, a Volta River Project Preparatory Commission was formed and a thorough study was made of the proposal. The plan for the multi-purpose project involved the erection of a dam and creation of a large lake for the generation of power, the building of an aluminium smelter and a new township of Tema as well as the construction of railways and ports for the bauxite.

The Preparatory Committee studied the intended project from other relevant angles also. The human problem, involving some 70,000 displaced people, their resettlement and compensation, was investigated. The up-stream and downstream effects of the damming and the strain on economic practices were studied. They investigated various public health problems which then existed and drew attention to the effect of the project on them.

The underlying principle of the project was straightforward. There would be a dam built across the Volta River. From the accumulated water, hydroelectric power would be drawn. The power was needed for normal development projects in the country, but primarily much of the power would be used to extract aluminium.

Railroads were needed for transportation of the bauxite to the smelter, the port of Tema was important for a link with the outside world; but the income from the production of aluminium was to compensate for the huge expense involved in the project.

The power project was estimated at £68 million. This would pay for the crescent rock-fill clay-core dam spanning 1,400 yards and up to 276 ft. in height; the preliminary survey for the work, included aerial surveys, roads, housing at construction site, compensations, resettlement, health maintenance, switch-gear and transmission lines. Half the amount was to be lent by the U.S.A., the World Bank, and the U.K. on a long term basis. Ghana had to find the rest.

The construction of the smelter and lines was estimated at a total expenditure of about £91,190,000. For the railways, £18 million provision was made. An investment of up to £8,500,000 was estimated for fisheries, navigation and agriculture and the building of Tema township. The Volta River Project was an expensive investment. But it was well studied and planned, and economically it was feasible and sound.

In 1964, the dam across the Volta River was completed. Inundation began and the lake started forming. It was estimated to cover 3,295 square miles, almost a fortieth of the total surface of Ghana. Until now Volta Lake stands as the largest single artificial lake anywhere in the world. It is 250 miles long and contains 120 million acre feet of water. It has a shoreline of over 4,000 miles and a maximum depth of 276 ft.

Upstream Effects of the Dam

The New Lake: The Volta River overflowed its banks for several miles and took on a completely different shape. Across its longest river tributary it was almost twenty miles wide. The streamlined Volta River which previously meandered majestically across the gentle Afram plains became a grotesque highly dentritic figure which has totally altered the landscape of Ghana.

In addition to the gross change in the physical character of the river, the new watery medium acquires additional limnochemical and physical characters which are different from those of the original river. This is

initially due to an interaction between the water and the soil, but at a later time, biological factors in the flooded terrain also contribute to the change. The incoming waters bring much suspended matter which together with the action of the moving water eats into the soil. This releases various forms of sediments and increases the turbidity.

Observations made on the hydrogen ion (pH) content of water from all parts of the country have shown values to be around normal. In the forest region some sheltered rivers have waters with pH values of less than 7. On the Volta Lake, the surface pH values have been of a range of 6 to 8. There is a definite downward gradient which decreases with depth making deeper waters slightly more acidic. Other chemical factors, including oxygen saturation, CO_2, total alkalinity, ammonical N_2, PO_4^{---}, SO_4^{--}, Cl^-, Fe^{++}, Ca^{++}, Mg^{++}, NO_2^+, NO_3^-, Na^+, K^+, Mn^{++} and SiO_2, show varying forms of gradation with depth but no particular pattern has emerged for some.

The concentration of carbon dioxide, for instance, increases with depth. This is to be expected since photosynthetic activities which would use removable CO_2 take place mostly in the upper better lighted layers. Concentrations of ammonia, hydrogen sulphide, total iron, manganese and phosphates also increase downwards. Iron is hardly detected in surface samples although high quantities are recorded from deeper layers. Laterite is a good source of iron and the brown flood waters bring in ferric ions which increase the iron deposited in the deeper waters. In the early days of the formation of the lake, iron hydroxide was often deposited in the pipes of the cooling system of the power generating machines. The water was drawn from the deep layers.

The dam slowed down the water movement and this had an effect on the fauna. The Volta River previously had been a fast flowing river with rocky outcrops over which the water tumbled and fishes and invertebrate fauna which were adapted for life in such conditions thrived. Some of these perished as the physical conditions altered with the flooding; others were favoured by the increase in volume of water and the release of large quantities of nutrients. Algal blooms, particularly of Microcystis, were common in these early days.

Records were made of the invertebrate fauna from 1965 to 1966 and subsequently during the initial stages of the formation of the lake. Later collections have shown an increase in the variety of the species of invertebrates now present. Most of these, especially the chironomid larvae and the nymphs of the mayfly, form food for fish. The quiet shores

have also been ideal for the breeding of molluscs. Among those collected are the Bulinus species which are intermediate hosts for the transmission of schistosomiasis.

Fishes and Fisheries: Before the dam was closed, very little unfortunately had been recorded of the fishes in the Volta River. The account of Irvine (1946) on fishes of the Gold Coast was the standard reference. Some of the species died out during the early period of dam formation. After the closure of the dam, between 1964 and 1966, a number of species were caught with limited facilities near Akosombo and Kpandu. Since then several species of fish have been recorded from the lake.

Around Kpandu for the period up to 1970, the dominant species were Tilapia galilae and T. zilli some of which had attained up to 29 cm. in size. Other species included Alestes dentex, Alestes macrolepidotus, Auchenoglanis occidentalis, Chrysichthys nigrodigitatus, Citharinus citharus, Clarias senegalensis, Ctenopoma kingsleyea, Hemichromis fasciatus, Heterobranchus bidorsalis, Hepsetus odoe, Hydrocyon brevis, Labeo coubie, Labeo senegalensis, Lates niloticus, Malapterurus electricus, Ophiocephalus obsecurus, Schilbe mystus and Synodontis nigrita. Of these the market value of Lates niloticus and Labeo coubie and L. senegalensis was rated high. In all, around the lake over 150 species have been recorded.

Further north near Krachie, 90 per cent of the catches were Citharinus citharus, some specimens of which were up to 60 cm. in length. In addition there were some of the other species previously listed including Alestes dentix, Alestes nurse, Auchenoglanis occidentalis, Clarias senegalensis, Ctenopoma kingsleyea, Distichodus rostratus, Eutropius niloticus, Hydrocyon brevis, Labeo coubie, Labeo senegalensis, Lates niloticus, Malapterurus electricus, Synodontis gambiensis, Synodontis membranaceus, Tilapia nilotica and Tilapia zilli.

At Yeji and from the villages in that area, the highest catch was of Alestes spp. Other species recorded were: Auchenoglanis occidentalis, Bagrus docmac, Bagrus bayad, Chrysichthys nigrodigitatus, Citharinus citharus, Distichodus rostratus, Eutropius niloticus, Gnathonemus pictus, Gymnarchus niloticus, Heterotis niloticus, [illegible] brevis, Hyperopsus bebe, Labeo coubie, Labeo senegalensis, Lates niloticus, Mormyrus rume, Ophiocephalus obscurus, Physalia pellicida, Polypterus senegalus, Schilbe mystus, Synodontis gambiensis, Synodontis sorax, Synodontis membranaceus, and Tilapia galilea.

Seventy miles north of Yeji at Mpaha, there was little fishing going on then but catches contained a variety of fishes among which were Alestes dentex, Alestes macrollepidotus, Chrysichthys nigrodigitatus, Citharinus citharus, Clarias senegalensis, Heterobranchus bidorsalis, Gnathonemus cyprinoides, Gnathonemus pictus, Gnathonemus senegalesis, Gymnarchus niloticus, Hydrocyon brevis, Hyperopicus bebe, Mormyrops macrophthalmus, Mormyrus rume, Synodontis gambiensis, Synodontis sorex, Tilapia galilea and Heteratis niloticus.

There are a number of interesting features about the fish distribution in the Volta Lake. First of all, a number of the genera and species recorded occur also in other African lakes and it is conceivable that new lakes which are created in other parts of Africa could have a similar spread of fish species. Another observation was that almost all the species then recorded occurred throughout the entire 250 mile length of the lake. The tilapias were numerous in the south and near Ampen in the Afram region where plankton had also been found to be abundant during that time. Near the dam where plankton had been reported to be scanty in the upper layers of the water; few specimens of tilapia could be caught. Lates niloticus, one of the most highly priced species on the lake, appeared to be present in all areas.

The fish population pattern has changed over the period under observation. From analyses of catches made from five months after lake formation to 1966, it was reported that some species became reduced in number as the lake formed. Chrysichthys spp. occured in small quantities in 1964 near Akosombo but became the predominant species by 1966. Lates niloticus on the other hand had been caught in reasonable numbers both at Akosombo and Kpandu. Latterly it increased considerably near Kpandu and decreased in the Akosombo area. Bottom feeders such as Labeo spp. and Synodontis spp. and the carnivorous Hydrocyon spp. and Lates niloticus have increased in size and in numbers. With the continued stabilisation of lake conditions and increasingly favourable distribution of dissolved O_2 and nutrients, a variety of fishes has begun to form the basis of what can become a prosperous fishing industry.

Preliminary estimates gave an annual turnover catch of about 60,000 metric tons a year in 1968. It is now almost an established pattern that the initial boon which increases fish production gradually subsides. Even so, the stabilised fish catch is always higher than before the damming of the river.

Previously the maximum catch estimate had been only 10,000 metric tons a year. In 1971 the estimate was about 42,000 metric tons. Fishing activity attracted people and increased the number of inhabitants around the lake. Previously only about 2,000 fished on the river and this increased until by 1969 there were about 20,000 and they used over 12,000 canoes. The increase in size of the lake has made the boats and gear previously used inadequate. They are being improved.

Under some conditions, it may be considered desirable to introduce new fish species into a river basin. The Nile perch has already invaded many watercourses in Africa. However, with the larger artificial lakes, introduction of exotic species may not be necessary. The increase in water volume and the enhancement of the nutrient regime trigger off appropriate mechanisms for the indigenous fish to flourish.

For successful fisheries, it is necessary to have a supporting long-term research programme. It is essential that such a research project be broad-based and multi-disciplinary. Such investigations have been carried out by the Institute of Aquatic Biology on the Volta to extract maximum benefit from the dam.

Erosion and Sedimentation as Problems: When rivers are slowed down active erosion is greatly reduced. But at the same time, the beds accumulate the sediment and matter which would have flowed out of the basin with the river water. With time, sedimentation and silting interfere with the storage capacity of reservoirs, but the overall effect depends on the characteristics of the particular dam. Sediments affect the chemical and physical quality of reservoir water. Additionally, since they may store chemical salts including phosphates, sediments also affect biological productivity. It is still early for this effect to be assessed on the Volta. However it is a fact that turbidity tends to be higher during the rainy season and more intense north of Kpandu. Any sedimentation that is going on must be more active northwards.

Effect of Dams on Seismic Activity: Large impoundments do increase earthquake activity within basins mainly because of the pressure they cause on the earth's crust. This activity is usually agravated by structural faults in the geological formation of the basin. After inundation, seismic activity apparently gradually increases to a maximum and then declines.

The Volta dam actually lies in a zone of earthquake activity. And indeed, there have been a number of tremors since 1964. Across the Volta Lake range, intensities of strength from IV to VI on the Modified Mercalli

Scale have been recorded. Using the seismic history of Ghana which goes back to 1862 when there was a disastrous earthquake, anti-seismic measures were taken during the designing and construction of the dam. The choice of a rockfill dam was one of the considerations. Fortunately, the topography in the lake area also ensures some measure of stability.

A set of W.W.S.S. instrumentation including short and long period seismometers have been installed 35 miles south-west of the dam. Although one set by itself cannot confirm whether shock waves recorded originate from the lake or neighbouring epicentres, some useful information may be collected.

There was a tremor of 5 in 1964 after the lake began to fill. It was believed at the time that the epicentre was about 30 miles south-west from the dam. There was another one in February 1969. The most recent was on the May 12,1973. This was monitored, and indications were that the shock wave started in the region of the dam. On Kariba, there was a major shock wave only five weeks after the water reached its maximum level.

Water Seepage and Ground Water Level: Because of the properties of water, one would expect the large amount which collects behind a dam to affect the basin which contains it. Particularly, where the dam is exceedingly high, the type of rock and its water tightness decide to a large extent whether there will be seepage downstream. Where the water level changes along the banks, it has a good effect on bank and forest growth.

For ground water level, where measurements are made through bore holes, it requires a period of time for results to come through. Only a little information is available on the ground water regime associated with large dams in Africa. In Ghana a series of bore holes have been dug for measuring the effect of the Volta Lake.

Results which have been obtained by the hydrologist for the Accra plains south of the dam show very little change for the period during which the holes have been operational. Between September 1972 and May 1973, the minimum and maximum readings have been 8.29m and 8.50m respectively. The higher value may have been affected by a previous rain. He records the rocks in the area to be phyllites and quartzites which are normally not water bearing.

Downstream Effects of Dams

In general, downstream effects of dams are not uniform. They tend to depend on the size as well as the location of the dam. In a temperate zone, a dam may actually interfere with the freezing pattern of water downstream as the thermal streamflow is disturbed. Dissolved oxygen in downstream water is reported to be low or high in some places but also unaffected by the dam in others. Much depends on the stratification pattern and the level at which water is let out from the dam. Spilling from the dam may also release nutrients and various chemical salts from deep layers and this would affect the chemical ion regime downstream.

On the whole, the physical and chemical changes which occur tend to affect the biological resources downstream. It would seem however that it is first the quantity of water which flows downstream, and secondly the timing and pattern of its availability which have a decisive effect on the flora and fauna. When there is too little water, flood plains downstream may lose their fish, birds, other animals and plants. When there is too much water birds, eggs, and nests may drown. Some downstream fish also require, quite often, the stimulus of a flood to spawn and the flow of water is therefore of key importance. Aquatic plants of economic importance have also been destroyed as a result of releasing water from spills at the wrong time.

Downstream creeks often have their own important biological resources. Such creeks depend on seasonal flow of water. If the river downstream is maintained at a higher level the creeks become perpetually flooded and major ecological changes occur which upset the biota. They often need alternate high and low water levels to maintain the rhythm of productivity. The Volta dam disturbed the breeding of Egaria and Atya gabonensis on the lower Volta. Previously these had constituted a prosperous business on which women made high annual incomes.

Another effect of artificial downstream flooding is the effect of the large quantity of fresh water which is spilled on the salinity of the estuary. The change may disturb the rhythm of the migration of fish and therefore the offshore seasonal fish catches. This did happen to the herring fisheries for a period.

There are reports also of accretion of material at estuaries for which downstream flow may be responsible. Where wastes are discharged into the dam there may be an adverse effect on the water quality and fish kill at the estuary.

Quite often also, the breeding of intermediate hosts of parasitic agents is also associated with the downstream area of dams. The similiidae, the mosquitoes and the tsetse fly group often find the change in water regime downstream an advantage. Similum in particular has been associated with spillways. The cool moist banks also tend to support the breeding of tsetse flies whilst temporary isolated puddles are good for mosquitoes. Similum breeding continues downstream of the Volta dam.

DAMS AND PUBLIC HEALTH PROBLEMS

Aquatic Weed Growth

One of the results of the ecological changes was the growth and establishment of aquatic weeds on the forming Volta Lake. In the Afram region in particular, a number of species were recorded. Weed growth is now patchy but extensive. Recorded plants include Ceratophyllus sp., Salvinia auriculata, Ceratopteris cornuta, Pistia stratiotes, Scirpus cubensis, Cyperus sp., Vossia cuspidata, Polygonum sp., Utricularia inflexa, Lamna sp., and Spirodela sp. Invariably these weeds have harboured and encouraged the growth and establishment of invertebrates which are a danger to the maintenance of good public health conditions.

In tropical regions, there are problems which accompany the accumulation of water. The changes in ecological systems create conditions which enhance the development and establishment of additional transmission foci for some endemic diseases, particularly insect transmitted infections including malaria, filariasis, onchocerciasis, trypanosomiasis, but also other infections as well as those which, like schistosomiasis require molluscan hosts. Not invariably, these are associated with weed growth.

On Volta only months after the closure of the dam, Bulinus snails began to appear. It was not long before schistosomiasis was recorded as being on the increase in specific areas. Since then, other parasite transmitting invertebrates including mosquitoes have also been identified within the basin. Five species of the tsetse fly Glossina, all potential transmitters of animal trypanosomiasis, have been identified and G. palpalis and G. tachinoides have been proved hosts of T. gambiense.

Above the dam, in Ghana, ecological conditions produced one excellent benefit. The simuliidae were eliminated from the area of the river flooded to form the lake. Previously the water tumbled fiercely over the rapids and the large, fast flowing Volta River was an ideal breeding place of S. damnosum the transmitting fly for human onchocerciasis. The incidence of infections was very high in the basin. The Volta Lake destroyed the breeding places.

The Human Factors: Resettlement of Displaced Persons

In Ghana, when the Volta basin was flooded 78,285 people were affected. They were living on about 3,500 square miles of land. The effective impact area was calculated at 26,000 square miles, about a quarter of the size of Ghana, on which lived 1,300,000 people, 19 per cent of the country's population at the time. Evacuation of the people began early. By 1963, 3,412 houses had been built in 10 settlements. In 1964, there were 44 settlements with 11,199 houses. The evacuation continued into 1965 by which time £8 million had been spent on the resettlement project. Of the displaced people, 69,249 had to be resettled in 52 new settlements. They had originally come from four regions of the country, but had been settled for a long time in the river basin. In all 739 villages were destroyed, 14,657 households were disrupted, 12,799 of them moved.

The people were not all fishermen. They had pursued various occupations such as farming, trading, pottery and other craft work. The first six months after their evacuation were critical. They had been provided with houses but they needed to build homes.

Especially in Ghana but also in the other African countries where large dams have been raised, a very serious problem has been that of providing the people with farming land as part of the rehabilitation process. It took quite some time for the farmers to begin producing their own food. For the first six months the World Food Programme supplied food for the relocatees, although in three places experimental farming had been started in 1962, two years before the closure of the dam.

MAN MADE LAKES AND ALTERNATIVE SOURCES OF ENERGY

There have been many arguments as regards alternatives to hydroelectric schemes as an energy source.

In many industrialised countries, energy sources conventionally tapped to produce power for both domestic and commercial use are largely fossilised materials such as coal and oil. In addition to these, investigations have been progressing in some countries for a number of years now to harness solar energy and release the power locked up in radioactive materials.

It was usually appreciated that there would be environmental hazards. But, as an energy source for the provision of electric power on the scale then envisaged, the Volta River had no comparison in the country. Ghana had no deposits of coal. It had no oil. It had no uranium. It had forests for wood fuel, but for power supply on the scale imagined, forest wood was

neither suitable nor adequate. The building of an atomic reactor or solar energy plant on a scale able to supply the energy required could perhaps have been seriously considered. But this would have been unrealistic and, in any case, at that time in history, there was too much emotion over atomic power production in a developing country. Even the small reactor erected for research purposes in Ghana turned out to be the centre of speculative intrigue on an international scale and work on it had to be indefinitely suspended.

In review, and particularly taking its primary function which is the production of hydroelectric power, the overall result of the development of the Volta River basin has been satisfactory and worthwhile. By 1971, the capacity of the power generating plant was 5.2. billion kilowatt hours. In 1972, it was to reach 8 billion kilowatt hours. The cost of power generated in 1971 was about 0.35 pence per unit.

For the twelve months in 1973, the total power generated was 3,871,560,000 kilowatts. VALCO, Tema bought ¢8,383,103.88, the Electricity Corporation of Ghana ¢6,193,857.40 and mining concessions and factories buy large quantities. It is impossible to imagine how they could be supplied without the Volta hydroelectric project.

WHAT OF FUTURE PROJECTS?

It must be firmly appreciated as a basic fact that any drastic ecological change such as that which ushered the creation of a lake as large as Volta (and also smaller reservoirs) will without doubt cause undesirable repercussions and pose hazards. With this in mind, there should be a deliberate consciousness towards taking precautions. Experience requires that for every dam project, early comprehensive planning be obligatory.

At that early stage of project consideration, there should be a thorough investigation and an assessment of possible adverse environmental impacts. The assessment should necessarily include the entire basin, and investigate its human, land, and water resources. Particularly concerning the effect of the project on the people, socio-economic studies should be extensive and they should start early.

For surveys and studies on the land and water resources, provision should be made at the planning stage to ensure a comprehensive problem-directed research programme and more importantly the availability of trained personnel, preferably of local extraction, to carry out the programme on a long term basis.

It is now accepted as highly desirable that decision makers should consult and work with an inter-disciplinary group of specialists whose expertise would be relevant to the planning and operation of the project. The participation of this group should be continuous throughout the project. This group should have the responsibility for direction to ensure environmental safety as well as effective management of the project.

CONCLUSION

I have been asked in various ways, sometimes openly, at other times through guarded and indirect questions whether I would build a Volta Lake if I had to do so now.

My answer has always been a deliberate yes, and will always be. I need not go over all the benefits which have accrued from Volta to support my reaction, neither do I need to list hazards and environmental problems and find excuses for them. The adverse impacts of dams in particular are already well known and often over-emphasised. I shall continue to take my present constructive attitude towards dams and their problems.

There is nothing more wrong with dams than with other projects such as mining coal or gold and destroying the earth's crust, over-fishing a sea, causing erosion and desertification or destroying wild animals and their habitats! Like dams these are good projects. We speak against them because we do not know how to cope with their adverse effects.

Now that we know what harm may be caused by dam projects, I would advise that pre-construction planning and surveys should be thorough and early. I would advise that as much as possible attempts are made to incorporate into designs and operations where possible and feasible those facts concerning dams and their ecology which have been collected up to date and which may minimise future problems.

I am convinced that if we ignore our present rich store of experience on man-made lakes, we shall continue to make retrogressive blunders and extend the scope of environmental degradation which now appears to be complementary to development projects in this particular field.

FISHERY RESOURCES: THEIR EXPLOITATION, MANAGEMENT AND CONSERVATION IN AFRICA

By

John Okedi, Director, East African Fresh Water Fisheries Research Organisation

INTRODUCTION

The beginning of the twentieth century saw the discovery of Africa's vast natural resources. Not only did explorers 'discover' lakes, rivers, forests and mountains, but scientists and naturalists also 'discovered' what at that time were called 'new' species of plants, fish and other animals. Thus scientific names were tagged to various species using the famed binomial nomenclature and immortalising the names of some of the people who first described those species. Africa of course abounds with thousands of different floral and faunal varieties and the early colonial scientists found the African environment lucrative from the point of 'discovery' of new species.

Colonial administrations astride the continent soon found great value in the natural resources of Africa. Some of these resources, e.g. forests, were logged for shipment to European countries. However, the advent of self-rule in the majority of African countries has thrown open many more possibilities. The exploitation of the natural resources is viewed with prospects for industrialisation in areas where poverty, malnutrition and unemployment are but the rule of the day.

Prospects of exploitation of natural resources have also brought to light the imminent danger that Africa's renewable resources could be exhausted within our lifetime. The impetuous resolve to exploit these resources has to be guided by basic management advice. In Africa the paucity of basic raw data which could be used to arrive at recommendations for management is a matter of fact. It is therefore imperative that research investigations be undertaken in all fields of natural resources for which exploitation is planned now or in the future.

This paper, therefore, attempts to describe the role science could play in the development and exploitation of one of Africa's renewable resources, namely fisheries. The basic requirements for sound planning and coordination are brought into play and involve the whole machinery of government. Examples are cited where improper planning and unavailability of scientific data have led to unfortunate experiences. A model has been demonstrated

particularly in East Africa where sound planning and coordination of research with development seem to have triggered worthwhile investment proposals.

FISH AND NUTRITION IN AFRICA

Recent surveys of nutritional requirements in Africa have shown hunger to be the greatest problem of the continent. Lack or inadequate supplies of protein have brought untold havoc to large populations, particularly in the younger age groups. Thus Kwashiorkor, a disease of protein malnutrition, is extremely common in the rural areas of Africa. The problem that many, if not all, developing African countries have to grapple with is how to find adequate supplies of animal protein to feed a continuously increasing human population.

Fish would therefore appear to be the answer to this problem as it is an excellent source of high-quality protein. Protein constitutes approximately 80 per cent of fish flesh and its nutritional value is superior to that of beef or poultry. Fish protein is more easily digested than beef and cooking does not denature it. Fish is also rich in fat (ranging from 1 to 20 per cent) and this fat is a good source of energy and vitamins. It is stated that fish flesh contains an anticholesterol which lowers the level of cholesterol in the blood lipids through their polyunsaturated fatty acids. High levels of cholesterol in the blood is one of the causes of heart diseases so common in the developed world.

CURRENT STATUS OF AFRICAN INLAND FISHERIES

The Catch

The greater part of the landed weight of fish in African inland water comes from the larger lakes. In 1970 the total catch was estimated at 1,400,000 metric tons (Department of Fisheries, F.A.O. Rome, 1973). Table 1 shows the major countries which contribute to African inland fisheries. From this it is easily seen that only Tanzania, Uganda and Zaire produced more than 100,000 metric tons whereas Mali, Nigeria, Egypt, Chad and Cameroun produced between 50,000 and 90,000 tons. The remainder of the countries produced less than 50,000 tons. However, seven countries produced less than 2,000 metric tons in 1970, and these were Ethiopia, Gabon, Gambia, Guinea, Rwanda, Sierra Leone and Somalia.

For the majority of African countries fish production was well below optimum. It can be said that for all these countries the potential to make moderate increases in the annual catch does exist. To do this, however, requires modern innovations and improvement of indigenous fishing techniques. Any substantial improvement in catches will of necessity

require knowledge of the habitat and ecology of the fish in relation to socio-economic infrastructure.

In Table 1 some countries have been selected depending on availability of data. Their current (1970) catch and the potential factors of increase of their output has been shown. Two countries, Ethiopia and Congo, can increase their catch by ten times. Kenya can treble its landings and the following double their catch: Sudan, Zambia, Zaire and Rwanda. The Table further indicates that for Malawi, Uganda, Ivory Coast and Madagascar only moderate increases can be made, attaining perhaps just less than double their current output.

Table 1. Possible Increases in Catch from Selected African Countries.

Country	Present Catch (metric tons)	Potential Catch (metric tons)	Potential Factor of Increase
Ethiopia	1,000	20,000-30,000	x 20-30
Congo	6,000	100,000	x 16.6
Kenya	26,000	90,000	x 3.4
Sudan	21,000	60,000	x 2.8
Zambia	39,000	100,000	x 2.5
Zaire	133,800	324,000	x 2.4
Rwanda	1,300	2,600	x 2.0
Tanzania	170,500	300,000	x 1.7
Malawi	37,000	60,000-70,000	x 1.6 - 1.9
Uganda	139,000	220,000	x 1.5
Ivory Coast	9,000	14,000	x 1.5
Madagascar	39,000	50,000	x 1.2

Source: Partly Department of Fisheries, F.A.O., Rome, 1973.

In terms, of really significant increases in weight, the following countries will rank as the major producers each capable of landing over 100,000 tons annually: Tanzania, Congo, Zambia, Zaire and Uganda. In total therefore the expected potential catch from African inland fisheries could be valued at over $11,150,000, but due to inflation this figure could be conservative.

Some thought could be cast onto the market value of fish. Nshrenguzi et al. (3) have shown that in East Africa the market value of fish is often three to five times the landed value. Hence if Africa's potential catch were harvested, its market value would be between $33,450,000 and $55,750,000. This is no mean effort in an area menaced by poverty and unemployment.

Employment

For a long time in Africa, fishermen earned little recognition as their subsistence industry was hard and precarious. Initially therefore, only the old runaway convicts, criminals and the socially discarded found their way into this industry. Independence in many African countries brought a pleasant change to the fishing industry. Young university graduates found their way into this realm of untouched knowledge, and professional fishery personnel appeared on the continent during the late 1960s. The African politician was eager to demonstrate that no segment of his country or constituency was left undeveloped and the power of the vote from fishing communities helped governments direct more attention to them. Fishing was shown to be lucrative and many young men including school leavers joined the industry at production level.

The numbers of fishermen in most African lakes, rivers and swamps is not known. Besides, the great majority of them are only seasonally active. However, for a few lakes where information is available, this is given in Table 2. Volta Lake in Ghana has over 25,000 fishermen, while Lake Victoria, Lake Bangweulu, Lake Malawi and Lake Chad have only 10,000 fishermen each. Kainji Lake is a reservoir like Lake Volta, and has over 6,000 fishermen. These are relatively new lakes in that they are less than 20 years old. Another man-made lake worth notice in East Africa is Nyumba ya Mungu Dam in Tanzania. This lake is relatively young but has already a fishing population of over 3,000 fishermen.

There is then a large number of people directly involved in fishing in African inland waters. From personal observation in East Africa, an average fisherman would support four to six members in the family. At this level of the industry, it is correct to assume that millions of individuals derive support from the fishermen in Africa. To these must be added all those involved in the processing (curing, drying, smoking etc.) of landed fish, those involved in the construction of boats however simple or complex, those involved in the transportation of fish on foot, bicycle or

Table 2. Numbers of Fishermen in Some African Lakes During 1969-70.

Lake	Country	Number of Fishermen
Volta (reservoir)	Ghana	25,700
Victoria	Tanzania	15,000
	Uganda	
	Kenya	
Bangweulu	Zambia	11,780
Malawi	Tanzania	10,154
	Malawi	
Chad	Nigeria	10,000
	Niger	
	Chad	
	Cameroun	
Kainji (reservoir)	Nigeria	6,320
Mweru	Zambia	6,000
	Zaire	
Kossou (reservoir)	Ivory Coast	1,000 - 4,000
Nyumba ya Mungu (reservoir)	Tanzania	3,161
Rukwa	Tanzania	1,281
Kitangiri	Tanzania	317

Source: Welcomme, (4).

truck, those in the factories manufacturing fishing nets (both in Africa and overseas) and a select few employed by governments, F.A.O. and other agencies to supervise the fishing industry in one way or another. In total therefore the total figure of those benefiting from the fishing industry in Africa must be staggering! All these people at various social strata need government support in provision of facilities like any other citizens of the country, particularly medical, educational, transportation and marketing infrastructure.

THE NEED FOR DEVELOPMENT

Three basic factors have so far been recognised:

(1) The need to raise the socio-economic welfare of the majority of the African population.

(2) The existence of large fishery resources which hitherto have been exploited haphazardly on a subsistence level, and which although renewable are capable of exhaustion and complete destruction.

(3) The widespread inadequacy of basic ecological and socio-economic data necessary to effect proper and organised development of fishery resources.

Proper exploitation of Africa's fishery resources can lead to an enhanced supply of high-quality protein, provide employment to large communities, raise the general standard of living and, where surpluses occur, provide possibilities for export and earning of much needed foreign exchange.

To date most of the African fisheries are on the indigenous **subsistence level** except Lake Tanganyika fishery, where the Greeks have operated light fishing and purse seines on a commercial scale. Yet the majority of African inland waters can support increased fishing activity to the extent of doubling or trebling current catches. However, for properly managed harvesting of Africa's fishery resources, basic ecological, economic and social data are a necessity.

Ecological Factors

Knowledge of ecological factors is not entirely essential for the exploitation of fishery resources on a subsistence level. It can be demonstrated that this kind of fishery has been going on in African inland waters from time immemorial. It depends on trial and error and out-put is extremely limited. However, for commercial exploitation of fishery resources to any extent the need for ecological information to guide the level of investment becomes an absolute necessity. It should be noted at the start that the details of such basic ecological data do not need to be refined to the extent of hampering or delaying development altogether.

What is required is the bare minimum of ecological information to assist the implementation of development programmes which would enhance the wellbeing of so many people. The precision of basic ecological information should, of course, increase as the level of investment in the fishing industry increases.

In a given body of water, therefore, the obvious questions for which development would require answers are:-

(1) What is the nature of the fish population in a given body of water, characteristics, behaviour and magnitude?

(2) What factors influence their distribution, behaviour and abundance?

(3) What fishing pressure (rate of harvest) can the fish population tolerate, and what could be the maximum sustainable yield for each species?

To answer these three basic questions it is therefore necessary to employ the expertise of a fishery biologist to study various aspects of the ecology of the species in each particular body of water. Initially it is necessary to elaborate on the types of fish present in the water and to give each species a scientific name by which it will be known in all the countries of the world. Then aspects of its size, composition and distribution have to be known. The feeding habits have to be studied in detail in order to forecast feeding requirements and factors limiting the size of the population.

The Biological Characteristics of the Stocks: The species that would normally be encountered feed on either plants (phytoplankton or other macrophytes) or on small invertebrates (zooplankton and other bottom living crustacea). Other types would feed on the eggs, young or adults of other fish. Examples of all these various types are found throughout the continent. The Tilapias are well known both along the Nile as well as in practically all other large bodies of water where they are endemic. These groups are by and large plant eaters feeding on both phytoplankton (small microscopic plants floating in the water) or on the larger plants (macrophytes). They are therefore termed primary feeders, converting directly plant material into animal flesh. They are economical in that they use a food item which is abundant and easily accessible. Food cannot therefore be a limiting factor for the Tilapia for purposes of species proliferation. Similarly there are many species which feed on the bottom dwelling invertebrate fauna including insects and crustacea which are available by the ton! Amongst these species the Mormyridae are an excellent example found in large numbers both in East, Central and West Africa. For these 'elephant snout' fishes, food is plentiful and they are termed secondary feeders. The next category cited are the predators or those which feed on other fishes including immature and adult forms. Amongst these the famous Nile Perch (Lates niloticus) is an excellent example, living both along the Nile from Lake Victoria to Egypt as well as in the Rift Valley Lakes and in West Africa. In many ways predators are not encouraged, as they tend to be wasteful in converting their fish prey into their own protein.

In all African inland waters many species live together in what is called multispecies fisheries, and the exploitation of one species therefore affects the wellbeing of others directly or indirectly. Overharvesting of the prey species could therefore endanger the predator's existence. In this way the large-scale exploitation of the Haplochromis of Lake Victoria, on which the Bagrus largely depend for food, will in the long run inhibit the development of the Bagrus fishery as the two species are always found living in co-existence.

Similarly the capacity of a population to breed and regenerate its stocks is of prime importance. Fishery biologists need to look at such problems as fish fecundity, numbers of fish fry which successfully attain maturity after spawning and therefore are recruited into the fishable stocks, breeding seasons, breeding habitats and periodicity. It is accepted that any interference with the ecological pattern stimulating successful breeding will often disrupt the success of spawning.

Once again an example can be taken from the Tilapia which are found throughout the African continent. Amongst them, some species, e.g. Tilapia esculenta and Tilapia nilotica, are mouth breeders. The adults ready to spawn prepare shallow depressions on hard bottoms which are used for elaborate courtship display prior to egg fertilisation and spawning. The fry are then sucked into the mouth where they are aerated and protected from predators. Other species, e.g. Tilapia zilli, are guarders who merely look after their young in shallow depressions constructed on the bottom. In all cases elaborate displays of courtship behaviour precede spawning.

For successful spawning of all these species, no interference should be made in their spawning grounds. Beach seining activity along the shores of Lake Victoria is supposed to have contributed to the decline of the Tilapia stocks as the beach seines, dragged across spawning areas, destroy the depressions. Further, the size of the buccal cavity of the adults limits the numbers of fry that can be accommodated.

The above illustrates one very important factor. Before an assesment can be made of the effect of human activity on its environment, it is essential to understand the intricate ecological patterns of all these faunal groups. Hence the dire need to undertake scientific investigations which in many quarters have often been misunderstood as the tendency of scientists to indulge in time-wasting practices. There are, of course, other ecological factors which need to be measured for proper understanding of the fish stocks, e.g. growth patterns, mortalities, etc.

Quality of the Environment: Ecologists need to concern themselves with the nature of the environment in which the fish stocks are dwelling. This aspect is directly related to factors influencing availability, distribution and behaviour of the fish stocks. It is important here to consider the quality of the environment that would offer the fish the best chances of successful breeding, availability of food supplies and therefore guaranteed existence. These factors are abiotic or biotic in nature.

Abiotic factors include, amongst others, the extent of radiant energy from the sun, nutrient input and its loss and oxygen supply. The volume or extent of lakes, rivers and swamps in which fish live depends on the morphometric characteristics of catchment areas. Biotic factors on the other hand control the production and distribution of important phytoplankton, zooplankton, benthos macrophytes and fish among whom intricate feeding mechanisms exist. Nitrogen and phosphorous have been shown by Mabaye (2) to be limiting growth in many waters and hence the need to evaluate concentrations of various dissolved salts in natural water cannot be over-emphasised.

It is important therefore to establish tolerance limits for each species for chemical and physical factors, such as temperature, oxygen concentration and other dissolved salts and gases. Paucity of fish in the aquatic environment may therefore be related to any or some of the physical, chemical or biological characteristics of the water. Moreover, an environment is liable to change drastically in its physico-chemical nature due to human activity (sewage, industrial effluents, etc.). Subtle differences in concentration levels of various physical and chemical characteristics, although not discernible easily, can mean life or death for the small aquatic plants and animals upon which higher animals depend for subsistence. This interference in the environment has caused international outcry about aquatic pollution and calls for concerted efforts by fishery biologists, health officers, planners, industrialists, etc. to ensure the maintenance of a healthy environment.

Potential Catch: Finally, consideration of the characteristics of the fish population and nature of environmental factors affecting its abundance should lead the fishery biologists to attempt to provide indices of how much of that population can be harvested on a sustainable yield basis. Indeed this is a basic point in management. Plant and animal resources are capable of regeneration and, subject to scientific management, can be utilised indefinitely. On the other hand, if utilised irrationally, such resources will disappear during our own lifetime. Experience elsewhere has shown that the costs of rejuvenation of such depleted resources are prohibitive.

It is to be emphasised here that no proper planning of scientific management for the use of our natural resources can be done without basic ecological information; hence the need to apply modern scientific theory and practice to the management of Africa's vast but delicate natural resources.

Socio-Economic Factors

For a long time fishing in African inland waters has been done on a subsistence level involving the use of local material for the construction of simple water craft. Fishing was done mainly with hooks, spears or traps and baskets using fishing craft constructed out of papyrus, reeds or tree trunks. These materials were adapted to local conditions but were of very limited durability. The fishermen, however, used these materials and techniques from time immemorial and so were completely adapted to them. The catch so derived was, however, very meagre, barely sufficient to feed the fishermen's extended families.

The expansion of the fishing industry therefore requires over-hauling the existing set-up in order to improve the fishermen's catches and to convert fishing to a cash basis. Before this is done it is essential to study the economics of the use of new and possibly improved materials for boat construction. This involves introducing such aspects as increased mobility on the lake, increased carrying capacity of the craft and increased safety. All these should obviously lead to increased earnings instead of merely introducing additional costs to the industry. First and foremost the use of local materials for the construction of boats should be evaluated. In a study done by Whiting (5) in Lake Victoria, it was demonstrated that by using wind-driven karua craft in the Nyanza Gulf fishermen were performing better than by attempting to motorise their craft with outboard engines. Hence the serious need to evaluate new proposals economically before under-taking such costly and possibly uneconomic innovations.

Similarly by operating a certain number of nets in his craft a fisherman can realise a certain amount of income. If such a fisherman doubled the number of nets in his craft would he necessarily double his earnings? Often this is not the case. In the same manner, if a fisherman travels daily a certain number of kilometers into the lake to fish and obtains a certain level of income, would he increase his income twice by travelling twice as far out into the lake as he did previously? These are questions of assessing the economic expediency of introducing new factors into the fishery, and they necessitate mathematical modelling. Yet these aspects are essential if we are going to advise the fishing industry properly

and avoid wastage of scarce financial resources. It is, of course, realised that traditional fishing gear must be improved, but the question is how far do we go in improving or modernising African traditional fishery?

Traditional or indigenous fishery lands only small quantities of fish. Should development and improvement occur in the industrialisation of the fishing units, then there arise logistic problems of efficient methods for the disposal of increased catches. No one in modern Africa can sensibly argue against improving handling and processing techniques. Problems would arise as to where to locate an ice plant, for example, and other ancillary handling and reception shoreline facilities, or even the breadth and length of these facilities to suit the level of planned industrial fishery. Such alternatives as exist should be guided by socio-economic factors, e.g. availability of an existing road network, electric power, urban markets, etc. It is, of course, arguable that such modern innovations in processing must be introduced in order to improve the keeping quality, flavour and purity of the fish, irrespective of whether or not these improvements generate higher price structures and earnings. Social scientists should, of course, be brought in to assess the impact if introducing fish products processed differently to markets and consumers who have been accustomed to particular ways and methods. The economics, therefore, of introducing new products to the consumers must also be judged from their social implications for the population.

As indicated above, the potential for increasing output of fish from many African fisheries does exist. In most cases these extra tons of fish can be harvested and the prospect of increasing protein supply seems bright. The most important aspect in this regard is to develop efficient means of marketing and distribution. For many countries fish are readily available to consumers on the shoreline of lakes, but become a rarity only a few kilometers inland due to lack of suitable roads and communication systems. It is once again imperative for socio-economists to be brought in to study levels of fish consumption in various forms and to recommend road and communication layouts to suit socio-economic factors. It is through such combined and planned marketing and distribution that proper utilisation of fish and fish products can be achieved. Even in this instance, what is called for is to study the existing set-up in order to recommend innovations which, while economic, are not at variance with established ways.

SUMMARY

This paper has attempted to point out the value of fish in human nutrition, provision of employment and uplifting of social and economic standards. The fishery resources of Africa are extensive and in the main not fully exploited. These resources like other natural resources are renewable although exhaustible. Efforts to exploit these resources must be encouraged, but scientific planning and management are called for.

The first step in this process of proper utilisation and exploitation of Africa's valuable natural and renewable resources is the identification of the resource itself. The initial identification of the resource should therefore lead to information on the magnitude of the resource, its characteristics, distribution, composition and the best methods of harvesting it. These would seem to be short-range objectives which should meet various goals and aspirations required by government and industry to effect rational development and management of the resource. It is, of course, imperative that planners in government and industry incorporate economic and technological information in evaluating possibilities for development and investment.

Depending on ecological information as set out above, coupled with economic and technological information and with good resource development possibilities, planners would have to look in greater detail at some of the critical factors. Ecologists, economists, sociologists, technologists and government planners would need to cooperate and provide more details to ensure that any proposals will be both economically and socially beneficial. It is at this level that ecological information has to be more precise in order to guide development and investment.

Development and investment would ensue from such initial studies. The exploitation of the natural resource would then require monitoring, regulation and management. The overall effects of methods of harvest on the resource and rates of harvest in relation to the resource size need continued examination by ecologists and economists. This then is the role of research for direct management and conservation of the resource.

From the foregoing it should be emphasised that the development and exploitation of natural resources call for collaborative planning at all levels involving ecologists, economists, sociologists, technologists and various other planners within the machinery of an entire government. The danger that exists in developing African countries is that over-anxiety to develop and industrialise and readiness to accept attractive new technological innovations from developed countries tend to lead to

precipitous decisions. Success, therefore, must be measured in the long term and careful planning and realistic evaluation of development alternatives must be brought into play, involving various cadres of government professionals.

A CASE STUDY OF THE EXPLOITATION OF THE LAKE VICTORIA FISHERY RESOURCES

Introduction

Lake Victoria is 26,000 square miles in area, and for many years before the appearance of white men in Africa indigenous methods were used by shoreline tribes to reap the fishery resources of this great lake, the largest lake in Africa and the second largest in the world. Local materials were used for fishing in this lake such as dugout canoes and cleverly woven papyrus and reeds boats, hooks and basket traps, etc. Later, the famous Sesse canoe was evolved and has demonstrated its suitability over the years. The modern gill-net was first introduced into Lake Victoria in 1905 by a Norwegian named Aarup. This increased catches from 50 to 100 fish per 60 yards of stretched gill-net.

Various entrepreneurs constructed larger boats and distributed large quantities of gill-nets since the prospects of a lucrative fishery seemed very good. However, since 1905 when catches per net were 50 to 100 fish, the situation has continually deteriorated to an appalling situation with catch in 1974 less than one fish per net! In fact, you would need to set three nets to catch one fish. This over-exploitation was brought about by several factors.

In the following paragraphs three specific examples of commercial scale fishing on Lake Victoria are cited. The first two examples led to loss of capital invested, as the schemes were doomed to failure. The reasons for their failure are examined. The third example gives a modern approach to planned development calling into play all aspects of research (ecological, socio-economic and technological) needed for a properly managed commercial fishery for the whole lake.

The Busoga Fisheries

In 1949, the Busoga African Local Government set up an industrial fishery to exploit the Mormyrid fish off Dagusi Island. The Lake Victoria Fisheries Board recommended this as research information showed abundant stocks of this genus. Further, there was a large African market in Jinja where various industries were operating including the construction of the Owen Falls Dam. However, due to the devastating effect of sleeping sickness, most of the northern shoreline including the islands were closed to human habitation.

The Busoga African Local Government made available £8,000 for capital development and £2,000 for recurrent expenditure. A Board of Management was set up under the chairmanship of the District Commissioner,

Busoga, and the following were members:- Treasurer of the Busoga African Local Government, the hereditary ruler, one County Chief and two political representatives. One manager was appointed and skippers were recruited to man the one motorised launch and five Karua type sailing craft. The Fisheries Research Department had indicated that the scheme could catch 40lbs of fish per net daily. The scheme expected the following revenue annually:

7200 lbs. fresh fish per week
Wholesale price at 50 cents per lb
Expected revenue for 1950 was £2,500.

When the scheme became operational catches averaged only 13 lbs. per net. Women in the area would not eat the Mormyrid fishes due to a taboo. The wholesaler who contracted to buy the catches was unable to pay cash. Through theft, large quantities of gill-nets were lost regularly. Initial delays in delivery of engines and boats caused losses in money and later the boats developed engine troubles. The catches subjected to smoking were ruined by high moisture of the atmosphere, and became unacceptable. The scheme therefore proved unworkable.

The Busoga Deep Water Fishing Company Limited

Failure of the Busoga Fisheries led the Fisheries Board to conclude that for the scheme to be successful it needed expansion and a significant injection of further funds. A new company was therefore formed in 1952 whose terms of reference were:

> To establish within two years a profitable industry which would make useful contribution to the provision of protein food for the local population for an outlay of £40,000 working capital less incidental receipts from the sale of fish and from interest on capital not yet employed.

The newly formed Busoga Deep Water Fishing Company, Ltd. took over assets of the Busoga Fisheries and arranged to build housing and a fishing station on Dagusi Island. It also arranged to purchase a processing plant, a trawler, batch drier, washing machines, ice plant, insulated boxes, generator and other workshop machinery.

However, two years after the formation of this company delivery of equipment from the United Kingdom was still delayed. The trawling became impracticable due to preoccupation in constructing the Dagusi base. The company made no headway and afterwards folded.

Comment

The two companies, the Busoga Fisheries and the Busoga Deep Water Fishing Company, Limited, were essentially similar in their motivation. Both wanted to provide adequate protein to the local population by industrialised fishery, exploiting the Mormyrid stocks. Both were doomed to failure for the same reasons. It will be interesting at this juncture to look at some of the problems and constraints which made these two companies fail in spite of so much enthusiasm from the organisers.

Lack of Adequate Ecological Information: The Fisheries Research Organisation advised that the company could expect to catch 40lbs. of fish per net, and the companies planned accordingly. There was, however, serious lack of vital information on the Mormyridae upon which the fishery was planned. The distribution of these fishes was not known other than general statements such as that they "are found in deep waters". There was no knowledge of their breeding, and therefore their capacity to regenerate the population was unknown and hence aspects of standing stocks, migrations and seasonality patterns could not have been provided in order to advise whether the Mormyridae could have sustained the planned industrial fishery. Further the fishery would catch many other species of fish whose characteristics such as size and distribution were not known. The companies were taken by surprise by the appearance of large quantities of other fish types for which no adequate arrangements were made. The Mormyrid fishes have since shown extremely diminished numbers and to date no sensible investment could be considered for the exploitation of this single, rather difficult-to-come-by, genus.

Lack of Technological Data: The two companies planned to operate gill-nets and trawlers. Since the behaviour of the species involved was unknown, it was also uncertain as to what the catch per unit of effort would be in each gear for each species. There was lack of information as to the most suitable mesh sizes for both the gill-nets and trawls that were to be used. There was no information as to sizes of boats for trawling and sizes of nets in relation to engine power. There was, of course, no information on the nature of the bottom where trawling was to be carried out.

Inadequacy of Processing Knowledge: The primary fish that the two companies aimed at exploiting was extremely fatty and difficult to cure by traditional methods such as smoking and sun-drying. The product that the companies obtained was mouldy and unacceptable. Alternative means of processing the Mormyrids were not investigated, nor were ways of processing other fishes examined. The companies landed quantities of fish for which no adequate processing

arrangements had been made.

Lack of Economic Information on Marketing and Distribution: The two companies began operations before collection of adequate data on the market for their products. They took for granted that the large African labour population in Jinja would form a highly absorptive market. This was proved wrong, and extensive information on market availability, capacity of consumers to purchase fish and in what forms, should have been gathered first.

Lack of Sociological Information: The two companies were taken with the idea that, due to shortage of meat in the surrounding Busoga and Buganda areas, the African population would automatically accept the Mormyrid fish as an alternative supply of protein. This particular fish, due to its finger-like snout is called kasulubana or 'elephant snout fish' and will not be eaten by women in these areas as the women would bear children resembling the elephant snout fish. This taboo meant that the women would rather suffer protein malnutrition than eat the elephant snout fish. The fishing companies were therefore disadvantaged from the outset by lack of essential sociological information pertaining to taboos or such questions as which fish is eaten by which tribes or which tribes prefer certain species processed in particular ways.

The Lake Victoria Fishery Development Project

The existence of vast fishery resources in Lake Victoria had been recognised for some time. During the latter half of the 1960s a new project was formulated incorporating collaboration between the three partner states, Kenya, Uganda and Tanzania, using multilateral assistance from the U.N.D.P. This new project, initiated in 1967, was to be executed by the F.A.O. of the United Nations and the local cooperating agency was the East African Community through the East African Freshwater Fisheries Research Organisation (EAFFRO). This project took into account the errors made in earlier schemes and every effort was to be made to ensure that sufficient studies were conducted before any investments were made.

The original aims of the project included:-

(1) To assist in the management and development of the Lake Victoria Fisheries, and

(2) To strengthen EAFFRO to enable it to meet the needs of industry and to provide basic data necessary for development and management.

The cardinal aim of the project therefore was to lay the foundation of which future development of the fishery in Lake Victoria could be based. This objective was to be achieved by collaboration between

various international organisations and the whole machinery of governments at the national level. It required coordination of planning among ecologists, economists, sociologists and technologists and involved experts from national governments, from the East African Freshwater Fisheries Research Organisation and from the United Nations.

The work involved the deployment of experts in various technical fields. Initially, it was essential to undertake a survey of the bottom of Lake Victoria in order to establish various characteristics such as depth, composition and whether it was possible to trawl in the lake at all. Further, experiments were carried out with various sizes of nets in order to establish the best net and the best cod-end mesh size that would be capable of catching the maximum quantities of fish. The speeds by which the trawls should be pulled had to be determined. Similarly, ecological investigation included determination of all the species that could be caught by the trawl nets including details of their characteristics, composition, age, etc. Stock assessment biologists finally found how much fish was available in the bottom of Lake Victoria. This involved application of mathematical calculation. This figure has now been set at approximately 700,000 tons of fish of which 80 per cent is composed of Haplochromis. Current recommendations include exploitation of 200,000 tons of Haplochromis. This fish is, however, small and is not readily acceptable as a food fish and hence alternative uses have to be found.

The availability of large stocks of fish necessitates investigations of marketing and distribution. It was necessary to find whether the large stocks of fish could be absorbed by East African markets, and since by far the greatest weight of fish was made up of one genus, namely Haplochromis, it was necessary to find if, turned to fish meal, the Haplochromis would find a ready market within East Africa and the neighbouring countries. All aspects of distribution had to be studied both for fresh and processed fish. At the same time, the sociological impact of new innovations in the fishing industry had to be evaluated, for example the impact of trawls on indigenous canoe fishermen; and fish preferences within different tribes and taboos had to be looked into. At the same time, the educational needs of the new fishery had to be investigated. Trawling means catching fish using motorised power. This calls for engineering capabilities as well as capabilities in fishing techniques. Technical arrangements called for training engineers, deckhand staff and others. Finally, investigations into the funding of a commercialised industry in Lake Victoria had to be carried out. Sources of capital needed to be identified, and the countries involved had to plan for fishing sites as well as sites for the development

of the necessary infrastructure. All these required extensive planning and the involvement of various planners and experts from the East African Community and the partner states, Kenya, Uganda and Tanzania and experts from the Food and Agriculture Organisation of the United Nations.

After a period of active research from 1967 to 1972, the project had gathered substantial data. Economic studies indicated that the market for fresh fish was extremely limited, particularly for the rural areas which in most cases were unable to either consume or purchase larger quantities. Although trawling had been refined, there needed to be schemes to train skippers, engineers, deckhands and fish handlers. New processing techniques needed to be looked into and the potential for markets in neighbouring countries needed to be evaluated, particularly their requirements or projected requirements of fresh fish, processed fish and fish meal.

On the basis of information obtained from the initial studies, it is now possible to plan for industrialised and commercialised fishing on Lake Victoria. In these investment proposals, it is essential to take into account the size of fish populations available for commercial exploitation and their characteristics; it is also desirable to plan the size of industry in accordance with available economic and social data.

This last example indicates the need for research before undertaking investment plans, and this should cover all essential disciplines involving experts in economics, sociology, ecology and technology. The need for patience on the part of planners cannot be over-emphasised as most of this research takes a long time.

BIBLIOGRAPHY

1. Food and Agricultural Organisation. Department of Fisheries. "A Brief Review of the Current Status of the Inland Fisheries of Africa." African Journal of Tropical Hydrobiology and Fisheries. Special Issue No. 1. Rome, F.A.O., 1973.

2. Mabaye, A.B.E. "The Role of Ecological Studies in the Rational Management of Fish Stocks." African Journal of Tropical Hydrobiology and Fisheries. Special Issue No. 2. Rome, F.A.O., 1973.

3. Nsherenguzi, C.K. "Fishery Economics Studies." EAFFRO Annual Report. 1970.

4. Welcomme, R.L. "The Inland Waters of Africa." F.A.O., CIFA/72/9, October 1972.

5. Whiting, P.S. "Costing Study of a Karua Tilapia Gill-Netter on Lake Victoria." EAFFRO Annual Report. 1968.

TRAINING AND RESEARCH IN INSECT PHYSIOLOGY

By

Thomas R. Odhiambo, Director,
International Centre of Insect Physiology and Ecology

One of the most cataclysmic events that may well have changed the orientation of scientific research in the last decade was the publication of Rachel Carson's book, The Silent Spring. It presented in stark, journalistic style the massive application of pesticides to the control of insect pests in farmlands and homes, the enormous and increasing problem of pesticide pollution in the environment, the worsening phenomenon of the development of insect resistance to pesticides, and the deleterious side-effects of pesticides on wildlife. There were factual errors in the book; there were also exaggerations and an apparent careful selection of extreme examples and not a few sober scientists objected to the method and tone of the presentation. Nevertheless, Carson succeeded as never before in kindling public imagination concerning the insect pest problem and how the developed world was going about solving it, and many scientists acquired a new consciousness about the whole approach to pest control.

So a new strategy for pest control was born, and an old insect science - insect physiology - was recruited to help with this approach.

DEVELOPMENT GOALS AND INSECT PESTS

African history, particularly in the tropical and sub-tropical belts, may well have been shaped to a large extent by the activities of insect pests. Sleeping sickness, East Coast fever, malaria, filariasis, locust plagues, armyworm infestations - to mention only a few insect pests - occupy a frequent and prominent place in the annals of oral history in Africa. Indeed, pestilences and plagues are one of the most reliable yardsticks that have been used in dating African history.

Human sleeping sickness and a similar disease in cattle have been known in Africa for centuries. Six hundred years ago, a written description was recorded by the contemporary Arab historian, Ibn Khaldun, as related by T.A.M. Nash in his book, Africa's Bane: The Tsetse Fly. (2) He relates the death of Sultan Mansa Sjata, who ruled over the great Melle Empire, whose capital was 55 miles south-west of Bamako, an area notorious even today for sleeping sickness. Ibn Khaldun wrote that in 1374-75 he met Honein Abou Abd'Allah-Mohammed-Ibn Ouacoul, "a man of proven veracity" who told him about the manner of death of Sultan Djata:

> He was finally overcome by lethargy, a very prevalent disease in this country which attacks mainly people in high positions. This indisposition begins with periodic attacks and reduces, in the end, the patient to such a state that it is very difficult to keep him awake for a moment. Then the disease becomes permanent and kills the victim. During two years, Djata suffered the attacks, and succumbed in the year 775 [1373 - 74].

Nash also relates the story of El Mansur, Shereef of Morocco, who sent an army of Moors to capture the source of gold in the Songhai Empire, which lay east of Timbuktu. After capturing Gao, the capital of the Songhai Empire, El Mansur sent his Moorish general, Mahmud ben-Zergun, to pursue the remnants of the Songhai army down the Niger until they reached the Mekon river in the Borgue district of Dahomey. Here, General Mahmud suffered "terrible trials" and he lost his entire cavalry. It is thought the horses died of nagana, carried by the tsetse fly, Glossina morsitans. which is still prevalent in that country.

The Africans in the sleeping-sickness areas knew that tsetse flies had a great deal to do with the disease. Nash states that Richard Burton, the explorer, in writing about the journey of Dr. J. Kirk from Lake Tanganyika to the Indian Ocean coast stated:

> The only proof that the fly in question (by which I was often stung) kills cattle, especially cows, is the universal report of the natives of different and distant tribes. One of our cows died in Unyamwezi, and all who saw her declared it was the fly's poison.

The 'natives' may not have known that the causative agent of sleeping-sickness was a protozoan parasite transmitted by the tsetse fly at the time it is feeding, but they certainly had discovered the association between the tsetse fly and the disease.

Similarly illuminating stories can be gathered about the other important pests of Africa. The salient point about these stories and historical events is that they illuminate the close association between the socio-economic history of Africa and the major insect pests.

These agricultural, veterinary and medical pests have not ceased to be important in present-day Africa. Indeed, with the intensification of agro-business and the progressive villagination and urbanisation of the population, the problems have become increasingly acute and threaten to become endemic. We are all impressed by the fact that the greatest single natural

resource in a great part of Africa is land. But the greatest lesson we have learnt from the dawning 'green revolution' is not that we have the potential to obtain massive harvests from our land, but that we can only attain this potential by a scientific application of sound agricultural techniques, involving the extensive use of fertilisers, water, new seeds and above all plant protection methods. Otherwise, we only produce more crops to feed more pests.

An interesting insight into how vital it is to consider all ecological aspects before launching into any large-scale biological application is seen in the effect of the introduction of fish farming in Western Kenya. Pond fish farming was introduced in the district north of Kisumu in 1957 to produce animal protein for human diet. The idea spread rapidly into other districts, and within three years more than 50,000 fish ponds were in existence. A serious side-effect of the scheme was a colossal explosion of the mosquito population, with Anopheles gambiae, the malaria carrier, being predominant. (1) We can therefore only neglect to consider the total environment and ecological situation at the peril of sustaining a serious ecological boomerang.

In terms of the economic losses Africa and other tropical regions suffer as a direct result of insect depredations on crops and livestock, and in terms of the debilitation and health problems caused by the insect vectors of the many tropical diseases, insects emerge as a prime factor in the social and economic development of developing countries.

In temperate regions, insects are not such a conspicuous element of nature. In the tropics, with their rich variety and abundance, insects certainly occupy a preeminent position in the ecological scheme of things. It would be impossible for the developing countries of tropical Africa to proceed with their development goals in any sphere where natural resources are concerned (except in the sea) without taking special cognisance of the insect repercussions that are likely to accompany such activities, unless, of course, pest problems have been averted in advance. The launching of extensive irrigation schemes is likely to lead to an eruption of the population of several species of biting flies (not to mention of bilharzia and other water-borne diseases); the introduction of exotic trees for large afforestation schemes may well lead to the outbreak of extensive damage caused by insects that, previously harmless, suddenly become pests under the changed conditions of the environment; the expansion of the livestock industry to new pastures previously inacessible cannot be sustained indefinitely because of the heavy toll of tick-borne diseases (not to mention

the major killer, livestock trypanosomiasis or nagana); and the provision of new low-cost housing units to cater for the bulging urban population frequently leads to the intensification of mosquito populations (e.g. Anopheles funestus) which previously may have been rare. The list is a long one. The burden of the evidence shows that the insect pest problem must command more respect and attention from planners of socio-economic development.

In these circumstances, what can we in tropical countries do to protect ourselves from the ravages of insect pests?

STRATEGY FOR PEST CONTROL

Most of the techniques used for insect control can presently be grouped under four headings:

1. Cultural methods, in which we time or alter our agronomic or hygiene practices in such a way that insects are kept out. For instances, we have a strict closed season for cotton so that there is little or no carry-over of insects from one harvesting period to the next planting season. These are fairly cheap methods, but require a disciplined approach by individuals or communities.

2. Biological control methods, in which insect parasites, predators or diseases are used to eliminate particular pests. One of the most instructive examples in this connection is the virtual control of the coffee scale insect from Uganda by the introduction to these insects of parasites from Kenya. Uganda did not originally have these parasites. A new effort is being made in many countries to control several moth parasites by killing them with a bacterium, Bacillus thuringiensis. Several agencies, including the Commonwealth Institute of Biological Control based in Trinidad, specialise in identifying biological control agents which can be employed for the control of specific insect pests, and in carrying out field trials. So far, the full potentialities of this approach have not been realised.

3. The scorched-earth approach to pest control. Probably, one of the most extreme illustrations of this technique is the traditional method of tsetse control which involves bush clearing (to alter the preferred environment of the insects), wholesale or selective elimination of wild game (to get rid of the presumed resevoirs of the parasitic agent and to starve off the tsetse flies), the use of herbicides (to open up the tsetse habitat

for insecticide application and to provide a wide open belt across which the insects are supposed not to fly), and the massive application of insecticides (to kill off the presumably exposed tsetse flies). Apart from the **tremendous ill effects** that these techniques have on the environment, they have not resulted in a permanent solution to the pest problem and have at best only provided an interval of amelioration.

4. The fire-brigade approach. The discovery of D.D.T. at the beginning of the Second World War was hailed as a 'miracle solution' to the pest problem. It did chart a new course in man's battle with insect pests, and the newer insecticides have added new weapons to this chemical armoury. However, with few exceptions, we have come to use insecticides as a club, without a deep understanding of the biology of the particular insect species involved. This chemical tool has therefore not been used as a sword, a precise fighting weapon. In any case, we have now discovered that most insects acquire resistance to these pesticides sooner or later. Consequently, they are not the ultimate weapon.

A new strategy is required to find new techniques for pest control. It requires a deep knowledge of insect ecology, behaviour, physiology, biochemistry and the inter-relationships of insects with other organisms and the physical world. This is an enormous task of basic scientific research, although it should be oriented to the important final task of pest control. The design of an actual control technique comes later.

All along, I have talked about pest control. I want to make it clear that this is shorthand terminology for a more complex thought. Until the end of the last decade, people glibly mentioned pest control, insect eradication or similar terms in discussing what we have really come to realise is pest management. It is terribly difficult to make an insect become extinct; we have not even succeeded in eradicating human lice from our midst, and in recent years there have been serious outbreaks of these pests in Denmark and Burundi. The best we can do - and what our scientific investigations should lead us to aim at - is to design new programmes of pest control that will ensure that the socio-economic importance of these insects becomes negligible and that this goal is reached without a major deleterious effect on the ecological balance of the total environment.

The new strategy requires that we draw up a detailed portrait of each insect pest species, each of which will require an effort approximately as great as we have taken to know the cow, the sheep, the fowl, the pig or any

of the animal or agricultural crops in which we are interested. How should we organise our capabilities for this concentrated research effort?

CONCENTRATED RESEARCH

A thorough study of the physiology of individual insect pests is likely to give us some clues as to what functions are most likely to succumb to modification thus leading to insect death or population decline. Such insights are only relevant to the ultimate goal and only feasible for investigative activity if the physiological questions are asked with a great deal of background in the natural history and ecology of the insect concerned. Any programme of research, therefore, requires that a multi-disciplinary team of physiologists, ecologists, behaviourists, biochemists, organic chemists, sensory-physiologists and experts in other disciplines (e.g. fine structure epidemiology, parasitology, agronomy, public health, population dynamics and economics) work on the same insect pest so that the eventual outcome of the research is a balanced portrait of the insect, its ecological relationships, possible pest management programmes and the cost-effectiveness of these programmes.

A unique institution carrying out this sort of research is the five-year-old International Centre of Insect Physiology and Ecology (ICIPE), established originally as a result of the deliberations of a few scientists who felt an urgent need for new fundamental knowledge to make possible the design of new pest control programmes. I have provided elsewhere a short history of the establishment of ICIPE. (3) However, there are a number of ideas that went into the establishment of ICIPE which, in concert, make it a unique research institute in Africa and the rest of the world:

1. It is a high-quality research centre doing fundamental research on individual insect pests with the ultimate goal of designing novel, ecologically-acceptable control methods.
2. It is deliberately sited in a developing country so as to provide an attractive focus to scientists from developing countries who would normally wish to go to the Northern Hemisphere for their professional advancement.
3. The quality of the research work being carried out at the centre is monitored by a consortium of several academies of science who have developed strength in insect science over the years.

4. The research activities of ICIPE are guided by a number of the world's foremost specialists in one or another aspect of insect science who act as directors of research, and who hold open house in their own home laboratories for any of ICIPE's scientists who may go there for a short period to deepen their experience in any particular field.

5. The ICIPE has appointed a small African Committee with representatives from all regions of Africa (except the dependent countries) whose mandate is to ensure that the research work of the centre is relevant to African problems and that ICIPE maintains high-quality training programmes for the technical and scientific staff of ICIPE as well as other interested institutions.

6. The management should be predominantly indigenous, while maintaining international standards.

It is probably the first time that an international institute, with international funding and professional guidance, has been located in a developing country with the specific intention that it should generate new knowledge for a development-orientated approach and that it should strengthen the scientific community of the developing country so that, in time, it can be self-sustaining in that field as well as being a centre of high-level training for the rest of the world. In a very real sense, therefore, ICIPE is unique, and is likely to be a forerunner of other institutes in other fields of development-oriented research in developing countries.

There are at least 300 insect species that are of crucial importance in the socio-economic development of tropical Africa. The first phase of ICIPE's research effort, which began in 1972 and will run until 1976, cannot deal with all these species concurrently. There is presently a scientific staff of 35 comprising researchers in insect ecology, behaviour, endocrinology, physiology, sensory physiology, fine structure, organic chemistry, biochemistry and parasitology, and this number should even off at 40 by the end of 1974. We reckon that with this staff, the present initial physical facilities and the available supporting funds, we can best tackle a limited number of insect species and insect problems. We have therefore chosen five groups of insect - tsetse flies (for livestock 'nagana'), Aedes aegypti mosquitoes (Yellow Fever carriers), termites (as grass-feeders), African armyworm (representing a serious continental migratory crop pest), and ticks (carriers of East Coast fever and swine fever) as the first target insects for a concentrated research effort.

The ICIPE's fundamental approach can be exemplified by one of the projects in which it has initiated research. This is chemical communication among termites. We know that the highly social termites (the so-called 'higher termites') are almost blind, except the winged reproductives, yet they live in highly architectural mounds and nests, with a complicated set of highways and byways leading to sources of food and other places of interest outside the nest. It is now known that the greater part of communication between the individuals of the nest (which may number several thousand, if not million) is effected through the medium of 'chemical messengers' or 'pheromones', perfume-like chemical substances which are employed by termites as a precise language of communication. All activities of the nest are in one way or another communicated by one or another pheromone. The pheromones seem to be species-specific, or at least each one is only understood by a restricted group of species. The ICIPE is making a thorough study of this chemical language: the behaviour of termites when pheromones are released, the organs concerned in their secretion, development and regulatory mechanisms, the chemical identification of the pheromones, the manner in which the pheromones are sensed by the appropriate sense organs of the responding termites, and just how one can interfere with this chemical language. If a breakthrough is made here it will be a major event, since other social insects, and indeed all insects, in a variety of ways employ distinctive chemical communication systems.

What the ICIPE has accomplished in its first two years' of actual research indicates that we have a very good chance of reaching the objectives which were set out in April 1970, when inspite of many initial obstacles the ICIPE was established. The question arises whether we can sustain this effort and whether we can inspire others to do a similar job in other areas of endeavour relevant to development.

TRAINING FOR INNOVATIVE RESEARCH

In developing countries, decision makers in the field of scientific research must do a tight-rope act: do we carry out unrestricted basic research with the ultimate joy of discovery and without a conscious thought for its application, or do we choose to do technologically-oriented research? Do we say, as many eminent scholars and statesmen have said before us, that it would be cheaper to import technical know-how and stop trying to expand a small and inefficient local research community? Or do we agree with others that economic considerations alone are not compelling and argue for the nurturing of an indigenous scientific community which will itself not only

decide on its criteria for priorities and relevance but also on its application and self-generating capabilities. This sort of dilemma was well put by J.M. Ziman in the Rutherford Memorial Lecture which he delivered in December 1968 at the University of Delhi:

> ... In a country such as India or Pakistan, I can see no justification for shall we say the neglect of practical animal husbandry for the sake of research in pure physiology ... and I simply cannot understand the intellectual snobbery of those silly people who give more credits for the discovery of another meson than for the design of a suspension bridge, and who cannot see that a zip fastener is a far more beautiful idea than a zeta function .... But the utilitarian argument against basic research can be carried far .... A certain amount of fundamental research must be sponsored in a developing country ....

The point I wish to make here is that this dilemma, first posed for public criticism in C.P. Snow's Two Cultures, should really become a dead horse in developing countries. It would seem to me that the question should become unimportant and irrelevant once we accept that what we are seeking is development-oriented research, a point of view I have argued at some length elsewhere. (4)

The point has been made many times in recent years that one major circumstance that results in the developing countries having Ph.D.-level scientists doing irrelevant research is that these scientists are largely trained in industrialised countries with little regard for their areas of concentration. Consequently, any far-reaching training programme for high-level scientific manpower geared toward development-oriented research must take place within developing countries themselves. Governments in developing countries are so conscious of this imperative and they are allocating such a large proportion of their national income to university education, that this goal is likely to be reached in the foreseeable future.

But there is a level of training for research which has scarcely been recognised in developing countries, and least of all in Africa. This is the training of post-doctoral scholars to deepen their experience in a different environment for a period of one to three years. The United States of America adopted this system early in this century in a big way and was virtually transformed from a near scientific backwater to pre-eminence within a space of four decades. Young American scientists flocked to Europe (to Oxford, Cambridge, Paris, Heidelberg, Uppsala, the Karolinska Institutes in Stockholm,

Amsterdam and many of the eminent scientific centres of excellence of that time) and then returned to the U.S.A. fired with inspiration to do just as well. In forty years they did. Japan repeated this experiment later on. And now the ambitious young European scientist is more likely to pay homage to American science than to go for his post-doctoral experience in another European research institution or university.

African universities must intensify their postgraduate training programmes to produce the varied high-level scientific manpower the continent needs. But they must initiate and vigorously support a post-doctoral programme in which their bright and innovative young scientists are given a chance to deepen their knowledge during a specialist 'finishing school' period before they settle down to the serious work of scientific research.

BIBLIOGRAPHY

1. Highton, R.B. "The Influence of Water Conservation Schemes on the Spread of Tropical Diseases in Kenya." In G.C. Gould, editor. Health and Disease in Africa. Nairobi, East African Literature Bureau, 1971.

2. Nash, T.A.M. Africa's Bane: the Tsetse Fly. London, Collins, 1969.

3. Odhiambo. T. R. "Need for Entomological Research in Developing Countries." In Microbiological Control of Insects. Proceedings of a Seminar held by the International Organisation for Biotechnology and Engineering in Helsinki, Finland, June 1971.

4. Odhiambo, T.R. "The Problem of Education and of Diffusion of Science in Developing Countries." Scienza & Tecnica 74. Milan, Arnoldo Mondadori Editore, 1974.

5. Ziman, J.M. "Some Problems of the Growth and Spread of Science in Developing Countries." The Rutherford Memorial Lecture delivered at the University of Delhi in December 1958. In Selected Lectures of the Royal Society. London, The Royal Society and Academic Press, 1970.

APPROPRIATE TECHNOLOGIES: NOTES FOR DISCUSSION

By

J.F. Rweyemamu, Dean, Department of
Social Science, University of Dar-es-Salaam

Any meaningful discussion of the subject of 'appropriate technologies' must start with a specification of either society's goals, i.e. some form of a social welfare function, or other embodiment in an industrial strategy. For if neither of these aspects is given one is bound to ask: appropriate technologies for what, for whom, and by whom? In other words, the measuring rod of appropriateness must be situated in a given resource and environmental context and in a historical framework.

In what follows, certain assumptions are made regarding the social context in which the choice of technology has to be made. In particular it is assumed that the economy and society in question is both underdeveloped and small.[1] As such, its major objective is to liquidate its underdevelopment by adopting a strategy that will transform it from dependency to maturity with a minimum of human suffering.[2] A fortiori, the industrial strategy in such a framework is part of the overall strategy of economic and social transformation.

An industrial strategy consists largely of four separable elements. It identifies a list of industrial activities that must be undertaken. These activities are geared to satisfy the overall needs of economic transformation. Thus, for example, activities may be chosen because of their basicness to the economic system. Here basic activities are defined à la Sraffa, i.e. as activities which either directly or indirectly are used in the production of all other goods in the economic system.[3] They appear on the last row of a triangular matrix of the combined current and capital input-output tables.[4]

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1. For an analysis of the problems of underdevelopment see especially 16, 22, 5, 24, 17, and 8.

2. For a discussion of appropriate strategies of economic and social transformation see 24, 17 and 22.

3. See Pierro Sraffa (20) for an elegant examination of economic systems and basic goods.

4. Leontief and Carter have discussed the internal structure of the metal working complex in their useful paper, the Position of Metalworking Industries in the Structure of an Industrializing Economy. (13) See also Simpson and Tsukui. (19) The latter authors discuss the existence of a fundamental structure of production which can be identified with basic goods.

Within the activities chosen, an industrial strategy must secondly specify the criteria for choice of techniques. These decision rules must be designed to meet certain societal objectives, e.g. industrial growth, income distribution, regional distribution, employment generation, minimisation of human indignities, etc.

Thirdly, an industrial strategy must specify the form of institutions and organisation in which such a strategy must be undertaken. These may include problems of ownership and control, e.g. it may be deemed desirable to establish organisational forms that minimise alienation, improve cooperation in the workforce, encourage the dignity of the working class, etc.[5]

Finally an industrial strategy must include an algorithm of sequencing the various activities over the entire planning time horizon. This is done to maximise the benefits of forward and backward linkages that are invariably brought about by the establishment of a pattern of industrial activities. Needless to mention that the choice of an appropriate planning time horizon is a political one implying definite relations between aggregate consumption and aggregate investment. (12)

Hence the question of choice of technologies is only a part of the larger problem of industrial strategy, just as the latter is only a part, albeit a significant part, of the basic problem of social and economic transformation.

Choice of techniques can be examined from various angles, viz. social-economic goals, resource endowment, environmental aspects and technical and economic aspects of the technology. Let us examine these aspects one by one.

The major socio-economic goals of underdeveloped economies, apart from the overall need for socio-economic transformation, include rapid increases in per capita output and more equitable distribution of resources (personal, regional and interclass). The major socio-economic issue arising from this has, however, been the generation of productive employment. It has been observed, for example, that the techniques of production that have been adopted by the underdeveloped countries have tended to be labour-saving, thus compounding the spectre of the urban unemployed and confounding the previously held dictum that promoting growth would also promote employment. (23, 3, 6 and 21)

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5. It is possible to argue that certain organisational forms are related to choice of techniques. We believe, however, that organisational issues of industry are separable from technological choices.

The widely held view that promoting growth implies promoting employment was related to the neoclassical assumption that variations in capital-labour ratios were the consequence of factor price changes, and that the resource endowment of under-developed countries was such that capital was scarce relative to labour.[6] The problematic issue of measuring capital was normally brushed aside. (See 9 and 27.) Despite the current interest in the measurement of capital, this paper will be concerned with certain implications of the conventional wisdom concerning the choice of techniques. First, it is noted that the neoclassical view held that under the conditions explained, the choice of techniques in underdeveloped countries must be labour-intensive. The economic rationale for this view is that static efficiency requires the equilibrium of marginal rates of factor substitution with the (implicit) wage-rental ratios, and to the extent that wage-rental ratios were assumed to be low in the underdeveloped countries, more labour-intensive techniques had to the adopted.

A number of explanations have been presented to explain the contrast between theoretical expectation and reality. One view invokes completely rigid technology in the face of which differences in relative factor prices would be irrelevant. (4) Another view holds that factor prices are unduly distorted in underdeveloped countries. Among the reasons adduced in support of this are over-valued exchange rates, generous investment allowances and other policy pressures which artificially reduce the price of capital. Furthermore, it is claimed that minimum wage legislation and pressures resulting from the establishment of and growth of labour unions distort factor price ratios in favour of capital relative to labour. (15) Still another view contends that the underdeveloped countries must expect to get factor-inappropriate techniques insofar as their factor endowments are different from the developed countries and they fail to establish capital goods industries. (17, p. 96)

Despite research undertaken on the question of appropriate technologies in the socio-economic context of underdeveloped countries, it has not been possible to test the above hypotheses satisfactorily because

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6. All of this is admittedly based on restrictive assumptions (though the neoclassicists do not regard them so!) which include profit maximising behaviour, unlimited supplies of two (and only two) homogeneous factors of production, continuous possibilities of factor substitution in production and efficiently functioning factor price markets in each production location.

meaningful testing is inordinately demanding in its data requirements. Full information would include specification of factor proportions of all known technologies at different levels of output, market sizes in all relevant countries, the technical possibilities of factor substitution in all relevant industries, fluctuations in demand and shadow and actual factor prices - as they have been or they are and as they are expected to be. Obviously most of this data is unavailable. Nevertheless it is useful to examine the above arguments in greater detail in order to at least take stock of our existing body of knowledge on the subject before we proceed.

In the first instance, it is reasonable to claim that despite the differences in factor endowments, technological rigidity is not a sufficient explanation for inappropriate technological choices for the underdeveloped countries. This is for a number of reasons. To begin with, even if one held a fixed-coefficients view of production functions within each industry, one would still expect the underdeveloped countries to concentrate on those activities which call for much labour and little capital. Secondly, there is sufficient evidence to indicate that, within some industries at least, considerable choice among technically efficient alternatives is possible. (14)

If technology is generally flexible and the opportunity costs of labour and capital differ significantly between the developed and under-developed countries (à la Arighi, 2) then the similarity of production techniques may be explained by deviations in the underdeveloped countries of actual factor prices from their true opportunity costs and/or by a failure on the part of decision makers to give full weight to prices in the factor markets. There is no doubt that factor prices deviate from their true opportunity costs. Nor can it be denied that the policies of underdeveloped countries have the effect of cheapening artificially the price of capital relative to labour. However, it cannot be asserted that factor price distortions are the cause of inappropriate technological choices unless it is established that decision makers are sensitive to variations in factor prices.

A number of attempts have been made to estimate the elasticity of capital-labour substitution for developing countries, and the results from four relevant studies are shown in Table 1. With the exception of the time series estimates for Argentina, the figures shown are all impressively high, indicating a reasonable sensitivity to factor price changes. If these are generally representative of industry in underdeveloped countries,

they would tend to offer strong support to those who believe that the deviations between the actual and true factor prices are the major cause of the disappointingly poor rate of growth of the industrial labour force in developing countries.

Table 1. Elasticity of Capital-Labour Substitution in Developing Countries.

Author	Country/Countries	Elasticity
Reynolds and Gregory	Puerto Rico	1.0
Erikkson	Argentina, Brazil, Colombia, Costa Rica,	
	Mexico	0.7
Harris and Todaro	Kenya	0.8
Katz	Argentina	1.0[a], 0.3[b]

Source: C. St. J. O'Herlihy, "Capital Labour Substitution and the Developing Countries", Oxford Bulletin of Statistics, p. 273, Vol. 34, No. 3, August, 1972.

Notes: a = 'cross section'
b = 'time series'

Yet a number of studies do suggest that extra economic considerations, e.g. risk avoidance, appeal to modernity, established procedures and familiar techniques, explain the existence of inappropriate technology in the under-developed countries. (26 and 25) It has been suggested that the basis for such decisions is the pattern of ownership and control, though this view has not gone unchallenged. (17)

The implication of these findings is that choice of techniques cannot be made independently of the choice of activities that must be under-taken in order to transform the economies of the underdeveloped countries. For techniques are embodied in capital goods industries. Once a machine is constructed, factor proportions determine output per unit of labour, since each machine requires a fixed amount of labour. There is, moreover, a close relationship between technology producers and users which facilitates the flow of knowledge between them, thus enhancing the embodiment of technical progress in capital goods. An important policy implication is for under-developed countries to produce capital goods if they want to have appropriate technologies.

It should be noted also that there is another school of thought, again based on neoclassical assumptions, which arrives at a contrary conclusion, namely that the underdeveloped countries should use more capital-intensive techniques. The argument is based on the influence of choice of techniques on income distribution and the size of the investible surplus, and hence its effect on growth of income and employment. More specifically, it is argued that since capital intensive techniques imply a smaller share of output going to wages, they will yield a larger investible surplus and a faster rate of growth of employment. (7 and 18)

As Arighi and Bator have pointed out, this argument is based on a number of very restrictive assumptions which may not be valid for the conditions of the underdeveloped countries. (1) Specifically, it assumes: (a) that the real wage rate is fixed whatever techniques of production are adopted and is constant through time, (b) that the reinvestment of the larger surplus associated with capital intensive techniques is feasible in the sense that either the productive capacity of the capital goods sector is sufficiently large to supply the capital goods required by such reinvestment or foreign exchange is available to make up the deficiency of capital goods through purchases abroad, (c) that the reinvestment of the larger surplus is not only feasible but desired by whoever controls its utilisation, and (d) that the rate of saving is a function of the choice of technique. The pervasive influence of foreign enterprises in the underdeveloped countries implies that most of the above assumptions are not valid.

Professor Hirschman also favours the adoption of capital-intensive techniques in the periphery, especially for large-scale ventures, in activities which must be maintained in top working order, in activities which must observe high quality standards for their output, in machine-paced operations and process-centred industries. This is based on his belief that the modern technology embodied in capital equipment helps management in underdeveloped countries perform unfamiliar and uncongenial tasks and co-ordinate the internal activities of the firm, since it is precisely those management skills which are most scarce in underdeveloped countries. (10) However, in a later review of the import substituting industrialisation strategy, Professor Hirschman observes that the problem of the underdeveloped countries adapting to factor proportions was "an idle question under these circumstances; given the sequential pattern of industrialisation, there is remarkably little choice". (11) Professor Hirschman further points out incisively that "the very nature of industrial operations - their precision, the need for exact timing, punctuality, reliability, predictability and all-round

rationality - which was expected to infuse these same qualities into policy making and perhaps even in the political process itself", did not do so. (11, p. 12)

A final theoretical issue concerning choice of techniques which needs emphasis concerns certain aspects of production relations. For example, it might be argued that, instead of considering the factor price frontier (the law of value problem), choice of techniques must be geared to minimising alienation, improving cooperation in the work force and encouraging the work force. Here is a whole area of research that has hardly received attention.

BIBLIOGRAPHY

1. Arighi, Emmanuel. International Corporations, Labour Aristocracies and Economic Development in Tropical Africa. Dar es Salaam, University College, 1967. mimeo.

2. Arighi, Emmanuel. Unequal Exchange: A Study of the Imperialism of Trade. New York, Monthly Review Press, 1972.

3. Baer, Werner and Herve, Michael. "Employment and Industrialisation in Developing Countries." Quarterly Journal of Economics. 70 (1) February 1966.

4. Eckhaus, R.S. "The Factor-Proportions Problem in Underdeveloped Areas." The American Economic Review. September 1955.

5. Frank, Andre Gunder. Latin America: Underdevelopment or Revolution. New York, Monthly Review Press, 1969.

6. Frank, Charles. "Urban Unemployment and Economic Growth in Africa." Oxford Economic Papers. New Series. 20 (2) July 1968.

7. Galenson, Walter and Leibenstein, H. "Investment Criteria, Productivity and Economic Development." Quarterly Journal of Economics. August 1955.

8. Girvan, Norman, editor. Social and Economic Studies. Special Issue. 22 (1) March 1973.

9. Harcourt, C. Some Cambridge Controversies over the Theory of Capital. London, Cambridge University Press, 1973.

10. Hirschman, A.O. Strategy for Economic Development. New Haven, Yale University Press, 1957.

11. Hirschman, A.O. "The Political Economy of Import Substituting Industrialisation in Latin America." Quarterly Journal of Economics. 82 (1) February 1958.

12. Lange, Oscar. "Planning and Economic Theory." Reprinted in Oscar Lange. Papers in Economics and Sociology, 1930-1960. Oxford, Pergamon Press, 1970.

13. Leontief, W. and Carter, A. The Position of Metalworking Industries in the Structure of an Industrialising Economy. Harvard Economic Research Project, August 1966. mimeo.

14. Mason, R.H. The Transfer of Technology and the Factor Proportions Problem: The Philippines and Mexico. Research Report No. 10. New York, UNITAR.

15. Pickett, J. The Choice of Industrial Technology in African Economies. U.N. Economic Commission for Africa. CMI.2/INR/TP/18.

16. Rodney, Walter. How Europe Underdeveloped Africa. Dar es Salaam, Tanzania Publishing House, 1972.

17. Rweyemamu, J.F. Underdevelopment and Industrialisation in Tanzania. Nairobi, Oxford University Press, 1973.

18. Sen, A.K. Choice of Techniques: An Aspect of the Theory of Planned Economic Development. Oxford, Basil Blackwell, 1960.

19. Simpson, David and Tsukui, J. "The Fundamental Structure of Input-output Tables, an International Comparison." The Review of Economics and Statistics. 47 November 1965.

20. Sraffa, Pierro. Production of Commodities by Means of Commodities. London, Cambridge University Press, 1960.

21. Stewart, Frances and Streeter, P. "Conflicts Between Output and Employment Objectives in Developing Countries." Oxford Economic Papers. New Series. 23 (2) July 1971.

22. Szentes, Tamas. The Political Economy of Underdevelopment. Budapest, the Centre for Afro-Asian Research of the Hungarian Academy of Sciences, 1970.

23. Ternham, D. and Jaeger, J. The Employment Problem in Less Developed Countries. Paris, O.E.C.D. Development Centre, 1969. mimeo.

24. Thomas, C.Y. The Transition to Socialism: Issues of Economic Strategy in Tanzanian-Type Economies. University of Dar es Salaam, 1972. mimeo.

25. Thomas, John W. The Choice of Technology in Developing Countries: the Case of Irrigation Tubewells in Bangladesh. mimeo.

26. Wells, Louis T., Jr. Economic Man and Engineering Man: Choice of Technology in a Low Wage Country. Background Paper for the Ford Foundation Seminar on Technology and Employment, held in New Delhi on March 21 - 24, 1973.

27. Wuyts, M. The Choice of Techniques: Some Critical Questions. Paper Presented at the Conference of the East African Agricultural Economics Society, held in Dar es Salaam on June 20 - 23, 1973.

INDUSTRIAL DEVELOPMENT AND POLLUTION IN MAURITIUS

By

L. Hurpaul, Head of Environmental Health Unit,

Ministry of Health, Mauritius

FOREWORD

This paper sets out to discuss the environmental problems involved in industrial growth in various parts of Mauritius and attempts to show that definite standards can be laid down for adequate industrial planning. Comparative case studies are presented showing some of the ways in which pollution occurs in urban and rural industrial areas. Its effects on water, air, plants and man have also been stressed. It is also pointed out that lack of sound development planning hampers the economic and social advantages that should result from industrialisation.

INTRODUCTORY BACKGROUND

Mauritius is a small island of 720 square miles off the eastern coast of Madagascar. Since the Second World War, with the virtual elimination of malaria, the population has increased at the rapid rate of 3 per cent per annum and now stands at 820,000. The climate of Mauritius is determined by its oceanic position and its location at 20° South in the belt of the south east trade winds. The winds blow strongly throughout the winter months of May to September, but in the summer months of November to April, they are weaker and veer east. Rainfall is markedly seasonal, particularly in the coastal region. The wet season lasts from December to May and the driest from July to October. Rainfall varies from 200 inches a year over the central plateau to 40 inches on the northern coast. The maximum night temperature during the hottest months averages 31°C, in winter it averages 25°C.

INDUSTRIAL GROWTH

The high population density has naturally created problems for the Mauritian economy which is predominantly agricultural with an annual production of about 700,000 tons of sugar. Recent efforts have been made to diversify the economy away from its complete dependence on sugar. It was obvious that Mauritius could not rely entirely on one crop for its economic growth. Mauritius, like other developing countries, in its efforts to meet its growing population and employment needs has opted for a short-term benefit approach to development and industrial growth but not without much harm done to the environment.

The developing industrial sector is of comparatively recent origin.

Up to the early 1960s industry comprised a small portion of the economy, and such manufacturing as the country then possessed was based mainly upon processing agricultural products such as sugar and tea. In the early 1960s government introduced a series of incentives and concessions designed mainly to encourage entrepreneurs to replace imported manufacture industries. With a wide range of concessions and incentives, industrial growth started to take place.

From the Census of Industrial Production undertaken in 1968 (See Table 1) it was found that a total of 180 large establishments, outside the production of sugar and tea, produced almost excusively for the small domestic market. (1)

Table 1. Growth of large establishments.

Industry Group	Number of Establishments 1967-68 Census	Bi-Annual March 1968	Survey March 1972
Mining and quarrying	4	4	4
Salt	4	4	4
Food	18	17	33
Bread	10	9	17
Biscuits and confectionery	6	6	9
Other	2	2	7
Beverages and tobacco	19	20	20
Distilleries	3	3	4
Wine and beer	7	8	6
Soft drinks	6	6	6
Compounding of spirits and cigarette manufacture	3	3	4
Textiles	8	9	4
Aloe fibre and sack factory	8	9	4
Wearing apparel	12	12	23
Footwear	5	6	8
Tailoring and shirt making	7	6	15
Wood and furniture	10*	11	17
Printing and publishing	18	20	24
Rubber and leather products	5	5	9
Chemical products	10	9	14
Non-metallic mineral products	22	23	22
Stone and concrete	19	18	16
Other	3	5	6
Metal products	11	10	19
Repairs of non-electric machinery	10	8	6
Repairs of electric machinery	4	5	5
Transport equipment	24	17	20
Building of transport equipment	4	4	5
Repairs of motor vehicles	20	13	15
Miscellaneous manufacturing	5	5	11
Total	180	175	231

* Includes one establishment in paper and paper products.

The greatest number of establishments was recorded in the sector of tailoring, dressmaking and allied activities. In addition, to support the housing and hotel expansion, construction and stone crushing establishments were erected haphazardly in all parts of the island.

Because of the early success of industrialisation, emphasis was then placed on export-orientated industries during the last three years. Two most important new industries which will replace substantial imports are under construction; a plant for the manufacture of 100,000 tons per annum of chemical fertilisers and a particle board plant with a capacity of 5,000 tons per annum using bagasse as the basic raw material. The prospect of setting up a plant with an annual production of 200,000 tons of cement is under consideration and will soon be implemented.

LOCATION OF INDUSTRIAL DEVELOPMENT PROJECTS

Industrial development siting has been geared towards solving unemployment problems and saving foreign currency. The whole concept of development planning has been largely directed towards the increase of gross national product, rather than the broader definition of social and economic development and the integration of environmental planning. Frequently in the planning of industrial development most attention has been directed to the availability of cheap labour and the increase of employment likely to be created within the area concerned.

With the exception of sugar mills and tea factories, virtually all industrial development has taken place in the environs of Port Louis and in the Plaines Wilhems district. It is more than likely that this industrial development will continue in Port Louis. The most important concentration, located one mile south east of Port Louis, is the Plaine Lauzun Industrial Estates where most of the light industries are established. Some 250 acres of tidal marsh have been reclaimed from the sea adjacent to the harbour, and this is likely to be reserved for the erection of noxious industrial plants, which include a chemical fertiliser plant, texile mills and food processing plants. It appears that the general policy favours the concentration of industries around Port Louis on the grounds that new industries, on which the growth of manufacturing depends, will be export-orientated. All materials used must be imported and all goods produced exported, so that access to the port facilities will be an important factor in their location.

Industrial development outside the capital is mainly concentrated in a type of ribbon development. Table 2 summarises details of industrial

development as of March 1972 by geographical distribution. The table also shows very clearly the marked concentration of employment in Port Louis and Plaines Wilhems. These two districts between them account for 92.6 per cent of large industrial establishments and 93.6 per cent of the total industrial labour force. Furthermore, a number of potential areas suitable for industrial sites have been identified, all in undeveloped urban areas. Out of a total of about 1,100 acres of land allocated for future industrial sites involving an estimated 70,000 workers, only 250 acres are in rural areas.

Table 2. Industrial establishments and employment by geographical district, March 1972.

Geographical District	Number of Establishments	Employment
Port Louis	160	7,049
Pamplemousses	4	109
Riviere du Rempart	4	251
Flacq	2	48
Grand Port	5	114
Savanne	-	-
Plaines Wilhems	64	3,179
Moka	1	153
Black River	2	20
Total	242	10,923

PHYSICAL PLANNING AND CONTROL IN RELATION TO INDUSTRIAL DEVELOPMENT

In the early days around 1960, inadequate rules and regulations governing manufacturing activity resulted in anarchic industrial growth. At that time regulations only dealt with factory layouts and sanitary aspects and to a very little extent with the health of workers. They did very little to control the many harmful effects of industrial activities.

It is proposed in the near future for the whole island to be declared a planning zone with the result that all physical planning for industry will be under the sole responsibility of a Town and Country Planning Board. Prior to this, legislative authority has been allocated by the central government to the urban and rural authorities. In addition, all industrial plans are approved by the Environmental Health Unit of the Ministry of Health.

There is at present no adequate legislation to implement policies of environmental control. However, the Environmental Health Unit in the Ministry of Health has been in operation nearly five years. Some of its

objectives are:

(1) the quality control of water including approval of treatment works;

(2) the quality control of effluents including air pollution, water pollution, liquid and trade waste;

(3) the control of the sanitary requirements of all buildings in rural and urban areas;

(4) sanitation and hygiene in food manufacturing plants; and

(5) industrial hygiene and occupational health.

INDUSTRIAL POLLUTION

The environmental problems of Mauritius fall into two categories: the problems arising out of poverty or the inadequacy of development itself, and the very process of development. The problems in the first category are reflected in the poor social and economic conditions that prevail in the rural and urban areas and in the second category : the problems are caused by uncontrolled industrialisation with its related health hazards.

The scope of this paper does not permit discussion of all the details of the pressing social and economic problems of Mauritius, but it is hoped that the emphasis which is now being given to a more unified approach to development will result in a better recognition of the environmental problems.

It is proposed to consider the environmental impact for some specific types of industries, or more precisely how the environmental consideration has been overlooked in their planning. As the process of industrial growth is still developing, industrial pollution has not yet reached alarming proportions in all areas. However, sporadic cases of environmental pollution occur from some of the new industries such as textile mills, a fertiliser plant and a cement plant. In addition, gross pollution has always been present from old established industries such as sugar factories. These are discussed below.

Pollution from Sugar Mills

The manufacture of sugar is the backbone of the Mauritian economy. Out of a total of 21 factories producing 700,000 tons of sugar annually most are located in the rural areas and many of them are within a few miles of the sea. (2)

Sugar Mill Effluent Characteristics: Waste water flows and characteristics vary widely depending upon the size of a mill and the methods and processes used. Few data are available on the quantity of water used by the sugar mills, but where sources of fresh water are abundant, mostly from nearby streams and rivers, water consumption can range from one to four cubic feet per second.

Few tests on the effluent characteristics have been carried out, but physical observations have been made to assess the extent of pollution on the receiving waters. Gross contamination has been shown at points of discharge and further downstream prolific growth of aquatic plants. A survey of 103 sugar cane factories in India has indicated an average production of 300 gallons of waste water per ton of cane with a biochemical oxygen demand (B.O.D.) of 570 mg/l and total solids of 2,500 mg/l. As a comparison to show the pollution potential of sugar mill effluent, the total solid content in drinking water should not exceed 500 mg/l and the B.O.D. in a clean stream should be below 5 mg/l. (5)

Stream Pollution: The average amount of cane handled by a local sugar mill in Mauritius is 2,600 tons in 24 hours. This will give a daily waste water flow of 800,000 gallons and require 4,600 pounds of oxygen in the stream to assimilate the waste. The effluent is frequently discharged directly into the nearest stream which within a few hours reaches the sea. Obviously, this short period of time gives the stream no chance whatsoever to purify itself by reaeration, and consequently the polluted stream water discharges directly into the sea with adverse effects on the beaches and the coastal waters.

In addition, the sugar harvesting season lasts from June to December at a time when most of the rivers have a low flow as these months are during the driest period of the year. Consequently, the rivers and streams receiving the sugar mill raw effluent provide little opportunity for dilution of the thermal wastes and thus there is heavy pollution at the point of entry into the streams. From inspections made of streams it has been noticed that within a distance of about half a mile from the point of entry of the thermal effluent into the streams the aquatic life undergoes severe stress. Fish and other aquatic organisms are totally destroyed and the river bed is covered with a thick layer of sludge.

At the same time the effluent from the sugar mills is rich in nitrogen content which accelerates the entrophication of the water in the streams and rivers. So, in many cases the whole body of water is choked by prolific growth of aquatic vascular plants. This is an ever-increasing nuisance to washerwomen and for other people who utilise the water for domestic purposes and constitutes an actual and potential breeding place for mosquitoes.

Another local example of the effects of sugar mill effluent has been the killing of fish by pollution of the water in a fish rearing lagoon. Had not appropriate measures been taken to pretreat the effluent, the fish

population would have been completely destroyed with consequent economic loss.

Also, it cannot be over-emphasised that with an ever-expanding tourist trade every effort should be made to control the discharge of raw effluent, consisting of floating particles of soot and bagasse, into the coastal waters so as to keep the beaches and sea-shores attractive and clean.

Air Pollution by Bagasse: Fibrous residue from the grinding and screening of particles from the sugar cane juice called bagasse amounts to 30 per cent by weight of cane processed. The average daily bagasse output per mill is of the order of 800 tons. Most of this is usually burnt in the boiler plant for generation of stream which provides enough power for the overall operation of the mill.

The soot and fly-ash escaping from the chimney stack is carried over several miles by the wind, depending of course on local meteorological conditions and topography. These particles emitted from the chimney are more a nuisance than a health hazard as they are deposited into and around peoples' dwellings and soil the laundry that is left out to dry. The Environmental Health Unit receives large numbers of complaints from householders about soiled laundry and spotted surfaces of furnitures. One example of this nuisance was that the wind born particles of flyash and soot were reaching a nearby hospital and contaminating the wards and operating theatre. It was suggested to the factory management that water jet traps be placed at different chimney heights to try to minimise the escape of soot and fly ash into the atmosphere. Some reduction in the amount of particles escaping from the chimney was achieved, but because of the large amount of bagasse burnt and the high velocity of the flue gas, these rudimentary traps did not prove to be very effective and the nuisance unfortunately continues during the crop season. Effective control of this emission would require the installation of sophisticated dust control equipment such as cyclone scrubbers, the cost of which is far in excess of the financial capability of the factory management.

PROPOSED CEMENT PLANT AT LES SALINES

Description of Locality

A proposed cement plant with an annual capacity of 200,000 tons is to be located at Les Salines about two miles west of the city of Port Louis and about one mile west of the existing docking facilities in a densely populated residential area (population 10,000). In the vicinity of the proposed plant site is situated the Robert Edward Hart Garden, a recreational park visited at all times of the year by local residents and tourists.

The Process

It is regretted that the writer is unable to furnish proposed details of the cement project, but it is understood that the cement plant will follow the standard processes of manufacture of the cement industry which shall be described.

The raw materials used in making all types of Portland cement are calcium carbonate, which is found in the form of limestone or chalk, and alumina, silica and iron oxide, found combined as clay or shale. The first stage of the manufacturing process consists of mixing the clay or shale to a slurry with water and then with the chalk or finely ground limestone. The slurry is screened and pumped to large storage tanks where it is kept agitated by mechanical stirrers or compressed air (in some cases both) pending its passage to the kiln. The kiln is a long mild-steel cylinder with a refractory lining, supported on rollers so that it can rotate about its own axis, and erected with a slight inclination from the horizontal. The prepared slurry is fed continuously into the higher end and moves to the lower end as the kiln revolves. The kiln is fired by pulverised coal blown into its lower end. As the slurry becomes heated it undergoes successive changes. First the water is evaporated; next the calcium carbonate is decomposed into calcium oxide (quicklime) and carbon dioxide. At a temperature of about $1,500^{\circ}C$, incipient fusion occurs and the components of the lime and the calx combine to form calcium silicates, calcium aluminates and other compounds which together make up the cement clinker. The clinker is finally cooled and ground to a fine powder. During grinding a small proportion - 4 to 7 per cent - of calcium sulphate (gypsum) is added to prevent the cement from setting too rapidly when used. The different types of Portland cement are obtained by varying the proportions of the raw materials, the temperature of burning and the fineness of grinding.

Details of the Proposed Cement Plant

Construction of a cement plant is considered highly desirable for Mauritius on purely economic grounds because the local demand exceeds the present imports and it is known that 90 per cent of the basic raw materials are available locally. The consumption of cement for the year 1973 amounted to 155,000 tons and with industrial and building expansion the consumption has been estimated to rise at a rate of 6 per cent annually.

The plant is to be sited at Les Salines where raw materials such as coral sand can be easily obtained. Coral sand, which amounts to 80 per cent of the basic raw materials for the manufacture of cement, will be dredged at the rate of 250,000 tons annually from the sea bed in the harbour area. Trachyte, a siliceous rock which is another ingredient in the manufacture of cement, will be mined at the rate of 20,000 tons annually from Piton du Milieu, 20 miles away from the cement plant. Another 20,000 tons of gypsum and silica sand will be imported per year.

The kiln will be fired by oil containing 3 per cent sulphur with an annual consumption of 28,000 tons.

Environmental Hazards of the Proposed Cement Plant

The proposed cement plant, however justifiable on economic grounds, appears to be a flagrant case of neglecting environmental considerations such as marine ecology, air pollution and zoning. These environmental consequences are discussed below.

Potential Threat to the Harbour Facilities: The hydraulic dredging of some 250,000 tons of coral sand annually from the sea bed between the harbour and the reefs surrounding the entrance to the harbour will most likely interfere with the natural balance and protection of the coastal area surrounding the harbour entrance. It is well known that the calm and sheltered waters in the harbour depend entirely on the protection afforded by the natural coral reefs surrounding the harbour. Removal of coral sand between the reefs and the shore could well jeopardise this protection. It cannot be said that the destruction of the reef would likely occur, but the risk is there, and should this happen the consequent cost of constructing breakwaters would be immense.

Moreover, it is not necessary to emphasise the vital importance of the harbour to the economy, indeed the very existence of Mauritius. Experience of the cyclonic weather with heavy seas running from a westerly direction points to a grave risk from tidal waves and cyclonic surf if there is any interference in the harbour's natural protection.

Possible Damage to Marine Economy: The proposed extraction of coral sand from the sea bed is not only hazardous to the safety and protection of the harbour, as already pointed out, but also dangerous because of the ecological changes that may occur to the marine environment. Coral reefs are important habitats for a multitude of marine life. A large number and variety of fish species and invertebrates live amongst these coral reefs. Often species of fish from the lagoons as well as from the ocean water spawn on or besides these coral reefs. Eggs larvae and juveniles of other types of fish are dependent on coral reefs for habitat during their early stages of life. It would be expected that the fish and other marine organisms would be under severe stress in these regions with grave consequences to the fishing industry. It is also quite feasible that the removal of coral sand during dredging operations will adversely affect the growth of corals on the reefs.

These ecological changes to the sea bed occuring as a result of the extraction of coral sand may extend a long distance away from the point of dredging. It cannot be stated here what damage will be done to marine life, but it would be wise to preserve this marine life as Mauritius relies heavily on sea fish.

Expected Hazard from Dust Fall-Out: The following points should first be mentioned. The pollution of the atmosphere by dust particulates from the cement kiln may have the following effects:

(1) reduced visibility;
(2) general dustiness in the area;
(3) retarded growth of the vegetation;
(4) nuisance to the inhabitants;
(5) deterioration of exposed materials;
(6) thermal pollution of atmosphere; and
(7) health hazards to workers and inhabitants.

The sources of dust are from crushing plants, grinding mills, at blending and transfer points and in the bag filling kiln. Emissions from the wet process of producing cement range from 15 to 50 pounds of dust per barrel of cement produced (4) (1 barrel = 45 gallons). Working with 30 pounds of dust per barrel of cement produced which is a typical value, the dust emission will be about 12,000 tons for the proposed plant capacity of 200,000 tons annually. Sulfur dioxide at the rate of 1,700 tons per year will also be emitted from the kiln as a result of burning oil. Ultra-fine particles of this dust remain in the air forever, whereas the larger particles settle to the ground with time. According to the size frequency distribution of dust discharged through the kiln stacks, 70 per cent of the dust will be below 5

microns. This fine dust is more harmful to human beings since it tends to stay longer in the lungs.

From tests carried out in India at 10 cement plants, the average air-borne dust concentration at the cement mill of 3 factories was above the threshold limit value (T.L.V.) of 1,750 parts per cubic centimetre (ppcc). However, the average air-borne dust at the cement mill for all the factories was 1,214 ppcc which was below the T.L.V. of 1,750 ppcc. (3)

From the foregoing it is obvious that the production of cement is a highly polluting industry. The most prevalent chemical constituents of the dust particles escaping from the kiln into the atmosphere are: calcium oxide (41 per cent) silicon dioxide (19 per cent) and aluminium oxide (9 per cent). The balance would be predominantly carbon dioxide and steam. The high temperature of the stack plume may well render the dust abrasive and harmful to health.

It is hoped that with the installation of electrostatic precipitators in the cement kiln, 90 per cent of the dust will be removed. Although a good percentage of the cement dust can be trapped (90 per cent or more) by appropriate gas cleaning devices, the collection of dust from cement kilns is a difficult and expensive process. These facts are confirmed by the results of the survey of dust control measures in cement factories carried out in India where electrostatic precipitators were working with very poor efficiency because of lack of maintenance and poor voltage regulation.

Possible Pollution Threat to the City of Port Louis: During the summer period there is a direct threat to Port Louis of dust fall from the cement kiln stack, especially during the months November to May when winds blow from a westerly direction about 20 per cent of the time. This will cause the dust laden air to travel inland and reach the Port Louis city centre.

Results from ten cement factories in India showed that the highest concentration of air-borne dust occured within one mile of the source. (3) It should be mentioned here that within a distance of one to two miles from the proposed plant are concentrated most commercial, administrative and many government buildings. It would appear that nearly all these buildings will be coated by the corrosive dust fall-out, with consequent harm caused to the residents and people coming to Port Louis. The harbour would not escape the dust fall-out during the summer months either, as it lies 1.1 miles due west of the proposed cement plant. Loading and unloading food commodities in the port might be seriously affected.

Detrimental Effects to the Robert Edward Hart Garden: The pollution effects of siting a cement plant in an area rezoned from 'recreational land' to 'industrial zone' would seriously harm the plants in the Robert Edward Hart Garden. Noise and dust emanating from the cement plant at a distance of $\frac{1}{4}$ mile from the garden would turn the place into a deserted area. It should be remembered that this garden is the only open and green space offering recreational facilities in this particular part of Port Louis.

ENVIRONMENTAL ISSUES IN THE INDUSTRIAL DEVELOPMENT PROCESS

It is possible that the various types of environmental problems which are of concern to Mauritius can be resolved to a large extent by the process of development itself. However, the experience of some developed countries has shown that unregulated industrial development can produce a lot of negative effects on the environment. Developing countries must therefore view the relationship between industrial development and the environment in a different perspective, so as to prevent similar undesirable conditions occuring.

There is a tendency in Mauritius to equate industrial development with the narrowly conceived objective of economic growth, as measured by the rise in gross national product. Since the economic well-being of the country is uppermost in the minds of many industrial developers, the environment is sacrificed to the cause of quick development and is frequently considered of secondary importance. This approach is clearly shown in the case study of the proposed cement plant where, because of anticipated economic gains, environmental hazards, although of equal importance in the opinion of the writer, do not appear to have been given the serious consideration they deserve.

It also seems to have been taken for granted by enterprises that the environment is a 'free good' which can be used and contaminated at will in the pursuit of high and quick profits. For the well-being of the people as a whole, the environment is part of a country's real wealth and cannot be treated as a free source. Only in a planned economy can care be taken for the whole scope of environmental problems. It is important that a new emphasis be placed on the attainment of social targets as part of development goals. The redefinition of development objectives must include greater stress on income distribution and employment, more attention to social services and welfare-oriented public goods.

It is apparent that the current trend in local industrial planning is for urban areas to become exclusively industrial and rural areas to depend exclusively on primary agricultural cultivation. This kind of industrial development will most likely lead to polarisation into urban and rural economies and consequently accelerate migration of workers from villages to towns. This trend should be vigorously counteracted inspite of the economic advantages of concentrating industries in urban areas where infrastructural facilities are currently available.

If the location and selection of industries are not controlled in the outskirts of towns, urbanisation will quickly become a pressing problem. The city of Port Louis, for example, spreading over an area of some 20 square miles with an estimated population of 140,000, is already congested and overcrowded. It frequently suffers from shortages of water for domestic and industrial purposes. The influx of an estimated 60,000 workers entering the industrial labour market, mostly in the towns, will aggravate the existing housing and community hygiene problems leading to more slums and will further strain the water supply situation.

Furthermore, with the growth of industries the demand for public and commercial transportation will obviously increase with its well known consequences of air pollution, noise and high accident rates. Traffic is dense in Port Louis and most of the urban areas. It has also been observed that clouds of diesel smoke from the exhaust systems of commercial and public hire vehicles are formed during peak hours in Port Louis and environs.

In the process of industrial development in Mauritius adverse effects to the environment can be avoided by sound planning. Sound planning means the balanced utilisation of land, air and water and of human resources for all purposes. It is true that economic activity, and in particular industrial production, consitutes the very basis of urban development, but it is also essential to ensure a healthy environment so that industrialisation may proceed under favourable conditions and the population may derive from it all the advantages hoped for.

There are many advantages to be gained at this stage of industrial planning by incorporating all necessary measures that will safeguard the environment into relevant legislation for environmental control, including regulations to deal with urban zoning, location of industries, protection of natural resources and powers of enforcement where necessary. To conclude it is a well known adage that "Prevention is better than cure" but it is even more true to say "Prevention is cheaper than cure" in some of the circumstances outlined in this paper.

BIBLIOGRAPHY

1. Mauritius. Four-Year Plan for Social and Economic Development. 1971.

2. Mauritius Sugar Research Institute. Annual Report. 1972.

3. Pollution from Cement Industry. Proceedings of a Symposium on Environment Pollution held at the Central Public Health Research Institute of India in 1973.

4. United States Public Health Service. Rapid Survey Techniques for Estimating Community Air Pollution Emissions. 1968.

5. World Health Organisation. Treatment of Sugar Cane Wastes. W.H.O. Technical Paper. 1970.

HUMAN SETTLEMENTS AND THE ENVIRONMENT: THE RURAL AREAS

By

A.L. Mabogunje and M.O. Filani, Department of Geography,
University of Ibadan

This presentation is in two parts. The first section examines the general nature and quality of environments in the rural areas, offers some explanations for the prevailing conditions and suggests areas of action where policy decisions and purposeful planning can ameliorate the low quality environments found in these rural areas. The second part presents a case study of a rural development project - the Niger Agricultural Project in Nigeria - which failed. Causes for this failure are examined in detail and suggestions are made as regards what could have been done to avoid failure as a rough guide for other future projects meant to upgrade low quality rural environments.

INTRODUCTION

The concern for the nature and quality of environment is becoming an increasingly important problem of interest both in the technologically advanced countries and the developing ones. Attention has often been drawn to the problems presented by the current trends in the growth of population, the difficulties of ensuring adequate food supplies for the human race and the continued strain upon stocks of renewable and non-renewable resources. The recent intense interest in environmental questions, however, could be attributed partly to increasing urbanisation and our lack of satisfaction with the physical and social environments that the cities provide. For instance, the rapid growth of cities, most especially in the twentieth century, has set in motion a range of nuisances which to many people have become quite intolerable. Such nuisances as atmospheric pollution, traffic congestion, crimes and the like are common phenomena not only in industrialised societies but also in the developing ones. Environmental problems are not confined to cities alone, they are also prevalent in rural areas of the world and, in particular, the rural areas of Africa. Generally, environmental questions have become political problems in many parts of the world as evidenced by the pronouncements and programmes of several governments and international agencies and the allocation of public funds to environmental planning.

ENVIRONMENTAL PROBLEMS IN RURAL AREAS

Environmental problems in developing countries are both urban and

rural in nature. They are problems which have arisen out of poverty, inadequate development and out of the very process of development itself. In particular, the environment in rural areas is affected by mass poverty, malnutrition, low quality housing, poor water supply, inadequate sanitation, prevalence of diseases, illiteracy and natural disasters. These problems are further compounded by the increasing wave of rural-urban migration and the poor perception of the rural areas not only by outsiders but by the rural inhabitants themselves. In the context of our concern for the human environment, these problems are no less than those of industrial pollution which clamour for attention in advanced countries.

Certain patterns of economic development in developing countries, especially in Africa, seem to have aggravated the acute social and environmental problems in rural areas. It is common knowledge that the space economy of most of the African countries (if not all) revolves around a few urban centres which to a large extent were developed during the colonial days to achieve efficient organisation of an export-oriented economic system. Over time, this had led to the development of a marked pattern of regional inequalities with these few urban centres developed out of proportion to the vast rural areas of the continent. Historically, such a spatial pattern of economic growth has, in many cases, been accompanied by excessive exploitation of the neglected rural areas by the few favoured urban centres, rising unemployment, greater inequality in the distribution of infrastructural facilities and an increasing poverty for large sections of the population in developing countries. This is more so when it is realised that these urban centres themselves are 'parasitic' rather than 'generative' in the process of economic development in different countries.

The predominant part of Africa's population (85 per cent) still lives in the rural areas. Often, these communities suffer from inadequate services of one kind or another, contributing to the persistence of low levels of production and hence incomes. Rapid population growth in recent times has tended to aggravate the problems and impose further strains on rural resources. Yet there is a strong relationship between various facets of environmental quality and people's income levels. One can in fact almost assert that the higher the income level of a society, the better the quality of its rural environment. This is particularly true with regards to the provision of certain social amenities.

As has been documented in all African countries, the per capita income of the rural population is invariably lower than that obtained in the urban centres. (6, p. 4) The economic gap between the rural and urban

areas continues to widen. As a result, tax bases are larger in the cities and this is reflected, as would be expected, in their greater allocation of funds for the improvement of facilities such as schools, water supply, electricity and the provision of greater cultural and social amenities. To this tax base advantage is added the greater political pressures which urban centres can exert on policy decision makers. The low income levels of the rural areas, in essence, create low quality environments, which in turn set in motion certain mechanisms which tend to accentuate urban-rural differences and aggravate the already low quality of life in these rural areas. Unfortunately, these mechanisms, once set in motion, make it less likely that the low quality environment will be upgraded.

CHARACTERISTICS OF LOW QUALITY ENVIRONMENTS

Before discussing these mechanisms, it is useful to analyse briefly some of the salient characteristics of the low quality environments in the rural areas. The economy of the rural areas in most African countries is typically a subsistence agricultural economy and is marked by little or no diversification and a low productivity level. In many cases, there is a concentration on a single primary product such as cocoa, palm oil or groundnuts. These are crops which are susceptible to world fluctuations in prices and demand. Thus, there exists an element of uncertainty in the resource base or income producing activities of the rural environment.

Added to this is the inadequacy of infrastructural facilities and the continued heavy reliance on the use of traditional methods and equipment for production - shifting cultivation, hoeing and the like. These account not only for some waste in land resources, but also low productivity, hence low income levels and low quality environments. Even when production is meant mainly for home markets (foodstuffs in particular), inadequate accessibility usually prevents regular movements of produce from villages into rural or urban markets. Lack of transportation and communication means lack of information on the availability of markets and market price conditions, factors which may exert direct or indirect constraints on the economic development of rural communities. The urban market structure itself quite often works to the detriment of the village farmer, most especially when the profiteering attitude of the middlemen is taken into consideration.

There are also natural disasters, many of which are quite difficult, if not impossible, to forestall. For instance, unprecedented rainfall may intensify soil erosion problems, and droughts, locust invasions and other types of disasters have been known to cause untold destruction to crops, the

failure of well-meaning development projects and the impoverishment of the overall rural economy. These cause severe hardships and a further deterioration of the environment.

The rural environment is also characterised by inadequate supplies of healthy drinking water. More frequently, the source of water is from a central point, usually a river at some distance from individual villages. Families may spend several man-hours per day in collecting enough water for their domestic needs. In some villages dug wells constitute the source of water supply. Shortage of water is a common occurrence in these communities, particularly during a prolonged dry season when both rivers and wells may dry up or the available water becomes grey-brown in colour. Thus, water is impure and there is virtually no chemical treatment whatsoever before drinking takes place. This untreated water poses a health hazard since certain diseases are commonly associated with impure drinking water. Drinking impure water could adversely affect the productivity of farmers in the rural areas. For example, guinea worm infection, a debilitating water borne disease, can cause a farmer to lose a large number of man-days of farm work annually.

Another critical characteristic of the low quality environment concerns poor housing conditions. We all know very well that, apart from food, shelter is a prerequisite for man's survival. Good housing can raise the morale, efficiency and productivity of workers. On the other hand, poor housing conditions can lead to unhappy family relations, ill-health and a high incidence of diseases. In many rural areas of Africa, housing is poor, defective in design and in the provision of sanitary facilities. (For a detailed discussion see 6.) Houses are still mostly traditional, designed in accordance with cultural heritage and traditional techniques. They are usually built by the local people who lack knowledge of modern construction techniques. Consequently, the rooms are small with little or no ventilation and overcrowding is frequent. The roofs are generally thatched, and just as leaking roofs create problems during the rainy season, the buildings also constitute fire hazards during the dry season.

These characteristics pose a serious problem for regional planning in the rural areas. This is particularly so because of the way the characteristics are communicated by migration and the perceptual values people attach to the rural environment.

MECHANISMS PERPETUATING LOW QUALITY ENVIRONMENT

The perception of rural environments and migration from them constitute two major facets of the mechanisms which render the upgrading of these environments difficult. These two operate in such a way as to sink the existing low quality environments further into the mire.

The perceptions or 'mental maps' that men hold of their environment are often critical in the formation of decisions which restructure the human landscape. Locational decisions about where to settle, where to locate industries, commercial enterprises and agricultural projects or what to grow are more often than not based on our perception of a given environment. Quite a number of studies of space preferences have been made and their results provide interesting evidence of how people perceive and evaluate geographical space in terms of residential desirability.[1] A common message which pervades all the works on perceptual environments relates to the fact that in developing countries, rural areas (low quality environments) are generally unattractive areas. This message is very important when one considers that the attraction of growth incentive activities - industries, commercial concerns or large scale agricultural projects - is highly dependent upon the ability to persuade certain management and skilled personnel to move to these low quality environments. Experience has shown that generally key personnel necessary for development projects are reluctant to move into rural areas. This makes it more difficult to introduce there those employment generating activities necessary to diversify the occupational structure and to inject money that could bring about better quality environments.

The second factor, rural-urban migration, is equally important if not more problematic. What makes migration from rural areas particularly disturbing is its highly selective nature in terms of skills, ages and education. More often, the younger, the better educated and the more highly skilled, who constitute the cream of the community, are those who migrate elsewhere. This group of people usually leave behind the older, the less educated and the less skilled. The generally unattractive image of the areas prevents in-migrants from other areas from replacing the losses, and there remains a population composition which is unfavourable to social and economic development.

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1. For a detailed study on perceptual environments see Gould (2), and also Saarinen (4).

The loss of the most productive elements in these areas adds a further dimension to their unattractiveness to potential industrialists and makes them less favourable locations for development projects. This loss also imposes burdens on those remaining, who, in turn, are less able to bear them than those who have left.

In short, the rural areas appear to be engulfed in a vicious circle of poverty in which one event perpetuates the other, making any attempt to break this circle a herculean task. As already argued in the early sections of this paper, the problems of rural environments partly emanate from the very process of economic development in various countries. It is significant to note here that the solutions to these problems will have to depend on this very process which created them in the first place.

POLICY ISSUES

Upgrading the low quality environments in rural Africa necessitates conscious regional planning programmes and activities to rectify the imbalances and inequity in the previous development patterns. The concern for these environments must be treated as an added dimension of national planning. Purposeful planning at the national level should get down to the level of the rural villages and communities where development goals should be expressed in terms of a progressive reduction, and eventual elimination, of mass poverty, disease, illiteracy, unemployment and inequality and the creation of a decent human environment. (5)

There are important reasons why measures have to be designed to eliminate inequality in environmental quality. These are not only moral, that is the right of an individual to have a decent living no matter where he lives, but also economic and political. It is clear that the problems of low quality environments can spill over into high quality environments and thereby reduce the quality or compound the problems of the latter. For instance, as migration waves from rural to urban areas continue unchecked, the problems of the cities are exacerbated and living conditions in them become intolerable. Social discontent and at times political upheaval may result from this situation.

It is thus the contention of this paper that the degree to which improvements in rural environments can be carried out depends on the extent to which planning is carried out to bridge the economic gap between rural and urban areas, to make available to rural areas a diversity of employment opportunities and to introduce there those activities which would increase

the productivity of rural labour and hence the incomes of the inhabitants. Some salient factors which become relevant in this regard are:

(1) the decentralisation of services from the existing few urban centres and a more equitable spatial distribution of infrastructural facilities and other amenities;

(2) a wide distribution of effective markets to ensure increased agricultural productivity in the rural areas;

(3) siting of public investment projects to which the rural inhabitants and their economy can relate; and

(4) effective integration of rural communities into the national planning framework.

One useful measure for preventing the alienation of rural inhabitants from well intended projects is to make local governments or local community development units participate more actively in national development plans. These units can be instrumental in promoting the constructive participation of citizens in development and themselves serve as building blocks for development efforts not only at the regional and national levels but also at the grass root level.

Within the rural areas themselves, there is always the question of where public investment and assistance, aimed at development, should be concentrated. Since it is practically impossible to locate amenities in every village and farm in the rural areas, it becomes desirable to create rural growth centres. These centres could provide suitable locations for the processing and craft industries mentioned earlier, for infrastructural facilities and amenities such as electricity and pipe borne water, schools and health centres. They will also serve to upgrade the low quality environment and make it more attractive to the professional workers and potential entrepreneurs necessary for economic development. Above all, the growth centres would become readily available markets for agricultural produce, especially foodstuffs and perishable goods. They will also reduce rural-urban migration since the potential migrants who might have acquired a certain amount of professional training can now stay and look for employment in their home areas.

CONCLUSION

Several questions have been raised in this paper concerning low quality environments in the rural areas. The close relationship between income levels and environmental quality has been highlighted. We have noted that the poverty of rural areas is underlined by the lack of diversity in their economy, the inadequacy of their infrastructural facilities and the insufficient amenities, all of which have been created by the very process of development in developing countries. This poverty is further compounded by certain mechanisms which seem to hinder possible regenerative processes. Particularly critical here are the negative perceptual values attached to the rural environments which deter the establishment of potential activities for economic diversification or regeneration, and selective migration which deprives the rural areas of their most productive and educated elements.

It is also argued that improvement of environmental quality in these areas is of critical significance and an indispensable strategy for any purposeful national or regional planning. In such planning, economic development programmes must be combined with policies of social development designed to make low quality environments more attractive to personnel required for generative activities. In order to accomplish this, it is suggested that rural growth centres be created to serve not only as effective markets for the predominantly agricultural population, but also as suitable locations for agro-industries and facilities such as education, health centres, piped water and other amenities hitherto concentrated on the few favoured urban centres.

CASE STUDY OF THE NIGER AGRICULTURAL PROJECT

The problems of rural areas of Africa have been the focus of a good deal of public concern and comment. Unfortunately, these problems continue to persist and in some cases they multiply daily. Few rural development schemes from the colonial era to post independence periods in various countries have been more than doubful successes, and several have been staggering failures. For example, while the Gezira scheme in the Sudan could be sited as an example of a successful agricultural project, others such as the East African Groundnut Scheme, the Kariba Dam Lake area scheme and the Niger Agricultural Project, to mention a few, are examples of those which have failed. In this section we present a case study of one of these development schemes - the Niger Agricultural Project - which failed. Reasons for its failure are treated in detail and suggestions are made for

avoiding the mistakes of the past in any future endeavour of this type.

The Niger Agricultural Project was one of the many regional economic development programmes undertaken in Nigeria to increase the income of farmers by raising agricultural productivity.[2] It was initiated in 1949 with the main objective of developing vast areas in the relatively sparsely populated region of Nigeria known as the 'Middle Belt'. The project was based in Mokwa, a small village about 520 kilometres north of Lagos and 40 kilometres north of River Niger. This area was declared a Settlement Area by the government and a limited liability company - the Niger Agricultural Project Limited - was formed to operate the agricultural scheme on it. The scheme's capital of N 900,000.00 was subscribed in equal parts by the Colonial Development Corporation and the Nigerian government. The Company's function was to clear the land and to plan and control agricultural operations. The settlers (farmers) were to weed, plant and harvest the crops. These settlers were to be peasant farmers attracted only from the more densely populated localities in the emirates where the project was situated. For political reasons settlers outside these emirates were discouraged and steps were taken to induce those from within the emirates to move to the project site.

The project aimed at increasing the production of groundnuts for export and of guinea corn (sorghum) for local consumption. It was also meant to introduce and demonstrate better methods of farming to the settlers. These methods, however, demanded a high degree of mechanisation, requiring strict control by the management of the farmers' activities. The harvest from each settler's farm was based on a share cropping system under which the Company was to receive two-thirds of production in cash or kind for services rendered while the settler took the remaining one-third of the reward for all his efforts.

Originally ten settlements of eighty families each were to be established with each family having a farm of 15 hectares of which 5 hectares would be fallow at any one time. This size of holding was later increased to 19.5 hectares so as to allow 9.8 hectares to be fallow instead of the original 5. It was envisaged that mechanisation would make cultivation, weeding and harvesting of the remaining 9.8 hectares by individual settlers possible.

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2. For a detailed and comprehensive review of the project see Baldwin (1), and for a comparison of the project with the Gezira Scheme see Mabogunje (3).

The first settlement of 79 farmers was established in 1951. The number of settlers increased to 135 in 1952, and 163 in 1953, while the acreages cleared increased from about 810 hectares in 1949 to roughly 4,000 hectares in 1953. Unfortunately by then, after only three years of operation, it became clear that the project was not and could not be in the near future a financial success. In 1954, the Company was liquidated and both the central government of Nigeria and the Colonial Development Corporation withdrew from the scheme. The then Northern Nigerian Regional Government purchased the Company's assets and carried on the scheme until 1959 when it ceased to function.

Reasons for the Project's Failure

In Baldwin's view, the Niger Agricultural Project symbolised "the gulf between the world of ideas and practices in which the decisions which led to the development of the Mokwa project were conceived and the totally different world of ideas of the peasant whom it was hoped successfully to incorporate in it as settlers". (1, p. VI) To him, the project in essence "did not evolve at a pace suited to the human and environmental circumstances as to establish by trial and error a new pattern of economic and social endeavour". (1, p. VI) In the note attached to Baldwin's study the Colonial Development Corporation admitted that "if one factor predominates, it is the surprising and fatal ignorance in which the scheme was planned, and started; hence most of its mistakes, hence the failure". (1, p. XIII)

The failure of this scheme could not be ascribed to the inefficiency of the liability company which, as was generally agreed, managed the project well and economically. In fact, quite a sizeable proportion of the Company's staff were recruited directly from the Gezira scheme, a similar project which succeeded. These men were experienced and were very knowledgeable about this type of scheme, but their competence was inadequate to ensure success here. Reasons for the scheme's failure are many and varied and we can generally categorise them under six major headings - initial planning, inadequacy of local knowledge, use of machinery, problems of overhead costs, nature of innovation and human problems. (3, p. 392)

On the initial planning Baldwin argues that the rejection of the use of paid labour by the Nigerian government, especially in the initial phase of the project, was a major reason for failure. Southern labour was discouraged and the failure to attract non-Nupe[3] labour meant that labour

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3. The local inhabitants of the area where the project was located are Nupes.

had to be sought in an area (Bida and Kontagora emirates) where there was no surplus of persons seeking employment. Thus, the scheme had to depend on induced labour from these emirates. This was sometimes done by administrative action which in many cases either failed or was not adequate. He also argues that the failure to use paid labour prevented the scheme from having time to collect data on such items as choice of crop, the variety, the dates, use of fertilisers, weed control, practicable size of farm holdings, suitable types of tractors and cost of mechanised operation - information which could have been very useful as guides not only to the project initiators but also to the settlers.

While the Company did its best to obtain such information about local conditions especially at the higher level, little attempt was made to utilise the local farmers' knowledge. It is important to note that a project of this type, to be successful, cannot completely ignore the mental outlook and deeply rooted habits of thought and activity patterns which the local farmers have acquired through centuries of development. These habits have produced in these farmers a general philosophy and psychological frame of mind which often influence their attitudes towards their livelihood. At Mokwa, however, the local farmers' reservoir of knowledge about the customary sizes of farm holdings, crops grown, yields obtained, labour units and amount of work performed seemed to have been completely ignored by those concerned with the project.

Baldwin considers the use of machinery uneconomical given the type of soil and vegetation cover, the limited range of work to be done and the shortness of the working season. In this area, the prolific lateral root system just below the surface of the ground caused severe damage and losses due to breakages of agricultural implements. Problems of overhead costs were related to these breakages in terms of the distance of repair and maintenance facilities for the machines.

On the factor of innovation itself, Baldwin argues that the undue haste in which the scheme was launched and implemented did not give the farmers enough time to satisfy themselves that the new methods were better than their traditional ways. Moreover, the new system was not clearly demonstrated to the farmers to be a better finacial proposition.

In assessing the human problems that confronted the scheme, Baldwin identifies certain issues which he considers crucial:-

(1) the ignorance of the project initiators about the local people's

perception of the Mokwa environment where the project was situated. The Mokwa district had never been regarded highly by the Nupe farmers. They had noticed that water was scarce and they considered the soil to be poorer than that in some other areas where they could go. Above all, Mokwa itself was regarded as very remote and isolated from Bida, their capital, which is about 135 kilometres away;

(2) the settlers were chosen from Bida and Kontagora Emirates. These were areas where the people had more than enough land for their needs and from which they had no desire to move;

(3) in exchange for their old villages and behavioural patterns, the settlers were offered places in artificial communities where they had to forge a new way of life both in the social and economic fields. The houses that were provided in the model villages were radically different from the settlers' original homes and were so far apart that people who had been neighbours and relatives before were physically separated;

(4) the settlers did not feel the produce belonged to them. There was considerable misunderstanding and suspicion among the local people that the project was an ordinary European commercial concern meant to exploit them. The share cropping system created mutual suspicion between the settlers and the management: the settlers felt they were being cheated while the management thought that the settlers were the ones doing the cheating.

Thus, the Niger Agricultural Project failed in achieving its intended objective to upgrade the low quality environment in the Mokwa district. It was a scheme in which, at the same time that new techniques and innovations were being introduced to farmers, changes in their social habits were also being superimposed on them. For the settlers, therefore, a serious ecological problem arose from their wholesale transfer from one locality to another for which their perceptual values were low. As Mabogunje remarked, "by taking settlers who had no desire to move and whose roots in the previous society were not severed by other means, such as a loss of right to land in their village, the scheme from its inception doomed itself to failure". (3, p. 392) In terms of the model strategy for development, he went on, the scheme failed because "there was no adequate unfreezing of the existing societal organization; only half-hearted attempts were made to move to new levels and scarcely anything was done to freeze group life at the new level". (3, p. 392)

For instance, land tenure laws were not dealt with by the government beyond declaring the Mokwa district a settlement area. The restriction of the project to Bida and Kontagora emirates itself did not involve the whole society, but people selected by the village heads. Those selected few continued to retain ownership of and allegiance to their lands outside of the scheme and could return to their former villages as a last resort. Thus, strict discipline, required to make the people work well, proved ineffective when they had alternative occupations open to them.

The Mokwa experience is a lesson on the importance of preserving traditional institutions, if only at the initial stages of such development projects, until new ways of life emerge and the local inhabitants are mentally and physically prepared to accept the innovations. Schemes such as the Niger Agricultural Project must be planned in such a way as to introduce changes gradually rather than by the usual radical attempt at changing overnight the local farmers' long established behavioural patterns. This project, even though a commercial failure, has shown the many questions that must be asked before the establishment of similar kinds of mechanised agriculture and settlement schemes. It serves also as a reminder that schemes of this type must be planned in a way that the local inhabitants can easily identify themselves with the schemes in terms of their social, political and economic environments.

BIBLIOGRAPHY

1. Baldwin, K.D.S. The Niger Agricultural Project: An Experiment in African Development. Oxford, Blackwell, 1957.

2. Gould, P.R. On Mental Maps. Discussion Paper No. 9. Ann Arbor, Michigan, Michigan InterUniversity Community of Mathematical Geographers, 1966. Also in P. English and R. Mayfield, editors. Man, Space and Environment. New York, Oxford University Press, 1972, pp. 260-282.

3. Mabogunje, A.L. "The Perceptual Dimension in Regional Development: Two African Examples." Ekistics. 36 (217) December 1973, pp. 388-394.

4. Saarinen, T.F. Perception of Environment. Resource Paper No. 5. Washington, D.C., Association of American Geographers Commission on College Geography, 1969.

5. United Nations Organisation. Development and Environment. U.N. Conference on the Human Environment. Subject Area V, A/CONF. 48/10, December 1971.

6. United Nations Organisation. Department of Economic and Social Affairs. Rural Housing: A Review of World Conditions. New York, United Nations, 1969.

NON-RENEWABLE RESOURCES AND THE ENVIRONMENT IN AFRICA

By

William Hance, Professor, Columbia University

Until quite recently few people in Africa gave much consideration to the environmental impact of resource utilisation on that continent. Today there is heightened awareness that there are costs attached to the consumption and use of resources beyond the simple costs of extraction. There are opportunity costs, because once a resource has been used for one purpose it is no longer available for another, and there are costs related to deterioration of the environment. The main purpose of this paper is to examine the ways in which the extraction of raw materials may have undesirable effects on the environment. But an effort is also made to relate this topic to broader concepts of resource availability and use.

DEFINITIONS

Resources can be defined in a narrow sense as tangible things consumed by man, or even more narrowly as raw materials. Neither of these definitions is satisfactory today. One must add: space in all its contexts, health, social harmony, knowledge, freedom, etc. And one must recall that man's own wisdom is the prime resource. Thus it is more accurate to define resources as the total environment of man. It should also be noted that a resource pre-supposes a person. Resources are not just things or substances; they are also functions which these things may perform or operations in which they may take part. But human culture rests on a basis of physical reality and nature sets the limits within which man can develop his arts to satisfy his wants.

The distinction between renewable and non-renewable resources is not as simple as it may first appear. The definition of non-renewable as 'once used, no longer available' is too rigid because of the possibility of recycling. As pointed out by Price, while the concepts of renewable or non-renewable

> are relative to human time; both break down on a geologic or astronomic time scale. Renewable resources can be managed to provide an annual production or <u>flow</u> for an indefinitely long period. Non-renewable resources are the finite <u>stocks</u> of minerals which, once used and dispersed, are henceforth unavailable. (30, p. 241)

But as he notes, there are overlaps. Many flow resources can be destroyed (e.g., soils, groundwater, plant and animal species, ecosystems, the beauty of the landscape). Some stock resources can be replaced by flow resources (e.g., fossil fuels by solar energy), and others can be replaced by other stock resources which are so plentiful as to be practically flow resources (e.g., silica for metals, building stone for steel). Flow, finally, sometimes depends on stock as in the dependence of agricultural output on inorganic fertilisers or pesticides.

While it is important to understand these concepts, it is necessary to restrict the coverage of this paper to non-renewable mineral resources to avoid encroaching on others' topics and because of the limitations of space.

THE IMPORTANCE OF MINERALS TO AFRICA

The African share of world mineral production is summarised in Table 1, which reveals its predominant significance for such minerals as diamonds, gold and cobalt and its important share in world output of platinum, vanadium, manganese, chrome, antimony, copper, tin, phosphate rock and uranium oxide.

The dependence of individual African countries on minerals varies enormously, as is indicated by Table 2, and only a few countries account for the vast bulk of African mineral exports (Libya, South Africa, Algeria, Nigeria, Zambia, and Zaire). Of 51 political units, including 10 not listed in Table 2, 13 have the majority of their exports in minerals, 7 have from 25 to 49 per cent in minerals, 7 have 10 to 24 per cent of exports in minerals, 9 record mineral exports at from 1 to 9 per cent, and 15 have nil or negligible mineral exports.

Table 1. African share of world mineral production, selected years 1938-1971.

Commodity	1938	1961	1970	1971
Metals				
Aluminum (bauxite)	——	6.7	5.8	5.6
Antimony	4.0	21.7	28.5	25.8
Arsenic	....	....	8.0	
Beryl	....	40.3	15.6	
Cadmium	0.3	5.6	3.6	
Chromite	35.0	34.1	33.1	30.0
Cobalt	87.0	76.9[a]	70.1	
Columbium-tantalum	——	82.3	9.2	
Copper	18.0	22.2	21.1	20.3
Gold	40.0	52.2	71.1	
Iron	3.5	3.2	7.3	9.2
Lead	3.2	8.2	5.7	5.9
Manganese ore	22.0	21.8	27.7	34.1
Nickel	0.5	0.8	2.6	3.6
Platinum group	9.2	30.0	35.6	
Silver	0.3	4.7[a]	2.7	
Tin	12.0	22.2	21.1	20.3
Tungsten	1.9	2.5	0.9[a]	2.2
Uranium oxide	——	5.2[a]	20.6[a]	
Vanadium	47.5	30.9[a]	45.2	
Zinc	1.3	7.3	4.7	5.6
Nonmetals[b]				
Asbestos	16.0	14.1	18.0	26.5
Barite	0.4	4.2	3.5	
Diamond				
Gem	)98.5	94.4	85.5	
Industrial	)	97.4	76.0	
Fluorspar	....	....	5.1	
Graphite	7.4	4.0	5.0	
Gypsum	....	....	1.9	
Magnesite	....	....	0.7	1.1
Mica	6.1	2.2	5.6	
Phosphate rock	33.0	26.4	23.7	34.0
Potash	....	....	1.3	
Talc	....	....	31.6	
Vermiculite	....	25.6	....	
Mineral Fuels				
Coal	1.0	2.3	2.8	3.0
Petroleum	0.1	2.2	13.1	11.5
Natural gas	——	....	....	0.2

—— nil
.... not available
a Excluding U.S.S.R. and China.
b Includes diatomite, 0.9, in 1970; feldspar, 0.1 in 1970.

Sources: U.S. Department of the Interior. Minerals Yearbook 1970. Volume 3. Washington, Government Printer, 1972. U.N. Statistical Yearbook 1972. New York, 1973.

Table 2. Mineral exports as share of exports of selected African countries.

Country	Year	Percent
Algeria	1972	66.2 (oil only)
Angola	1971	39.7
Botswana	1971[a]	22.2
Burundi	1970	1.0
Cameroon	1971	8.6 (aluminum from imported alumina)
Central African Rep.	1970	40.8
Chad	1971	—
Congo	1969	17.3 (including diamonds of foreign origin)
Egypt	1970-71	3.6
Ethiopia	1970	—
Gabon	1971	54.4
Ghana	1970	17.6
Guinea	1971a	72.0
Kenya	1970	0.5
Ivory Coast	1970	18.4
Lesotho	1971	74.2
Liberia	1971	99.8
Libya	1971	8.1
Madagascar	1971	—
Malawi	1970	—
Mali	1971	87.0
Mauritania	1969	32.6
Morocco	1970	17.3
Niger	1972	61.9 (in 1972, petroleum only, 81.2)
Nigeria	1970	42.1
Rwanda	1969	11.1
Senegal	1972	0.1
Seychelles	1971	76.6
Sierra Leone	1972	—
Somalia	1971	65.6
South Africa	1972	55.3
South West Africa	1971	—
Sudan	1971	32.1
Swaziland	1971	12.5
Tanzania	1970	37.3
Togo	1972	39.0 (petroleum, phosphates only)
Tunisia	1972	8.4
Uganda	1970	—
Upper Volta	1971	76.0 (copper, diamonds, tin only)
Zaire	1970	98.4
Zambia	1971	

— nil
a estimated

Source: U.N. World Trade Statistics 1970. New York, 1973.
I.M.F. Financial Statistics. October 1973.
National statistical sources.

The fact that many African countries are heavily dependent on minerals for providing the means to promote economic and social development and the knowledge that minerals are wasting resources have contributed to several significant politico-economic trends. The desire to benefit as fully as possible from a non-renewable resource helps to explain the trends toward national participation and ownership in mineral exploitation, the further processing of minerals before export and the call by some for confiscation of foreign holdings and/or the withholding of resources until such time as the owner-nation can utilise them itself. This is not the place to discuss development strategies, but it is pertinent to note that any study of the impact of resource use on the environment must include an assessment of the impact of the rate of consumption. At the same time it should be recognised that no nation can be independent in its supply of raw materials and that the role of natural resources differs with the stage of development. In the developing process they are important as a source of capital accumulation and an engine for economic growth; later they play a less important quantitative role as capital and technical and managerial knowhow become more important.

THE SUPPLY OF MINERALS

Since the consumption of minerals has an undeniable impact on the environment it is appropriate to summarise as concisely as possible the arguments regarding the possible supplies of mineral resources, where one finds a sharp dichotomy between those who may be loosely termed the pessimists[1] and the optimists[2]. Those who support the 'limits to growth' arguments state that resources are finite and cannot sustain an indefinite exponential growth.

Whatever one may conclude with respect to the validity of the conflicting claims regarding resource availability, there is wide agreement that there is a need for the adoption of conservation policies to prevent waste and reduce pollution. There is also increasing support for developing what Maurice Strong calls a new 'low-energy life-style' (New York Times, November 22, 1973), and for a more equitable sharing of available resources. Defining waste presents certain problems, however. Exhausting a resource without using it, as when gas from an oil field is blown or burnt off, is clearly waste. Leaving half of the coal in a seam to permit lower-cost

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1. See for example an article in The Ecologist (1), Commoner (4) and (5), the Ehrlichs (10) and Meadows et al. (23)
2. See for example The Economist (9), Kaysen (17) and Cole et al. (3).

mining may also be wasteful. But is it wasteful to use a scarce resource for a purpose that might be fulfilled by a more plentiful resource (e.g., burning gas rather than coal to produce electricity, using copper for decorative purposes which have no relationship to its qualities of conductivity)? The problems of how to determine the highest use for a given material and how to restrict its consumption for that use are likely to be extremely difficult, especially since we cannot predict with any certainty what technological and resource use changes will occur in the future. Assuring the efficient use of a given material is difficult because it may involve more man hours and a higher cost than the current value of the material conserved.

While it is difficult to define and enforce the concepts of waste prevention and efficient use, there are constructive steps which are appropriate in resource utilisation. These are such steps as substituting renewable or plentiful resources for the exhaustible ones (e.g., natural rubber for synthetic rubber). However, the use of much greater energy inputs to unlock minerals from lower grade rock is not seen as a way out because it would increase the rate of consumption of other resources and increase pollution in one way or another, especially the emission of an intractable amount of waste heat.

The optimists counter the 'limits to growth' proponents by claiming that they use models that are too simple, do not allow for technological advances which are also exponential, take no account of adjustment mechanisms, lack realism in projecting from present or recent trends and are too naive in calling for a radically new social order. The focus on exponential curves is also criticised because this suggests that whatever efforts are made now not to be wasteful really give only another few years at the end. Landsberg suggests that "one cannot have it both ways: if added reserves don't matter, neither does frugality in consumption".

More positively, the optimists note that resources are not fixed, that the ability to exploit lower grade deposits enormously increases available reserves, that very low cost energy will indeed unlock vast resources and may even permit extraction of minerals from more or less common rock, that we may expect technological developments and resource discoveries impossible to foresee and that the ability of man to react to dynamic problems is very great.

The attention focused upon shortages of specific materials has also been questioned as being unrewarding, because of the enormous scope for substitution and because the kinds of cost increases involved

are manageable without disruption. Examples of sustitutions are legion, and it is true that raw material prices, with some exceptions, have more often reflected a tendency toward over-production that toward a short supply. Some suggested steps are to make materials work harder (e.g., avoid built-in obsolescence, re-use containers instead of using throwaways, strengthen steel with alloys); give materials a second life through recycling (e.g., more effective recovery of scrap, conversion of waste into usable materials); give greater attention to research designed to bring submarginal resources into use and to finding use for abundant minerals; and synthesise new materials.

Thus far attention has been given to those aspects of resource utilisation which relate to supply and efficient use, since the rate of consumption has an impact on the environment. It does not follow, however, that the impact is in direct relation to the level of output since improved technology should be designed to reduce undesirable effects more rapidly than the rate of production rises. It is now appropriate to turn to an examination of the more specific aspects of the environmental impacts of mineral exploitation.

THE ENVIRONMENTAL IMPACT OF MINERAL EXPLOITATION

There are priorities in considering the impact of mineral exploitation, of which human health and safety rank first. Other concerns include environmental and economic health, land-use planning objectives and the conservation of natural and environmental resources. (See 36, p. 71)

Very few quantitative measures are available of the impact on the environment of mineral exploitation and use, and most of what is available applies to the developed nations. For the United States it is estimated that mining with its associated processing industries ranks second only to agriculture as a source of solid wastes and contamination. One estimate is that mining and refining generated 1.1 billion tons of solid wastes or 27.2 per cent of the total in 1968; another holds that mineral solid wastes totalled 1.7 billion tons, 39 per cent of the total in 1969, most of which came from mineral and fossil fuel mining, milling and processing industries. The copper industry ranked first, followed by iron and steel, bituminous coal, phosphate, rock, lead, zinc, alumina, and anthracite coal, these eight minerals accounting for an estimated 80 per cent of the solid wastes from 80 mineral industries. Three million acres of land have been affected by strip mining alone, with less than a third receiving any reclamation. It is estimated that by 1980 some 5 million acres will have

been affected by surface mining and that about 2 billion tons of solid wastes will be generated by mineral extraction and processing. The contribution of these activities to air pollution is even less well known, though iron and steel mills, petroleum refineries, inorganic chemical manufacturing, smelters and carboelectric stations are rated among the top seven industrial polluters. Non-ferrous smelters are thought to account for about 13 per cent of sulfur oxide emissions in the United States, with petroleum refining and use accounting for 20 per cent, and carboelectric plants for 52 per cent.

The costs of curbing environmental deterioration and pollution are also very difficult to estimate since much depends on the character of the existing plants and on technological advances in a field which is receiving much more attention than was accorded in the past. Costs are likely to be lower if safeguards are included from the beginning; after-the-fact programmes to remedy past abuses are likely to be costly, but are still needed. It has been estimated that pollution control in the U.S. in the period 1972-1976 would add 4-5 per cent to the price of cement, 2.8-7 per cent to the cost of power (involving an expenditure of $10.7 billion, of which $7.5 billion is for air pollution control and $3.2 billion for thermal pollution control), 4-6 per cent to the price of aluminum, and 0-8 per cent to the price of refined copper. The cost of reclaiming strip-mined land, if done at the time of mining, is estimated to be about 2 per cent of the selling price. Thus, while very large sums are required to achieve better protection standards, there is little indication that such costs will be prohibitive or that prices will skyrocket because of them. Nor should the offsetting savings be forgotten - savings resulting from improved health, greater cleanliness, improved capabilities for using reclaimed land for other purposes, higher productivity of waters for fishing and recreational use, etc.

THE COMPARATIVE POSITION OF DEVELOPED AND LESS DEVELOPED COUNTRIES

Numerous observers have professed to see marked contrasts in the significance and concerns regarding environmental matters between the less developed countries and the developed countries. The major environmental concerns of the less developed countries reflect poverty and lack of development and there was considerable effort at Stockholm to broaden the concept of the environment to include these concerns. While certain environmental problems are closely related to the stage of development of the less developed countries it is necessary for the sake of clarity to disassociate the broad problem of development from those of environmental pollution and degradation. Nonetheless, it is pertinent to note that the

environmental despoilation problems of the less developed countries are likely to be different in kind and in relative importance from those of the developed countries.

In Africa, for example, the following environmental problems are of grave concern, much more so than in most developed areas:

(1) deterioration of the soil which is, above all, the prime physical resource of the continent;
(2) deterioration of the vegetation;
(3) high incidence of human, animal and plant diseases;
(4) inadequate provision of sanitary water supplies; and
(5) inadequate sewage disposal systems.

Another contrast between the developed and less developed countries is the more direct effect in the less developed countries of population growth on the environment and on economic development itself.

The contrasts between the developed and less developed countries with respect to environmental concerns has raised a series of questions which deserve sympathetic consideration - such questions as : isn't the concern for the environment a disease of the wealthy? Isn't it more important for the less developed countries to have industry than to have no pollution? Will environmental standards in the developed countries reduce the markets of the less developed countries who will pay for the devices and programmes required to meet pollution standards? Will technical assistance be provided to the less developed countries? What attention will be given to the kinds of environmental problems directly affecting the less developed countries? Will the costs of providing pollution control in the developed countries result in a diversion of funds previously to aid? And will increased recycling of raw materials reduce markets for the less developed countries?

Space prohibits more than a partial answer to these questions. There are a number of factors which permit the 'importation of pollution' to the less developed countries without as deleterious an impact as would be experienced in the developed countries: the smaller number of vehicles which are the major source of air pollution in the developed countries, the markedly lower consumption of energy, the much lower number of polluting industries and, for specific areas, the greater availability of natural waters and lower population densities. (See 39, p. 12) Theoretically, a nation with lower pollution standards and higher tolerance levels may prove attractive to industries for which pollution control represents a significant cost, and thus less developed countries may gain industry if they are willing to serve

as 'pollution havens'. There is something distasteful, however, about exporting pollution even when it is acceptable to the receiving nation, since the price of the competitive advantage will eventually have to be paid by that nation.

With respect to the impact of pollution controls on trade, the picture is very mixed and not easily predictable. A loss in markets for lead-free gasoline may be offset by increased sales of platinum to be used to reduce pollutants in automobile exhausts. The desire to reduce pollution and to conserve exhaustible resources may eventually favour the sale of natural rubber, fibres, insecticides, etc., and development of more of Africa's huge hydroelectric resources.

The degree of conflict between the developed and the less developed countries in the matter of environmental despoilation has probably been exaggerated. Comments from a recent conference in Zambia are pertinent:

> we see much evidence in Zambia today of pollution hazards, which we would rationally wish to avoid, as far as it is possible, for what virtue is there in repeating the mistakes and distortions of amenable environments that have been allowed to develop, unchecked, in the highly industrialized societies?...The problems in Zambia, in relation to pollution of the environment are little different to those of many other countries whether developed or in the process of developing. (48, pp. 6 and 31)

There is little doubt that concern for the environment has been badly neglected in the less developed countries. In The Careless Technology, the results of a conference designed to investigate the question: to what extent have the ecological costs of introducing technology affected the less developed countries?, it is revealed

> that little concern had ever been given to anticipating ecological costs and side-effects, to say nothing of having such factors serve as inputs to decision-making in development projects. In example after example, we found that (a wide variety of programs) were being promoted throughout the world with little or no attention to their environmental consequences. (11, p. xiii)

CLASSIFICATION OF ENVIRONMENTAL IMPACTS

The environmental effects of material flows can, following the authors of Man, Materials and Environment, be described by reference to nine major elements:

(1) the material involved, e.g., metals, energy materials, etc.,
(2) the stage of the materials cycle, from exploration through extraction, transport, processing, use and recycling to ultimate disposal;
(3) the form of the environmental disturbance;
(4) the environmental medium that is abused;
(5) the geographic character of the source of the disturbance;
(6) the geographic character of the effect of the disturbance;
(7) the character of the damage to human welfare;
(8) the magnitude or severity of the disturbance; and
(9) temporal factors. (36, pp. 10-11)

In the following sections attention is focused upon minerals and the environment with particular reference to the impacts of extraction and primary processing on man and his environment.

THE ENVIRONMENTAL IMPACTS OF MINERAL EXTRACTION

The impacts of mineral extraction on man and on the environment vary considerably according to the systems of extraction employed, which may be listed as follows:

1) drilling (oil, gas, steam, salt, sulfur)
2) surface mining
   a. quarrying, open-pit mining
   b. dredging, hydraulic mining, potholing
   c. auger mining
   d. strip mining
      (1) area
      (2) contour
3) underwater operations
   a. drilling
   b. mining

Drilling

Drilling for oil and gas both on ground and under water involves several environmental hazards, which may have spectacular dimensions as in the case of the Santa Barbara blowout (35) or occasional wild wells. The petroleum industry has developed sophisticated techniques to minimise such events, but it is a truism that the use of oil is impossible without losses - in production, transportation, refining and consumption. Inadequate regulatory mechanisms have resulted in tremendous oil pollution in the open oceans (8, pp. 296-7) with perhaps a third of the total having come from discharges by vessels (now prevented by the 'load on top' method),

a fifth from such disasters as the Torrey Canyon and Santa Barbara episodes and the remainder from spent lubricants, in-completely burnt fuels and untreated industrial wastes. Oil well blowouts are now very uncommon (e.g., there has only been one, occuring in 1948, in Canadian history), and their impacts can be fairly readily confined on land, but the impact of oil pollution at sea is now seen to be much more complex and subtle than had been thought. Careful operational procedures as well as restrictive measures are required to minimise the effects of offshore spillage and seepage, which menace aquatic life and beaches, sometimes many miles from the occurrence. 'Formation water', which is usually about one-and-a-half times as salty as ocean water, found in intimate contact with petroleum, and produced in quantities about two to three times as great as the oil produced, is normally returned to the producing formation to avoid polluting streams and to help force out the remaining oil. Flaring of gas should be controlled wherever possible as a conservation measure.

Land subsidence due to the withdrawal of oil, gas and associated water, steam for geothermal power and ground water has caused millions of dollars of damage in the United States. The solution to this problem usually involves repressuring with water. With exploitation of oil and gas now taking place in about nine African countries and exploration proceeding in about half of the African countries, the concern for environmental impacts must increase in the years ahead.

Geothermal energy, which is tapped by drilling as for oil and gas, is thought to be the 'cleanest' source of power, and its environmental effects may be expected to be limited to within a few miles of the area tapped. Nonetheless, there are environmental hazards and further experience and research will be required before the best control techniques are known. These hazards include:

(1) the emission of gaseous and particulate matters;
(2) land pollution with liquid and/or solid wastes;
(3) land subsidence;
(4) seismic considerations;
(5) water pollution;
(6) biologic effects through chemical changes in soil and water, destruction of specialised habitats or long-term alterations in humidity; and
(7) social effects occasioned by high noise levels, odor or conflict with other land uses. (14)

Surface Mining

The surface mining cycle usually consists of four stages:

(1) site preparation, clearing vegetation and other obstructions, constructing access roads and ancillary installations including the area to be used for disposal of spoil or waste;

(2) removal and disposal of the overburden;

(3) excavation and loading of the ore or rock; and

(4) transportation of the ore or rock to a concentrator, processing plant, storage area or directly to market. (Taken mainly from 8, pp. 348-69)

A fifth stage, reclamation, is often not included in the cycle, but experience shows that it is more effective and cheaper to do so, mainly because the same machinery can be employed to level spoil piles, segregate toxic materials and establish controlled drainage from the site.

The use of ever larger pieces of equipment permits exploitation from the surface of lower and lower grade ores beneath increasing depths of overburden. Thus the danger of deleterious environmental impacts is increasing, but so is the ability to reclaim the land, providing appropriate regulations are enforced and reclamation is preplanned.

The environmental impacts of surface mining are numerous and sometimes practically irremediable. The direct effect on human health and safety is generally less significant than for underground mining, though dust may present a health problem to the workers and dust and vibrations may be a public nuisance in nearby communities. The impact on the land surface is the most serious aspect of surface mining. Contour stripping is perhaps the most destructive type, because it is extremely difficult if not impossible to restore the terraced slopes to anything like their previous condition, and because areas far greater than the mined-out terrace and the downslope on which the spoils are dumped are adversely affected.

Area stripping may also radically disfigure the terrain unless proper reclamation practices are enforced. Other forms of surface mining may leave massive piles of waste or otherwise drastically reshape the surface, while landslides have sometimes blocked streams and highways. All these and other results of surface mining may seriously impair the economic and aesthetic value of whole landscapes.

Surface mining may also destroy protective vegetation and it is frequently difficult to replant an area because of the toxic nature of the spoils. A more serious impact is that of water pollution from mine drainage and sediment. Dredge mining is particularly objectionable in contributing large quantities of material in suspension; it not infrequently causes a complete upheaval of the stream bottom likely to destroy aquatic flora and fauna both on site and downstream, which may destroy spawning grounds for fish and adversely affect potable water supplies. But drainage of acidic waters from mines and mined areas is more serious and far more widespread. Acid formation occurs when water and air react with sulfur-bearing minerals in the mines or refuse piles to form sulfuric acid and iron compounds. It has been estimated that over 4,300 miles of major streams in the United States are polluted significantly by acid drainage, and that 3.2 million acres of land are producing acid drainage as a result of surface mining activities and erosion. (18, p. 100) Mine drainage may also seep into and affect underground water. Surface mining contributes to air pollution primarily through dust blowing.

The adverse impacts of surface mining are diminished if the operation is relatively confined, as in the case of a quarry or open pit mine, or where the mine is situated in a low-productive and sparsely populated area. Fortunately, the vast bulk of mining operations in Africa are relatively confined or are situated in low-productive and/or sparsely populated areas. Exceptions include the phosphate mines of North Africa, alluvial diamond and gold mining in Sierra Leone, Ghana, Zaire and elsewhere, tin-mining in Nigeria, and some of the latest coal mining in South Africa.

Reclamation may, of course, greatly reduce the deleterious impacts and in some strip-mined lands in Indiana it is claimed that reforestation has actually raised the value of the surface use above its previous level. Other possible benefits or features partially offsetting losses to surface operations include improved storage of ground water (e.g., on some strip-mined areas in the American Midwest, some of which have become massive man-made aquifers), the creation of small lakes which may have recreational value, provision of materials which may be used in construction and use of stripping sites or abandoned open pits for waste disposal. Use of mine waste as ballast for road construction is sometimes dangerous, however, because it may contribute to acid drainage, and such use is [illegible] prohibited by law in some states.

Underground Mining

Protecting the health and safety of workers is of particular importance in underground mining. No fewer than 80,000 deaths from explosions, fires and cave-ins have been recorded in American coal mines. Cave-ins of serious dimensions have occured in recent years on the Witwatersrand and on the Zambian Copperbelt.[3] In addition to the necessity to provide a safe void in which the mining takes place there is the necessity to assure workable temperature conditions and adequate ventilation. The dust from some minerals is particularly dangerous: some 200,000 or more coal miners in the U.S. suffer from pneumoconiosis or black lung disease with about 4,000 deaths a year being attributed to this disease, gold miners in South Africa have been subject to a high rate of silicosis, workers dealing with asbestos are in danger of getting asbestosis, a form of cancer, and radiation is a concern in uranium operations from mining through all subsequent stages.

In a recent paper on copper mining in Zambia, Charman states that, despite increased ventilation per ton of rock broken underground, pollution levels have increased during the last eight years.[4] While pollution from dust and blasting fumes has been reduced over the last thirty years,[5] the new element in the picture is the use of a considerable number of diesel-powered L.H.D. (load-haul-dump) vehicles which generate heat and gases in higher concentrations than were previously recorded. The other main source of gas is from blasting operations. Efforts are made to control gas levels by use of platinum-based catalytic converters, fume diluters, and water scrubbers and through continual maintenance of vehicles to reduce emissions. But no alternative has been found to providing sufficient ventilation to dilute emissions. Reducing heat levels, which are already high because of geothermal heat and which occasionally subject workers to unacceptable conditions of heat stress, may require use of the pre-frozen

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3. An interesting, if deplorable, irony appears in a recent book by Houghton and Dagut in which the relationship of mining safety to development of the 'colour bar' in South Africa is briefly shown. See (15), pp. 29-30.

4. J.A. Charman, "The Changing Picture of the Underground Working Environment in the Copper Industry of Zambia," in (48), pp. 71-85.

5. The maximum allowable concentration of siliceous dust as determined with the Witwatersrand Konimeter is 350 particles per cubic centimeter (p.p.c.c.) in Zambia. The average concentration on the Copperbelt is actually 180 p.p.c.c., while one mine achieved a level of 95 p.p.c.c.

water jacket, developed in South Africa. High noise levels, coming from fans, rock drills and vehicles, are also a menace in some underground mines, in Zambia fans have been fitted with silencers and some drills are equipped with noise mufflers.

The impact of underground mining on the land surface includes subsidence and the deposition of vast piles of waste which are unsightly and which may contribute to other forms of pollution. Various solutions have been attempted to reduce the undesirable effects of waste disposal. Sometimes waste may be returned to a mine as back fill or may be used as land fill: spoils may be landscaped and covered with top soil or organic wastes from sewage disposal and refuse plants, occasionally they are stabilised with masonry or concrete, but these methods are often not practical and they tend to be expensive. The cheapest and most effective method appears to be the establishment of a permanent vegetation cover. This has been receiving increasing attention in Zambia where large dumps of toxic wastes lie bare at Kabwe (the Broken Hill lead and zinc mine) and even larger dumps exist on the Copperbelt.[6] In Zambia a search has been made for plants which are drought resistant, tolerant of high temperatures and toxic materials, self-reproductive and which require a minimum of fertilisation. Particular attention has been given to biogeochemical indicator plants which have been recognised for some years as indicators of the presence of specific minerals and which cover old mine workings naturally. Even after a cover is formed, however, care is required to prevent damage to the still basically unstable surface and the onset of soil erosion. It is thought that a good and profitable solution lies in the development of forestry plantations.

The side-effects of uncontrolled spoils heaps include dust blowing and other air pollution and water pollution. Dust blowing is controlled best by vegetating the dumps. Other air pollution is most serious from bank fires. But the huge size of some mine dumps may also create hazards; on the Rand, for example, it has been shown that the 100 to 400 foot-high dumps contribute to temperature inversions with a high pollution content.

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6. The information on Zambia in this paragraph is based on Conor Reilly, "The Development of Vegetation in Mine Wastes," in (48), pp. 86-92.

Smelting

The processing of ores, particularly smelting, frequently is a greater source of environmental hazards than extraction itself. Emissions of gases, especially sulfur and nitrogen oxides and hydrogen fluoride, may cause direct damage of flora and fauna and indirect damage through increasing soil acidity and reduction of soil bacteria within a radius of as much as 25 miles from a smelter. A variety of steps may be taken to reduce these hazards: extraction of sulfur from coals before they are used in smelting; equipping smelters with efficient dust and fume collecting systems; desulfurisation of stack gas; removal of particles by electrostatic precipitation, scrubbing or filtration; and location of smelters to take advantage of prevailing winds to dissipate pollutants over unpopulated areas. A recent note on air pollution in Zambia concluded that it was rather low, though the author cautioned against complacency and called for a close watch on pollution concentrations and trends.[7] Explanations for the low incidence include the high frequency of thunderstorms in summer, the low incidence of fogs, extreme dryness of the atmosphere in winter and strength of the winds. The new Selebi-Pikwe lead-zinc smelter in Botswana is designed to extract large tonnages of sulfur which will be sold as a byproduct, while a 500-foot stack has been constructed to disperse remaining fumes.

CONCLUSION

A considerable variety of topics has been introduced, all of them sketchily, in the preceding pages. More questions have been raised than answered. Conclusions which may be pertinent to the discussion of resources availability are that prudent consumption is appropriate, that developed societies should contemplate greater emphasis on quality and less on quantity and that international cooperation is likely to be more fruitful than national isolation.

With respect to the more direct environmental impacts of the extraction and processing of non-renewable resources, it is obvious that the developed nations are paying heavily for past neglect. It is also apparent that less developed countries must give greater attention to the effects of resource development on human health and ecological systems. The very limited availability of detailed studies of the environmental impact of development in Africa suggests the need to give far greater attention to this subject.

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7. U.R. Acharya, "Meteorological Aspects of Air Pollution," in (48), pp. 64.

BIBLIOGRAPHY

1. "Blueprint for Survival." The Ecologist. January 3, 1972.

2. Cloud, Preston E. Resources and Man. San Francisco, W.H. Freeman, 1969.

3. Cole, H.S.D., et al. Thinking about the Future: A Critique of the Limits to Growth. London, 1973.

4. Commoner, Barry. Science and Survival. New York, Viking Press, 1966.

5. Commoner, Barry. The Closing Circle: Nature, Man, and Technology. New York, Knopf, 1971.

6. Conference Internationale sur la Conservation de la Nature et de ses Ressources à Madagascar. Comptes Rendus. Morges, Switzerland, I.U.C.N., 1972.

7. Dasmann, Raymond F. et al. Ecological Principles for Economic Development. New York, John Wiley and Sons, 1973.

8. Detwyler, Thomas R. Man's Impact on Environment. New York, McGraw-Hill, 1971.

9. The Economist. March 11, 1972.

10. Ehrlich, Anne H. and Ehrlich, Paul R. Population, Resources, and Environment: Issues in Human Ecology. San Francisco, W.H. Freeman, 1972.

11. Farvar, M. Taghi and Milton, John P., editors. The Careless Technology: Ecology and Economic Development. Garden City, New York, The Natural History Press, 1972.

12. Goodman, Gordon T., Edwards, R.W. and Lambert, J.M. Ecology and the Industrial Society. New York, John Wiley and Sons, 1965.

13. Hart, G.H.T. "Some Planning Complications of Atmospheric Pollution over Mining Ground" Journal for Geography. (Johannesburg, South Africa) pp. 919-29.

14. Hickel, Walter J. Geothermal Energy: A National Proposal for Geothermal Resources Research. Anchorage, Alaska, University of Alaska, 1972.

15. Houghton, D. Hobart and Dagut, Jenifer. Source Materials on the South African Economy: 1860-1970. Volume 3: 1920-1970. Cape Town, Oxford University Press, 1973.

16. Illinois Institute of Technology Research Institute. Proceedings of the Symposium: Mineral Waste Utilization. Chicago, 1968.

17. Kaysen, Karl. "The Computer that Printer W*O*L*F*." Foreign Affairs. July 1972, pp. 660-668.

18. Kneese, A.V. et al. Managing the Environment: International Economic Cooperation for Pollution Control, 1972.

19. Linzon, S.N. "Effects of Sulfur Oxides on Vegetation" Canadian Forestry Chronicle. 48 (4) 1972, pp. 1-5.

20. McHale, John. The Ecological Context. London, Studio Vista Ltd., 1971.

21. McKenzie, Garry D. and Utgard, R.O., editors. Man and His Physical Environment: Readings in Environmental Geology. Minneapolis, Burgess Publishing Co., 1972.

22. Malagasy Republic. La Protection de la Nature à Madgascar. Tananarive, June 1971.

23. Meadows, D.H., et al. Limits to Growth. Potomac Associates for the Club of Rome. New York, Universe Books, March 1972.

24. Morton, Rogers C.B. "Strip-Mining Reform: Some Political and Economic Ideas". Environmental Affairs. 2 (2) Fall 1972, pp. 294-302.

25. Nelson-Smith, A. "The Problem of Oil Pollution of the Sea". Advanced Marine Biology. 8 1970, pp. 215-306.

26. "The No-Growth Society." Daedalus. 102 (4) Fall 1973.

27. Owen, D.F. Man's Environmental Predicament: An Introduction to Human Ecology in Tropical Africa. 1973.

28. Pettyjohn, Wayne A., editor. Water Quality in a Stressed Environment: Readings in Environmental Hydrology. Minneapolis, Burgess, 1972.

29. Potter, Jeffrey. Disaster by Oil. New York, Macmillan, 1973.

30. Price, Edward T. "Values and Concepts in Conservation." In Ian Burton and R.W. Kates, editors. Readings in Resource Management and Conservation. Chicago, University of Chicago Press, 1965.

31. Rockefeller, L.S., et al. The White House Conference on Natural Beauty: Report to the President. Washington, D.C., U.S. Government Printing Office, 1965.

32. Stacks, John F. Stripping: The Surface Mining of America. San Francisco, Sierra Club, 1972.

33. Steinhart, Carol E. and Steinhart, John S. Blowout: a Case Study of the Santa Barbara Oil Spill. North Scituate, Massachusetts, Duxbury Press, 1972.

34. Strahler, Arthur N. and Strahler, Alan H. Environmental Geoscience: Interaction between Natural Systems and Man. Santa Barbara, Hamilton Publishing Co., 1973.

35. Strong, Maurice, Verney, R.P. and Iliff, N.A. "Human Environment: the Impending Crisis." The Geographical Journal. 138 (4) December 1972, pp. 411-429.

36. Study Committee on Environmental Aspects of a National Materials Policy. Man, Materials, and Environment. A Report to the National Commission on Materials Policy. Washington, D.C., National Academy of Sciences, National Academy of Engineering, 1973.

37. Study of Critical Environmental Problems. Man's Impact on the Global Environment: Assessment and Recommendations for Action. Cambridge, Massachusetts, M.I.T. Press, 1970.

38. Thomas, William L., Jr. et al. Man's Role in Changing the Face of the Earth. Chicago, The University of Chicago Press, 1956.

39. United Nations. Economic and Social Council. Committee on Natural Resources. Environmental Pollution Tolerance and the Potential for Expansion of Mineral Processing in Developing Countries. E/C.7/Add. 4, 11 January, 1971.

40. United Nations. Food and Agriculture Organization. Marine Pollution and Its Effects on Living Resources and Fishing. Rome, 1970.

41. United States. Bureau of Mines. Mineral Facts and Problems. Washington, D.C.,1970.

42. United States. Bureau of Mines. Research Program on Recycling and Disposal of Mineral-, Metal-, and Energy-Based Solid Waste. Information Circular 8529, 1971.

43. United States. Department of the Interior. Surface Mining and Our Environment: A Special Report to the Nation. Washington, D.C., 1967.

44. United States. Department of Commerce. Council on Environmental Quality. Environmental Quality Annual Reports, 1970, 1971, 1972.

45. United States. Department of Commerce. The Economic Impact of Pollution Control. Washington, D.C., March, 1972.

46. Walter, I. "Evironmental Control and the Patterns of International Trade and Investment: An Emerging Policy Issue."Banca Nazionale del Lavoro Quarterly Review. 100 1972, pp. 82-106.

47. Wilson, Thomas W., Jr. International Environmental Action. Cambridge, Massachusetts, Dunellen, 1973.

48. Zambia, University of. Proceedings and Report of the Second Seminar on Pollution and Environment. Lusaka, 1973.

49. Zimmerman, E.S. World Resources and Industries. Second edition revised. New York, Harper, 1951.

VISITOR AND VEHICLE PRESSURE IN NATIONAL PARKS

By

Perez M. Olindo, Director
Kenya National Parks

The question of establishing national parks as an important aspect of national development continues to appeal to many sovereign states, for a variety of reasons. The industrialised nations are motivated to create parks and reserves to protect rapidly disappearing species of plants and animals and also to provide recreation areas for population densities locked up within metropolitan areas. The developing countries have tended to look at the role of national parks as constituted in Eastern Africa and ask many questions about the role of parks as a basic tourist attraction, and hence a significant economic baseline around which a thriving tourist industry may be built such as the situation in Kenya, Uganda and Tanzania, to mention but a few of the developing countries well known for attracting tourists.

The place of scientific research, the protection of representative gene pools of fauna and flora and the use of natural areas for education are some of the common values that spur both developing and developed countries to set aside national parks as logical institutions within their national development plans.

When the question of national parks is considered by an economist or a casual investor, emphasis is placed on doing everything possible to maximise economic returns from wildlife, scenic areas or shorelines as natural resources. To the investor, the sooner he can recover his capital the better his profits are going to be in time. Lodges and hotels are built and extensive advertising is undertaken to ensure that a viable occupancy rate of 60 per cent is reached, maintained and wherever possible surpassed. Sooner or later the question of expansion is raised because the developers cannot afford to see a single soul turned away for lack of aecommodation..

The visitor, having paid a fair amount of money to have a safari arranged naturally expects to get fair return for the money. In many cases, the visitor has saved over a very long period of time and this one journey may be the first and only one to distant lands. The result is therefore a very high demand from the visitors to the safari organisers and a perpetual state of anxiety on the part of the organisers to please - this being the most reliable method of safari advertising and promotion. The extreme conservationist would on the other hand remain completely content

with a natural area where human activity is excluded. A preliminary evaluation of the outcome of either of the foregoing approaches brings out the fact that, pursued to the nth degree, progressive development and utilisation or human exclusion both end up with unsatisfactory results.

If a natural area is set aside without considering human needs, then its significance to humanity may be so minimised as to endanger its continued existence as a national park or reserve.

Kenya has attempted to establish National Parks to protect representative fauna and flora, while allowing limited areas within those parks to be utilised for tourism, education and research. Conservation of the natural environment is seen to be the main objective around which the other activities can and actually do revolve. Originally, game lodges were built inside the national parks and the vistor was actively informed of the unique experiences of being surrounded by wildlife sounds in the night; but gradually small townships of 200-300 people have developed having unique social-political problems whose solutions tend to conflict with the national parks concept. The national parks of Kenya have therefore resolved to pursue a policy of peripheral development for now and the future, and it is hoped that a phasing out programme will be adopted to remove the developments that already exist inside these areas at some appropriate time.

Roads

The construction of road circuits in the parks initially led to areas of large concentrations of wild animals, birds or vegetation of outstanding beauty. Over the years it has been learned that roads which are built along natural contours are not only cheaper to maintain but they are also aesthetically more acceptable. Special road designs have been developed to serve as fire breaks either when accidental fires occur or when planned management fires are set by the administration to achieve desired results.

Roads in the Nairobi park are well laid out, well maintained and they are not going to be increased in length. The problem in the Nairobi park, then, is not with the official roads, but with people driving cross-country, taking short-cuts, following and surrounding animals, etc.

From our observation, we are able to confirm that it takes very little time when the soil is wet to create tracks. It takes many years before a track recovers its natural indigenous vegatation, if ever.

Driving cross country in the dry season leads to the formation of permanent tracks. We have accordingly come out with a recommendation to prohibit cross-country driving in parks altogether. Although we were not able to quantify the effects of pollution emitted by visitor vehicles, this important aspect should never be overlooked in the final analysis.

Another important problem closely associated with roads is that of murram pits. Murram for road maintenance has been, and continues to be dug from all parts of the park, leaving bare patches which are not covered with indigenous vegetation or, for that matter, with any vegetation at all. We have recommended that murram should be brought into the park from outside for all road works; we are nevertheless mindful that vegetation and animal life new to a given park could be introduced into it in this way.

Integrated Planning

The inadequacy of national parks as eco-systems or biotopes is dramatised by the regular animal and bird migrations into and out of these areas. This observation means, in effect, that if a majority of national parks in the world were fenced off and the areas used by a majority of migrating species were put to other uses unrelated to conservation, e.g. the building of residential areas, then within a very short period of time most world parks would cease to be viable biological entities. In fact, many of them would end up as enlarged zoos or game farms which are becoming popular in industrialised countries.

It is now clearly recognised here that for any national park to survive planning of the land use in adjacent areas must take into consideration the existence of the park concerned and vice versa. This means in effect that in a farming or ranching area certain activities beneficial to the community may be discouraged in favour of the park. In this case, national park authorities may be called upon to compensate that community for the resultant loss of revenue. If national parks are to survive, this principle must be accepted. The writer is aware of the fact that this proposal is a departure from conventional practices, but the fact of the matter remains that if the interest in lands adjacent to parks is not taken care of the national park concept is doomed to fail.

In Kenya, Uganda and Tanzania, there are national parks which could benefit from additions of parcels of lands outside, and there are certain portions included inside the declared national parks that could be excised

from the parks and put to other uses without any detriment to the parks. If an attempt is made to implement this kind of thinking then the philosophy must not be one-sided, by park authorities or their neighbours.

CASE STUDY: A RESUME

A study in human pressures on the national parks of Kenya, with special emphasis on the problem of vehicle pressure, is presented. This study is in many ways a preliminary investigation into a massive problem to which most if not all national parks in the world have or must find a solution. How to transport visitors around the parks, assure the visitor what is referred to as a 'unique personal experience', avoid crowd situations and still allow the visiting public to go to parks without the inconvenience of programming and advance booking and the accompanying disappointment of being turned away at the gate of a national park because the optimum number of visitors has already come in.

The writer extends his sincere appreciation to the East African Wildlife Society for financing the study and his colleague, Mrs. Hanka K. Lee, with whom he continues to undertake the study.

Introduction

> The National Park has a dual purpose: (1) to conserve the scenery, wildlife and natural and historical objects; and (2) to enable these assets to be enjoyed in a manner that would leave them unimpaired for the enjoyment of future generations. (Senge)[1]
>
> National Parks give protection but they also must be protected. There are few countries where parks have not been threatened by being overrun, reduced, altered or even destroyed by external pressure. But there are also internal ones such as overuse by visitors. (Curry-Lindahl)
>
> The National Park is required to meet popular demand, but such a popular demand is not always reasonable. Those advocating rigid protection of nature or loving wilderness reject any type of development. Those enjoying recreation demand the expansion and improvement of roads, camping grounds, and other recreational facilities.[2] Such expansion of facilities or any type of development should, however, be suitable to the desirable use of National Parks and the protection of the natural environment.

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1. The quotations on this page are taken from papers given by world authorities on national parks at the Second World Conference on National Parks at Yellowstone and Grand Teton National Parks in 1972.

2. In East Africa these 'other recreational facilities' should be located as far out of the parks as possible.

To this end, both qualitative and quantitative restrictions on park use are needed. Qualitative restrictions mean those which cover activities in parks and quantitative restrictions refer to the number of park visitors. (Senge)

Natural areas have carrying capacities governing their conservation and use in a rational way. To make the best use of the carrying capacity consistent with the protection of nature, park use is restricted and a limit placed on the extent and degree of development. In other words, it is an optimum people-land use ratio. So far, no theoretically right scale of carrying capacity has been worked out, but such a scale would become an important guideline in determining the proper relationship of nature conservation and development for national parks in the future. (Senge)

Human pressures in general, and tourist pressures in particular, are increasing rapidly in the national parks all over the world. The establishment of a measurement of carrying capacity is of the greatest urgency, as can be illustrated by a few examples:

In Japan, the number of park visitors increased more than two-fold between 1960 and 1970, from 140 million to 300 million.

The number of daily visitors to Hakone, close to Tokyo, reached 150,000 in July 1971.

In the American Rocky Mountains Park, gathering of stones and disposal of litter by park visitors is measurably affecting the high tundra ecosystem.

In the East African parks, many ostriches are deserting their eggs after being frightened off by visitors driving too close to sitting birds.

In Serengeti, cross-country driving has affected the drainage patterns: rain water now flows rapidly in car tracks, damaging the vegetation rather than improving it.

The problem of human pressure in national parks is not a new one, but it is only in the past few years that scientists in a number of different countries have begun to show an increasing interest in the matter and are attempting to establish criteria for the measurement of human carrying capacity on which it is hoped that management policies will be based. The United States has exhibited the greatest concern, which has resulted in studies of, to name a few: The recreational carrying capacity of the national parks; effects of visitors on the natural ecosystem in the Rocky Mountains National Park; a study to develop criteria for determining the carrying capacity of areas within the national park system.[3] It is,

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3. See Bibliography, Appendix 2

in fact, quite understandable that the U.S.A. should show this concern: the country in which, one hundred years ago, the idea of the creation of parks developed may now be undergoing a period of decline of the parks system and is often cited by its own experts as the outstanding example of overuse of parks.

A comparison of the situation - quantitatively and qualitatively - in the national parks of the U.S.A., Japan and even Europe with those of East Africa, and particularly the Kenya parks system which received the highest recognition at the 1972 Yellowstone Conference, could lead to the conclusion that East Africa need have no worries about overuse of her parks for some considerable time. Such a conclusion would be totally wrong, and dangerous, for a number of reasons:

1. Firstly, the animals of Africa are unique: some species are, and always have been, restricted to this continent; others once widely spread over different parts of the world have in many places been exterminated and therefore, if not protected, may be easy to destroy in Africa too. African, and particularly East African, countries have a responsibility to themselves and to the rest of the world to conserve these animals. It is also a challenge to show that African countries can do better than has been demonstrated in other continents.

2. Secondly, tourist development in East Africa is increasing and seems to be very much encouraged as an important source of income for the respective states. For example, between 1969 and 1970 the number of beds in Kenya's game lodges increased by more than 30 per cent. It may be easy to overbalance the number of visitors, to increase the area and influence of tourist facilities and thus to destroy the basis for this revenue. This temptation should be resisted.

3. The third important reason is that the rapid spread of education and development generally has and will continue to bring increasing numbers of foreign and local visitors into the parks. What we are concerned with here is the danger of crowds overrunning the protected areas and erasing the experience which visitors expect to acquire out of visiting a national park.

The particular character of the East African parks limits our ability to use the studies conducted in the U.S.A. and elsewhere because the circumstances differ. Although the concept of the national park throughout most of the world is the same, the interpretation and application of it are often very different. Unlike the North American parks, those in East Africa should

not and cannot be treated as primarily areas for human recreation in the common sense of the word if they are to serve the purpose of conserving fragile and unique wildlife and its habitats for present and future generations. The needs and security of the natural inhabitants of the park must come first, with humans as privileged spectators. Human physical recreation in the American parks has brought hotels, restaurants and pleasure grounds, and thus destruction to the natural habitat. Let this be replaced in the African parks by mental recreation and educational purposes.

Even if this is achieved, humans are bound to affect the parks by their presence and by artifacts, such as roads, necessary for their presence. How far this development can and should go, and where to draw the line is what we will try to establish in the hope that it will help to build a secure overall policy for the Kenyan, and perhaps other East African national parks. This policy would tend to ensure the safety of the parks for the future in changing circumstances. We also hope that the study will be useful not only for Kenya and East Africa, but that it will contribute to the general knowledge of human pressures in parks throughout the world.

General Description of the Study

From most human activities in wild and protected areas, three main types of relationship can be discerned:

(1) humans (and their vehicles) and the landscape (physical features);
(2) human and animals and vegetation; and
(3) humans and humans (mainly psychological).

A number of authorities, prominent among whom is Senge[4], adapt these relationships to the definition of capacity:

(1) Physical Capacity. This is the capacity of the land surface available, related to geophysical features.
(2) Ecological Capacity. This relates back to the primary function of the park to conserve; the capacity is that within which the ecological balance is not disturbed.
(3) Psychological Capacity. This is the capacity according to the preference of the human users of the parks; experimental values could be obtained through psychological tests.

The foregoing may sound somewhat academic but is useful for the purposes of presentation. In reality, all three types of relationships intercross with one another. For instance, the vehicles damage the soil

4. See also Senge's paper to the Yellowstone Conference.

as well as the vegetation and detract from the pleasure of other visitors; building a ledge not only changes the landscape but deprives animals of a certain feeding area, and so on.

The relationship between humans and natural areas seems to be in constant conflict, in the sense that the human species takes over a part of the area for its exclusive use. But in the overall balance of an ecosystem (which a park, or a part of a park, is assumed to be) the negative influences may be counter-balanced to an extent by policies based on detailed research. The balance between these two aspects should be retained for the survival of the parks. Since it is the policy of the Kenya national parks to allow as little human interference as possible in the parks, leaving them as natural as possible, the negative influence of tourist activities should be minimised.

Each park has a part in which the impact of human influence is felt most strongly: walking areas, camping grounds, roads and buildings specially erected for human use. We will call these areas of direct human influence in contrast to the areas of indirect human influence. The latter are caused mainly by different types of pollution of air, water or soil by biocides used outside the protected area, industrial waste, noise and so on.

The area of direct human influence can be measured and related to the total area, giving some indication of park use. Indirect influence should also be measured, but this may have to involve a much longer scientific study, not only in the park itself but also outside (pollution, for example, often comes from outside the park and penetrates within). The influence on the parks from the outside world is often forgotten or deliberately ignored - which seems to be a great mistake as it may prove to be of vital importance. Small parks with easy access, situated near large towns or industrial areas, are much more susceptible to such influences than those parks in wilder areas. It may seem sensible, therefore, to divide parks into four categories: with easy or difficult access, and large or small.

This preliminary study was undertaken in two Kenyan parks - Nairobi and Nakuru - both of which are small and situated near large towns, and therefore suffer great threats to their survival. The first step of the study was to collect basic information which could prove useful. This was done from a number of different sources, but special attention was paid to information supplied by the park wardens and staff. The data were used and discussed from different angles enabling us to draw some conclusions and to formulate some recommendations. We realise that the study is still not

comprehensive and should be complemented by a number of other features which could only be obtained on the basis of specific research covering a longer period than was available. Nevertheless, we were able to build a part of the primary structure for use in similar studies in other parks. The pattern of data required has been laid out as follows:

1. Character of the Park and its Surroundings

   (a) Geological, geographical and ecological features of the park, and its size.

   (b) The character of the surrounding area, and any development proposed there.

2. Visitor Characteristics

   (a) Number of visitors and vehicles in the park by time period and by type of entry permit.

   (b) Projections of visitors and vehicles.

   (c) Distance travelled and time spent in the park by visitors.

   (d) Main areas of concentration and visitor influence.

   (e) Any other information, especially that needed to estimate the psychological capacity of the park.

3. Development in the Park

   a) Existing.

   ROADS: length of official roads and tracks in the park; all-weather and dry-weather surfaces; numbers of visitors related to road length; damage done by maintenance of the road system; any other characteristics.

   LODGES: number of lodges; area of each; number of staff and their families; number of visitors; sewage system and any other pollution; type and number of accompanying buildings; any other relevant characteristics.

   WALKING AREAS: situation, area, type of vegetation; number of visitors; effect on ecology.

   CAMP SITES: number, type, area; number of visitors and vehicles; effect on ecology.

   AIR STRIPS: number, type, area; use; size; effect on ecology.

   OTHER AREAS OF HUMAN DEVELOPMENT

   b) Proposed development or improvement.

4. Indirect Human Influence on the Park, and its Sources

Water, air, soil, aesthetic pollution, etc; both inside and from outside the park.

In the further study, this information should be complemented by any other which may prove useful in the particular circumstances of different parks. As no similar study has been undertaken in East African parks, it is anticipated that this report will stimulate discussion and decision making in a number of areas to solve problems and to define important questions, preferably before long term developments are embarked upon or casual permission granted, e.g. for driving off the roads.

In our study of visitor and vehicle pressure in the national parks, emphasis was placed on the Nairobi and Lake Nakuru National Parks, partly because of their smallness and ease of access and partly because of their location, close to high human population.

The numbers of visitors and their vehicles were recorded; the road pattern was carefully studied and some understanding arrived at as to why large numbers of drivers tended to drive off the road all over the park. It was noted that mating and hunting animals were separated or seriously disturbed and a strong recommendation was made to restrict vehicles to maintained roads.

At the time of presenting this paper (April 1974), it was gratifying to note that a majority of the recommendations made following this preliminary study have been implemented. The administration of the Nairobi park has gone further in that plans are underway to harrow and seed with local grasses the undesirable vehicle tracks to help speed up the healing of scars brought about by visitor and vehicle pressure.

It is the intention of the researchers to publish their study at a later date when additional information is available and the study is more complete.

The immediate steps to be taken to solve some of the problems would be as follows:

Recommendations - Nairobi National Park

1. DRIVING OFF ROADS SHOULD BE PROHIBITED BY LAW.

   This would prevent the destruction of vegetation from vehicle pressure, particularly in the park's central area.
   It would also keep some animals and birds from being molested, run over, scared from their nesting places, not being able to hunt or breed properly, others from becoming dangerously tame.

This would save labour (in digging ditches) due to the half-policy being exercised at the moment.
This would solve the potential danger of accidents to animals and to vehicles on their own.
Driving off the roads should be prohibited for parks' employees, e.g. lorry drivers working on road maintenance, etc., as well as for visitors.
Prohibition of driving off roads should not be seen as a completely new requirement since a similar regulation is included in the Tsavo National Park Regulations of the National Parks of Kenya Act.
What we recommend is simple. To extend the same to the other parks as a total prohibition of driving off roads in all parks, especially, Nairobi, Amboseli and Lake Nakuru National Parks.

2. REGULATIONS SHOULD BE ENFORCED.
Penalties for disobeying regulations such as the speed limit regulations of the National Parks of Kenya Act (Nairobi Park Regulations Section 6) should be strictly enforced. We recommend an on-the-spot fine or immediate arrest on breach of regulations in parks.

3. INFORMATION AND REGULATIONS SHOULD BE BETTER PRESENTED TO THE PUBLIC.
The information and regulations should be better exhibited and preferably also printed on separate sheets of paper and distributed to visitors as they enter the parks; or else the regulations should be printed on the reverse of entry tickets.

4. THE EDUCATIONAL PROGRAMME SHOULD BE EXTENDED AS ESSENTIAL.
This programme should be on two levels, one for the employees of the parks and one for the public. The understanding and participation of members of the public in parks matters is essential for the future security of the parks.

5. PARK BUSES OR MINIBUSES SHOULD TAKE VISITORS AROUND THE PARK.
This would solve the problem of overcrowding the park for some considerable time to come.
It would give the park authorities easier and better control over visitors.
It would lower pollution created inside the area.
It would help to ensure visitor exposure to the educational programme.
Most important, it would help ordinary citizens to visit the parks.

6. ENTRANCE FEES FOR VEHICLES SHOULD BE RAISED.

This should be done for weekends and public holidays to discourage excessive use of parks at those times and to encourage use of the parks on weekdays.
This measure would also help to increase vehicle occupancy rates.

7. NO MORE ROADS OR BUILDINGS SHOULD BE CONSTRUCTED IN THE PRESENT AREA OF THE PARKS (NAIROBI AND NAKURU).

Any necessary extensions or additions to existing buildings should be put outside the park boundary.
Murram for maintaining the park roads should be brought into the park from outside, not dug from inside the park as the case is now.

8. AN ECOLOGIST-PLANNER SHOULD BE EMPLOYED.

To advise the park authorities on any developments which may be necessary, an ecologist-planner should always be consulted in matters concerning any physical changes within the park.

9. A PROGRAMME OF RESEARCH SHOULD BE UNDERTAKEN IN THE FOLLOWING SUBJECTS:

- changes in animal species and types of vegetation.
- changes in animal behaviour within the park.
- pollution, its sources and its effects on vegetation and animal life in the park. This research should also include certain areas outside the park and the plans for their development - as a possible element of influence in the future.

10. KITENGELA SHOULD BE ACQUIRED AS AN EXTENSION TO THE NAIROBI PARK.

It is our considered opinion that, if this recommendation is not adopted, the park will greatly lose its present quality since the natural instincts of animal migration cannot be preserved in miniature. Animals migrate to the Kitengela in the wet seasons; and if the area is not included in the park, it will be developed or farmed more intensively and this will put an end to migration. Carnivores, e.g. lions and cheetahs, retreat to Kitengela also, and once the area is farmed they will gradually be exterminated.
Enlarging the park will help with the problem of pollution from outside which inevitably penetrates within.

The capacity of the enlarged park in terms of visitors will have a much greater chance to meet the needs and the pressures of the growing tourist industry.

Summary of Recommendations - Nakuru National Park

Recommendations 1 to 9 dealing with Nairobi apply equally to Nakuru. Additional recommendations, specific to Lake Nakuru National Park, are listed below:

1. The extension of the park should be completed as soon as possible.
2. The research programme should be expanded, with special emphasis on pollution. A constant check should also be kept on the level of chemical and other foreign substances finding their way into the lake.
3. Efforts should be made by the Kenya national parks to achieve some control over the use of the catchment area, but more definitely, the parks should have a say in what pesticides and fertilisers may be used in the catchment zone.
4. No further development should be undertaken in the Park without the ecological impact of the proposed development being investigated in great detail. A new gate will be necessary in the extension to reduce traffic on the heavily-used main road.
5. Roads in the Park should not be increased in length without prior written agreement from the Parks Director; nor their design and general characteristics changed, except that all official roads should be provided with an all-weather high standard murram surface. We do not recommend tarmac in the Nakuru Park. A limited number of viewing places (laybys) for cars should be provided along the road. Passing places should be constructed on the narrower sections of the roads. Special care should be taken not to damage the vegetation around the observation hides.
6. Research should be undertaken on the impact of camping in this park and in other parks. If excessive damage is occuring camping in the Nakuru Park should be discontinued for the present.
7. Walking areas on the lake shore should be well defined and adhered to.

   In general, walking should be allowed in national parks in specified areas but some further study of this subject should be undertaken.

Continuation of the Study

We believe that this study, which can be no more than preliminary, will be useful to the Kenya national parks and to scientists working on similar problems elsewhere. We also realise that, on the national and international level, its value may be limited. Only two parks have been examined and these not extensively (only over three months). If full value is to be obtained from this study in the examination of human and vehicle pressure in the parks and meaningful criteria established to assess one of the most urgent problems in wildlife management, then the study should be continued for another two or three years.

If this study is continued, it would probably focus on the following fields:

A continuation of the study of visitor characteristics, but extended on the lines of the recommendations in the U.S. National Parks Service publication, 'A Study to Develop Criteria for Determining the Carrying Capacity of Areas within the National Parks System'. This would involve the circulation and analysis of an enlarged questionnaire to determine visitor preferences, thus possibly yielding an estimate of the parks' psychological capacity. The extended questionnaire would include the Nairobi, Nakuru and Amboseli parks.

An examination of particular points of pressure (e.g. Mzima Springs, the lodges, the Naro Moru route up Mt. Kenya, etc.) and suggestion of measures to alleviate these pressures if necessary.

A record of areas of direct human influence, and noting other fields of human influence on which further action seems desirable.

A record of measures taken in certain parks to relieve pressures which could be relevant elsewhere.

From specific recommendations for each park, drafts of revised national regulations, policy and other measures (e.g. improved statistical data collection and recording) which seem desirable.

Conclusions

In less than ten years the number of tourists in the Nairobi National Park is likely to double.

Precautions should be taken now to prevent the park from being overrun.

Particular care should be taken to preserve vegetation from destruction by vehicles driving across country.

The number of visitors is not very large when averaged over the years, but it must be remembered that there are some months, some days (Sundays and holidays) and certain hours (3 to 7 p.m.) when much greater numbers are in the park.

There are also areas where people concentrate (particularly the central sectors) such that the number of people there is much higher and the vehicle pressure greater than a mere average would suggest.

APPENDIX 1. NAIROBI PARK VISITOR CHARACTERISTICS

Table 1. Average Vehicle Occupancy.

	People	Vehicles	People per Vehicle
Non-residents	43%	38%	3.92
Residents	57%	62%	3.28
TOTAL	100%	100%	(3.52)

Table 2. Distance and Time Travelled in Park.

	Distance	Time	Speed
Non-residents	46.2 km	2.7 hrs	17.1 km/h
Residents	42.5 km	2.5 hrs	17.0 km/h
TOTAL	43.2 km	2.6 hrs	17.0 km/h

Table 3. Time of Entry to Park.

3.00 - 3.59 p.m.	24%
4.00 - 4.59 p.m.	30%
5.00 - 5.59 p.m.	12%
All other times	34%

70% of respondents were in the park at 5.00 p.m.

Table 4. "Have you Visited Other Parks?"

	Yes	No
Non-residents	60%	40%
Residents	86%	14%
TOTAL	76%	24%

Table 5. Favourite Parks for Those Answering Yes in Table 4.

	Nairobi	Tsavo	Amboseli	Samburu	Ngo'goro	Other*
Non-residents	38%	38%	0%	0%	0%	24%
Residents	29%	12%	26%	9%	9%	15%
TOTAL	32%	19%	19%	6%	6%	16%

* The number of people naming other parks individually was statistically insignificant.

APPENDIX 2. NAKURU PARK VISITOR CHARACTERISTICS

Table 6. Average Vehicle Occupancy.

	People	Vehicles	People per Vehicle
Non-residents	39%	38%	3.61
Residents	61%	62%	3.81
Total	100%	100%	3.73

Table 7. Distance and Time Travelled in Park.

	Distance	Time	Speed
Non-residents	17.8 km	2.2 hrs	8.2 km/h
Residents	21.6 km	1.7 hrs	12.8 km/h
Total	20.3 km	1.9 hrs	10.9 km/h

Table 8. Distance Travelled in Park.

	0-10 km	11-20 km	21-30 km	30+km
Non-residents	39%	33%	6%	22%
Residents	34%	21%	21%	24%
Total	36%	26%	14%	23%

Table 9. Length of Stay in Park.

	Under 1 hr	1 - 2 hrs	2 - 3 hrs	Over 3 hrs
Non-residents	16%	47%	16%	21%
Residents	33%	45%	12%	9%
Total	27%	46%	13%	13%

Table 10. "Have you Visited Other Parks?"

	Yes	No
Non-residents	96%	4%
Residents	97%	3%
Total	97%	3%

Table 11. Favourite Parks for Those Answering Yes in Table 10.

	Tsavo	Nakuru	Amboseli	Samburu	Nairobi	Aberdares	Others*
Non-resident	20%	30%	0%	10%	10%	10%	20%
Residents	20%	9%	20%	11%	11%	3%	26%
Total	20%	16%	13%	11%	11%	5%	24%

* The number of people naming other parks individually was statistically insignificant.

APPENDIX 3. AREAS OF HUMAN INFLUENCE IN NAKURU PARK.

	Hectares
Roads	
Main roads	13.7 (assumed 2½ m width)
Tracks	1.3
Sub-total	15.0
Building	
Ranger post office gate	2.6
Staff quarters and warden's house	2.7
Presidential pavillion	2.8
Sub-total	8.1
Observation Areas	
South shore	18.0
West shore	21.0
Observation hides	0.2
Hippo point	0.4
Sub-total	39.6
Picnic Sites	
Sub-total	0.5
Camp Sites	
Magadi	0.3
Njoro	0.7
Sub-total	1.0
TOTAL	64.2

Total land area of park averages 3,600 ha.
Area of human influence is thus around 1.8 per cent of total.

Source: Assistant Warden of Nakuru Park.

APPENDIX 4. AREAS OF HUMAN INFLUENCE IN NAIROBI PARK.

	Hectares
Roads	
Main roads	90 (assumed 5 m width)
Tracks	90 (assumed same as main roads)
Sub-total	180.0
Buildings	
Staff buildings	10.4
Ranger posts, etc.	0.6
Sub-total	11.0
Gates	
Main, orphanage, HQ	15.1
East	0.2
Langata	0.1
Cheetah	0.1
Banda	0.4
Sub-total	15.9
Walking Areas	
Hippo pool	1.8
Observation points	0.1
Picnic area	0.1
Sub-total	2.0
TOTAL	208.9

In East African Parks, unlike those in most other parts of the world, visitors are generally confined to their vehicles and, due to the particular circumstances, walking is seldom allowed. The roads and their surroundings are strongly influenced by people and their vehicles. The more people and vehicles there are on the road, the more roads are needed and the more the area of human influence.

Source: field measurements.

BIBLIOGRAPHY

I. Africana. Various issues.

2. Alldredge, Rendel B. Some Capacity Theory for Parks and Recreational Areas. Kenya National Park Service, July 1972.

3. Bradley, Robert Marvin. Some Aspects of the Ecology of the Warthog in Nairobi Park. M.Sc. thesis, University of East Africa, August 1968.

4. Brown, Leslie. East African Mountains and Lakes. Nairobi, 1971.

5. Chabeda, P.I.M. Environmental Pollution and Wildlife Potential in Developing Countries with Particular Reference to Kenya. February 1972.

6. The Conservation Foundation. National Parks for the Future. Washington, D.C., 1972.

7. First Wildlife Conference for Eastern Africa. Nairobi, 1969.

8. Held, R. Burnell, Brickler, Stanley and Wilcox, Arthur T. A Study to Develop Criteria for Determining the Carrying Capacity of Areas within the National Parks System. For the United States Department of the Interior, National Park Service. Colorado State University and the Center for Research and Education, Department of Recreation and Watershed Resources, November 1969.

9. Kenya. The National Parks of Kenya Act. Cap. 377.

10. Kenya. Board of Trustees of the Kenya National Parks. Lake Nakuru National Park, Kenya. Nairobi, n.d.

11. Kenya. Ministry of Finance and Economic Planning. Tourist Study. Nairobi, 1967.

12. Kenya. Ministry of Natural Resources. National Report on the Human Environment in Kenya. Nairobi, Ministry of Natural Resources, 1971.

13. National Geographic. 14I (5) May 1972.

14. Olindo, P.M. Planning Natural Parks for High Density Tourist Uses. Paper presented at the fourth session of the Working Party on Wildlife Management, held on February 1-3, 1972 in Nairobi.

15. Report of the Second World Conference on National Parks. Held on September 18-27, 1972, in Yellowstone and Grand Teton National Parks, U.S.A.

16. Rudnai, Judith A. Social Behaviour and Feeding Habits of Lion in Nairobi National Park. M.Sc. thesis. University of East Africa, 1968.

17. Stanley-Price, M.R. The Feeding Ecology and Energetics of Coke's Hartebeest. January 1973.

18. Sudia, Theodore W. and Simpson, James. Recreational Carrying Capacity of the National Parks. Washington, D.C., National Park Service, Office of Natural Science, 1972.

19. Tanzania. National Parks of Tanzania. Research Bulletin. Various issues.

20. Willard, Beatrice E. and Barr, John W. Effects of Visitors on Natural Ecosystem in Rocky Mountains National Park. For the United States National Park Service. Institute of Arctic and Alpine Research, June 1962.

BIBLIOGRAPHY

1. Africana. Various issues.

2. Alldredge, Rendel B. Some Capacity Theory for Parks and Recreational Areas. Kenya National Park Service, July 1972.

3. Bradley, Robert Marvin. Some Aspects of the Ecology of the Warthog in Nairobi Park. M.Sc. thesis, University of East Africa, August 1968.

4. Brown, Leslie. East African Mountains and Lakes. Nairobi, 1971.

5. Chabeda, P.I.M. Environmental Pollution and Wildlife Potential in Developing Countries with Particular Reference to Kenya. February 1972.

6. The Conservation Foundation. National Parks for the Future. Washington, D.C., 1972.

7. First Wildlife Conference for Eastern Africa. Nairobi, 1969.

8. Held, R. Burnell, Brickler, Stanley and Wilcox, Arthur T. A Study to Develop Criteria for Determining the Carrying Capacity of Areas within the National Parks System. For the United States Department of the Interior, National Park Service. Colorado State University and the Center for Research and Education, Department of Recreation and Watershed Resources, November 1969.

9. Kenya. The National Parks of Kenya Act. Cap. 377.

10. Kenya. Board of Trustees of the Kenya National Parks. Lake Nakuru National Park, Kenya. Nairobi, n.d.

11. Kenya. Ministry of Finance and Economic Planning. Tourist Study. Nairobi, 1967.

12. Kenya. Ministry of Natural Resources. National Report on the Human Environment in Kenya. Nairobi, Ministry of Natural Resources, 1971.

13. National Geographic. 141 (5) May 1972.

14. Olindo, P.M. Planning Natural Parks for High Density Tourist Uses. Paper presented at the fourth session of the Working Party on Wildlife Management, held on February 1-3, 1972 in Nairobi.

15. Report of the Second World Conference on National Parks. Held on September 18-27, 1972, in Yellowstone and Grand Teton National Parks, U.S.A.

16. Rudnai, Judith A. Social Behaviour and Feeding Habits of Lion in Nairobi National Park. M.Sc. thesis. University of East Africa, 1968.

17. Stanley-Price, M.R. The Feeding Ecology and Energetics of Coke's Hartebeest. January 1973.

18. Sudia, Theodore W. and Simpson, James. Recreational Carrying Capacity of the National Parks. Washington, D.C., National Park Service, Office of Natural Science, 1972.

19. Tanzania. National Parks of Tanzania. Research Bulletin. Various issues.

20. Willard, Beatrice E. and Barr, John W. Effects of Visitors on Natural Ecosystem in Rocky Mountains National Park. For the United States National Park Service. Institute of Arctic and Alpine Research, June 1962.

ENVIRONMENT AND STYLES OF DEVELOPMENT

By

I. Sachs, CIRED/EPHE

After the anti-novel and counter-culture, zero-growth. These are three symptoms, though very different from one another, of the re-examination of values by a society in search of new ideological responses to problems which have remained insoluble despite the spectacular progress of material growth, or which have arisen as a result of that progress: the generalised malaise of the young, the persistence of poverty, the aggression against the environment, the frustration of the Third World which today is wondering whether the very concept of development, founded upon efficiency, should not be replaced by that of liberation, centred on social justice and the creation of a new man.

Only a profound sense of uneasiness can explain why the theme of zero growth should have so captured the public imagination and why it should have been taken up by public opinion within so short a time despite the fact that it represents a complete reversal of the ideological outlook of the last two centuries and, still more, of the past fifty years. The frenzy of the mass media, the abuse of the computer, in order to give credibility to this or that idea by investing it with scientific trappings, explain part of this phenomenon but not all. In a world traumatised by the crisis of the 1930s, the appearance of the socialist camp and the emergence of the Third World, growth was in good standing with capitalists and revolutionaries, profit-makers and lovers of justice alike, and the only differences of opinion related to the methods and uses of growth. Today, however, the merits of growth are being questioned and - curiously enough - both the Left and the Right are dividing up into opponents and champions of growth.

The new awareness of environment problems appears to be both one of the causes and one of the symptoms of this new outlook. True, the degradation of the environment is reaching unpleasant if not dangerous proportions here and there. But would this in itself have been sufficient cause for challenging the very objectives of society? Whatever the causes may be, the debate is now open.

Its over-simplifications, not to say mystifications, tend to be tiresome. Man is presented, now as the arrogant lord of creation and demiurge, now as the prisoner of a machine on a world scale in which production and pollution are conspiring to crush him and in which the only kind of history is natural history, in the sense that the degradation of energy introduces an element of irreversibility. For some, the quality of life is obtained at the price of limiting material production; for others it is, on the contrary, proportional to the abundance of products.

Beyond these clumsy arguments we should not fail to observe an emerging political practice which has several claims upon our interest: the long-term future is becoming operational, the notion of organising possible futures and choosing a desired future is gaining acceptance, an approach to planning which is both global and normative at the same time is beginning to take the place of extrapolation, and the systems approach is replacing the sectoral method legitimised by Cartesianism. The hope of achieving continuous economic and social development hand in hand with rational management of the environment presupposes a redefinition of all objectives and all methods of action. The environment is a dimension of development, and must therefore be internalised at every decision-making level. Problems of resources, energy, environment, population and development cannot, in fact, be correctly understood unless they are examined in relation to one another; and this implies planning within a unified conceptual framework.

For the poor countries the alternative presents itself more than ever in terms of original projects of civilisation or of non-development, since to follow the path travelled by the industrialised countries appears neither possible nor, indeed, desirable. The rich countries will in future have to limit their wasteful use of resources which are in the process of relative exhaustion; price fluctuations will enforce this to some extent, but it would be dangerous to leave such matters to the hazards of the market. The elimination of waste and the confinement, within acceptable limits, of the pollution caused by the production or consumption of certain goods will also raise the problem of limiting the growth of material consumption, and at the same time of extending the range of social services in the broadest sense of the word in order to arrive at a form of development which makes less intensive use of resources and is, at the same time, less harmful to the environment. Such restriction of consumption cannot be achieved without institutional changes more radical than is at present realised, starting with the redistribution of incomes and the reduction of social inequalities.

In addition, there are a number of international problems: assumption of responsibility for the global environment, development of collective international resources regarded as the common heritage of mankind (e.g. the sea-bed), the impact on poor countries of policies initiated by the rich countries, and the creation of an international order capable of helping both to redefine their styles of life.

There is enough here to occupy a whole generation of social scientists. In fact, a new connexion will have to be established between the human and the natural sciences in order to achieve a better understanding of the interaction between natural and social processes of which man is both the subject and the object: a subject, let us add, conscious of belonging to nature and of his own gradual growth. Beyond an excessively possibilistic human geography and an excessively deterministic ecology, there is a new synthesis to be made in which the contradictions between anthropology and history will be abolished, and models of energy circulation will be linked with models of the production and circulation of matter and commercial goods. In the meanwhile, the charting of the future must be based on the practice of operational history in the Braudelian sense. In order to learn to define possible futures we must start by dismantling the manifold models of the past, in which population, resources, energy, technology, environment and social institutions are fitted together in a variety of fashions. In this context, La Terre et l'Evolution Humaine by Lucien Febre remains astoundingly topical after the passage of fifty years.

How is the new awareness of environment problems affecting the planner's field of vision?

Let us begin with a few necessary distinctions and definitions.

The term 'environment' covers, on the one hand, the sum total of identified and identifiable natural resources existing in finite quatities on Earth, and, on the other hand, the quality of the environment or, if one prefers, of the milieu, which constitutes an important element of the the quality of life and which also determines the available amounts and quality of renewable resources. In fact, the dividing line between the renewable and non-renewable resources is not drawn once and for all. Renewable resources may in the end be destroyed by abuses, and recycling makes possible the repeated used of non-renewable resources. Generally speaking, however, the distinction between these two groups of resources remains valid and useful.

Let us now consider the environment proper. A more ambiguous concept has rarely been known. Of the multitude of proposed definitions, we shall set aside two which are largely complementary.

For the systems approach experts, the environment is made up of everything that does not form part of the purposive system under consideration, though it does affect the performance of that system. As the system endows itself with environment policies, so the environment, in the sense of everything outside the system, recedes, and the success of these policies will consequently be measured by the disappearance of the concept of environment, which will in the end be internalised by the system.

Let us now abandon the game of paradoxes, and draw attention to one operational advantage of the above definition. It leads us to make a clear distinction between the ecological and the social action undertaken in order to achieve the explicit objectives of the purposive system constituted by development policies. Such an analysis should lead to a redefinition of development objectives with a view to more effective control of the ecological and social impacts of proposed action.

At a different level, the United Nations Environment Programme(UNEP) speaks of the total habitat of man. This ecological definition of the human environment has the disadvantage of being too comprehensive. But it can be interpreted more restrictively.

Let us distinguish three subsystems within the environment:

1. the natural environment;
2. the man-made technostructures; and
3. the social environment.

Now let us endeavour to study the effects of each of these on the living and working conditions of the different social agents and on the operation of enterprises (this corresponds, in an expanded form, to the problem of positive and negative externalities). The quality of the environment will be described by means of 'objective' indicators and will, at the same time, be apprehended at the level of its perception by the different social agents. Hence the need for a set of indicators ranging from physical and chemical measurements of the quality of water or air to psycho-sociological surveys and including analyses of the availability and accessibility of collective facilities, housing and social services, which will entail simultaneous recourse to statistics and to the time-budgets of the various agents.

As already stated, the two above definitions are not mutually exclusive. The former stimulates the planner's awareness of the inter-relations between natural and social processes. The latter concentrates on a more limited problem which is nevertheless of fundamental importance in the choice of development objectives - that of the quality of the environment properly speaking.

Let us now try to establish a relationship between the environment (M) and the population (P), techniques (T), natural resources (r) and the product (Y).

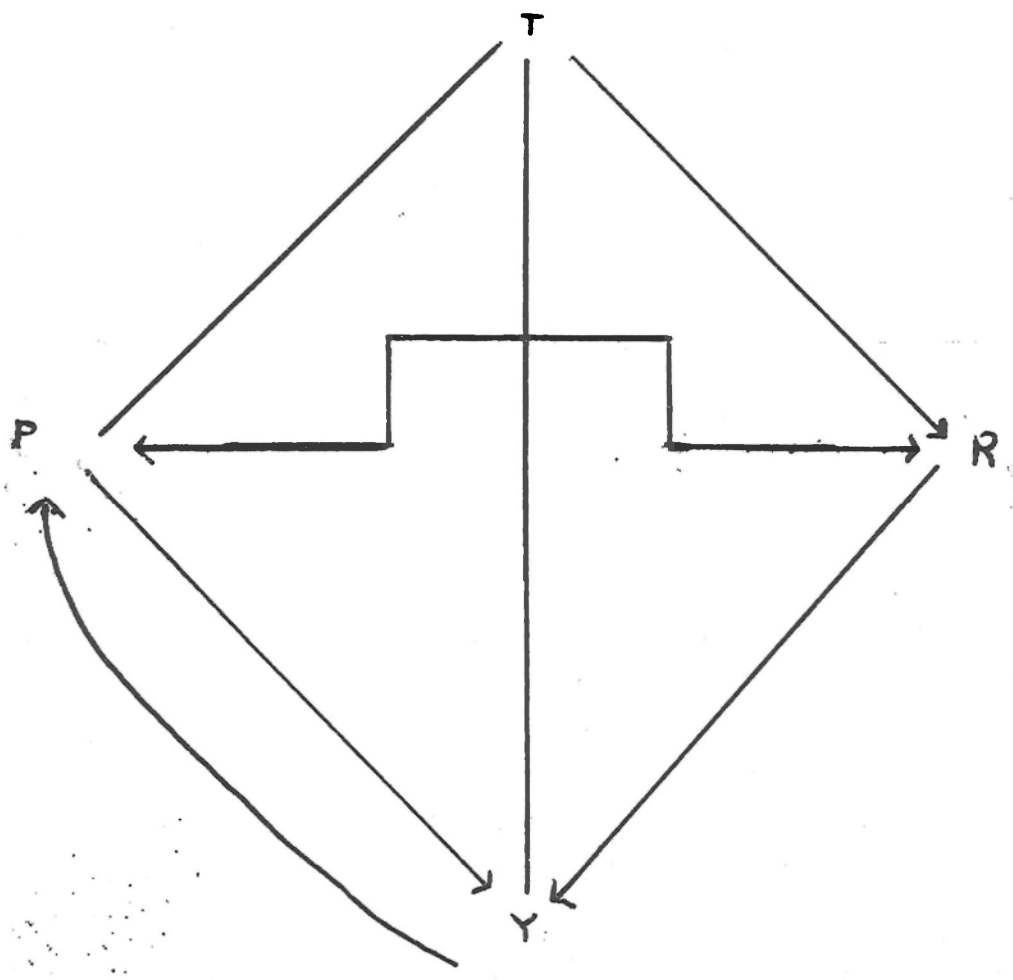

Figure 1.

The development economist's traditional field of vision is represented in Figure 1. By means of the available techniques, the population transforms the resources into the appropriate product for purposes of consumption and social reproduction. The dialectic between demographic pressure and resources forms the subject of a large literature dealing with technological and social change. Is it a source of progress or of involution? Put in such general terms, the question cannot be answered. There is no single model to describe the numerous configurations of these variables. On the contrary,

systematic efforts on the part of historians and anthropologists are called for to arrive at a typology of situations based on concrete data.

Let us now introduce the environment M. Figure 2 indicates the relevant new relationships:-

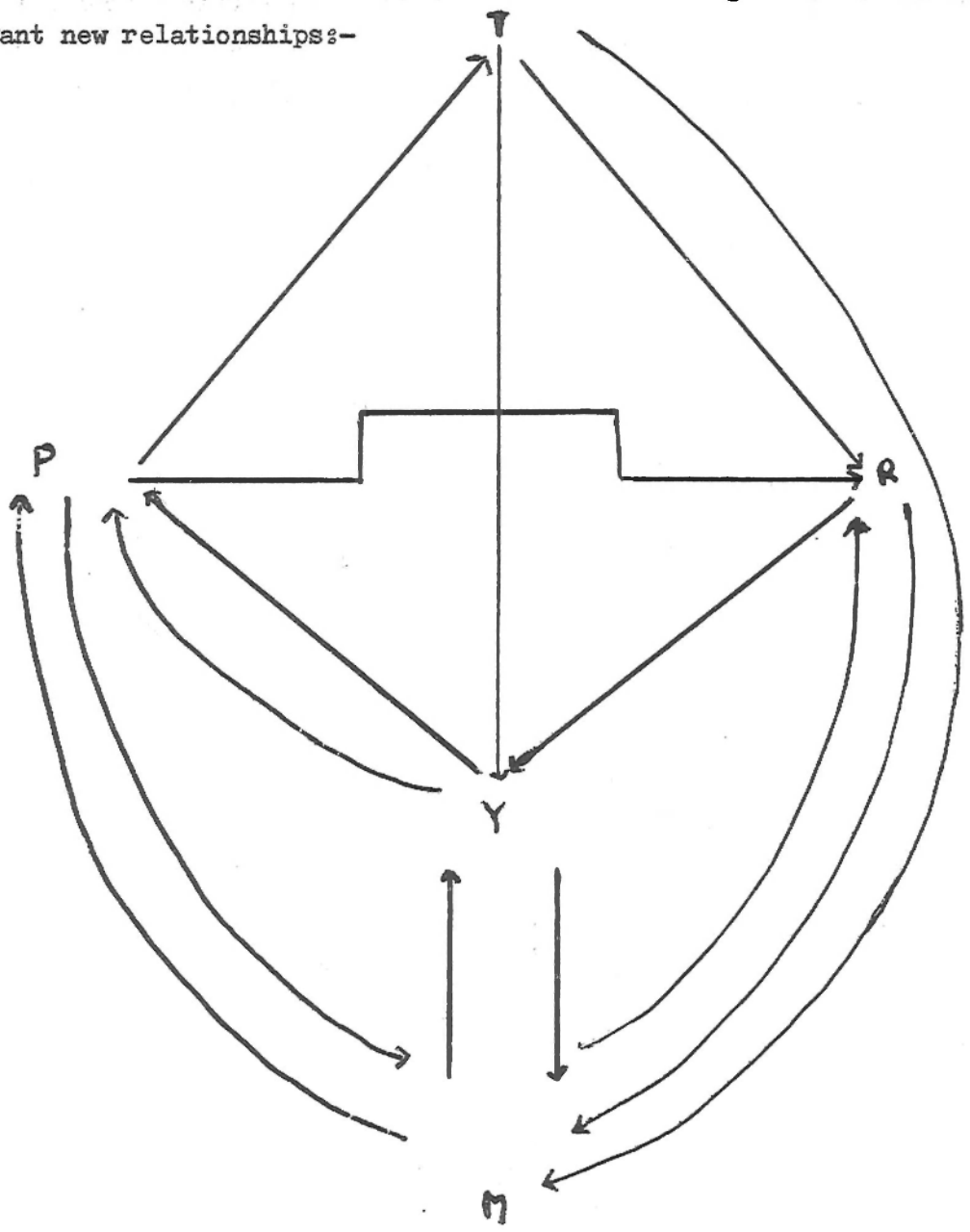

Figure 2.

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 Africaare 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 run-off. 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 ar

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 range-land 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. 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 apecies 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.

SEMINAR PROGRAMME

Sunday April 14, 1974

Check in at hotel

Monday April 15, 1974

8.30. a.m.	Registration/orientation
9.30 a.m.	Welcome by Dr. Liberty Mhlanga, Adlai Stevenson Institute, Chicago Opening remarks by the Hon. W.O. Omamo, Kenya Minister of Natural Resources; Dr. William Polk, President of the Adlai Stevenson Institute; and Prof. Dharam Ghai, Director of the Institute for Development Studies.
10.30 a.m.	Africa's interest in environment: Dr. Nicholas Otieno, Chief of Natural Resources, Economic Commission for Africa, Addis Ababa
12.00 noon	Lunch
2.00 p.m.	Round table discussion: Dr. Otieno, Dr. Mhlanga and Mrs. E. Dussauze-Ingrand of I.D.E.P., Dakar
3.30 p.m.	Tea
4.00-5.00 p.m.	Discussion
6.00-8.00 p.m.	Reception at the Panafric Hotel

Tuesday April 16, 1974

8.30 a.m.	Soil problems: Dr. Peter M. Ahn, Professor of Soil Science, University of Nairobi
9.30 a.m.	Water problems: Dr. Letitia E. Obeng, Director of Fresh Water Biology Research, Volta Project, Ghana
10.30 a.m.	Break
11.00 a.m.	Renewable resources: Dr. John Okedi, Director of the East African Fresh Water Fisheries Research Organisation, Jinga, Uganda
12.00 noon	Lunch
1.30 p.m.	Research: Dr. Thomas Odhiambo, Director of the International Centre of Insect Physiology and Ecology, Nairobi
2.30 p.m.	Appropriate technologies: Dr. Justinian F. Rweyemamu, Dean of the Department of Social Science, University of Dar-es-Salaam
3.30 p.m.	Tea

Tuesday April 16, 1974 (cont.)

4.00-5.00 p.m.	Pollution: Mr. L. Hurpaul, Chief of the Environmental Health Unit, Ministry of Health, Mauritius
7.30 p.m.	Film

Wednesday April 17, 1974

8.30 a.m.	Rural settlements: Dr. A.L. Mabogunje and Dr. M.O. Filani, Department of Geography, University of Ibadan, Nigeria
9.30 a.m.	Urban settlements: Mr. Abbas Hussain Shah, Director General of the Karachi Development Authority
10.30 a.m.	Break
11.00 a.m.	Non-renewable resources: Dr. William A. Hance, Chairman of the Geography Department of Columbia University, New York
12.00 noon	Lunch
1.30 p.m.	Tourism: Mr. Perez Olindo, Director of Kenya National Parks
2.30 p.m.	Eco-development: Miss Krystyna Winawer, CIRED-EPHE, Paris
3.30 p.m.	Tea
4.00-5.00 p.m.	Presentation of Kuumba case study: Dr. Mhlanga
7.30 p.m.	Film

Thursday April 18, 1974

8.30 a.m.	Choosing small groups and discussion of case study
12.00 noon	Lunch
2.00-5.00 p.m.	Further discussions

Friday April 19, 1974

8.30-12.00 a.m.	Case study due
12.00 noon	Lunch
2.00-(6.00)p.m.	Field trip to Nairobi Game Park

Saturday April 20, 1974

8.30 a.m.	Exchange of small discussion group recommendations
10.00 a.m.	Break
10.30-12.00 a.m.	Plenary session with one or two leaders discussing the proposals

Saturday April 20,1974 (cont.)

Afternoon	Free

Sunday April 21, 1974

6.30 a.m.	Leave for field trip to Nakuru
8.00 p.m.	Tentative return

Monday April 22, 1974

9.00 a.m.	Presentation of second case study; choose small groups
10.30 a.m.	Break
11.00 a.m.	Small group discussions
12.00 noon	Lunch
2.00-5.00 p.m.	Further discussions

Tuesday April 23, 1974

8.30 a.m.	Small group discussions
12.00 noon	Lunch
2.00-5.00 p.m.	Small group discussions
7.30 p.m.	Film and lecture on Earth Resources Technological Satellite: Mr. A.B. Cahusac, National Environmental Secretariat of Kenya

Wednesday April 24, 1974

8.30 a.m.	Plenary discussion of case studies
12.00 noon	Lunch
2.00-5.00 p.m.	Summation: Dr. Kai Curry-Lindahl, United Nations Environmental Programme, Nairobi, and others
5.30-7.00 p.m.	Public lecture: Barbara Ward (Lady Jackson)

Thursday April 25,1974

Departure

BOTSWANA

1. Edwin Tjakabaka Matenge, Under Secretary, Ministry of Mineral Resources, Private Bag 18, GABORONE, Botswana.
2. W.S. Pintz, Planning Officer, Ministry of Mineral Resources & Water Affairs, Private Bag 18, GABORONE, Botswana.

ETHIOPIA

3. Dr. Kelkilew Tadesse (Engineer), Head of Environmental Health Division MPH, P.O. Box 5504, ADDIS ABABA, Ethiopia.

LESOTHO

4. Mr. M. Molapo, Senior District Administrator, Box 911, MASERU, Lesotho.
5. Mr. T.E. Khechane, Assistant Secretary, Central Planning Office, Box 630, MASERU, Lesotho.

MALAGASY

6. Mr. Joseph Andriamampianina, Chief of Forestry & Natural Resources, Université de Madagascar, TANANARIVE, Madagascar.
7. Mr. Sylvere Rakotofiringa, Science Faculty, Université de Madagascar, TANANARIVE, Madagascar.
8. Mr. Claude Rakotomalala, Sanitary Engineer, S.E.S.M.S.B.P. 866, TANANARIVE, Madagascar.

MALAWI

9. Dr. Peter Mwanza, Principal, Chancellor College, University of Malawi, Box 280, ZOMBA, Malawi.

SOMALIA

10. Mohamed Hersi Bahal, Head of Agriculture Planning Sector, Ministry of Planning & Co-ordination, MOGADISCIO, Somalia.
11. Mohamed Musa Awaleh, Head of Range Management, Ministry of Livestock, Forestry & Range, MOGADISCIO, Somalia.

SUDAN

12. Dr. El Sammoni Abdalla Yacoub, Secretary General, Nat. Council for Research, P.O. Box 2404, KHARTOUM, Sudan.
13. Dr. Ali Mohayad Bannaga, Director, Agricultural Research Council, Box 2404, KHARTOUM, Sudan.
14. Mr. Abdalla Mahgoub, Councellor, Economic Dept. , Ministry of Foreign Affairs, KHARTOUM, Sudan.

SWAZILAND

15. Mr. O.Z. Dhlamini, Permanent Secretary, Agriculture, P.O. Box 162, MBABANE, Swaziland.
16. Mr. M.J. Dhlamini, District Commissioner's Office, P.O. Box 20, SITEKI, Swaziland.
17. Mr. P.K. Lukhele, Project Manager, R.D.A. (North) Box 54, PIGG'S PEAK, Swaziland.

TANZANIA

18. Dr. S. Taki, Ministry of Economic Affairs and Development Planning, P.O. Box 9242, DAR-ES-SALAAM, Tanzania.

TANZANIA (cont.)

19. Mr. Bakari M.N. Mbano, Game Management Officer, Wildlife College, Box 3031, MOSHI, Tanzania.
20. Mr. G.K. Mwanjabala, Ministry of Foreign Affairs, P.O. Box 9000, DAR-ES-SALAAM, Tanzania.

UGANDA

21. Mr. C. Semugoma, Dept. of Town & Regional Planning, Box 1911, KAMPALA, Uganda.

ZAMBIA

22. Mr.B.D.Chileshe, Under Secretary, Ministry of Lands, Natural Resources, Box 55, LUSAKA, Zambia.
23 Mr. T.N. Mulala, Regional Planning Officer, Box 1296, NDOLA, Zambia.
24. Mr. B.S. Liboma, Office of the Conservator of Nat.Resources, Box RW42, LUSAKA, Zambia.

KENYA

25. Mr.W.N.Mbote, Dep.Director of Fisheries, Ministry of Tourism & Wildlife, Box 40241, NAIROBI, Kenya.
26. Mr. Mukina Muturi, Senior Economist, Min.of Finance & Planning, Box 30007, NAIROBI, Kenya.
27. Miss Rose W. Gakuya, Dept. of Physical Planning, Box 45025, NAIROBI, Kenya.
28. Dr. S. Ominde, Chairman, Dept. of Geography, Univ. of Nairobi, Box 30197, NAIROBI, Kenya.
29. Dr. Richard S. Odingo, Univ.of Nairobi, Box 30197, NAIROBI, Kenya.
30. Dr. Alfred Hove, Univ. of Nairobi, Box 30197, NAIROBI, Kenya.
31. Mr. J.M. Gachui, Environmental Secretariat, Office of the President, Box 72480, NAIROBI, Kenya.
32. Mr. William W. Wapakala (Senior Soil Chemist), Agricultural Chemistry Section, Ministry of Agriculture, Box 30028, NAIROBI, Kenya.
33. Fr. G. Muhoho, Environmental Secretariat, Office of the President, Box 72480, NAIROBI, Kenya.
34. Mr. John Swai, Ministry of Finance & Planning, Box 45025, NAIROBI, Kenya.
35. Mr. B. Cahusac, Environmental Secretariat, Office of the President, Box 72480, NAIROBI, Kenya.
36. Mr. George Mambo, Urban Industrial Mission, A.A.C.C., Box 20301, NAIROBI, Kenya.
37. Dr. Gary Herbertson, UNEP, Box 30552, NAIROBI, Kenya.

MAURITIUS

38. Mr. Guy Danjoux, Principal Town & City Planning Officer, PORT LOUIS, Mauritius.
39. Mr. Leckraz Hurpaul, Chief Environmental Health Unit, Ministry of Health, PORT LOUIS, Mauritius.

SENEGAL

40. Dr. Elizabeth Dussauze-Lagrand, U.N. African Institute for Economic Development and Planning (I.D.E.P.), B.P. 3186, DAKAR, Senegal.

FRANCE

41. Miss Krystyna Winawer, International Centre for Research on Environment & Development (CIRED), 49 Boulivard Raspail, PARIS VIIe, France.

SEMINAR COORDINATORS

1. Prof. Dharam P. Ghai, I.L.O., Box 500, CH 1211, GENEVA, Switzerland. (At the time of the Seminar, Prof. Ghai was Director of the Institute for Development Studies, University of Nairobi.)
2. Prof. William R. Polk, President, Adlai Stevenson Institute of International Affairs, 5757 South Woodlawn Ave., CHICAGO, Ill., 60637, U.S.A.
3. Mr. William Mares (Fellow), Adlai Stevenson Institute, 5757 South Woodlawn Ave., CHICAGO, Ill., 60637, U.S.A.
4. Dr. Liberty Mhlanga (Fellow), Adlai Stevenson Institute, 5757 South Woodlawn Ave., CHICAGO, Ill., 60637, U.S.A.

RAPPORTEURS

1. Dr. L. Mureithi, Dept. of Economics, Univ. of Nairobi, Box 30197, NAIROBI, Kenya.
2. Mr. H.W.O. Okoth-Ogendo, I.D.S., Univ. of Nairobi, Box 30197, Nairobi, Kenya.
3. Dr. George Alibaruho, East African Community Management Institute, Box 3030, ARUSHA, Tanzania.
4. Mr. Kabwegyere, Univ. of Nairobi, Box 30197, NAIROBI, Kenya.

AUTHORS OF PAPERS PRESENTED AT THE SEMINAR

1. Dr. Peter Ahn, Department of Soil Science, Univ. of Nairobi, Box 30197, NAIROBI, Kenya.
2. Mr. Abbas Hussain Shah and Mr. David Cook, c/o The Project Manager, Master Plan for the Karachi Region, U.N. Information Centre, Box 7700, KARACHI-3, Pakistan.
3. Dr. William A. Hance, Chairman, Department of Geography, School of International Affairs, Columbia University, NEW YORK, N.Y., 10027, U.S.A.
4. Mr. L. Hurpaul, Environmental Health Unit, Ministry of Health, PORT LOUIS, Mauritius.
5. Dr. Kai Curry-Lindahl, U.N.E.P., Box 30552, NAIROBI, Kenya.
6. Dr. M.O. Filani and Dr. Akin L. Mabogunje, Geography Department, Univ. of Ibadan, IBADAN, Nigeria.
7. Dr. Letitia Obeng, Director, Institute of Aquatic Biology, P.O. Box 38, ACHIMOTA, Ghana.
8. Dr. T. Odhiambo, Director, International Institute of Insect Ecology & Physiology, Box 30772, NAIROBI, Kenya.
9. Dr. J. Okedi, Director, East African Fresh Water Fisheries, Box 343, JINJA, Uganda.
10. Mr. Perez M. Olindo, Director, Kenya National Parks, Box 42076, NAIROBI, Kenya.
11. Dr. Nicholas C. Otieno, Chief, Environmental Unit, U.N. Economic Commission for Africa, Box 3001, ADDIS ABABA, Ethiopia.
12. Dr. J.P. Rweyemamu, Dean, School of Social Science, Univ. of Dar-es-Salaam, Box 35045, DAR-ES-SALAAM, Tanzania.
13. Dr. Ignacy Sachs, Director, International Centre for Research on Environment and Development (CIRED/EPHE), 49 Boulivard Raspail, PARIS VIIe, France.

INTERPRETER/TRANSLATOR (English to French)

Mrs. Polak, NAIROBI, Kenya.

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1. United Nations Environment Programme, Box 30552, NAIROBI, Kenya.
2. International Development Research Centre, Box 8500, OTTAWA, Canada.
3. Adlai Stevenson Institute, 5757 S. Woodlawn Ave., CHICAGO, Ill., 60637, U.S.A.