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SUSTAINABLE DEVELOPMENT AND NATURAL RESOURCES MANAGEMENT

This document has been prepared in response to the request of the Council at its Ninety-fourth Session to progressively translate the concept of sustainable development into practical and operational policies and programmes in the agricultural, forestry and fisheries sectors. As noted by the Council, FAO has been involved for a long time in actions to promote sustainable production systems. The Council considered that FAO's mandate and vast experience made it the key agency within the UN system to promote environmentally sound and sustainable agricultural development. It concluded that FAO had an important role to play in planning and in providing assistance to solve problems related to sustainable development at global, regional and country levels, and should continue to contribute to the development of national conservation strategies along with other international and non-governmental organizations.

The intention of this document is to seek the views and guidance of the Conference on developing practical and operational policies and programmes for ecologically sound and sustainable agriculture, forestry and fishery development. This will help FAO to be better prepared to assist interested member countries in promoting sustainable agricultural development and contribute to the proposed 1992 UN Conference on Environment and Development as well as related activities now underway within the UN system. The document presents FAO's preliminary views on the general approach to be followed, starting with a discussion of the conceptual basis for an overall strategy, and then indicates the major elements of the strategies for each of five resource types. This document is complemented by Document C 89/8, and especially Chapter 12, "FAO Support to Member Countries in Conservation and Amelioration of the Natural Environment and Introduction of Environmental Considerations into FAO Projects and Programmes", which reports on present and past activities that are related to sustainable development and natural resource management.

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SUSTAINABLE DEVELOPMENT AND NATURAL RESOURCE MANAGEMENT

I. INTRODUCTION: THE NATURE OF THE PROBLEM

1. FAO has been working on environment matters such as combatting soil degradation, desertification, loss of genetic resources, deforestation and over-fishing since its inception (see document C 89/8). Over the past twenty years it has played a key role in many important environmental events. FAO provided policy and technical assistance to the 1972 United Nations Conference on the Human Environment, one of the first international conferences to draw attention to environmental issues. The Special Chapter of SOFA 1977 contained an assessment of the state of natural resources and the environment; subsequent studies included regional reviews on the state of natural resources for food and agriculture for Africa, Asia and Latin America and the Caribbean, and a report for the Near East is being prepared. FAO played a central role in the 1977 United Nations Conference on Desertification, and subsequently assisted in implementing the plan of action to combat desertification. The Organization was deeply involved, in collaboration with IUCN, UNEP and Unesco, in preparing the 1982 World Conservation Strategy, which drew heavily on FAO studies and information. FAO is now cooperating in the development of the Second World Conservation Strategy. It is also the focal point for the 1985 Tropical Forestry Action Plan, an inter-agency effort which seeks to control deforestation through carefully planned conservation and utilization of all types of tropical forest resources.

2. It is now well understood that development which destroys the natural resources that sustain it is not development. In its well-known 1987 report, Our Common Future, the World Commission on Environment and Development (the Brundtland Commission) emphasized the central necessity of agricultural sustainability. 1/ This was an important step, above all because it reflected growing awareness among political leaders of the need to promote environmentally sound development.

3. Environmental damage hurts everyone, but above all it hurts the rural poor of the developing countries, who are most immediately dependent on the natural habitat for their survival. Deforestation, soil degradation and erosion, and destruction of fish and wildlife resources, impoverish everyone and threaten the entire human race, but the poor are hit first and hardest. The poor also are the first to suffer when access is restricted to over-exploited or degraded resources. For this reason, top priority needs to be given to promoting sustainable development and particularly sustainable agricultural production systems. Increasing agricultural, forestry and fishery output today at the cost of degraded soil, ravaged forests and depleted fish stocks tomorrow must be seen as the antithesis of development.

4. While consensus has grown around this principle, much remains to be done to ensure that this basic understanding actually influences development promoted by governments and international agencies. Today's

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1/ The World Commission on Environment and Development (WCED), Our Common Future, Oxford University Press 1987. The Sustainability concept first came into prominence in 1980, with the World Conservation Strategy of the International Union for the Conservation of Nature (IUCN).

challenge is to reach a consensus on prerequisites for sustainable agriculture, to build a solid phalanx of national and international political support for clearly-defined, well-understood objectives and to put them into operation. One of the key objectives for both developed and developing countries must be the better integration of environmental considerations into agricultural and economic policies. In the case of many developing countries a complementary objective must be the slowing down of population growth.

5. What is "sustainability"? What is to be sustained? Economists might stress "sustaining" economic growth and consumption levels of food, firewood and other necessities. Ecologists and biologists, on the other hand, might argue that it is the biosphere that needs to be sustained rather than the human population or economic growth. They would seek to preserve above all genetic and biological, including habitat, diversity. Anthropologists and sociologists, by contrast, might remind us that many demands placed on the environment are culturally determined. For example, cultural preferences for meat and crop foods sometimes promote deforestation and soil depletion, preferences for fish may put pressure on the marine environment. Some critics would go much further and argue that what we are really proposing to sustain is the present international division of wealth and power, which imposes different - and inequitable - environmental demands on rich and poor countries. Most will agree, however, that the concept of "sustainability" also includes ethical considerations of intergenerational equity: what happens today carries implications for generations as yet unborn.

6. The problem of defining "sustainability" can complicate the construction of a global effort: it is difficult to make long-term strategic and policy choices in favour of a concept that is not clearly defined, or when there is no universally accepted definition (Box 1). FAO has therefore formulated its own definition which was approved by the FAO Council in 1988, as follows: "Sustainable development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable".

7. Fortunately, however, most environmental threats to food production, (e.g. soil degradation and erosion, deforestation, water pollution) would fit any definition of what needs to be sustained. Moreover, despite their differences on how to define "sustainability", the economist, the ecologist and the anthropologist all would agree that sustainability necessitates the reduction and reversal of these processes of environmental degradation.

8. Given an agreement on what needs to be done, what are the specific policies and programmes, at the international, regional, national and local levels, that can promote sustainable development? What kinds of efforts are likely to be most effective, and where and on what population groups should efforts be concentrated? How do these efforts differ between developed and developing countries?

BOX 1

Alternative definitions of sustainable development

'Development which meets the needs of the present without compromising the ability of future generations to meet their own needs ...' (WCED, 1987, p.43)

' ... sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations' (WCED, 1987, p. 46).

'Sustainable development ... as a pattern of social and structural economic transformations (i.e., 'development') which optimizes the economic and other societal benefits available in the present without jeopardizing the likely potential for similar benefits in the future'. (R. Goodland and G. Ledec, Neoclassical Economics and Principles of Sustainable Development, Ecological Modelling, Vol. 38, Nos. 1/2 1987).

' ... development that maintains a particular level of income by conserving the sources of that income: the stock of produced and national capital'. (P. Bartelmus, Accounting for Sustainable Development, UN/DIESA Working Paper No. 8, 1987).

' ... sustainability ... the ability to maintain productivity, whether of a field, farm or nation, in the face of stress or shock'. (G. Conway and E. Barbier, After the Green Revolution, Futures special issue, 1988).
Editorial note: Stress implies, for example, growing salinity, soil erosion or indebtedness. Shock could be a large increase in input or energy prices, a rare drought.

'Sustainable development is economic change subject to the constancy of natural capital stock - the stock of environmental assets is held constant while the economy is allowed whatever social goals are deemed appropriate. (D. Pearce, Economics, Equity and Sustainable Development, Futures, Special Issue, 1988).
Editorial note: The problem here is that the natural resource stock is not given in an operational sense. In fact, the natural capital stock cannot be held constant.

No greater precision of definition than the above is required at the general level. At the operational level, of course, much greater precision is required. The difficulty arises less from defining the concept of sustainability, particularly in terms of natural resources, than in specifying the conditions in which sustainability breaks down.

9. This chapter argues that all levels of organization and action, from the international to the local, must be utilized and integrated into strategies to promote sustainable development. In particular, international, national and regional authorities should use the means at their disposal (macro-economic and trade policies, development aid, etc.) to change the incentives which shape behaviour at the local level in a manner that will reduce or prevent damage to the environment. International development agencies and governments should implement policies, programmes and projects which both encourage and support the rural poor to adopt agricultural and other practices which will prevent or at least minimize environmental damage.

10. Environmental problems are not restricted temporally or spatially to a particular region or climatic zone. Droughts are a normal feature of agriculture in North America's Mid-West as well as the Sahel. Longer-term climatic changes arising from the greenhouse effect are likely to affect food and agriculture in both developed and developing countries, with winners and losers in both groups. Even efforts to protect the environment in one country may affect others. For example, land "set-aside" programmes which conserve soil resources in the North have important implications - both positive and negative - for trade and food aid flows with the South. Furthermore, techniques and policies developed in the North to manage the environment may be inappropriate for the South.

11. In an interdependent world, the chain of sustainability can be only as strong as its weakest link. All nations, rich and poor alike, must search for the appropriate technologies to enable developmental goals to be attained without incurring irrevocable environmental damage; international organizations must do their part, but so must governments and the people they represent. Governments must recognize that their use of territorial natural resources may have regional or global environmental consequences. While it is essential that FAO, other IGOs and NGOs work together to promote sustainable agricultural practices at the local level, this must take place in the right overall national and international context. FAO and others can help solve technical problems at the local level, but this cannot substitute for national commitment. In addition, through financial and technical assistance, rich countries can help the poor countries to find sustainable ways to develop. On the other hand, conditionality regarding the transfer of financial resources subject to perceptions of sound natural resource management, is unlikely to be acceptable.

12. In recent years, environmental issues have become of increasing concern in most developed countries, partly as a result of rising awareness of the cumulative nature of certain problems, but particularly because voters have put pressure on governments to confront such problems as food contamination and water pollution resulting from unsafe and excessively intensive agricultural production methods. But this awareness has not yet assumed a global dimension. Can an international effort to promote global sustainable agriculture succeed in the absence of such a dimension?

13. The developed countries cannot stand outside the debate of sustainable development because they too need to reorient production and

consumption patterns. The rich countries must find ways to pursue their economic goals without the present, unacceptably high levels of environmental damage, such as inefficient combustion of fossil fuels that results in acid rain and contributes to the greenhouse effect, nuclear accidents and oil tanker spills associated with energy production, continued use of hazardous chemicals and accumulation of toxic and nuclear wastes, and certain intensive agricultural practices which pollute water and contaminate food.

14. Of course, some forms of environmental damage originating in the developed countries do not affect directly agriculture in the Third World. Neither the Chernobyl nuclear accident nor the Alaskan oil spill will have an immediate impact on Nigerian or Peruvian farmers. But other forms of environmental damage in the North will affect the South. The destruction of the ozone layer by the chlorofluorocarbons (See Box 2), most of which are produced and consumed in the North, will affect all parts of the world.

15. In the developing countries, an emphasis on the rural poor is necessary for four reasons. First, because they are the populations at greatest immediate risk from environmental degradation, whether or not they contribute to that degradation. Secondly, because much environmental damage which ultimately hurts the rural poor is brought on by destructive practices that immediate economic necessity and survival often forces on them. Thirdly, because multinational and bilateral development agencies can influence policies and programmes affecting the rural poor directly through development projects and technical assistance. Fourthly, some agencies, IMF and the World Bank in particular, as well as developed country governments, can help also to promote sustainable development by considering the environmental impact of their economic relations with the developing nations.

16. There are fears that environmental damage in the indebted nations may be accelerated by economic structural adjustment programmes. Natural resources may be overexploited to provide the foreign exchange to service debts. Structural adjustment programmes which reduce urban employment can increase population pressures in rural areas. The need to cope with immediate debt and balance of payments problems diverts attention from longer-term needs such as the sustainable management of natural resources. It also may destabilize the political environment, making it more difficult to introduce unpopular but necessary measures aimed at improving natural resource management.

17. Governments must adopt economic, social and agricultural policies which encourage sustainable behaviour. They must adopt and put in place legislation, and implement policies which make it possible for people to attain higher living standards without irrevocably destroying forests and the soil. In many countries, effective family planning programmes are also sorely needed to reduce population pressures on the environment. Only if government policy seriously seeks to promote sustainability will efforts by international organizations have much impact. Reducing or reversing environmental damage and promoting sustainable agricultural practices will require, above all, changes in the way people live, farm and fish.

BOX 2

Climate change: ozone layer depletion and the greenhouse effect

Industrialization and deforestation are altering the chemical composition of the earth's atmosphere in ways that may already be producing climate changes which could threaten agriculture, the ecological balance and even human health.

The earth's heat balance is the result of the complicated and dynamic interchange of infrared radiation between the earth's surface and the atmosphere. This balance is controlled by trace gases in the atmosphere that maintain heat absorbed from the sun's radiation, just as glass does in a greenhouse. The best known trace gas is carbon dioxide (CO_2) which occurs naturally in the atmosphere and plays a major role in the growth of almost all living organisms. Four other gases also absorb radiation, and can therefore affect the earth's heat balance: the chlorofluorocarbons (CFCs), methane, nitrous oxide (laughing gas) and ozone. Methane and nitrous oxide are produced both naturally and artificially. CFCs, however, are man-made substances used mostly in refrigeration and as aerosols and solvents.

These atmospheric changes pose two major threats. The first arises because CFCs release free chlorine in the upper atmosphere which then catalyzes the breakdown of ozone. This is a serious health threat since the ozone layer which they are slowly destroying filters out solar ultraviolet radiation - a major cancer-causing agent. The first important international step toward protecting the ozone layer was made on 16 September, 1987, when 30 countries and the EEC signed the Montreal Protocol to cut CFC consumption in half by the end of the century. The protocol came into force in 1989.

The second atmospheric threat is the greenhouse effect. Since the onset of industrialization, consumption of fossil fuels has increased dramatically in the world, leading to the release of massive quantities of CO_2. The concentration of CO_2 in the atmosphere has increased by nearly 25 percent since 1850. While industrialization and its associated consumption of fossil fuel is the main cause, forest fires, fuelwood consumption and deforestation also contribute to the problem.

Our ability to predict future atmospheric CO_2 is limited, as the carbon cycle is still not well understood. One model of the global carbon cycle, however, predicts that the CO_2 level will increase to between 1.4 and two times its pre-industrial levels by the year 2050.

The exact consequences of this greater concentration of CO_2 and other trace gases remain uncertain. On the positive side is the potential boost to plant growth through the impact of higher CO_2 concentrations on photosynthesis. Another possibility, on the negative side, is that it will act like a screen around the earth and limit heat loss from the latter's surface - hence the term

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"greenhouse effect". Such global warming may create serious problems for agriculture in many areas, while benefitting others. Apart from the direct temperature effects on plant and animal growth, global warming could result in sea level rise due to thermal warming of oceans, greater net precipitation and, in worse case scenarios, melting of polar ice caps. Alternatively, global warming could cause more water to evaporate from the earth's surface, creating more clouds which, in turn, would block more incoming radiation, perhaps mitigating somewhat the greenhouse effect.

Predicting the consequences of the greenhouse effect is difficult because models of the atmosphere must account for a multitude of interconnected and not always easily measurable factors. For example, the melting of ice and snow would feedback in ways that are difficult to predict: on the one hand, less solar radiation would be reflected back out into space, but increased cloud cover might block out solar radiation. It is also likely that the world's climate system would not respond in a uniform way to global warming, but rather would exhibit critical thresholds at which small increases in temperature would lead to sudden major changes. We still have a very imperfect idea of what these thresholds are and what changes would be triggered off when they are reached.

Despite uncertainties, some recent studies suggest that warming has already begun and will accelerate in the years ahead. If these studies are correct and unless dramatic reductions in rates of fossil fuel consumption and deforestation occur, the planet could warm by at least 1.5^{o} to 4.5^{o}C over the next 50 years or so. While we cannot predict the effects of such changes on society, it is possible that drought, desertification and soil erosion will worsen. Ecological hazards, such as floods, storms, forest fires and the outbreak of pests and diseases could also increase. A significant percentage of the low lying parts of the world's most fertile and most populated areas could be flooded or subject to dryer conditions, whereas other areas could receive better rainfall. In short, the environmental destruction resulting from fossil fuel consumption and deforestation threatens major, possibly calamitous changes for the entire planet.

18. FAO has a long history of initiating or supporting actions to bring about such changes, and an account of these has been given elsewhere. 2/ This chapter therefore draws on FAO's past and present activities to propose approaches to and elements of strategies on how to speed up and widen the adoption of such changes, and thereby move from defining the concept of sustainable development to making it operational. The next section builds on the foregoing discussions regarding the nature of the

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2/ FAO, Aspects of FAO'S Policies, Programmes, Budget and Activities Aimed at Contributing to Sustainable Development, CL 94/6, 1988. Also FAO Review of the Regular Programme, Chapter 12, "FAO Support to Member Countries in Conservation and Amelioration of the Natural Environment and Introduction of Environmental Considerations into FAO Projects and Programmes", C89/8, 1989.

problem of unsustainable resource development and indicates its magnitude. The following section considers certains issues which must be addressed if progress is to be made. The final substantive section provides the key elements of FAO's proposed strategies which will, of course, have to be tailored to meet specific country requirements.

II. THE MAGNITUDE OF THE PROBLEM

19. Mankind received a tremendous natural resource inheritance, notably some 3 billion years of species and ecosystem development and soil and groundwater resources that in some instances took millennia to build up. Until about the beginning of the 18th century we had maintained much of this inheritance. A few species and ecosystems had been lost, and the soils in some areas damaged beyond repair, but these represented only a very small proportion of the total inheritance. During the past two hundred years, however, and at an accelerating rate, we have been progressively destroying our inheritance and endangering the well-being of future generations. The destruction has global, regional, national and local dimensions which have recently been reviewed by FAO and therefore are only treated here selectively. 3/

The Global Dimension

20. Mankind is faced with a number of problems, which, though they relate generally to national actions, are really global in nature and need collective responses. Three are of particular concern, namely potential climate change, loss of genetic resources, and the choice of agricultural technologies.

Climate change

21. There is a growing scientific consensus that man's activities are causing climate change. The global warming that appears to be taking place through the greenhouse effect and which is primarily caused by fossil fuel consumption (the longest part of it in the North), if not arrested, may produce climate changes which could severely affect agriculture in many parts of the world. (Box 2)

Loss of genetic resources

22. During the past ten thousand years or more, man is estimated to have used well over 100 000 edible plant species, as well as numerous animal species. Although productivity was generally low, this genetic diversity added greatly to the stability of production, and restricted man's vulnerability to plant disease epidemics, etc. Population growth and the rising demand for food, fuel and timber has now appreciably reduced this genetic diversity either directly through the destruction of ecosystems, species, and local varieties, or indirectly through changes in consumption patterns. Barely 150 plant species and 15 types of livestock are now under widespread use. Most of mankind is now dependent on only twelve plant species for the major part of their food energy intake.

3/ Environmental Aspects of Agricultural Development, Chapter 11 of FAO, Agriculture: Toward 2000 (AT 2000).

23. Although the losses of a species or variety may occur at the local level, the problem is a global one given the interdependence of countries for germplasm. The dwarf wheat varieties, for example, which played such an important part in the 1960s "Green Revolution" in Latin America and South Asia, were developed from Japanese germplasm that was introduced into the USA and which, after further improvement, was passed on to CIMMYT in Mexico, for the use of other developing countries.

24. Losses in genetic resources over the past 30 years are estimated to have been particularly serious in the tropical moist forests which represent approximately one third of the five million terrestial species existing in the world.

Agricultural technological choices

25. Finally, and related to the problem of lost genetic resources, is the question of agricultural technological choices that are not sustainable and which are global in nature because they reflect the collective decision of countries. As indicated below, this question concerns in particular choices regarding mineral fertilizer use, the intensification of livestock production and the use of pesticides. For example, when faced with rising pest problems as a consequence of crop intensification, the almost universal response has been to resort to pesticide use. The environmental consequences have been disruption of ecosystems because of the death of non-target species, the accumulation of pesticide residues in the environment and in food, and the build up of pesticide resistance in the target species.

26. Since the 1940s, over 1 600 insect species have developed significant resistance to major pesticides because of their long-term and non-selective use. This resistance problem concerns both field and storage pests and, to a lesser degree, fungi and weeds. Consequently, the pesticide industry is continually trying to keep one step ahead of the pests by developing new pesticides, but with no guarantee of being able to do so. FAO and others, therefore, have been encouraging, since the 1960s, the development and promotion of integrated pest management (IPM) techniques which combine the use of resistant varieties, cultivation practices, and pesticide application at lower rates and frequencies so as to reduce adverse environmental effects and reduce the risk of pesticide resistance.

The Regional Dimension

27. Many of these issues have regional implications. In the fisheries sector, for example, notwithstanding the extension of national jurisdiction over marine fisheries, the migratory nature of many species emphasizes the need to tackle the challenges of sustainable development and management through inter-country or regional efforts.

28. Fish stocks throughout the world, most of which are now exploited within national fishing zones, are under increasing pressure. Potential demand by the year 2000 is towards the upper limits of the further potential for increased production, after allowing for continued growth in supplies from aquaculture. (Table 1)

29. Acid precipitation, in contrast to the above, is affecting both managed and "natural" terrestial and aquatic ecosystems, and is the

TABLE 1. FISH FOR FOOD: PROJECTED DEMAND AND SUPPLY (MILLION TONS)

Increase in demand 1980-2000		Estimated potential (1985) for increased production	
Location	Quantity	Category	Quantity
Developing countries	+ 22.5	Demersal	1-8
Developed countries	+ 5.9	Shoaling pelagic	3-10
		Other marine	4-6
Total	+ 28.4	Freshwater & aquaculture	5-10
		Total	13-34

Source: World Agriculture Toward 2000 (1988).

indirect effect of energy policies outside agriculture, forestry and fisheries. The most extensive damage is in North America and Europe, but it is nonetheless apparent in some developing countries, particularly near large urban-industrial centres.

30. It is difficult to assess the magnitude of the acid precipitation problem because of the complexity of the chemical reactions between the most important gases involved (sulphur dioxide, oxides of nitrogen, and ozone) whilst they are still in the atmosphere, and those taking place on leaves, in the soil, and in surface waters following deposition. Nonetheless it is clear that millions of hectares are affected to a greater or lesser degree. There has been extensive damage to forests in both North America and Europe, and some crop losses, though these are difficult to quantify. Thousands of lakes have been acidified (particularly in Scandinavia) with serious reductions in fish populations. Some soils are being rapidly acidified to as much as one metre, which, unless counteracted by liming, will adversely affect future production. And finally, a number of natural ecosystems are threatened, especially certain wetlands.

The National and Local Dimensions

31. Uncontrolled forest clearance, soil erosion and other forms of resource degradation, although they may have global or regional implications, are essentially the result of, or stem from, national and local decisions. Economic growth and population pressures during the past two to three decades have increased such degradation to levels which threaten the long-term survival and sustainability of nations. Future population growth in the absence of appropriate corrective actions will make the problem worse.

32. The nature of the national dimension tends to differ between developed and developing countries. In developed countries the unsustainability of current practices generally relates to the secondary effects of inputs for intensive production systems, whereas in developing countries the unsustainability is largely the consequence of extensive production systems that result in overgrazing, overcropping and excessive fuelwood collection. But in developing countries it is not just an agricultural technology issue. It is a wider development issue. FAO's study "Land, Food and People" has shown that there are some developing countries whose projected year 2000 population exceeds their potential population supporting capacity assuming the full use of their arable land and the maximum use of currently available technology. 4/

33. The most widespread agriculturally related environmental problems of the developed countries fall into three main categories: The pest resistance to biocides mentioned earlier; groundwater and surface-water contamination by mineral fertilizers, livestock wastes and pesticides; erosion, compaction and other forms of soil degradation.

34. Although the extent and severity of ground- and surface-water contamination varies considerably within and between countries, it is a problem in all developed countries. It is particularly serious in parts of the EEC, USA, and USSR, where intensive arable or livestock enterprises predominate. Though the exact contribution of mineral fertilizers is not precisely known, it is clearly an important factor underlying the widespread rise in groundwater nitrate concentrations, which in some areas have exceeded those considered safe for human consumption, and has led to the closure of some wells or the installation of costly purifying equipment. Similar problems have arisen with pesticide residues in drinking water sources.

35. Historically, soil degradation in developed countries has been as serious as that currently to be found in developing countries. It is now less serious, and geographically more restricted, but there are still significant areas where the rate of soil loss through wind and water erosion exceeds to a considerable degree the rate of natural soil formation. Moreover, such losses are compensated, in part, by the higher use of nitrogen and phosphate fertilizers, thereby potentially compounding the water contamination problem considered earlier.

36. Whilst developing countries face some of the same problems as the developed countries, the unsustainability of their current production systems is most apparent in the extent and various types of cropland and rangeland degradation, including nutrient mining, and in the rates of deforestation.

37. Three main degradation processes are involved:

- chemical degradation including the accumulation of excess salts;
- physical degradation, notably wind and water erosion;
- biological degradation, including deforestation and rangeland destruction through over-grazing.

4/ FAO, Land, Food and People, 1984 (based on FAO/UNFPA/IIASA "Potential Population Supporting Capacities of Lands in the Developing World")

38. All attempts to provide a clear assessment of the condition of the world's natural resources soon run up against the sparseness, inaccuracy and non-comparability of available data, and weakness in our understanding of some of the processes involved. This data constraint is particularly serious in developing countries and regions. It is therefore difficult to make estimates of the magnitude of land degradation, and those available tend to be qualitative or applicable only to the survey areas. Nonetheless, there is no doubt that land degradation pervades every region of the world, encompassing different cultures, climates and ecosystems. Similarly, there is no doubt that such damage must be overcome if agricultural production is to be raised and sustained.

39. Land degradation occurs widely in areas of natural rangeland, and where the soils have been cultivated for many years. In Africa, north of the equator, for example, some 11 percent of the total land is affected by water erosion and 22 percent by wind erosion. The situation is even more serious in the Near East, with some 17 percent of the total area affected by water erosion and 35 percent by wind erosion.

40. The various impacts of land degradation are integrated, in a sense, in crop yields and their decline. Two examples help to illustrate this link:

> Cassava yield in the Mondomo area of Colombia. Trials by CIAT have shown that whereas in the past the traditional 5-10 year fallow was sufficient to maintain soil fertility and therefore yields, this is no longer the case. Soils are now so degraded through erosion that the only way to maintain or raise yields is by the addition of mineral or organic fertilizers.
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> Maize yields in Malawi. Unfertilized maize yields have declined substantially over the past 25 years (Table 2). During this period, land pressure has increased and, as a consequence, fallow periods are no longer possible in many areas and the land is cropped every year. Soil organic matter has declined and surface erosion is now widespread. Soil nutrients have been removed by crops in amounts that natural mineralization or nitrogen fixing soil flora cannot replace. Without remedial action, the farmers are caught in a downward spiral leading to poverty and deprivation.

41. In the distant past, climatic fluctuations resulted in the expansion and contraction of deserts. Today, most desertification is caused by increasing human and livestock populations, overgrazing, bushfires, expansion of agricultural crops and deforestation due to demand for fuelwood. Mismanagement of resources is considered to be responsible for over 80 percent of recent worldwide desertification.

42. Some 3 billion hectares, or approximately one quarter of the earth's land surface is desert or is damaged by factors which contribute to desertification. Of this area, 60 percent of the rangelands and rainfed croplands are moderately to severely damaged. As some areas go out of production due to desertification, others come into production due to restoration efforts, but the overall balance is a net loss.

43. Moreover, the rate of desertification appears to be accelerating in parts of Sahelo-Sudanian Africa, the Near East and in Iran, Pakistan and

TABLE 2. AVERAGE YIELDS OF UNFERTILIZED LOCAL MAIZE IN MALAWI

Area	Yield (kg/ha) 1957-62	Yield (kg/ha) 1985/86-86/87 1/
Lilongwe	1 760	1 100
Kasungu	1 867	1 120
Salima	1 693	1 060
Mzuzu	1 535	775

1/ Mean of National Crop Estimates for 1985/86 and 1986/87. The means include small areas of fertilized local maize.

TABLE 3. ESTIMATED ANNUAL RATE OF DEFORESTATION IN TROPICAL DEVELOPING COUNTRIES DURING 1981-85

	Area '000 ha	% per year
Africa	3714	0.5
West Sahelian	389	0.9
East Sahelian	695	0.8
West	1199	2.2
Central	575	0.2
Tropical southern	700	0.3
Insular	156	1.2
Asia	1989	0.7
South	308	0.5
Continental south-east	484	1.0
Insular south-east	972	0.7
Centrally planned tropical	225	0.6
Latin America	5653	0.6
Central America and Mexico	1022	1.5
Caribbean	25	0.1
Tropical South America	4606	0.6
Oceania Pacific Islands	32	0.1
Grand total	11385	0.6

Source: FAO, An Interim Report on the State of Forest Resources in the Developing Countries, 1988

North-West India, though reliable monitoring data are not readily available. The semi-arid area of North-East Brazil is subject to desertification and similar conditions are being created in parts of Argentina. In North Africa, areas of Morocco, Tunisia and Libya are losing some 100 000 hectares of rangeland and cropland each year due to desertification.

44. Another major problem is the one arising from too much water. Some 30-40 percent of the world's irrigated area is either waterlogged or suffers from excessive salinity, or both, and will go out of production unless remedial measures are taken. Between 60 and 80 million hectares are affected to some extent, and a further 20-30 million hectares are severely affected. The problem is most commonly associated with high and rising groundwater levels, due to poor water management and drainage, and the presence of salts in irrigation water. The resulting salinity or sodicity can lead to increased soil moisture stress and, in some cases, toxic effects.

45. Current rates of deforestation are unsustainable. The situation is most serious for tropical forests (both closed and open) which were estimated in 1980 to be declining by some 11.4 million hectares per year , pending the 1990 World Forest Resources Assessment undertaken by FAO (Table 3). Reafforestation and afforestation only offset about 10 percent of this loss. Much of the land cleared primarily for crop production or ranching has poor quality soil which erodes easily once cleared of its protective cover.

46. The main causes of deforestation are the expansion of agriculture and the collection of fuelwood, though in some countries uncontrolled commercial logging is the primary agent. Population pressures and slow technological progress seem set to continue this deforestation. According to AT 2000, an additional 80 million hectares of land will be brought into cultivation in the developing countries (excluding China) by the end of this century. Some of this land will be obtained by tropical forest clearance, yet many tropical forest soils are unsuitable for continuous cultivation or intensive grazing, unless sustainable production systems can be developed.

47. Deforestation is also of major concern because:

- forests have an important role in regulating hydrologic regimes within watersheds;
- erosion following deforestation can cause irreversible damage to soils;
- forests play an important role in the maintenance of biological diversity, as a source of medicinal plants, in the provision of indigenous foods and support to indigenous cultures.

48. Deforestation can cause soil erosion rates 10 to 100 times greater than the "natural" levels, leading to the siltation of river channels, lakes and dam storage schemes, and to increased downstream flooding. In India, for example, more than 20 million hectares of land are flooded annually due in part to deforestation in neighbouring countries.

III. ISSUES IN SUSTAINABLE DEVELOPMENT

49. This section focuses on developing countries because discussions are underway in the OECD and other fora on the environmental issues facing the developed countries and the policy options that they may consider. 5/ This does not imply that the responsibility for reversing natural resource degradation rests only with developing countries. The entire globe is interdependent in this context.

50. There are three main reasons for unsustainable agricultural - including forestry and fishery - practices being used in developing countries: lack of access to land, inputs and other productive resources by rural households and communities; lack of awareness among policy makers of the economic costs involved; and lack of environmentally sound alternative technologies acceptable to farmers, and to forest and fishing people.

51. These problems lead to a number of issues which can be addressed conveniently at three levels: household; community; and national. Of course, these three levels are interconnected. Decisions at the national level about crop prices, credit or release of new crop varieties will affect the decisions made by millions of farming families. Exchange rate adjustments may alter incentives for investment in soil conservation, animal husbandry or tree crops. Research priorities will affect the course of development of rural communities. Thus, the link between macroeconomic policies and rural behaviour must be understood by policy-makers.

Household Survival Strategies

52. Environmental degradation is closely associated with rural poverty. At the root of the problem is the lack of access by poor households to sufficient productive resources for meeting basic needs. Identifying solutions requires a detailed understanding of the microeconomics of resource use and the perceptions of resource users.

53. Degradation of the environment often arises from overpopulation which puts unprecedented strains on natural resource capacity in the absence of a compensatory increase in agricultural productivity or off-farm employment opportunities (Box 3). Whereas several generations ago ample land, forest and water existed to meet the needs of most rural communities, population growth is now leading to diminishing farm sizes and increasing fragmentation of holdings. Moreover, much of the new cropland being brought into use, for example, in the Amazon, Sumatra or the Himalayan hills is of fairly low productivity unless expensive inputs are used. Looking into the future, natural resources are further threatened by the 20-40% growth in population that is expected during the next decade in many rural communities. If food production is to keep pace with population growth, most of the increased production will have to be derived from intensification. Degradation also is sometimes aggravated by inappropriate economic signals, arising from government decisions and distant commercial forces.

5/ For example, see FAO, Integration of Environmental Aspects in Agricultural, Forestry and Fisheries Policies in Europe, ERC/88, 3 May 1988 and Socio-economic Aspects of Environmental Policies in European Agriculture, ERC/90/3, forthcoming.

BOX 3

Population pressure and resource degradation

Population growth is a major threat to the environment - especially in countries where the population is doubling in less than 30 years and in some, in less than 20 years. In the future, the additional pressure on resources in most countries will come mainly from urban demand for food, fuel and other products. Of the additional 2 200 million people who will be born in the developing countries between 1985 and 2010, about 1 500 million will live in urban areas. The greatest population increase will be in south Asia (more than 800 million, three-quarters of whom will be urban-dwellers). The smallest increase in the Third World will be in Latin America (238 million, virtually all urban-dwellers). Nevertheless, even if rural-urban migration continues at a high rate, rural population will grow almost everywhere.

However, to see problems of environmental degradation as a consequence of increasing population and their subsistence requirements alone is to over-simplify or to incorrectly diagnose the situation.1/ In some cases, environmental problems are worse than would be expected from the fast increase in population alone, or a growing population may be in balance with the environment. It is population growth working in conjunction with other factors which is bringing about widespread environmental deterioration. The most important of these factors are:

The widespread **breakdown of traditional systems** of resource management under external commercial and population pressures. Traditional communal forms of resource management commonly achieved sustainable exploitation of the resource. Efficient and ecologically sound production systems with extensive tree or bush fallows evolved to manage a variety of fragile or other environments. Often such systems were kept in demographic balance by social regulation of fertility, mortality, migration and marriage. In most cases, such systems have been unbalanced or destroyed by human and cattle population pressures in the absence of appropriate technological responses, and to a lesser degree by commercial and political domination.

Commercialization. The impact of the commercialization of demand on the traditional cultural attitudes of indigenous populations - towards wildlife, for example, during the colonialization of America - has been well documented. Other examples of the commercial exploitation of resources often leading to their degradation, are logging of tropical forests in Asia, the clearing of forests in Latin America, and the expansion of groundnut and tobacco cultivation in sub-Saharan Africa.

Inequality in access to land and other natural resources, and fragmentation of holdings. Land distribution is worsening in many developing countries and holding sizes are declining. Compared to small holdings, land on larger farms tends to be used less intensively and to employ less labour per unit area.

1/ R. Repetto and T. Holmes, The Role of Population in Resource Depletion, Population and Development Review, Vol. 9 No. 4, December 1983.

TABLE TO BOX 3. TOTAL, URBAN AND RURAL POPULATION PROJECTIONS BY DEVELOPING REGIONS 1985-2010

Region	1985			2010			Growth Rate		
	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
	(Millions)						(Percent)		
Africa	555	165	390	1158	528	630	3.0	4.8	1.9
East Asia	1130	265	865	1456	514	942	1.0	2.7	0.3
South Asia 1/	1573	435	1139	2402	1055	1347	1.7	3.6	0.7
Latin America	405	279	125	642	515	127	1.9	2.5	0.1
Developing Regions	3663	1144	2519	5658	2612	3046	1.8	3.4	0.8

1/ Including Melanesia, Micro-Polynesia

Source: UN 1987, The Prospects of World Urbanization - revised as of 1984-85, New York.

54. Understanding what sustainability means to the rural poor in developing countries requires a close examination of the choices they face in their daily struggle to survive. An understanding of household decision-making is an essential pre-condition for strategy and policy formulation because in many instances it is the rural poor who determine the outcome of government actions to promote sustainable development through their decisions on resource allocation, production practices and consumption. The survival strategies they adopt involve many decisions about environmental goods: soil, woody biomass, pastureland and water. Some choices result in sustainable actions; others do not.

55. Frequently, poor people have no option but to over-exploit natural resources in order to survive. Everyday security takes precedence over concern to any great extent with the future. Even meeting immediate food security needs is beyond the reach of many rural poor. Consequently, much natural resource degradation arises because the rural poor are forced to employ cultivation and pastoral practices that degrade the environment, thereby introducing the vicious circle that makes it more difficult to achieve long-term reduction of poverty and conservation of resources.

56. Sheer necessity forces them into mining soil nutrients, cultivating steep slopes or overgrazing rangeland in order to feed themselves. Significant degradation of these resources directly affects the welfare of populations including their direct dependence on water for homes, animals and irrigated crops; through immediate needs for fuelwood; and through

requirements for animal fodder. Such degradation threatens economic development at the household, community and national levels.

57. Not only do we need to understand better the factors which cause rural households to adopt practices which influence environmental degradation, we also need to understand how these households respond to the natural resource scarcity which results from such degradation.

58. As farm size reduces or soil fertility decreases, households may be forced to alter the type of crops they grow. In Ethiopia, for example, the larger among the small-scale farmers grow significant areas of the low yielding but preferred grain crop teff. Small farmers, however, cannot afford to do so and plant sorghum or other less well liked grains which produce more calories per hectare. Of greater significance is the switch from pulses to winter cereals through much of south Asia - induced not only by land pressure but by the Green Revolution technology and complementary policies which favoured the cultivation of modern cereal cultivars and neglected the development of high yielding pulses: a case of environmental costs of this technology.

59. Even in conditions of moderate poverty, many households invest off-farm. One common strategy is to arrange, by whatever means, an education for the children so that they may migrate away from the farm. This investment in human capital improves the prospects for future income to the household, and may relieve pressure on natural resources. Yet if educated children migrate, it represents a transfer of resources out of rural areas.

60. As household food security is threatened and local solutions for increased production become fully exploited, family members move to other agricultural or urban areas in search of seasonal or permanent income. As one example, more than half of the household income of Pakistani farmers scraping a living on the slopes of the Hindu Kush is derived from off-farm income. Similarly, a major source of foreign earnings of Nepal is remittances from Hill people working in India. Indeed, as will be discussed later, migration from overstressed, low potential land has to be part of a sustainable development strategy.

61. Resource degradation often leads to a series of decisions by household members with consequences for deforestation, soil erosion, decline in water availability and quality, as illustrated by the following example of the degradation cycle:

- As fuelwood or clean water supplies grow scarce women have to walk further to gather wood and water. This may reduce the time available for other productive activities including food crop cultivation. They may be forced to use poor quality water with far-reaching implications for the health of the family.

- Children - and female children in particular - may have to help with fetching fuelwood and water. School enrolments fall.

- When distances to forests become too great families may be forced to purchase fuelwood supplies. Real income left over for other basic

needs declines. Women seek to reduce cooking time by turning to foods that require less cooking. Diets change. Fewer meals per day may be prepared. Nutrition may suffer as a consequence and the risks of bacteriological infection increase.

- Animal dung and crop residues may be used as fuel instead of being returned to the land as fertilizer, leading to soil depletion and decreased food production. Such actions have been well documented in many poor countries, including Bangladesh, Ethiopia and Senegal. Increasingly, low potential lands are brought under cultivation, contributing to the cycle of soil erosion and deforestation.

- Resource scarcity encourages men to migrate to urban areas or to other countries in search of cash income, leaving the women to manage the farms. As many as one-third of rural households are headed, de facto, by women. In many cases, notably Latin America, women also may have to abandon the land, often exchanging their meagre rural living for urban employment.

- As plant cover declines traditional medicines and bush foods are lost. Fuelwood scarcity inhibits many small industries, such as fish smoking, food processing for resale, and other typically female activities.

62. Clearly, strong interdependencies exist between crops, livestock, forestry and the household. The treadmill of diminishing natural resource productivity, falling returns to greater labour input, greater "mining" of resources and growing poverty continues.

63. Development policies still tend to focus on the male as apparent head of the household. This tendency ignores the fact that women are major users of natural resources. Inter alia women farm, provide fuelwood and water, cook food, and process and market produce. Their central role in managing natural resources must be recognized by policy-makers if policy is to accomplish its objective of sustainable development. The division of labour by gender within the rural household, the different roles that women and men play in the local economy, the differing perceptions of resource problems and the contrasting responses that male and female may have to resource scarcity, must be taken into account by policy-makers. In particular, we need to understand how different members of the household contribute to and are affected by these processes. The roles of men and women are almost always substantially different in rural areas. The behaviour of each must be understood if policies and strategies are to be developed to redirect their behaviour in environmentally sound ways. Otherwise, attempts to modify behaviour are almost sure to fail, or at least result in non-optimal decisions about resource use.

64. Women frequently bear an unduly heavy work burden which, if more equitably distributed, would result in greater efficiency. Furthermore, they often lack equal access to credit, extension services and property rights. This situation often compromises productivity - and hence also the ability to provide for basic needs without overexploiting resources. Greater sexual equality thus might simultaneously improve both equity and efficiency, by improving the overall economic viability of the household.

65. Artificial scarcities imposed by sex inequalities also punish women. A Beijer Institute study in the Kakamega district of Kenya found critical fuelwood shortages among women in the midst of extensive woodlots on land controlled by men. Despite the presence of adequate fuelwood resources, many women were obliged to buy charcoal or to deplete their soils by burning sugarcane stalks, maize cobs and other crop residues for fuel. The men, for whom the idea of growing the trees for fuelwood was new, were largely unaware of the fuelwood problem. Since women have no rights to plant and harvest trees in this society, they could obtain wood only from the bush, an open access resource.

Community Decisions and Common Property Resources

66. Common property resource management faces the difficulty of generating agreement on use rights among users yet there are many examples of sound and sustainable communal management of water and forest resources (see Box 4). Local level management seems essential - when governments nationalize common property resources in the name of better management, over-exploitation often results.

67. The dependence of the poor on forest and tree products is a frequently overlooked fact. Consequently, encroachment of cropland on forested areas is often to the detriment of those who rely upon such areas for food, fuel, shelter and income. Community forestry projects run the same risk, as improved forest productivity leads to higher returns to additional inputs of labour which attract the interest of richer groups in the community. Conflict in the community is also often overlooked. Measures to introduce, on a test basis, improved village pasture management in eastern Turkey ran into the difficulty that rich absentee village leaders invested in steer fattening enterprises requiring summer grazing on the best pastures, whereas poorer villagers also required pastures for hay for winter feeding of breeding stock. Ironically the practices of the absentee village elders may have been more "sustainable" because they more closely integrated the grass and livestock systems, involving nutrient recycling.

68. Resource conservation is essential in areas adjoining those used for agricultural production. For example, watershed forests need to be managed to ensure that river-basin agriculture is not adversely affected by siltation, flooding and similar problems. There is little point in designing environmentally sensitive agricultural systems if they are to be undermined by logging, ranching and ecological destruction in neighbouring areas.

National Policy

69. The third main reason for unsustainable agricultural practices tends to arise because policy-makers, including Heads of State or Ministers of Finance or Planning, who generally decide how much money is allocated to which type of agricultural, forestry and fishery development and to environmental protection, are often not informed of the real costs of soil erosion, soil nutrient mining, forest destruction and marine pollution or

BOX 4

The concept of common property - effects on sustainability 1/

The term "common property" is often misinterpreted, giving rise to confusion on how the concept affects the management of natural resources concerned. Many have argued that common property regimes unavoidably lead to an abuse of resources or to what has been termed the "tragedy of the commons".2/ The common property condition has been blamed for many social and economic problems, including resource depletion or degradation, pollution, misuse of labour and capital, poverty among users of the resource, and backwardness in technology use. Solutions to such problems have tended to fall in either of two camps. One is to privatize the common property: that is, to place it under the individual ownership of the former users involving the distribution of legal titles, etc. The other is for the government to intervene to bring private and social costs into line either through taxes or subsidies, or under direct state control - the resource is nationalized.

A closer look at the terminology is needed for a better understanding of the concept, however. The expression "common property" refers to the rights of common use as opposed to a specific use right held by individual owners. Common use means the distribution of resource property rights in which several owners are co-equal in their rights to use the property; that is, the resource is not everybody's property and users who are not members of the group are excluded. Many wrong conclusions simply result from confusing the term "common property" (res communes) and "unowned resources" or open access regimes (res nullius).

History shows that common property regimes may very well be compatible with sustained management of natural resources. Some grazing lands and forests in Europe have been managed for centuries as common property resources on a sustained-yield basis. Strict regulations concerning access and use have successfully prevented overgrazing or similar resource-degrading effects. Illustrations of commons which have remained intact include some forest areas in West Germany and uplands in Switzerland which have become some of the best examples of progressive forest or pastoral management. Thus, common property, with the socially based institutional regulations it implies, is capable of sustainably managing natural resources.

It is the undermining or destroying of such local level institutional arrangements that convert common property regimes to ones of open access that in turn lead to the degradation of resource.
The common property concept can be employed to help solve important resource policy problems, such as grazing land and fisheries. For instance, common property institutions have introduced various types of fishery regulations, such as individual or national quotas, fishing

seasons, exclusive national fishing zones and territorial waters, in attempts to respect the concept of maximum sustainable yield. The main difficulties in managing the resource have arisen mainly from a lack of understanding of socio-economic pressures acting on the fishing communities and of the dynamics of the fish stocks, rather than deriving from the nature of common property itself.

1/ See S.V. Citiacy-Wantrup and R.C. Bishop, Common Property as a Concept in Natural Resource Policy, Natural Resources Journal Vol. 15, No. 4, 1975.
2/ G. Hardin, The Tragedy of the Commons, Science, Vol. 162, 1968.

of the national income and foreign exchange savings that could be generated through the adoption of sustainable agricultural practices. The analytical tools used in advising policy-makers often ignore or at least undervalue environmental considerations, such as depletion of natural resource stocks. Consequently there tends to be inadequate integration of environmental matters into agricultural and economic policies. 6/ There is also a lack of integration between agricultural, forestry and fishery policy-makers in arriving at sustainable solutions to environmental problems.

70. Often governments, responding to immediate political and economic needs, neglect the longer-term impact of policy choices on natural resources. Therefore, efforts must be made at the national and international levels to encourage governments to formulate their agricultural development programmes with a longer-term perspective.

71. Economic analysis can be made more sensitive to environmental problems at the macroeconomic level, by at least partially incorporating the value of environmental resources into national accounts. Pricing policies might then be considered to encourage sustainable activities. Methods of project analysis also can be more environmentally sensitive.

Environmental Accounting and National Accounts

72. Until recently, natural resources such as water, land and forests were regarded as more or less freely available, and hence were not treated like other forms of capital whose economic value was reflected in price. As we become aware of the finite character of these once seemingly infinite resources, approaches to account for their depletion and destruction must be developed.

73. Monitoring "natural capital stocks" is a useful first step towards accounting for the overall environmental costs of economic activity. Inventories of natural capital stocks incorporate, for example, new discoveries or depletions of energy resources, or growth or degradation of plant and animal resources. The Norwegian Government keeps "balance sheets" of natural resources while sophisticated techniques are used in France to determine "patrimony accounts" which include the physical components of the environment.

6/ FAO, 1988 op.cit.

74. Such environmental accounting, however, is not at present extended into economic accounting, since it is not represented in terms of prices and unit values. Quantifying the environmental value of a forest or a river is difficult. Such difficulties are shared, of course, with other social dimensions of development. Social indicators have been incorporated into the System of National Accounts (SNA) only imperfectly and with great difficulty. For most practical purposes, social indicators are still treated separately. Most non-market production (e.g. women's work in the household) and much investment in human capital (e.g. parenting) are still unaccounted for in SNA. Determining shadow prices, for example, to estimate the value of non-market household work (e.g. drawing water, transporting fuelwood and preparing food) can help bring national accounts closer to real economic values and measure, albeit imperfectly, the real costs of environmental degradation.

75. The value of the environment is difficult to express within the SNA framework for several reasons. First, market values reflect individual preferences; it is difficult to predict how future generations will value environmental goods and services. Second, part of the price of economic activity is the "consumption of disamenities" such as pollution, urban congestion and physical insecurity. The often high environmental price, paid by everybody, cannot be precisely quantified. Despite these difficulties, it is important to try to incorporate environmental considerations into national accounts as much as possible, if we wish to know the real costs and benefits to society of various forms of economic activity.

76. The difficulties of measuring the costs of environmental damage are even greater with factors such as water quality. But since there clearly is an economic value to such functions as the waste-disposal service provided by waterways and, equally clearly, an economic cost of the resulting degradation of clean water resources, it is necessary to try to determine as accurately as possible what these values and costs are.

77. There are three types of qualitative costs of environmental degradation:

- Direct costs of environmental maintenance. This would include both preventative measures (e.g. cropland conservation measures or reforestation of areas to prevent soil erosion and declining yields) and reclamation (e.g. cleaning land of toxic wastes or the reclaiming of saline land).

- Regulatory measures to protect environmental quality. Such measures cost money, which is usually paid by consumers of private sector goods and services.

- The cost of environmental damage to economic activity (e.g. the impact of polluted water on fishing and tourism).

78. To determine the net costs to society of environmentally damaging activity, the economic benefits of such activities must also be calculated - using the environment as a free disposal service is an economic value, however foolish. Clearly, calculating these costs precisely is impossible.

Nevertheless, reasonable approximations can be reached by a combination of identifying and measuring those environmental values and costs that are measurable, either directly or through surrogates; identifying costs that have already been measured, such as clean-up expenditures, forest replanting and other efforts to remedy the externalities of economic activity; and noting those areas that are currently unmeasurable, but important, and devising ways to estimate their economic value.

Pricing Policies

79. Two main pricing mechanisms are used to internalize externalities such as natural resource degradation:

- the polluter pays principle (PPP), widely employed in some OECD countries to discourage and compensate for pollution. PPP could also be applied to aquaculture and also internationally (e.g. when transboundary pollution occurs) and efforts should be made to set standards for quantifying damage.

- the concept of "marginal opportunity cost of resource depletion", developed by the World Bank to incorporate the direct costs of resource degradation and externalities, as well as the benefits foregone by those who otherwise would have been able to use the resource in the future.

80. Given the centrality of prices, subsidies and taxes among the array of measures available to implement policy, these mechanisms could be used more than they presently are to provide incentives for sustainable agricultural practices in situations where markets are failing to internalize environmental costs. Governments should take into account environmental impacts when establishing producer support prices for agricultural products. For example, governments could provide incentives for those crops whose production is least damaging to the environment. Tree crops tend to have more positive external effects on the environment than do annual crops such as cotton. Fertilizer and pesticide abuse may also be discouraged by reducing subsidies. Overuse of water can be discouraged by raising its price and that of electricity (needed for pumping groundwater). Higher taxes on timber extraction (stumpage charges) could encourage logging companies to replant and cause international prices to reflect better the environmental value of trees.

Project analysis

81. Cost benefit analysis is widely used to assess projects and programmes. With some modification, environmental impacts can be incorporated into cost-benefit analysis. Three main adaptations can be used to accomplish this goal. First, socio-economic cost-benefit analysis often uses shadow prices to estimate the long-term effects and other externalities of projects and programmes, including effects on the environment. This should be done regularly, even when it is impossible to make accurate estimates of environmental costs and benefits; for example, the value of a rare genotype. As a by-product to their main function, environmental impact assessments provide data useful for making such estimates. Secondly, cost-benefit analysis may include safe minimum standard criteria, such as those widely used in engineering designs. Safe

minimum standards could specify the environmental criteria that development projects should meet, although natural resource systems are usually highly complex and appropriate criteria are difficult to specify. Any additional costs required to satisfy the standards could be added to other project costs in the analysis. Thirdly, while it would be unrealistic to expect every development project to have a positive environmental impact, this could be insisted on at the programme level.

82. Another problem concerns the central role of the discount rate (r) in investment decisions. The use of any particular "socially optimum" discount rate in cost-benefit analysis gives a mathematical expression to the social rate of "time preference", or the relative importance of present and future consumption. That rate can never be precisely known because we cannot know the preferences of future generations. But we do know that sound management of natural resources often entails short-term costs to obtain greater benefits in the long term. The process of discounting future benefits and costs at some "r" to net present value can significantly reduce the calculated value of environmental direct benefits and services. The use of a higher "r" on the grounds that the opportunity cost of capital is high, a situation prevailing for many developing countries, places little value on costs and benefits arising even one generation hence, let alone further in the future. Alternative ways of dealing with this issue include the setting of "r" equal to the long run trend rate of return to natural resources or the real growth of output , both significantly below the opportunity cost of capital. The adoption of such a rate implies giving significant weight to future generations. Nevertheless, an exercise of judgement would still be essential, making greater use of indigenous technical knowledge whenever possible.

Technologies for Sustainable Agriculture

83. This issue has important institutional, economic and research components, particularly the latter, because resource users have inadequate access to the technologies, or they are uneconomic, or research systems have not taken sustainability as a major objective. Many farmers are aware of the benefits of improved seed and mineral fertilizers, and the key role they can play in sustainable systems, but generally lack access to credit for their purchase, or cannot obtain them because of weaknesses in infrastructure and marketing systems.

84. In Malawi, for example, less than 20 percent of the male farmers and 10 percent of the female farmers have access to credit. Yet, in the absence of sufficient land to permit adequate fallows or of sufficient organic residues, mineral fertilizers are the only way to raise or maintain soil fertility levels and sustain production, and credit for their purchase is commonly essential.

85. The economic component is not just about the financing of technology use. It is also about the risks of technology use and their perceived profitability. Poor people are inhibited from the use of technologies based on purchased inputs when there is short-term uncertainty about the returns on such inputs even though in the long run they may be profitable and ecologically sound. This is particularly the case in drought-prone areas where the risk of crop failures may be as high as one year in five. They are also inhibited from the use of labour-intensive technologies which intensify seasonal labour shortages or compete with other non-agricultural tasks. Two responses are proposed increasingly to address this issue.

- First, that soil and water conservation and other measures to achieve sustainable development should, where possible, be designed to show benefits to the farmer in the year of application, because otherwise they are unlikely to be widely adopted. Simple water harvesting methods can match this requirement, as can certain forms of minimum tillage.

- Secondly, that there should be greater stress on low external input farming systems, both to reduce undesirable fertilizer and pesticide residue problems in the environment, and to reduce the cost of external production inputs.

86. Most attempts over the past 30-40 years to raise crop and livestock productivity in developing countries have been centred on the substitution of traditional mixed cropping systems by mono-crop systems, and of fallow and the recycling of organic material by mineral fertilizers and other off-farm inputs. It is now commonly argued that mono-crop systems based on off-farm inputs cannot be sustained and that there should be a shift to low external input mixed farming systems which would be more appropriate for resource poor farmers. Whilst this is a laudable objective from an ecological and an equity point of view, it is unrealistic for many situations at the present time from both an economic and a humanitarian standpoint, because food availability would decline and food prices would rise.

87. Many of the low external input systems currently available for the tropics and sub-tropics cannot produce the required output levels or match the net producer returns of the high input systems they would have to replace. Densely populated countries or those with high populations relative to the available area of good arable land have to achieve relatively high yields in order to satisfy growing comsumption requirements. Even China, with its long history of biological waste utilization and of green manuring, has been unable to achieve high levels of food self-sufficiency on the basis of low external input systems alone. China produces substantial amounts of biological wastes and overall some 50-60 percent is collected and used as fertilizer (compared with less than 25 percent in Bangladesh and Pakistan). Nonetheless, since 1949 China has had to supplement organic manures with mineral fertilizers on an increasing scale so that the latter now accounts for above three-quarters of the nitrogen input and two-thirds of the phosphate input.

88. The adoption of low external input systems is commonly dependent on the integration of crop and livestock production systems to provide both manure and draught animal power. This integration has yet to take place in many areas, and ten or more years may be required to gain social acceptance for suitable agro-pastoral systems and their implementation. And even where the integration has taken place, the high labour requirements for manure collection and spreading can be a serious constraint. Furthermore, population pressures in some areas have already resulted in farms that are too small to maintain sufficient livestock to provide enough manure to raise yields to subsistence levels, although there are widespread opportunities for the introduction of stall feeding systems. Future population growth will inevitably exacerbate the problem, particularly in sub-Saharan Africa where growth rates are between 3 and 4 percent per year and in some countries are still rising.

89. Small farm size not only prevents or limits the adoption of low input systems based on crop and livestock integration, but also those systems

based on more complex inter- and relay-planting practices. These practices have been applied successfully for hundreds of years in high rainfall or irrigated areas where double and triple cropping is possible, and appropriate modern versions have been developed. They are, however, generally not an option for areas with one relatively short growing season; that is, for some 30 percent of the arable land of the developing world, and over 40 percent of sub-Saharan Africa's arable land. It is currently impossible in such areas to produce the subsistence needs for an average family of 5 to 6 persons from low external input systems unless the farms are large enough to permit adequate fallows.

90. In Malawi, for example, maize is the basic staple. It provides 80 percent of total calorie intake. An average farmer needs to grow some 1 500 kgs. of maize per year for subsistence, seed and sale, or barter for other goods and services. Many farms are already less than 0.5 ha, and because of population growth, a high proportion will be less than 0.25 ha by the year 2010. It follows that such farms would have to achieve yields equivalent to 3 000 kg/ha now and 6 000 kg/ha by the year 2010. These yields are impossible with low input systems and barely achievable through high input systems under the most favourable soil and agro-climatic conditions. Natural biological nitrogen fixation and release under conditions of continuous monocropping will support a maize crop of 400 to 800 kg/ha depending on soil type and rainfall. These yields could possibly be doubled if sufficient manure were available, and tripled by inter-cropping or green manuring with leguminuous plants under ideal conditions. Such yield increases, however, would still fall short of those required to compensate for the small family plot size, and the use of mineral fertilizers is therefore unavoidable.

91. Another important constraint to the adoption of low external input systems is their labour requirements that are commonly very high and which exceed, on a seasonal or more prolonged basis, the household labour supply, or are unprofitable at prevailing hired labour and commodity prices. Once again this constraint is of particular significance in sub-Saharan Africa where seasonal labour shortages are widespread and serious, particularly for female-headed households which in some countries represent 20-40 percent of the total. Although certain low input systems spread labour requirements more evenly over the growing season, and reduce the need for weeding by maintaining more complete ground cover, their total labour requirement may still exceed what is available. Moreover, these labour shortages can also constrain the adoption of certain soil and water conservation practices which tend to require large labour inputs, yet are essential for sustainable agriculture.

92. The foregoing limitations regarding low input systems underline the fact that there are no easy options regarding input use in developing or developed countries. Actions will have to be tailored to the agro-ecological and socio-economic situations, and are likely to involve a blend of both low input and high input systems. Nonetheless, the minimization of external input needs is likely to be a central objective for most countries. Low input systems will have to play a key role in the rainfed and semi-arid areas where both the returns on mineral fertilizer are too low and the risks of crop failure too high. They will also be important in better rainfed areas. Firstly, in those landlocked developing countries where high transport costs can raise mineral fertilizer prices to exceedingly high levels or where fertilizer imports are a significant

burden on foreign exchange earnings. Secondly, for almost all developed countries and some developing countries where nitrate contamination of ground- and surface-water is a problem.

93. Thus both international and national research systems are faced with two important challenges. The first is to develop environmentally sound and sustainable technologies to replace or ameliorate those technologies currently in use that have adverse environmental consequences. The second is to develop sustainable technologies for the vast areas of marginal land which have been largely neglected by research.

94. There are, for example, over 200 million hectares of vertisols in the developing world that are barely utilized at present, but could be moderately or highly productive. Similarly, there are vast areas with chemical soil constraints such as aluminium toxicity which could be used sustainably given the development of appropriate management systems and aluminium tolerant cultivars.

95. These challenges are being taken up. The Consultative Group on International Agricultural Research, for example, has recommended a number of changes in the priorities and approaches of the International Agricultural Research Centres (IARCs). 7/ Some of the Centres have, in fact, been active for a number of years in developing successfully sustainable technologies, notably those for vertisol management and for the utilization of toxic soils. But, if they and the national systems are to continue to be successful, their research must give greater attention to socio-cultural norms and to local farming systems that may have complex tree, crop and livestock mixtures. The poor adoption rates of their past technological products can, in part, be attributed to the neglect of such factors in research and technology development. 8/

96. In summary, efforts to promote sustainable agriculture must focus on the calculations of millions of mostly poor households regarding the use of natural resources. We also must consider, however, the overall resource context and therefore the management techniques required to conserve or raise yields and to provide employment opportunities in order to accommodate population increases; meet increased demands for food and fuelwood from urban areas; and provide for increases in per caput consumption. The distribution of wealth and land is extremely important in this regard. Landlessness and underemployment often encourage over-exploitation of the resource base. Impoverished persons are unlikely to dedicate effort and resources to the replenishment and renewal of trees, plants and land that they do not believe they will have continued right to use.

7/ CGIAR, Sustainable Agricultural Production: Implications for International Agricultural Research, 1989.

8/ FAO, The Technology Applications Gap: Overcoming Constraints to Small-Farm Development. FAO Research and Technology Paper no.1, 1986.

IV. Towards a Strategy for Sustainable Agriculture, Forestry and Fisheries

97. The intention in this section is not to put forward fully articulated strategies for the ecologically sound and sustainable management of the major resource types. To do so is neither feasible in such a short document nor appropriate given that such strategies need to be tailored to specific country situations. Rather the intention is to present FAO's views on the general approach to be followed and to indicate what should be the major elements of the strategies, starting with a discussion on the conceptual basis of an overall strategy, and then considering strategies for each of the resource types.

An overall strategy

98. Two particular facts should be underlined. First, appropriate technologies do not exist to sustain the present and projected populations forecast for many resource-poor areas, and even some resource-rich areas are reaching their maximum output. It is therefore evident that in many instances strategies to achieve sustainable crop, livestock, forestry and fishery production systems, and combinations of them, will fail unless they are complemented by policies to slow down population growth and enhance alternative employment opportunities. Second, production systems used by many producers are unsustainable, due either to commercial over-exploitation or the attempt to meet survival needs, and induced either by inadequate or inappropriate public incentives or private incentives. Public policies to induce producers to increase commercial production will simultaneously have to encourage producers to use natural resources in a sustainable manner, with the overall objective being to create an economic environment in which it is more profitable to conserve resources than to destroy them. In the absence of effective national and international support and alternative employment opportunities, the rural poor are forced into the mining of soil nutrients, the cultivation of steep slopes, the over-grazing of rangeland, and the excessive collection of fuel materials in order to feed and warm themselves. It is they, therefore, who govern the success or failure of policies to induce them to achieve sustainable production systems because, unless they respond positively to them, degradation will continue. The micro-economics of sustainable production systems, household labour availability and the perceived needs of the rural poor at the local level must therefore be the starting point for national strategy and policy formulation and for guiding those components of the producer support systems that will have to be initiated largely at the central level.

99. FAO's proposals for an overall strategy is therefore built around considerations of human needs, poverty alleviation and production incentives. Soil and water conservation measures, for example, should, where possible, be designed to show an economic return or some other benefit to the farmer in the year of application, because otherwise they are unlikely to be widely adopted. Similarly, habitat conservation and game cropping for tourism should be seen as a socially and economically profitable alternative to forest and savannah destruction. Much of the discussion of sustainable development has centered on marginal areas with low production potential, where environmental degradation and rural poverty tend to be most severe - rainfed semi-arid areas and areas of

unreliable rainfall, steep slopes and upland tropics. This is understandable, since such areas tend to be the ones where the poorest of the poor must eke out their meagre livings. However, it is important to give equal or relatively greater attention to the high potential areas so that they can take some of the pressure off the marginal areas, and reduce the losses of forest and rangeland to arable farming. These areas account for the bulk of food and agricultural production and support a far greater population; consequently, when they are environmentally degraded, the loss of output is substantially greater. In adopting this low and high potential typology, FAO is not suggesting that there is a rigid distinction between the two resource types: what may be regarded as of low potential from a crop production perspective, may have a higher potential for the production of wood or fodder or constitute an important water catchment, for example. It is proposing, however, that, from both a strategic and an operational point of view, there are important differences in their respective needs (Box 5).

100. Most land that is currently harvested is of the high potential type. According to FAO's Agriculture: Towards 2000 (AT 2000) in an analysis of 93 developing countries, excluding China, nearly 60 percent of harvested land in 1982-84 was high potential land (good rainfall, naturally-flooded and irrigated land) and only 21 percent was marginal (low and uncertain rainfall rainfed land). Another 22 percent was characterized as "problem land", with excessive rainfall, steep slopes or poor soils. (Table 4)

TABLE 4. SHARES OF TOTAL HARVESTED LAND OF DIFFERENT POTENTIALS, 1982-84, 93 DEVELOPING COUNTRIES

	Low potential land 1/	High potential land 2/	Problem land 3/
Sub-Saharan Africa	37.3	36.3	26.4
Near East and North Africa	25.4	55.6	15.9
Asia	18.2	60.0	21.8
Latin America	10.6	65.6	23.8
Total (93 countries)	20.9	56.7	22.4

Notes: 1. Low potential land : low and uncertain rainfall, rainfed land.
2. High potential land : good rainfall rainfed, naturally flooded and irrigated land.
3. Problem land : excessive moisture and/or unsuitable soils.

Source: Adapted from World Agriculture: Toward 2000, FAO, Belhove Press, London.

101. AT 2000 also showed that high potential land is responsible for a relatively greater proportion of crop production because of higher yields and multiple-cropping. Non-irrigated arid and semi-arid areas of developing countries (excluding China) in 1983/84 accounted for only

about 9 percent of total cereal production and 6 percent of root and tuber production. The bulk of cereal production (more than 80 percent) came from high potential land, and nearly 90 percent of root and tuber production was from high rainfall lands. There are, of course, considerable regional differences, but even in sub-Saharan Africa where low potential land accounts for nearly 40 percent of total harvested land, it produces only 30 percent of the cereals. Were China to be included, the share of high potential land in total production would be even greater. The share of crop production coming from high potential areas is expected to increase even further by the end of the century.

BOX 5

High and low potential land: the intensive and extensive margin of production

For the many developing countries with limited land, the key to sustainable development will be their ability to develop and introduce ecologically sound technologies to raise the potential productivity of low potential or marginal land and reverse its current widespread degradation, as well as to raise significantly the productivity of high potential land in order to take the pressure off marginal land. High potential land can be enhanced to generate greater yields without damaging its future yield capacity: this is the intensive margin of production. Low potential land cannot in general be exploited intensively for staple food crops using techniques modelled on those developed in Europe or North America without provoking progressive environmental degradation. Even opening up new areas to low intensity cultivation - the extensive margin of production - entails some environmental risk.

The dilemma for many poor countries is that population pressure, coupled with inequitable access to high potential land is forcing more and more households onto low potential land. Enabling these people to feed themselves today without destroying the land's ability to feed them tomorrow is the main challenge facing governments and development agencies.

Low potential is not necessarily synonymous with low productivity - for example, shifting cultivation and transhumance pastoralism exhibit high labour productivity and very efficient utilization of natural nutrient recycling and forage production. But the sustainable yields of low potential areas are generally constrained by agroclimatic factors and by economics. If costs can be ignored, then the possibilities are almost limitless. For example, hydroponics and man-made environments can provide high food production potential anywhere. What is required, however, is food that the poor can afford to buy and farmers with limited resources can afford to grow. This is not to say that yields cannot be raised economically in low potential areas - in many cases they could be doubled, for example, with appropriate moisture conservation techniques and improved cultivars - but their population supporting capacity will still be low compared with the high potential areas. 1/

1/ FAO, Land, Food and People.

102. It is clear from the above that, for most developing countries, the alleviation of rural poverty and the attainment of food security will depend mainly on establishing sustainable production systems in the high potential areas of forest, arable and range land. This does not mean, of course, that the low resource areas should be neglected since to do so would condemn the poorest to becoming even poorer, and could force them to further over-exploit natural resources just to survive.

103. There are lessons to be learnt in this respect from the developed countries. The first agricultural revolution of the 18th century, based on improved crop rotations and the greater integration of crop and livestock production, allowed marginal land in these countries to be taken out of arable cultivation and used instead for livestock grazing or forestry. Similarly, the second, science-based agricultural revolution of the 20th century allowed off-farm inputs, particularly mineral fertilizers, to substitute further for marginal land.

104. Four other factors need to be considered in formulating a balanced strategy between the low and high potential lands. The first is the promotion of rural infrastrucure, industries and services. In the past, urbanization has helped to reduce pressures on the land, but urbanization creates other social problems, and in many developing countries is now proceeding too rapidly. It does, however, provide an alternative to eking out a living on low resource land, leading to its eventual degradation. Rural off-farm employment, focused on smaller towns or villages rather than big cities, can have similar benefits without putting such great strains on urban institutions and infrastructure. Broad based rural development, therefore, should be an important component of the strategy.

105. The second is the expansion of the utilizable area of high potential land by ecologically sound methods of controlling infectious diseases of humans and livestock (onchocerciasis and trypanosomiasis respectively).

106. The third is improving both productivity and equity through land reform in economically viable units with adequate input supply and marketing services. Particularly in Latin America, and to a lesser degree in other developing regions, large areas of high potential land could be allocated to the landless and near-landless through reform of property rights. The final factor is appropriate technical knowledge. Our knowledge of improving production on marginal land is still inadequate, though promising research opportunities exist. Most so-called improved technologies tend to expose farmers to greater uncertainty regarding net returns to labour inputs and so have met with only limited success, especially with poor farmers. In high potential areas, however, given improvements in price and non-price incentives for increased production for the market there are a number of under-utilized technologies which are discussed below. Research must be intensified, however, to ensure a continuous flow of additional technologies for the future.

107. In developing sustainable and operational production systems, the particular needs of five resource types must be given priority:

(1) marginal, "low potential" areas, where inadequate or unreliable rainfall, adverse soil conditions, or topography limit agricultural output and increase the risk of chronic land degradation;

(2) "high potential" areas, which, given sound land management practices, can sustain intensive output of crops and livestock at high and rising levels of productivity;
(3) forests and other lands with trees as an important component;
(4) coastal and inland fisheries;
(5) biological diversity and genetic resources concerning each of the above resources.

108. In addressing these five priority resource types, an approach fully integrating crop, livestock, forestry and, where appropriate, fishery activities is essential. In practice, three separate but complementary steps can be used to achieve such integration in a scientific way. The first is land use planning which determines the capacity of a piece of land to support human populations and identifies complementary land uses and development strategies to realize the full potential of the land. The second is environmental planning and management which addresses the factors necessary to ensure that policy programme and project initiatives are compatible with the environmental conditions of the region and are sustainable. The third is environmental impact assessment (EIA) which analyses individual development projects to identify any potentially negative effects on the environment. These steps can address the full range of land uses from preservation of habitat through to cash cropping.

Strategy for sustainable agricultural development of the low potential areas

109. In the low potential areas, conditions do not favour accelerated agricultural development. Even supporting existing populations often will require far greater efforts to conserve soil and water resources than presently are being made. Nevertheless, many environmentally "marginal" agricultural areas such as drylands and highlands are preferred areas for people and livestock to live because they have healthier climates. In other cases, they support landless people and their livestock, migrating from overcrowded high potential land.

110. Land degradation involves a continuous decline in productivity as a result of the impoverishment and depletion of vegetative cover, exposure of the soil to wind and water erosion, reduction of the soil's organic and nutrient content, and deterioration of the soil structure and its capacity to retain water. 9/ In some areas, the battle to restore degraded land has already been lost. In other areas, reversing land degradation will prove slow, costly, and difficult to achieve. Especially in many semi-arid areas, "sustainable development" will require the creation of alternative employment opportunities or migration to reduce the population on the land, conserve resources and supplement incomes. It follows, therefore, that:

9/ Erosion is a natural process which cannot be entirely stopped. A sustainable situation exists when soil losses to erosion are offset by the additions to soil arising from natural processes such as weathering of the underlying rock, humification and siltation. "Moderate" land degradation is usually defined as a loss of productivity of up to a quarter, while "severe" degradation means a loss of up to half the land's previous potential productivity.

- agricultural development must seek to strike a balance between conservation and meeting the short-term necessities of farming families;
- agricultural technology in such areas needs to be designed to accommodate precarious environmental conditions, not solely to maximize crop yields;

- economic policy changes will usually be needed to change the market signals that poor people receive.

111. In the past, land degradation, particularly soil erosion, was viewed almost exclusively as a physical problem requiring technical solutions. Soil science sought to understand the physical but not the socio-economic forces encouraging such degradation. The knowledge gained about soils permitted advances in technical prescriptions such as terrace construction and contour cultivation, but did not improve understanding of why land degradation occurred.

112. Incorrect land use and poor land management are the principal causes of accelerated soil erosion. They result from a combination of economic, social and political pressures which constrain the farmer's behaviour. The first step towards developing soil conservation programmes for resource poor areas is, therefore, an analysis of why undesirable land uses are practised. The analysis might determine that several factors are at work: the pressure of population on the land, the existing land tenure system, agricultural pricing policy, inappropriate technology etc. Solutions that meet the needs of local people may not be economically feasible or might incur political opposition. However, available options need to be made explicit so that the required institutional and legal changes can be considered.

113. An analysis of the structural impediments to a more sustainable agricultural system in low resource areas is essential if governments are to avoid embarking on costly development programmes that do not work, perhaps because they address only the symptoms, rather than the causes, of land degradation. Many conservation projects have failed because they were imposed from the top, without sufficient cultural sensitivity or involvement of local people. Local communities, which were not involved in the planning or maintenance of the projects, saw no short-term advantages and abandoned them. For example, FAO estimates that about $1 000 million of donor funds were ineffectually spent during the 1970s and 1980s on group ranches and grazing schemes in Africa because the schemes paid insufficient attention to local cultures and needs. 10/

114. Donor resistance to small-scale projects has led to their neglect over the same period, particularly because the cost of preparing them is thought to be excessive compared with larger-scale projects. This is unfortunate because the greatest low-cost opportunies for increased and sustainable food production in low potential areas are through such

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10/ FAO, African Agriculture: The Next 25 Years, 1986.

activities as water harvesting, soil erosion control, alley cropping, use of crop residues as fertilizer, agro-forestry, community afforestation and small-scale irrigation. To be effective, such projects need to be devised in consultation with the local communities and as far as possible managed by them.

115. The key to sustainable development in low resource areas is better management of farm production systems to minimize risks and to enable the farm household to withstand shocks and stress to the farm system. Sustainable natural resource management thus rests on four essential pillars:

- economic and social incentives;
- community management of local projects;
- sound land-use planning, including the integration of forests and wooded areas; and
- the development of improved farming systems that reverse land degradation, recognizing that erosion and "soil loss" are symptoms and not causes of the problem.

116. In low potential areas, single-component solutions such as planting improved varieties or applying mineral fertilizers will rarely solve the problem, but relatively simple innovations may be appropriate in some situations: stone and earth bunds were introduced successfully to improve water infiltration in Burkina Faso; water harvesting has been successful in Kenya; and contour ploughing proved beneficial in Ethiopia. In most cases, however, a broader, holistic approach is needed to increase simultaneously the production of food, livestock feed and household fuel, through the closer integration of agriculture, forestry and fisheries, including aquaculture. 11/

117. The following elements of a strategy are essential to promoting development and conservation at the farm and community level in the low potential areas:

(1) the perception of the environment as fundamental to present and future livelihoods (i.e. jobs, income and cost savings);
(2) the development of labour- and time-saving technologies for fuelwood and water collection, food preparation and post-harvest storage to alleviate the pressure on women and enable them to undertake environment-saving but more labour-consuming farm technologies;
(3) the substitution, wherever possible, of farm-grown inputs which make little demand on household finances for purchased inputs - integrated pest management, biological nitrogen fixation, organic waste recycling and composting, and biogas production are examples of such inputs;
(4) the creation of non-farm income opportunities to promote, not undermine, sustainable farming systems. Poor households

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11/ See "Sustainable Development in Famine-prone Areas: Approaches and Issues", paper prepared by the FAO Investment Centre for IFAD, International Consultation on Environment, Sustainable Development and the Role of Small Farmers, Rome, Oct. 1988.

will adopt sustainable practices only if they are perceived as income-enhancers. Governments and donors must be careful that efforts at income supplementation do not discourage sustainable practices;

(5) the search for other means of supporting household livelihood when common access to resources such as grazing lands leads to increased degradation of the resource, usually because the local institutions controlling access are breaking down;

(6) the adoption of government policies that seek to fill those gaps in the food system that are of critical importance to poor people in low resource areas: post-harvest technology to avoid food losses, agro-forestry, decentralized marketing, better biomass utilization, alternative sources of income generation. This will require the development and dissemination of improved agricultural technology;

(7) an emphasis by policy-makers on the integration of tree growing in farming systems as well as the integration of food, fodder and fuelwood systems. It is an error to see agricultural systems and forestry as isolated from each other: poor households must manage farm and forestry resources in an integrated way; and

(8) better environmental monitoring (satellite predictions, remote sensing, etc.) to improve planning and assessments of the population-supporting capacities of land and water resources.

Strategy for sustainable agricultural development of the high potential areas

118. High potential areas commonly require many of the foregoing measures but they can generally sustain intensive crop production using existing technologies as long as care is taken not to exceed the soil's regenerative capacity. These areas are either irrigated or blessed with reliable and adequate rainfall. Soil fertility is generally high or has the potential to be so. Existing agricultural technology is capable of raising the "population carrying capacity" of such lands. 12/

119. Unfortunately, many of the development projects undertaken in these resource rich areas have not been environmentally sound. For example, some intensive irrigation programmes have neglected drainage, leading to salinity, sodicity or both. Other projects waste scarce water. In yet others, the indiscriminate use of fertilizers and pesticides is a problem. Unwise agricultural "development" has devastated rain forests, silted up dams and reduced soil productivity. Often, scarce financial resources have been diverted from more sustainable development possibilities and non-renewable resources have been needlessly and irreversibly depleted.

120. Priority must be given to sustaining the land's productive capacity while reducing its vulnerability to environmental hazards, many of which result from technological "progress" in agricultural production. Sustainable development of high potential areas must also be coordinated where necessary with the ecologically sound development of geographically contiguous zones, such as watershed forests.

12/ FAO, Land, Food and People, 1984.

121. As mentioned above, for most developing countries, food security and the alleviation of rural poverty will depend on establishing sustainable production in the high potential areas. For example, in Asia, where more than three-quarters of the world's 750 million poorest people live, 82 percent of cereals are grown on high potential, naturally flooded or irrigated land. Not only is it essential to maintain and increase staple food production on irrigated land to feed the rural and urban poor, but it is essential that natural resource management be improved in areas contiguous to irrigated river-basins and highly-populated intensive farming systems that they support.

122. The food production success story of the 1970s and early 80s was the Green Revolution, which was developed for high potential areas. The Green Revolution expanded irrigation and introduced high yielding varieties of rice and wheat (HYV's) which, under controlled irrigated conditions, responded dramatically to mineral fertilizers. Pest control was improved with new pesticides, which had to be used more because of the greater vulnerability of intensive mono-crop cultivation to attack. However, this success carried certain economic and environmental penalties.

123. Such high-input, high-productivity farming systems are dependent on a steady supply of relatively expensive inputs: mineral fertilizers, fuel and pesticides. They can carry unsustainable environmental costs, so some changes are required to ensure that the advances in production are maintainable in the foreseeable future. Particular attention must be paid to the structure of soils under heavy cropping regimes, and soil nutrient balance. Sustainability and equity would both be served by a shift to lower external input, mixed farming systems, but such systems would have to be profitable to producers and at the same time enable the satisfaction of growing consumption needs. Such a shift would, therefore, have to be made gradually and carefully.

124. Means of minimizing or preventing environmental damage arising from such intensive cultivation include: balanced fertilizer application to compensate for the increased yields and hence greater soil nutrient removals; the introduction of new disease- and drought-resistant genetic materials; integrated pest management - a combination of cultural practices and biological and chemical controls that keeps to a minimum the need for, and use of, pesticides; and the implementation of effective regulatory controls. 13/ In fact there is ample evidence from both temperate and tropical countries that the judicious use of modern inputs can raise soil fertility through the return of more crop residues to the land and increased microbiological activity. However, suitable technologies have not been developed for all problems and situations and therefore the strategy must emphasize both the strengthening of international and national research systems and the redirection of research programmes towards the requirements for sustainable agriculture.

13/ The International Code of Conduct on the Distribution and Use of Pesticides, 1985, is aimed at protecting users of pesticides from the most toxic materials and thereby maintaining confidence in scientific pest control.

125. The following environmental threats need to be addressed with urgency in the irrigated zones:

(1) salinity, sodicity and waterlogging of irrigated land, as well as the widespread incidence of malaria, schistosomiasis and other waterborne diseases;
(2) the dangers deriving from mono-culture agriculture, under large-scale irrigation, which increase susceptibility to plant diseases and pests. Environmental and health problems are likely to become more severe from a possible doubling of pesticide use by the end of the century; and
(3) increasing over-exploitation of groundwater resources in areas where alternative sources of irrigation are lacking.

126. Solutions exist to minimize these threats: mixed cropping and genetic diversification can reduce the risks that attend reliance on mono-cultures, while monitoring groundwater resource and regulating access to and the take-off of water can prevent devastating shortages of water. Operational improvements will have to focus more on increased water use efficiency and better on-farm water management, two vital sustainable components for irrigated areas. In general, better management of natural resources in irrigated regions, and improved irrigation performance will require more integration between irrigation management and national resource planning, particularly the links between lowland and upland water catchment areas. Integrated water management needs to be extended outwards from areas with groundwater problems, while forest and soil conservation efforts in adjacents areas must ensure sufficient water supplies for the high potential areas. The importance of these water considerations is emphasized by the fact that for many countries irrigation is the only way of attaining acquired increases in sustainable increases in production.

127. Agricultural production in the high potential areas will be dependent for the foreseeable future on the relatively intensive use of purchased inputs such as fertilizers and pesticides.

A strategy for these areas should, therefore, stress the following points.

(1) the development of environmentally safer, lower-input integrated farming systems.
(2) closer integration between the management of high potential areas and that of the land, water and forestry resources of contiguous areas.
(3) reform of land tenure and property rights to secure access to high potential land by poor farmers, including households headed by women.
(4) improved water management to economize on water use, to reduce land loss caused by waterlogging, salinity and sodicity,and to facilitate the safe use of marginal and waste water for irrigation.

Forests and other wooded lands

128. Forest resources are of vital importance to sustainable development for three reasons. First, forests protect and maintain the soil and water base. Secondly, they are a major source of employment and income, through the harvesting, processing and sale of products not only from forests but also of trees grown as a component of farming systems. Finally, fuelwood remains the principal source of energy for most of the world's rural poor and, often in the form of charcoal, for many urban dwellers as well. Each of these essential functions, however, makes forest resources difficult to protect in the face of growing population pressures.

129. Tropical forest ecosystems are also the world's principal genetic reserve because of their unparallelled richness of species and ecosystems. 14/ Developing forest resources sustainably means simultaneously preventing genetic erosion and maintaining a balanced resource base, essential to other ecological zones. In some cases, at least those where ecosystems are varied and threatened by imminent destruction, emphasis should be placed on slowing or even preventing development, rather than stimulating it. In other situations, however, economic development can be pursued safely to provide livelihoods without irrevocably damaging the environment.

130. The problems of the forests have global effects and global causes. Deforestation contributes to the degradation of land and to the greenhouse effect by upsetting the global carbon dioxide balance. 15/ Simultaneously, fuel emissions from the industrialized countries lead to "acid rain", which causes considerable damage to the forests of Northern and Eastern Europe and North America.

Forest resources for environmental protection and sources of livelihood and fuel

131. Forests are essential to resource conservation in several critical ecological zones. Deforestation of mountainous and hilly land not only causes soil erosion on the land that is cleared, but also, because of the burden of material transported by the increased run-off, poses a threat to downstream areas. To prevent serious environmental degradation, which threatens agriculture in both areas, integrated watershed management is needed. This means not only forest conservation and reforestation, but maintenance and rehabilitation of watersheds through appropriate

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14/ Just a handful of countries (Brazil, Colombia, Mexico, Zaire, Madagascar and Indonesia) have the bulk of both global tropical forest reserves and the world's living terrestrial species.

15/ Estimates vary widely regarding the relative contributions to the greenhouse effect of fossil fuel consumption and tropical deforestation. Current estimates assign about 5 100 million tons of CO_2 a year to the burning of fossil fuels, and about 1 500 million tons to tropical deforestation, forest fires and other "natural" sources.

conservation methods including, where necessary, the construction of physical works to control erosion and flooding.

132. In arid and semi-arid lands, where wind rather than water is the main agent of erosion, forests can contain the effects of soil erosion and stay green when grasslands dry up. Forest areas are therefore important reserves for livestock feed. 16/ Similarly, tree planting can rehabilitate salt-affected land and sand dunes by tapping moisture and nutrients in the deeper soil layers. Forests similarly represent an important barrier against encroaching deserts and drought.

133. Forest cover is also essential to soil protection in the humid tropics. Traditionally, shifting cultivation maintained ecological balance in the tropical forests, preventing irreversible soil degradation. Increasing population pressures, however, have necessitated shorter fallow periods which do not allow fertility to be restored. One solution to this problem would be to encourage permanent systems of cultivation, but many poor farmers already experiencing declining yields cannot afford the improvements required to maintain fertility and prevent further degradation. They simply continue to deplete the soil until it is no longer viable, and then move on and clear more forest. In some cases, they receive financial incentives to do so. 17/ A better option may be to develop agro-forestry as an alternative to both shifting cultivation and intensive, permanent production systems.

134. Forests are a major source of food in many parts of the developing world. In some parts of Africa as much as 70 percent of animal protein supplies come from such forest game as birds and rodents. Forests are also important revenue sources for developing countries. Indonesia, for example, makes an estimated $120 million a year from products harvested from the topical forest - rattan, resin, sandalwood, honey, natural silk and pharmaceutical and cosmetic compounds - even though these activities do not qualify for the fiscal and other incentives enjoyed by the logging industry. Forestry and related activities provide rural employment and income. Exports of tropical woods and forest products also are an important source of foreign exchange for many countries. Developing countries earn roughly $7 000 million annually from exports of forest products - about 9 percent of their total agricultural export earnings. Forest management is labour intensive. Most of the employment it provides is at the artisan and household level - in latex collection, carpentry, handicrafts and making charcoal.

135. Fuelwood comprises about 85 percent of the wood consumed in the developing countries. It accounts for more than three quarters of total energy consumption in the poorest countries. In general, the poorer the country, the greater its dependence on fuelwood - and the more vital that forests be conserved as a resource. Fuelwood is essential for cooking, without which some staple foods such as cassava are unsafe for human consumption. Other foods require cooking to make them palatable and free from pathogens.

16/ For example, during the peak of the Indian drought in 1987-88, protected forest lands were opened for livestock feeding.

17/ See, for example, H. Binswanger, Fiscal and Legal Incentives with Environmental Effects on the Brazilian Amazon, Discussion Paper 69, World Bank 1989.

136. About 100 million rural people in the developing countries live in areas with an acute scarcity of fuelwood. Another 1 000 million or so live in areas where current levels of use cannot be sustained (Table 5). The problem is already so serious that it is unlikely that we can do more than mitigate it. Severe shortages of fuel seem bound to continue in the rural and low income urban areas of many developing countries until, and unless, new alternative sources of cheap energy are developed and made available on a large scale.

TABLE 5. POPULATION EXPERIENCING A FUELWOOD DEFICIT, 1980 AND 2000 (IN MILLIONS)

	1980				2000	
	Acute scarcity		Deficit		Acute scarcity or deficit	
Region	Total Popn	Rural Popn	Total Popn	Rural Popn	Total Popn	Rural Popn
	..... millions					
Africa	55	49	146	131	535	464
Near East and North Africa	-	-	104	69	268	158
Asia and Pacific	31	29	832	710	1 671	1 434
Latin America	26	18	201	143	512	342
Total	112	96	1 283	1 053	2 986	2 398

Note: Total population and rural population (total population less that of towns with more than 100 000 inhabitants) in zones whose fuelwood situation has been classified.

Source: Adapted from FAO, Fuelwood Supplies in Developing Countries, 1983 (FAO Forestry Paper No. 42) Table 2.

A strategy for forested areas

137. Striking the right balance between development and environmental protection is necessary if forests in the developing world are to continue to play their essential economic role. The following techniques and approaches are essential in finding a balanced strategy:

- Watershed management is necessary to guarantee food production in high potential areas. Links need to be maintained between forestry and food production through an integrated approach to watershed management. Incentives must be provided to rehabilitate degraded watersheds.
- Agroforestry - which combines agriculture with forestry and pastoralism - is a most promising way to link food

production,especially in low potential areas, with improved forest management.

- Multipurpose forest management which involves production of timber, non-wood forest products, fuelwood, fodder and fibre, wildlife management and provision of services: water quality, shelter, control of air pollution, protection of soil, recreation and protection of natural heritage and genetic resources.
- Monitoring and evaluation systems , including adequate base line surveys, geographic information systems, application of environmental impact assessment and assessment of local community's benefits and involvement.
- Protection of genetic resources is fundamental to any forest strategy (see below).

The Tropical Forestry Action Plan

138. Seeking to find the right balance between development and environmental protection, this plan, which dates from mid-1985, represents the first serious international effort to confront the problem of saving the tropical forests in an integrated way. The Plan, launched by FAO, the World Bank, UNDP and the World Resources Institute and currently supported by 20 donors, has the following main objectives:

- to restore productive capacity of forested land;
- to develop the sustainable use of forest resources;
- to improve food security through better land use;
- to increase the supply of fuelwood;
- to increase income from the sale of locally manufactured products in forested areas;
- to increase local participation in forestry and forest-based industries; and
- to conserve natural ecosystems and genetic resources in the forests.

139. Operationally, the Action Plan covers five closely interrelated priority areas:

(1) The Action Programme on Forestry and Land Use focuses on the links between forestry and agriculture and the direct contribution of forestry to food security through agro-silvipastoral development; integrated watershed management; arid zone forestry and desertification control; and land-use planning.

(2) The Action Programme on Forest-Based Industrial Development aims at promoting appropriate forest industries to fully yet sustainably use the wide range of wood and non-wood products of tropical forests, based on intensification of resource management; efficient harvesting; development of appropriate forest industries; recuperation of waste; and development of marketing capabilities. It aims to associate the forest with industry and local people for economic development.

(3) The Action Programme on Fuelwood and Energy aims at restoring fuelwood supplies in countries most affected by deficits through increasing the supply of wood by improved management of existing resources and by massive increases of fast-growing multi-purpose

trees in land-use systems outside the forest; more efficient use of wood energy through improved conversion technologies; and replacing domestic wood energy with other forms of energy where possible yet using wood energy for rural industries where a surplus of wood exists.

(4) The Action Programme on Conservation of Tropical Forest Ecosystems addresses the need to prevent the degradation of tropical forest plant and animal species and to promote the integrated management of wildlife and other non-wood products. The goal is to protect ecosystems and genetic resources in such a way that suitable development opportunities are at the same time offered to local people.

(5) The Action Programme on Institutions focuses on strengthening the institutional framework within which sustainable tropical forest development takes place, by strengthening the financial and operational effectiveness of public forestry agencies; building education and training programmes to meet professional, technical and vocational manpower requirements; establishing strong research and extension capabilities; and strengthening the institutional capabilities of local people for self-sustained action.

140. The inter-disciplinary and interactive approach of the TFAP and the way it helps, through a dialogue between technical experts, donors, policy-makers and the forest rural people themselves, to establish priorities and projects and the means to finance them, could provide a model for the sustainable development of natural resources in general. Since its inception in 1985, 61 countries have begun the process of formulating national forestry action plans arising from the adoption of the TFAP, which has been completed for 20 of them.

Marine and inland fisheries

141. For centuries, fishing communities practised what is now called sustainability, intuitively aiming to achieve maximum sustainable yield. In traditional societies, rights to fish certain areas were carefully controlled and conserving fish stocks was a matter of common interest. Moreover, early in the twentieth century concerns over the rising levels of exploitation in the temperate fishery zones of the world led to growing attention to management practices and to problems arising from excessive fishing effort. After the Second World War, strong and sustained demand for fish for human consumption and livestock feed, in both the developed and developing countries, put increasing pressure on fishery resources.

142. Improved fishing technology enabled these increased demands to be met (Table 6.) The two most important changes were the use of synthetic fibres in the manufacture of nets and the freezing of catches at sea. These innovations, together with electronic aids, mechanical net-hauling and improved vessel design, permitted widespread use of large nets and a dramatic increase in the size, versatility and operational range of fishing craft. Freezing at sea facilitated the spectacular expansion of distant-water fishing fleets in the 1960s and the 1970s. Assisted by such rapid advancement in technologies, the world catch doubled from 20 million tons in 1950 to 40 million tons in 1960. The deployment of distant-water fishing vessels on a global basis by the 1960s resulted in production increasing again by another 25 million tons by 1970.

TABLE 6. ANNUAL WORLD LANDINGS OF AQUATIC RESOURCES (EXCLUDING MAMMALS AND SEAWEEDS)

	1958-62	1968-72	1978-82	1985	1988 1/
	million tons				
Total: all species	39.8	67.1	73.0	86.0	96.5
Inland waters	5.8	8.9	7.7	10.6	13.5
Species used for fish meal	9.0	23.8	22.3	24.3	28.1
Supplies for direct human consumption	30.8	43.3	50.7	61.7	68.4

1/ Provisional

Source: Yearbooks of Fishery Statistics FAO, Rome.

143. These pressures on the fish stocks, followed by only marginal increases in production between 1970-75 provoked widespread action by coastal states to protect their fisheries from international fishing fleets; many unilaterally extended their fisheries jurisdiction to 200 miles. In effect, the rapid acceleration of fisheries production by a limited number of technologically advanced fishing nations caused the international open-access condition of fisheries which had prevailed for centuries, to be closed. By 1980 almost all coastal states had taken legal steps to extend their jurisdictions to 200 miles, thereby asserting national ownership over 90 percent of the world's marine fisheries resources, and affecting the operations of vessels fishing at long range. This marked change in the legal regime of the oceans was ultimately recognized in the United Nations Convention on the Law of the Sea (UNCLOS), adopted in December 1982.

144. After a period of slow growth which marked the 1970s, fish production has risen significantly during the 1980s and now well exceeds 90 million tons annually. However, this renewed expansion is attributable mainly to increased catches of small shoaling pelagic species which are not only notoriously subject to fluctuations in abundance, but are in great part reduced to fish meal for animal/fish feed rather than used for direct human consumption. The demersal stocks of fish have generally shown no real increases in production, thereby confirming that the yields of the stocks of most preferred fish for food have reached levels of full if not over-exploitation.

145. Meanwhile, the demand for fish, both for human consumption and for fish meal, continues to rise. Total requirements almost certainly will well exceed 100 million tons by the year 2000. In order to satisfy these

growing demands, the sustained development of the fisheries sector must depend not so much on the exploitation of species hitherto neglected because of market preferences or extraction costs but rather on concerted efforts on a number of fronts.

146. First, further improvements in utilization practices could make a significant contribution to increasing the supply of fish. Three main areas merit priority attention: rescuing discards from trawling operations for preferred species, reduction of post-harvest losses through better landing, storage and marketing facilities, and the wider use of small pelagic species for human food products.

147. Second, there remains considerable potential for continued growth in the contribution of aquaculture to food supplies. Major gains may here be obtained from the culture of fin-fish species through extensive aquaculture systems, fishery enhancement in reservoirs, lakes and even in the open seas. Greater support to artisanal aquaculturists could make a significant nutritional and social impact in rural areas of low-income countries.

148. Finally, high priority must be maintained on the better management of the world's fish resources. Management is indeed the key to the sound, sustained development of fisheries. Extension of national jurisdiction over fisheries, whilst a precondition for rational management, does not of itself ensure the more efficient conservation and use of the fish stocks. The enactment of national sovereignty must be reinforced with the legal and operational institutions necessary to design and implement conservation and management schemes.

149. Management must be concerned with the overall economic performance of the fisheries. To this end, intervention in fisheries must include measures not only to reduce fishing costs and improve revenues but also to satisfy social objectives. These social considerations involve the need to protect and enhance small-scale or artisanal fishing communities which, whilst often among the very poorest sectors of society, produce well over 20 million tons of fish a year, almost all for direct human consumption.

150. One of the expectations resulting from the new regime of the seas was that distant-water fishing would be curtailed in favour of new opportunities for small-scale fisherfolk. This has occurred to some degree with the share of the world catch taken by long-range fleets declining from 12% in 1978 to less than 9% in 1986. Concerns are beginning to emerge, however, that so far governments have been unable to provide an appropriate framework for the well-being of national fisherfolk. The open access characteristics formerly associated with fisheries world-wide continue to prevail within national jurisdictions, resulting in an excessive number of fishing units, declining yields and reduction in incomes. Small-scale fisherfolk are often unable to compete with the more technologically advanced mobile fishing gears, such as trawlers, which encroach into inshore fishing areas. Although some governments have legislated reserved zones for small-scale fishing, in many cases physical protection has not been provided to ensure that these zones are not exploited by other fishing vessels. The sustainable development of fisheries thus rests in large measure upon governments' abilities to establish the required institutions to impose common property regimes in the fisheries, within their jurisdiction. This becomes crucial when the

fishery resources reach their finite limits of exploitation and in order to avoid conflicts and social dislocation.

A strategy for fisheries

151. It was in response to the challenges posed by the increasing demand for fish bearing on stocks already heavily or even over-exploited, as well as the opportunities, responsibilities and problems created by the new regime of the seas arising from UNCLOS of 1982, that the 1984 FAO World Conference on Fisheries Management and Development endorsed a Strategy for Fisheries Management and Development associated with five Programmes of Action for implementation, mainly but not exclusively by FAO. Five years later, the principles and guidelines of this Strategy remain valid to guide the sustainable development of global fishery resources.

152. The Strategy covers eight major elements. While these are interlinked, two are of particular relevance to the issue of sustainable development:

- principles and practices for the rational management and optimum use of fish resources;
- the special role and needs of small-scale fisheries and rural fishing and fish farming communities.

153. The first listed element of the Strategy recognizes that although fishery resources are renewable, they are subject to over-exploitation, depletion and to the influence of environmental factors. Their management should be based on knowledge of the magnitude, distribution, annual recruitment levels and interaction between species. Obtaining such knowledge involves research. Furthermore, management should be focused on entire ecosystems.

154. Governments have to play a major role in exercising such management through the acquisition and dissemination of information, the formulation of objectives, the adoption of fishery policies and their implementation, and the evaluation of the results. It is important to involve all groups concerned in the fishery sector because the formulation of objectives for fisheries management involves political decisions on the allocation of access privileges and the distribution of benefits from the resource. To ensure that fish stocks are not depleted and to avoid excessive fishing effort, fishermen must have clearly defined fishing rights and allowable catches which do not exceed the productivity of the resource.

155. Steps have to be taken by governments and international organizations to prevent or abate pollution and any form of environmental degradation in order to maintain fish stocks in good condition, to protect critical coastal ecosystems such as mangroves, and to secure the quality of fish as food. Environmental and conservation considerations apply not only to fisheries in oceanic and coastal waters but also to inland fisheries and aquaculture where there is a particular need for protection from the deleterious effects of industrial and agricultural pollution.

156. Cooperation between states is required to ensure the conservation, rational and harmonized management and optimum utilization of stocks occurring within the EEZs of two or more coastal states or in shared resources of inland waters. Cooperation should extend to foreign fishing

taken to be a major element of biological diversity. Moreover, since genetic diversity also occurs in domesticated plants, animals, and fish, these are included by FAO in the concept of biological diversity. 18/

160. The starting point for FAO's proposed strategy for biological diversity and genetic resources is founded in Article 1 of its constitution, which states that "The Organization shall promote and, where appropriate, shall recommend national and international action with respect to ..... the conservation of natural resources". In the 1950s and '60s the strategy focussed on plant genetic resources, and on the strengthening of national capabilities for the collection, conservation, evaluation, exchange and use of plant germplasm. The focus was broadened in the late 1960s to include forest gene resources, so that substantial progress had been made before the Stockholm Conference in 1972 and the establishment of UNEP in 1973.

161. Since 1973, the activities have been widened further to include animal and fish genetic resources. FAO has developed, with UNEP, activities for the improved management and conservation of national and regional animal genetic resources. Regional gene banks in Africa, Asia and Latin America, and a global animal genetic data bank have been established. In 1983, FAO and UNEP set up a joint Expert Panel on the Conservation and Management of Animal Genetic Resources. FAO is active in the conservation and utilization of fish genetic resources, in particular by promoting the establishment of reserve areas to maintain genetic diversity at the stock level in lakes and rivers, by contributing to the reduction of the risks involved in species transfers and introductions, and by helping to preserve genetic diversity with regard to aquaculture.

18/ Biological diversity denotes the variety of life forms, the ecological roles they perform and the genetic diversity they contain, and includes all intraspecific, interspecific, and ecosystem diversity. Intraspecific diversity is a concept of the variability within a species, as measured by the variation in genes within a particular species, variety, subspecies, or breed. Interspecific diversity refers to the variety of living organisms on earth and has been variously estimated to be between 5 and 30 million or more, though only about 1.4 million have actually been described. Ecosystem diversity relates to the variety of the habitats, biotic communities and ecological processes in the biosphere. Genetic diversity provides the biotic support for all biological diversities. It includes all intra- and interspecific diversity and accounts for most ecosystem diversity. From an operational perspective, genetic diversity is equivalent to the concept of genetic resources. The FAO Global System (International Undertaking, Intergovernmental Commission and International Fund) on Plant Genetic Resources covers the conservation and use of ex situ and in situ biological diversity in plant genes, genotypes and genepools at molecular, population, species and ecosystem levels. Adapted from B.A. Wilkox, Concepts in Conservation Biology: Applications to the Management of Biological Diversity. In J.C. Cooley and J.H. Cooley , eds. Natural Diversity in Forest Ecosystems: Proceedings of the Workshop, Athens, University of Georgia, 1984. Also see FAO/IUCN/UNESCO/UNEP, Plant Genetic Resources: their conservation in situ for human use, I989.

162. The establishment in 1987 of the International Fund on Plant Genetic Resources was an important step towards ensuring that the genetic resources of the tropical forests are conserved and wisely utilized. Field projects are being designed to help countries establish and make use of gene bank facilities. Ex situ conservation in gene banks or live collections must be complemented by in situ conservation. Countries must be given help to establish pilot areas where genetic conservation can be combined with sustainable utilization. They also need help to conserve animal genetic resources. Finally, advances in biotechnology related to plant and animal genetics must be applied in breeding programmes in different ecological conditions.

163. FAO's proposed strategy is built around two primary objectives. First, the conservation of sufficient inter- and intra-specific diversity to ensure that mankind has the genetic resources to respond to both specific problems such as new pests and diseases; and to general and potential problems such as deterioration in growing conditions as a result of climate and other environmental changes. Second, promoting the utilization of appropriate genetic resources and biodiversity in order to raise the economic and social importance of natural resources in specific ecosystems: for example, genetic resources for agro-forestry, livestock or fisheries breeding; and biodiversity for game cropping in natural savannah areas.

164. The primary mechanisms for implementing such a strategy on biological diversity and genetic resources could be the following:

- the International Undertaking on Plant Genetic Resources, which provides a basic legal document with the objective to ensure that plant genetic resources will be explored, collected, preserved, evaluated and made available, without restriction, for plant breeding and other scientific purposes;
- The Commission on Plant Genetic Resources, an international forum where countries - donors or users of germplasm, or final technologies - can discuss matters relating to plant genetic resources, and monitor the implementation of the principles contained in the International Undertaking;
- The International Fund for Plant Genetic Resources, a channel for the various bodies concerned - governments, NGOs and private industries and individuals - to fulfill their common responsibility to maintain the world's plant genetic diversity, intended to help ensure conservation and to promote the sustainable utilization of plant genetic resources;
- The establishment of other financial mechanisms to permit some global sharing of the costs of local/national restraint in resource use.
- The TFAP's programme on conservation of tropical forest ecosystems, as outlined in the above discussion on forestry;
- The maintenance of panels of experts, for example, on forest gene resources and on the Conservation and Management of Animal Genetic Resources (jointly with UNEP);
- The promotion of in situ conservation;
- The establishment of protected areas and ex situ gene banks;
- The training and other measures to strengthen national capabilities for the collection, conservation,

evaluation, exchange and use of germplasm; and
- Assistance for the introduction and exchange of germplasm.

Conclusion

165. This discussion began by observing that "sustainable development" can be defined in different ways, but that however defined, in practice sustainable agriculture means halting natural resource depletion and destruction, and promoting the maintenance of ecologically sound increases in agricultural productivity. It observed that such processes are brought about by poverty, ignorance and perverse economic incentives that induce environmentally destructive behaviour. It emphasised that since unsustainable agricultural activity hits the poor in rural areas hardest, reform efforts must be focused at the household level. International, regional and national action should seek, above all, to change the incentives which presently encourage the misuse and overuse of natural resources. It noted further that women have an important economic role in the use of natural resources. Understanding that role and the incentives that shape their behaviour is therefore an essential step towards better conservation and use of natural resources.

166. Possible ways to incorporate better the costs of environmental damage into both macroeconomic and microeconomic analysis were next examined. Such techniques as environmental accounting and cost benefit analysis can be useful in estimating the externalities of economic activity. Pricing mechanisms (including taxes and subsidies) can be used to discourage destructive behaviour, by "internalizing" its costs.

167. The final section examined the issue of promoting sustainable development in different resource types and the various strategies that are called for. In low potential areas, development efforts should emphasize conservation and alternative employment opportunities, rather than putting additional strains on the environment by seeking major increases in production. In high potential areas with better natural resource endowments, higher productivity can be achieved if sufficient attention is paid to reducing environmental costs. The depletion of the world's forestry and fishing resources were also looked at, noting that protecting these vital resources will require considerable efforts to change the incentives which presently encourage poor people to engage in unsustainable practices.

168. FAO can play a positive role in these efforts to achieve sustainable agriculture by providing technical assistance on all aspects of the agricultural and rural development processes, by promoting an integrated approach to natural resource management and by integrating environmental concerns into all of its activities. This will not always be easy. The natural resource endowment differs greatly from country-to-country, and so will the strategy for a sustainable agriculture. Specialists in different areas of development work tend to see problems from narrow perspectives, whether crop or livestock production, forestry or fisheries. The interrelationship of environmental issues, noted so many times in this discussion, requires a more holistic view that must be encouraged at all times.

169. FAO can help promote sustainability in several specific ways. In areas where serious and/or irreversible environmental degradation is an

immediate threat, policies should be encouraged that give top priority to conservation. Special efforts must be made to discourage abuses of technology. FAO can also work with governments and other international organizations to set international standards of behaviour. Tropical forests, mangrove coasts and other genetic reserves should receive priority attention.

170. Interventions in less immediately threatened areas, be they low or high potential, must go beyond mere conservation, and encourage new forms of sustainable production, especially in agriculture. This will involve not only the application of existing knowledge and technology, but also experimental interventions aimed at improving and expanding our understanding of how to increase agricultural output while respecting environmental limits.

171. Promoting small but meaningful changes in the ways the rural poor live, increasing their ability to enhance income and helping them to withstand shocks and stress in their life support systems are necessary components of any sustainable development strategy. However, such small changes by themselves will not be enough to ensure sustainable development. Policy measures pitched at the national and international level will not be enough by themselves, either. The objective should be to link by policy interventions local changes with innovations on a wider scale and at higher levels. The challenge is to devise mutually supportive policies at the local, national and international levels which will encourage actions at the household level that will contribute to the attainment of the objective of sustainable development at all levels.

172. Creating a truly effective and integrated international effort to promote sustainable development is a great challenge both intellectually and politically. It will require the integration of a wide spectrum of research and policy activities among technical agencies of the UN system, donors and governments. It also will require the building of substantial political consensus among the various actors. Above all, it implies a recognition that the environmental problems of the developing countries ultimately are woven into international markets, trade patterns and capital flows. As a consequence, reform of these structural relations is also needed: sustainable agriculture requires investment which developing nations and especially their poor, living hand to mouth, cannot afford. This means more than just increased and improved foreign aid. It requires structural changes in the international economy, to ease debt burdens of developing countries and to improve their terms of trade in order to release resources needed to develop sustainable agricultural practices. Only in this way will developing countries be able to afford policies which cope not just with the emergencies of today, but also with the needs of tomorrow.