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FOSTERING SUSTAINABLE DEVELOPMENT IN THE COMMODITY FIELD

Experiences concerning environmental effects of commodity production and processing: synthesis of case studies on cocoa, coffee and rice

Report by the UNCTAD secretariat

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Preface

1. This report is a synthesis of a preliminary series of case studies on the environmental effects of commodity production. These studies are being undertaken thanks to financial support provided by the Governments of the Netherlands and Norway. At the time of writing the following case studies had been completed:

(a) The effects of producing and processing cocoa on the environment: A case study of Nigeria;

(b) Coffee and cocoa production and processing in Brazil;

(c) Environmental impact of coffee production and processing in El Salvador and Costa Rica;

(d) Rice and the environment: Environmental impact of rice production, policy review and options for sustainable rice development in Thailand and the Philippines;

(e) L'impact de la culture du cacao et du cafe sur l'environnement au Cameroun.

2. An initial draft of a case study covering cocoa, coffee and rice production in Indonesia was made available. A report on ecological farming and related policies in China had also been prepared. The current series on the three commodities includes two studies on, respectively, the environmental effects of cocoa production in Ghana, and cocoa, coffee and rice production in Côte d'Ivoire but these had not yet been completed at the time of writing. Similar studies on the minerals sector are underway; others are being planned for different agricultural commodities as well as for the forestry and fisheries sectors.

3. These studies are being conducted in consultation with the World Bank, the Organization for Economic Cooperation and Development (OECD) and, in particular, with the Food and Agriculture Organization of the United Nations (FAO). Those on agriculture fall within the framework of interagency follow-up cooperation on the United Nations Conference on Environment and Development (UNCED) on sustainable agriculture and rural development.

Introduction

4. This report is a contribution to the debate on natural resource management in the commodity sector. By shedding some light on impacts on the environment, in general, and on the natural resources base on which rests the production and processing of cocoa, coffee and rice, in particular, it is hoped that the present synthesis will assist policy-makers in designing a framework for action at the national and international levels in order to achieve sustainable development in the commodity sector.

5. According to the Brundtland Report, "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

> the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
>
> the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs". [1]

It is the whole of this definition and not just the often-quoted first part which sets the basic parameters of this report. It also supports the three elemental premises underlying the approach adopted here as well as the proposed policy framework.

6. The first premise rests on the idea of sustainability. Many of the environmentally harmful effects of commodity production on the environment appear to be local and of immediate concern only to the local population, in particular producers. However, consumers of the products also have a stake in preventing harmful effects and in encouraging environmentally preferable development. The meeting of needs especially in terms of income and employment of the future generations living in the areas of production, will depend on sound management of the natural resources necessary for local agriculture. Satisfying the needs of future generations of consumers is inextricably linked to the preservation of productive capacities in the producing areas. Present consumers owe it to future consumers to help preserve these capacities.

7. The second premise follows from the question of needs in terms of the economic plight and poverty of commodity producers in most developing countries. Plans and proposals to encourage changes in production methods aimed at safeguarding the environment should include universal recognition that this implies both sound management of natural resources in the commodity sector and acceptance by consumers of their inherent responsibilities to support such concerns. This recognition would pave the way towards (a) adoption of mechanisms remunerating the developing countries for the environmental services provided by their commodity sectors and rewarding environmentally sound production, as well as (b) provision of appropriate assistance to developing countries to facilitate the adoption of environmentally preferable practices. The latter is particularly important. When such practices involve either expenditure or income foregone, whether in cash or in kind, compensation would assume rational management of resources. Otherwise, environmentally harmful practices may persist in spite of the willingness and even the express desire of producers to adopt environmentally better practices.

8. The third premise stems from the notion of limitations imposed by technology. The current state of agricultural technology offers numerous possibilities for lessening the environmental impact of production. However, the ability to implement environmentally preferable practices is closely related to "the state of technology and social organization". In order to serve well, technologies need to be applicable by actual producers; for this, farmers must be sufficiently trained. An important prerequisite to appropriate policy orientation for conserving the resource base is a better understanding of both the producers' response, under different types of social organization, to economic and other stimuli and of the social-organization aspects of consumers, in terms of their interest in environmental protection in the producing areas. Policies and measures will be more effective and the adoption of preferable practices willl be facilitated when these concerns are better understood and articulated.

9. This report provides a systematic review of environmental effects - as described in the case studies mentioned above - and explores their causes. The conclusions, although based on a limited sample, offer a framework for embarking on specific steps towards the adoption of environmentally preferable and economically viable practices in agriculture in developing countries. National Governments and the international community have a paramount role to play in this endeavour.

I. ENVIRONMENTAL EFFECTS OF AGRICULTURE

10. For the countries covered in the case studies, the cultivation of at least one of the commodities in question - cocoa, coffee, rice - holds a significant place in the national economy (see table). Moreover it provides employment to a large part of the population. Cocoa and coffee generate an important part of foreign exchange earnings for Cameroon, Costa Rica and El Salvador. Coffee is one of the most important export items for Brazil. Cocoa is the most important non-oil export product for Nigeria. The importance of rice derives from its being an indispensable staple in the Asian diet but it also provides a major part of Thailand's export earnings. In Indonesia and the Philippines, it is grown mostly for local consumption.

11. The case studies revealed two types of effects on the environment arising from the production and processing of cocoa, coffee and rice. The first type comprises environmentally positive effects realized through the provision of environmental services. These effects either generate a net positive contribution to the overall environment or prevent and neutralize any potentially harmful effect of production on the environment. An example of the generation of a net positive contribution made by the cultivation of coffee and cocoa lies in the fact that these trees, in combination with other shade trees, often made up the only tree cover in some areas and provided services that would normally be expected from forests. Amelioration of a potentially harmful effect is illustrated by recycling of water in coffee processing and the use of potentially polluting by-products as agricultural inputs. The second type of effect concerns those with a potential to be environmentally harmful. Included are improper use of agrochemicals, planting practices which lead to erosion, and the clearing of forests with subsequent loss of biodiversity in the effort to expand arable land. Most of these harmful effects, however, can be averted through the adoption of production methods which are superior from an ecological point of view. Given the complex relationships between the various direct and indirect effects, certain impacts may not be easy to identify. This is especially true of synergistic effects. However, this report will mainly deal with direct effects.

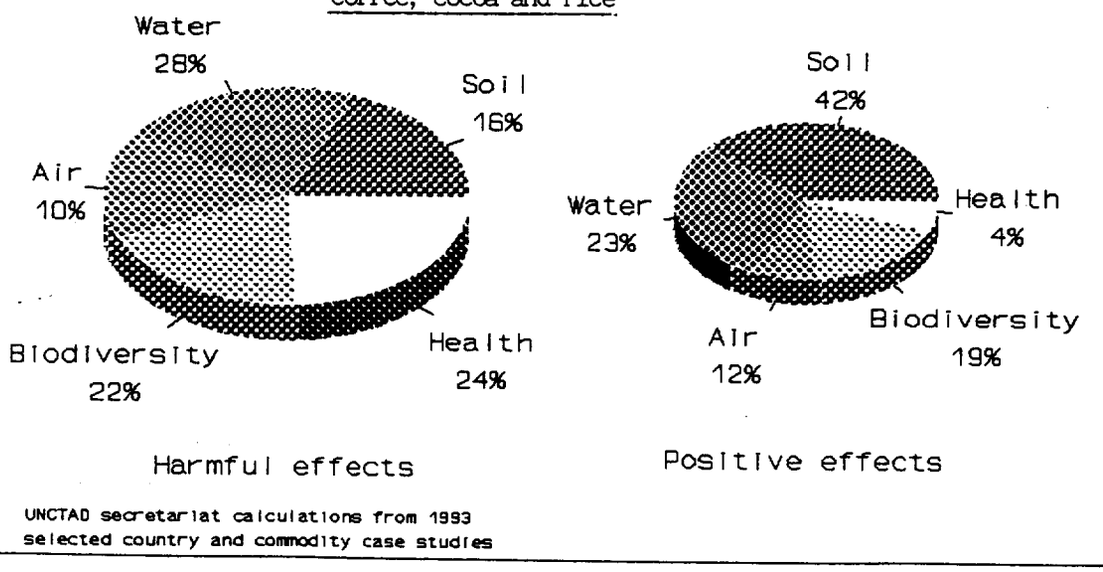
Table

Export earnings from cocoa, coffee and rice (1989-1991 averages)

Country	Export earnings (mill. $)	Percentage of total exports	Percentage of non-fuel commodity exports
		Cocoa	
Brazil	326	1.0	2.3
Cameroon	154	10.1	17.9
Indonesia	115	0.4	2.0
Nigeria	145	1.3	50.7
		Coffee	
Brazil	1390	4.3	9.9
Cameroon	184	12.0	21.3
Costa Rica	265	18.5	27.6
El Salvador	226	45.3	73.7
Indonesia	413	1.6	7.2
		Rice	
Indonesia	4	0.0	0.1
Thailand	1350	5.7	16.0
Philippines	2	0.0	0.1

12. So as to form an initial systematic view of the environmental effects from cocoa, coffee and rice production, the different effects cited in the five case studies have been classified into a number of categories. The frequency distribution[2], which is understandably subjective, shows that environmentally harmful effects have been cited by the authors of the case studies more frequently than environmentally positive effects. This may be seen in the difference in the size of the "pies" in the chart. It was for rice that the effects were most heavily biased towards those considered harmful. Of course this should not be taken to mean necessarily that it would be more difficult to find ways for shifting to sounder management of natural resources in the case of rice than for coffee or cocoa. A shift to certain production methods, such as integrated pest management techniques in rice production, could probably eliminate a relatively large number of environmentally harmful effects.

CHART. Distribution of environmental effects from the production of coffee, cocoa and rice



UNCTAD secretariat calculations from 1993 selected country and commodity case studies

13. The chart shows that while the pollution of water resources was the most frequently mentioned harmful impact, for environmentally positive effects the highest frequency was accorded to soil for the aggregate of the three commodities. This is particularly evident in the case of coffee. For cocoa, the conservation of forestry and biodiversity was the most frequently cited positive effect.

14. The rest of this chapter describes specific environmental effects from the production and processing of coffee, cocoa and rice, covering both positive and harmful effects. It also discusses various production methods and processing techniques available to reduce environmental problems without compromising productivity. The findings support the view that economic viability and environmental protection are not mutually exclusive concepts but rather reconcilable and possibly mutually reinforcing.

15. Environmental effects are grouped according to their impact on the different natural resources considered (soil, water, air, forests, biodiversity and health). As the elimination of harmful effects requires particular attention and, in many cases, changes in policies and production methods, this aspect occupies a considerably greater part than environmentally positive effects in the discussion below.

A. Effects on soil

16. Farm land can be rendered unproductive through exhaustion of nutrients or by environmentally harmful agricultural practices. Land-use changes in response to population growth, a phenomenon common to all developing countries, has led to the encroachment of urban areas on agricultural land, on the one hand, and increased pressure to produce more food on the other. Since the supply of arable land is limited, it is in the interest not only of farmers but also of society as a whole to ensure that the productivity of soil is sustained.

17. The application of fertilizer, be it natural or chemical, is necessary in order to replenish the nutritive qualities of the soil. Fertilizer misuse and abuse, however, figure among the principal causes of soil degradation. The case studies suggest that even more fundamental and basic determinants of sustaining the productivity of the soil are to be found in planting formations and techniques used in establishing a plantation. Coffee plantations in Central America, for instance, had been incorporated into natural forests by carefully thinning existing tree cover and selectively clearing ground vegetation. Original vegetation, including nitrogen-fixing leguminous plants, had been left basically intact with the result that the ecosystem was barely perturbed. Moreover, a forest-like appearance was regained within a few years when the coffee seedlings matured into trees.

18. In the mid-1970s, shade trees were razed and other vegetation cleared in coffee plantations in Costa Rica in order to enhance the coffee trees' productivity. Although yield increased in the short run, this method proved to be ecologically counter-productive. Direct exposure to the sun accelerated photosynthesis which, in turn, led to rapid soil exhaustion. Moreover, the removal of nitrogen-fixing leguminous plants necessitated increased dosage of nitrogen fertilizers. Loss of the protective natural cover and of roots hastened soil loss from wind and particularly rain, as manifested by the heavier sedimentation load of nearby rivers.

19. A parallel system for cocoa plantations, called the "clear-cut system" has meant removal of all non-cocoa vegetation, and was actively advocated in Brazil

Box 1. The combination of coffee with commercial shade trees

Traditional coffee plantations supported a relatively high plant diversity by combining shade trees from the leguminosae family with banana and citrus trees. They also provided shelter to large animal populations, especially insects, birds, soil arthropods and small mammals which are essential to maintain the natural chemical and physical processes in the soil. The combination of shade and coffee trees not only created richer and more complex agro-ecosystems, but larger trees also served as efficient soil holders on the moderate to steep slopes which are predominant in the mountainous coffee-growing regions of Costa Rica and El Salvador. Leguminous trees serve particularly as nitrogen fixers, and for this reason modernization of coffee management systems, which included the elimination of other trees in Costa Rica, implied an increased need for nitrogen fertilizer applications to the soil. This is probably one of the causes of the increase in the amount of nitrate leached into the groundwater used for drinking in the Costa Rican Central Valley.

The removal of shade trees in Costa Rica, where formerly the large root systems and shade protected the soil from erosion, has caused an increase in the sediment load of nearby rivers. This run-off has directly led to a lowering of the natural fertility of the soils. Moreover lack of nitrogen-fixing species and the greater metabolic efficiency of the new coffee varieties grown in open sun have exacerbated the situation.

In El Salvador, in this century, the establishment of coffee plantations eliminated practically 90 per cent of forest in the middle altitudes. Coffee plantations in El Salvador, owing to the management system of producing under shade, now constitute virtually the only permanent forest in the country. The Association of Coffee Processors and Exporters of El Salvador states that coffee plantations are forests that protect the environment. It emphasizes the need for sound rational management of these vital agro-ecosystems, in order to minimize disruption of the ecological equilibrium.

The possibility of harvesting shade trees of commercial species is currently being studied as an alternative to compensate for low coffee prices and as a means to earn income, both in El Salvador and in Costa Rica. In Costa Rica, low interest credit is being offered to coffee planters who combine commercial shade trees with coffee plants, instead of the traditional leguminous trees. There has also been discussion about the possibility of using reforestation incentives to plant trees in coffee plantations. In any case, small farmers in both countries often take advantage of shade trees. This springs from a solid economic logic whereby the production of fruit, wood and firewood are effectively combined with coffee. The leguminous plants contribute not only shade but also provide nutritious elements to enrich the human diet.

at about the same time as in Costa Rica. However, the traditional cabruca system, whereby cocoa seedlings are planted within a natural forest, remains the most common. Cabruca plantations for cocoa are considered by many to be the most environmentally positive form of agriculture practised in Brazil today.

20. Cocoa plantations in the Cameroon and Nigeria feature a combination of both systems: forests are selectively thinned to make room for cocoa. Together with other fruit trees, a forest-like appearance is regained after a few years. Cocoa plantations are generally "sound" from the point of view of their impact on the soil, both for their relatively heavy ground cover and their capacity to absorb recycled by-products as organic fertilizer. In Nigeria, for example,

although cocoa production is the principal user of artificial fertilizers, the absolute levels of this use are still quite limited. The leaves shed annually by cocoa trees are composted and reapplied to the soil as organic fertilizer.

21. One of the principal techniques advocated in modern rice culture to ensure production increase was soil puddling. This method enabled the planting of as many as three crops per year instead of the traditional single annual harvest. It had, however, the effect of excluding the traditional practice of crop rotation whereby soil was naturally refurbished with nitrogen and other organic nutrients derived from other plants. Synthetic fertilizers, especially nitrogen, phosphorous and potassium, have to be applied in increasingly bigger dosages to offset the rapidly deteriorating condition of the soil. Repeated agrochemical applications in turn lead to the disappearance of another important natural source of nutrients, the nitrogen-fixing algae, whose absence can contribute to increased dependency on agrochemical inputs.

22. In some instances, agrochemical use does not have to be excessive in order to have negative effects on soil quality. For example, although agrochemical use in Nigeria is relatively low, new cocoa seedlings planted to replace aging trees have not established themselves readily in cocoa farms where certain chemicals have been used to fight diseases.

23. Coffee and cocoa trees, being deep-rooted, minimize the risk of erosion. This characteristic may be enhanced by the particular planting configuration used. For example, in Brazil, initially, the pattern used for the formation of coffee groves was that of planting perpendicular to the slope, independent of local topographic conditions. There was minimal concern with soil conservation but following an inevitable decline in crop productivity drastic measures were taken.

24. In the mid-1960s, the Brazilian Government launched a major campaign for coffee eradication, resulting in uprooting 1.2 billion trees. Later, in response to increased world prices, the Government stimulated new plantings, dictating credit terms that required contour planting, restricting credit to areas considered agro-ecologically suited for growing coffee, and providing subsidies for increased use of industrial inputs. New plantings from this period demonstrate reduced soil losses.

25. A comparison of perpendicular to contour planting systems on steep slopes showed a reduction in soil losses from 4.4 to 3.1 tons per hectare; furthermore contour planting reduced runoff by 25 per cent. Contour strips provided further control, but most effective were systems that involved planting of grass within coffee groves, reducing soil losses to 0.2 tons per hectare and rainfall runoff by 90 per cent.

26. In rice cultivation, for which flat areas are preferred, erosion is not a significant problem. When cultivation takes place on hills, the practice of levelling and bundling has served to strengthen the slopes against landslides.

27. In rice plantations, the introduction of heavy duty machinery compacts the soil in paddies as well as other fields, and destroys paths and surrounding vegetation along the way. Excessive soil compaction exacerbates the problems of soil run-off, including the displacement of applied fertilizers and pesticides, and of erosion. Moreover, it inhibits water and air circulation, and hampers root growth and penetration.

B. Effects on water

28. Modernization in the agricultural sector to meet rising demand for agricultural products has led to the use of techniques and plant varieties requiring more and better quality water. Like land, the scarcity of water is influenced by increased competition for this natural resource from other, non-agricultural sectors. The quality of water used in agriculture and elsewhere is crucially affected by agricultural production practices and processing activities.

29. In agricultural areas, the contamination of water with nitrogen and phosphorous compounds, oxidizable organic matter and pesticides increases in importance as an environmental problem when agrochemicals are inappropriately used in terms of type, quantity and timing, and do not correspond to the nutrient needs and absorption capacity of the soil. Contamination of the water table threatens the potability of drinking water while the presence of foreign elements in the aquifer could disrupt the cleansing functions of water amoebas and micro-organisms. The increasing level of nitrite found in the Costa Rican Central Valley's drinking water supply is directly attributed to leaching into groundwater of agrochemicals used in surrounding coffee plantations.

30. Excessive presence of nitrates and phosphorus in surface waters and marine ecosystems was also observed in Costa Rica. Nutrients were seeping up to the surface and mixing with the direct discharge of coffee residues and water used in pulping and washing coffee beans. Contamination is manifested by noxious odours and unsightly debris, weakened ecosystems of micro-organisms in and along riverbeds and, in extreme cases, fishkills from oxidation emitted during the process of organic decomposition. Pesticide run-off from cocoa plantations in Brazil are also said to have caused fishkills and contamination of drinking water supplies. Furthermore, pesticide containers are often washed in running rivers before being reused for other purposes. Strict supervision of agrochemical applications would minimize the risks of serious water contamination.

31. Although coffee processing is potentially an important source of water pollution, the filtering and re-use of water in coffee processing is possible. This is effective in reducing contamination. Filtered coffee residues are then applied to the plantation as fertilizer. Brazilian coffee processors also recirculate used water, minimizing the risk of micro-organic contamination through excess chlorination. Nevertheless, the dumping of bean parchments into rivers is a cause of water pollution.

32. Pollution of water owing to the dumping of untreated wastes and by-products into rivers can be prevented by regulation and economic measures. For example, in El Salvador a relatively high price is set for water; fees for dumping dirty water into rivers have pushed people to find methods for benefitting as much as possible from a limited resource. Coffee mills in El Salvador use roughly one-tenth as much water as in Costa Rica. Water is recycled for an average of three days and certain processes are less water-intensive; for instance workers (especially female labour) are relied on instead of water processing in coffee selection.

33. Agriculture, especially irrigated rice production, competes with other activities for the use of water. In the Philippines, in line with the national policy of self-sufficiency in rice, canals were constructed to irrigate rice paddies, thereby diverting water from other uses including non-rice crops. In Thailand, however, under the pressure of water shortages, the Government decided

to allow available water in the rice-growing basins to be used for non-agricultural purposes.[3] Because of this, for example, in the 1993 dry season, the second crop was expected to be small. From an environmental point of view, this approach is positive as double-cropping of irrigated rice is ecologically less "stable" than rice cultivation in the rainy season only.

C. Effects on air

34. Agricultural production, in particular, production of tree crops contributes positively to the global environment by acting as a carbon sink. This effect on the global commons should be taken into account in evaluating the ecological implications of cocoa and coffee production. However, some agricultural activities can lead to local air pollution and globally undesirable atmospheric emissions, such as the generation of methane in rice fields. As far as producers are concerned, effects on air do not have as high a priority as undesirable local impacts on other natural resources, such as water and soil as these affect productivity levels directly. Moreover, since the incidence of air pollution is usually temporary and invisible, it does not arouse the same degree of concern as, for instance, soil alkalinity, salinization and drinking-water contamination.

35. Crop spraying is the most often cited cause of air pollution arising from agricultural activities. It is also the preferred means of pesticide application because it distributes chemicals efficiently and evenly over large surfaces faster than by other methods. For the same reasons, agrochemical particles spread outside the area of treatment and are difficult to contain. Micro-droplets of agrochemicals applied aerially, through heavy spraying, for example, may be carried by the wind beyond the area being treated. The surrounding water bodies, forests, wildlife habitats, human settlements and fields on which other pesticides may already have been applied become the recipients.

36. Dust particles and gases released during the processing, roasting and grinding coffee also create environmental problems in the producing countries.

37. Combustion of agricultural waste is another source of air pollution. Agricultural waste and by-products of processing activities are either discarded or burned; combustion releases considerable emissions of CO2 and particulate matter. Apart from getting rid of the waste, such burning has little utility. Alternative uses of waste exist, either as organic agricultural inputs or for the production of consumer products, but this potential is seldom fully exploited. Case studies mention only the use of cocoa shell ashes for non-commercial soap-making in Nigeria and their occasional use as a source of energy. Traditional reliance on smoke as a natural fumigant and pest dissuader has been replaced by the use of industrial pesticides.

38. All the case studies expressed varying degrees of concern about air pollution resulting from combustion. They consistently pointed out the need to develop new uses for discarded materials. (The potential for recycling and marketing of by-products is discussed below).

D. Effects on forest cover

39. Like the extensive temperate forests which were once located in today's industrialized countries, the bulk of recent global deforestation is

attributable to the encroachment of agriculture on forest areas. The case studies revealed that for the three crops examined, this took place to a large extent at the time commercial crops were introduced.

40. Natural vegetation in Central America, especially in the areas where coffee is now cultivated, consisted almost entirely of dense forests and very diverse ecosystems. In Costa Rica this vegetation originally covered 99.8 per cent of the total area. This vegetation was seen as one of the main obstacles to agricultural colonization and so it was cleared.

41. In general the clearing of the forests makes considerable economic, if not long-term ecological, sense. Retrospective studies in Brazil, estimating the user costs of forest-resource depletion since 1970, suggest that agropastoral expansion has been responsible for a loss in sustainable forest product value in market goods (wood and non-timber products) representing, on average, only a little more than one fifth (22%) of the value of incremental primary agricultural and livestock products derived from frontier expansion in the late 1970s. Thus, from a strictly economic point of view, deforestation was rational. Its ecological effects and the loss of non-market values, however, have not been quantified. If appropriate values could be accorded to present and future uses such as the provision of genetic diversity and other eco-system functions with local and global benefits, the economic rationale would probably change.

42. Currently, given the low prices for coffee and cocoa, areas planted with these trees are not increasing. Nevertheless, in certain areas such as parts of the Cameroon, a slash-and-burn system of land clearance is still used. As this is done mostly by small-scale producers using manual methods, the negative environmental effects are not excessive. The loss of vegetation when forests are cleared to establish new cocoa farms is only temporary because when cocoa trees grow the forest ecosystem is re-established to a considerable extent. There is, however, loss with respect to wildlife and some forest species.

E. Effects on biodiversity

43. Biodiversity loss refers to the loss of life in any of its forms, levels and combinations. The main cause is human-induced changes in the environment. This affects, in particular, diversity of ecosystems, species and genetic variety. Agriculture is one of the main vehicles of human induced changes.

44. In the natural order, the propagation of each species is kept in check by a system of prey and predator. The balance is delicate. The cycle may be disrupted and destabilized by physical changes in natural habitats and food sources as well as by the introduction of substances toxic to animals and species.

45. First, as wild areas (be they forests or other), are converted to agricultural use, some animal and plant species lose their natural habitats and disappear. Secondly, biodiversity is lost when benign and even beneficial flora and fauna are killed by continued agrochemical applications. In trying to make up for the useful functions provided by disappearing birds, small animals and other insects, more agrochemicals are applied; this contributes to further loss of biodiversity.

46. The reclamation of wetlands and clearing of forests to expand agricultural areas, the diversion of rivers and streams to irrigate farmlands, the run-off

Box 2.

The "Cabruca" system of cocoa planting in Brazil and the preservation of the Atlantic Forest

Two planting systems for cocoa are employed in Brazil's state of Bahia, the main cocoa-growing zone of the country. The traditional cocoa agroforestry system, known as cabruca, involves the planting of cocoa seedlings within native forests, after removal of flora substrata along with about 90 per cent of the original tree cover. Cocoa is shaded by native tree species retained for this purpose. An alternative system involves clear-cutting of all original vegetation, which is then substituted by cocoa planted initially under banana and, after establishment, intercropped with fast-growing leguminous shade species. Most of the cocoa zone remains under the cabruca system.

The environmental advantages of cabruca lie chiefly in the retention of a range of species representative of the threatened Atlantic Forest: the originally dense tropical moist forest that covered the coastal zone in Brazil, and which has been reduced to only 2 per cent of its original extent since becoming subject to human-induced alterations. In Bahia, which has retained less than 0.1 per cent of its original forest cover, the survival of native species in cocoa farming systems, together with a small area in parks and reserves, constitutes the only means to preserve this unique habitat. When the "forest islands" invariably found on cocoa farms are included, it is estimated that Southeast Bahia retains approximately 1.3 million hectares under forest cover, whether primeval or secondary, significantly exceeding the 26,000 hectares enjoying federal protected-area status in the region.

The cocoa plantations also function as "corridors" enabling wildlife to migrate among forest islands, allowing contact between groups established in different remnants, and increasing opportunities for choice of potential territories. Many vertebrates have adapted themselves to conditions present in cocoa plantations, or have been able to compensate for reduced native forest area by exploiting adjacent cocoa groves.

of water from farms carrying excess nitrogen into lakes and other water bodies, the presence of agrochemical elements in the air, and the removal of hedge-rows to facilitate the movement of heavy-duty farm machines, all contribute to reducing the number of species and their chances of survival.

47. Over 1000 species of predators and parasitoids have been identified in the traditional rice culture, including nitrogen-fixing algae and other sources of plant protein as well as natural enemies of rice-attacking pests. Repeated use of fertilizers, insecticides, molluscicides, herbicides and rodenticides has indiscriminately decimated the number and type of rice paddy inhabitants. The disappearance of nutrient-manufacturing algae and vegetation deprives rice plants of naturally fertile ground, while the loss or contamination of such life forms as water reptiles, fish, frogs and snails deprives people of an important food source.

48. In rice production, monoculture is the norm in irrigated paddies, although examples to the contrary are widespread in Thailand, for instance. Because rice varieties are selected on the singular basis of productivity and are further interbred to maximize this trait, there is growing concern that this practice may have shrunk the pool of genetic resources. A related issue is the dwindling pool of genetic resources in the face of reliance on uniform hybrid seeds and high-yielding varieties which are expanding at the expense of genetically varied

types. In the process, plant characteristics such as pest resistance which existed in traditional rice strains may disappear.

49. The case studies have repeatedly mentioned the potential use of natural predators in pest management. Its usefulness has been illustrated in the case of Brazil, where Ugandan wasps were successfully introduced to control coffee borer attacks in the early 1980s. In spite of its success, the Brazilian experiment was an isolated case reported in the studies.

F. Effects on health

50. The second most frequently cited negative effect of agricultural production in the case studies focuses on health. Improper use of agrochemicals is an important health hazard for farmers themselves, as well as nearby populations, consumers and domestic animals. The case studies widely reported adverse effects of the application of agrochemicals on human health.

51. Effects on health in developing countries stemmed from various reasons. Factors such as lack of training, inadequate protective gear, and even, perhaps most seriously, the intensive use of hazardous pesticides that have been banned in developed countries, pose a serious occupational health risk for farmers of all three crops. For example, the incidence of several ailments, including skin and bronchial diseases, is estimated to be as much as six times higher among rice farmers using agrochemicals intensively than among other farmers.

52. Through wind drift and water contamination, agrochemical exposure and related health risks are not limited only to farm workers. Also at risk are people living in settlements within the range of the drift and getting drinking water from aquifers located nearby.

53. The type of chemical and the timing of its application are crucial elements of appropriate agrochemical use. It has been found, for instance, that if pesticide is sprayed during the latter cycle of fruition, it tends to penetrate through to the coffee bean causing a health hazard for the consumers.

54. The presence of agrochemicals on grazing grounds, on dried hay and in water pose a hazard for domestic and farm animals. In this context, examples of animal poisoning were reported in the case studies. It had arisen from the improper re-use of pesticide containers.

II. DETERMINANTS OF ENVIRONMENTAL EFFECTS

55. The review in the previous chapter of the case studies described examples of agricultural production that was both economically viable and environmentally sound. The case studies themselves contain many references to government policies and regulations formulated to ensure environmental protection. Details of some are presented in annexes to this report. Their existence attests to a universal resolve to halt environmental degradation. Nevertheless, environmentally undesirable practices still continue; valuable laws and policies may remain dormant; policies with contradictory results may be implemented. A crucial issue, therefore, is the identification of factors which play a role in determining the environmental soundness of agricultural production.

56. These factors, which exhibit significant interrelationships, can be divided into two groups. Some of them are endogenous while others exogenous to

agriculture. The first group, inherent in production and processing activities, affects the environment directly. The second group comprises factors outside the scope of agriculture. For the latter group the environment is indirectly affected through impacts on agricultural production. This chapter identifies and discusses some of these factors.

A. Determinants inherent in agricultural production and processing

57. Determinants inherent in the agricultural sector itself include: natural factors such as the characteristics of the product and the geophysical features of the region; the choice of production methods, especially input use; and social and organizational variables such as the scale of production and labour-intensity. Although they will be discussed separately, these factors are all interrelated. They mutually affect each other. In particular, the choice of production methods and input use is largely determined by natural factors, and by social and organizational variables, including extension training services.

1. Natural factors

58. The nature of the product has an unequivocal impact on the environment. For example, the carbon-sink functions of tree crops or the water requirements of rice are innate to the product in question and are not likely to be modified with changing production technology.

59. Likewise further processing to increase the value added that is retained in the producing country is a similar factor. Special environmental impacts non-existent in the primary production process may be generated thereby, introducing new kinds of pollution, by-products and waste.

60. The specific geophysical features of an agricultural area affect its susceptibility to different ecological risks such as erosion. Environmentally sound agricultural practices in such areas may call for special measures to be taken by producers in terms of, for example, planting patterns and irrigation systems (see also paragraph 25). Certain planting techniques have been proven to strengthen natural earth formations against erosion of topsoil and run-off. In many instances, however, these call for extra care. For example, terracing slopes for rice culture prevents erosion but the terraces themselves may cause landslides when not properly maintained or if neglected.

61. Unprecedented demographic growth, which is common to most developing countries, has aggravated pressure on arable land, bringing marginal and ecologically fragile areas into cultivation. Moreover, land suitable for agriculture is being increasingly converted into industrial zones and residential areas in keeping with economic growth. In Thailand, rice paddies are being converted into orchards and fishponds, for example, in line with export diversification policies. In many cases, the new land use causes more ecological strain than rice production did.

62. The geophysical characteristics of an area also have significance in terms of water quality and water-related problems such as salinization. Heavy pumping for irrigation in low-lying areas can entrain encroachment by saline water into freshwater aquifers, for example. Appropriate irrigation and drainage techniques, however, can minimize such risks.

Box 3.

Cocoa fermentation and defoliation

Once the cocoa beans have been extracted from their pods, the next stage of activity is fermentation. The process of fermentation of beans requires that palm fronds, banana or plantain leaves be used in the case of basket fermentation, or along with a raised platform of sticks, in the case of heap fermentation.

In gathering the required quantities of leaves, several branches of palm trees and plantain or banana plants may be cut down. Such a practice may not only result in several trees being defoliated but also exposes the ground to erosion or rapid run-off during rainfall.

Alternatives exist to the use of palm branches and banana leaves. Synthetic materials can be used to construct canopies to provide shade for nursery plants. In the case of such alternatives, the environmental implications of using synthetic materials must also be taken into account. Research shows that jute sacks can be used successfully instead of banana leaves to cover cocoa beans under fermentation.

In Nigeria, the issues surrounding the access of producers to palm branches, bamboo and banana are not clearly defined. In many of the communities, individuals may not cut branches from other people's palm trees or banana plants or cut other people's bamboo stalks. In some communities, however, palm and banana branches and rafia palm branches (sometimes used in place of bamboo) appear to have a "common property, free access" status. In the circumstance such natural resources risk being left open to degradation and over-consumption. One saving grace is that banana plants are prolific producers of leaves. The plants also multiply rapidly through their suckers. Palm trees are numerous in wild palm groves and appear to have adequate supplies of branches. The trimming of palm branches is sometimes undertaken as part of maintenance activities required to enhance the production of forest fruit bunches. Furthermore, there appears to be an understanding within the communities that the branches/leaves of plants should not be removed to an extent that is detrimental to the plants.

2. Production methods: Intensity of input use and utilization of by-products and waste

63. Most of the negative environmental effects of agriculture are attributable to the utilization of agrochemical inputs. This factor is determined to a large extent by the nature of the crop, the type of seed and the physical and biological environment. Moreover, the scale of production and the kind of technical advice given to farmers also exert important influences on the intensity of in-put use. (Annex II provides information on national regulations concerning agrochemical use.) There are different ways of using fertilizers, and of fighting pests and weeds in the production of the same commodity, whereby different quantities and different kinds of inputs are needed. Some practices can be preferable to others from an environmental standpoint.

64. In developing countries, the availability and use of agrochemicals now banned in the industrialized countries is a very important factor in assessing environmental damage. Their use may be aggravated in several instances by the spreading of inappropriately large amounts or ill-timed applications.

65. The case studies also demonstrate that where agrochemicals are abundantly

applied, a reduction in their application does not necessarily entail a fall in yields. For example, in Brazil, despite a considerable decline in application of insecticides in cocoa production during the 1980s, a commensurate decline in yields was not evident. In Nigeria, however, where agrochemical use had been much lower to start with, the declining application of agrochemicals prompted by the rise in their prices in accordance with the Structural Adjustment Programme was thought to be one of the reasons for declining productivity there, along with ageing of trees and the planting of the older Amazon variety.

Box 4.

The "Green Revolution" and rice

"Green Revolution" technology aims at high yields per hectare sustained by high external in-puts of, for instance, fertilizers and a high output per man hour. It has been made possible through the introduction of high-yielding varieties of plants which respond well to fertilizer application. However, they are at the same time more susceptible to pests. Because of the importance of water supply, this technology was especially linked to irrigation schemes for its success. Rice so grown could be harvested up to three times a year. In the 1970s, this technology spread rapidly throughout Asia. Schemes were implemented to supply such inputs as seeds, fertilizers and insecticides, together with the necessary credits to make the in-puts available, often on the basis of heavy subsidies. Large government investments were made in irrigation schemes, roads and processing facilities. Extension services were set up to give instxuction to farmers on the use of the technology.

Irrigated rice production in the Philippines currently shows a declining yield trend in both International Rice Research Institute stations and farmers' rice fields for both wet and dry season crops. At the research station the decline was estimated at 1.28 per cent per year and was attributed to environmental degradation, including increased pest and disease pressure, rapid depletion of soil micro-nutrients and changes in soil chemistry brought about by intensive cropping and the increased reliance on low quality irrigation water. The rate of deterioration of the paddy environment was greater than the rate of growth in yield potential of newly developed varieties.

An important environmental effect of extensive pesticide use touches aquatic life in the paddy fields. Paddy fields once supplied farmers with a source of protein through edible frogs, snails and fish that have recently disappeared as a consequence of the intensive use of insecticides, molluscicides, herbicides and rodenticides. Organochlorine insecticides can also accumulate in the food chain. They were found to be present, albeit in low amounts, in about half of the bloodsamples taken from farmers.

66. As one option for reducing the use of agrochemicals, the case studies have highlighted the importance of a mix of crops. For coffee and cocoa, the planting of leguminous and nitrogen-fixing plants alongside coffee and cocoa trees has been recommended. In the rice studies, crop rotation with leguminous plants was proposed along with other natural ways of soil-enrichment, such as ensuring the presence of nitrogen-fixing algae in the paddies. It was generally believed that diversification from coffee and cocoa into other crops would increase agrochemical use with more potentially harmful effects on the environment.

67. In general, modern methods have fostered productivity by changing

production factors or system components in isolation; they have usually devoted little attention to productivity in terms of the total agro-ecosystem. The latter is the objective of Low External Input Agriculture and Organic Farming, currently being advocated, inter alia, by the Food and Agricultgural Organization of the United Nations (FAO). Key elements in this holistic approach are that each farm is an autonomous ecosystem fostering the productivity of the total agro-ecosystem; it is knowledge-intensive agriculture. Strategies are incorporated to prevent pest and fertility problems and thus reduce any need for external inputs. Rotating, for example, rainy season rice with other crops in the dry season is expected to be beneficial, impeding the survival of rice pests, restraining methane emissions and improving physical and chemical soil properties. Rotation with leguminous crops could meet the nitrogen requirement of the subsequent rice crop; green manures can supply far more than the quantity of nitrogen needed for the rice crop.

68. One of the principal causes of land and water pollution is the improper disposal of by-products and waste generated during production and processing. These are either heaped and left to rot, creating favourable breeding grounds for pests and facilitating the spread of human and plant diseases; dumped directly into rivers, causing biochemical reactions that could adversely affect the water's potability and could result in fishkills; or burned, contributing to air pollution. The case studies suggested that if use of these products were actively promoted and if new markets were opened for them, they would not only make agriculture ecologically more viable (since they would diminish the volume of waste to be disposed of and limit the need for synthetic fertilizers), but also provide supplementary income sources to farming families.

69. The utilization of potentially polluting agricultural waste as fertilizer is a well-known technique. Incorporation of rice straws, for instance, has been proven to reduce the need for nitrogen fertilizers by 30 per cent, and to supply the soil with valuable organic matter. This potential is present in all three crops included in the case studies but, except for the application of composted cocoa leaves shed during the annual leaf-fall in cocoa production in Nigeria, it has not been widely exploited. There are some technical reasons for this. For example, for each ton of cocoa beans harvested, the production process generates nearly ten tons of pod husks which can be either discarded or maintained within cocoa groves as organic fertilizer. The latter practice, however, has been found to favour the propagation of some plant diseases.

70. Studies have demonstrated that organic residues could be used as an alternative source of fuel, for drying cocoa and coffee beans, or for sale in the form of briquetted charcoal to other users of wood fuel in the region, such as bakeries and ceramics industries. This could ease some pressure on forests for firewood. Other uses include livestock bedding, cattle ration, and extraction of certain chemicals.

71. The possible uses of cocoa husks range from soil fertilizing agents to livestock feed ingredients, to components in paper and fibreboard manufacture. Cocoa sweatings could be used in wine, alcohol, vinegar and jelly production, while sub-standard beans could be included in livestock feed instead of maize and groundnut cake. Cocoa shells make excellent mulch because they are rich in nitrogen, potassium and phosphorus. The viscous pulp which surrounds the cocoa bean in the pod is now increasingly used in juice manufacture, while cocoa "honey" produced during fermentation is fast becoming a standard ingredient in jelly-making. Support is needed at the initial stages to increase the commercial viability of such uses. As products made from agricultural waste prevent potential pollution, they may be considered as providing an

environmental service. Thus their prices should, ideally, reflect the value of this service. Organizational difficulties, such as the collection of waste for processing, act as local barriers to realizing the full potential of its commercial exploitation. These can only be surmounted by technical and financial support which, on environmental grounds would be desirable.

3. Scale of production and labour-intensity

72. The case studies show that the scale of production influences heavily the extent and nature of environmental impact. Because of their easier access to capital, big estates tend to use heavy machinery and more agrochemicals to cut labour costs and obtain maximum yield. In highly mechanized farming, risks of soil compaction and displacement, disturbance of the natural wildlife cycle, and destabilization of other natural elements increase. In contrast, the production methods used in small-scale, family-operated farms are more labour intensive and environmentally more benign. Even deforestation, when undertaken by labour-intensive methods, is less harmful to the environment.

73. Another characteristic which differentiates family-operated farms from large-scale enterprises is the variety of crops produced. Small farms, for economic and ecological reasons, tend to plant a variety of crops, on a rotation or inter-cropping basis, to enrich the family diet, to forestall disease and pest attacks on a single crop, and to shield themselves from dependency on a single crop should the price decline. The environmental merits of these methods lie in the use of soil-enriching plants and vegetation which increase the nitrogen content of the soil and thus reduce the need for synthetic fertilizers. Large-scale enterprises, in contrast, normally specialize in only one or a few cash crops. Monoculture tends to deplete the soil at a faster rate because the same type of nutrients are used up over an uninterrupted period. Furthermore the crop is more prone to pest attacks and diseases.

74. In most cases examined, production was characterized by the predominance of human labour and farm-animal power rather than the use of heavy-duty farm machinery. This is explained by the relative abundance of labour and the geophysical conditions. Coffee production in Central America, for example, allows for little or no mechanization in cultivation and none in harvesting. Machinery is not very useful in the mountainous terrain where coffee grows. However, in many places there is a general tendency to replace labour with off-farm inputs. Rice-growing once required 200 man-days per hactare per year; today 100 man-days suffice for many farms.

75. There are also cases where the ready availability of family labour prevents the adoption of environmentally preferable practices which could involve cash outlays. Often farmers are not willing to make inputs beyond the labour they and their family members invest in the farm; it is therefore difficult to convince them to move from processes that entail little or no cash expenditure to those that do.

76. The studies also mention cases where farm conditions have deteriorated owing to a lack of labour resources. For example, conditions on Nigerian plantations conditions degenerated during the oil-boom period, when young farm workers massively left rural areas for more lucrative jobs in the petroleum industry, leaving only elderly parents and young children to operate and maintain the plantations.

4. Technical advice and extension services

77. Technical advice and extension services play a critical role in the development of agriculture. They are the direct link between research institutions and producers. It is through them that findings and recommendations are channelled to farmers and actual production conditions and problems are relayed back to the research institutes and Governments. In particular for small-scale producers, such services are often the only access to technical advice and information systems. Their role in raising the awareness of ecologically preferable and economically feasible production methods is vital. The dissemination of information on pest attacks and contagious plant diseases, as well as on soil quality, correct use of agro-chemicals, options for crop rotation, inter-cropping and gradual diversification, forms the core of extension services.

78. Poorly managed extension networks, in particular those lacking a coherent approach at all levels of policy-making or ones deficient in effective surveillance and law enforcement, would be most unlikely to promote environmentally preferable methods. As production techniques become more complex, particularly in terms of the drive towards sustainability, the need to strengthen and reorganize extension services takes on greater importance. This was reflected in all the case studies presented.

B. Determinants external to the production and processing activities

79. While the endogenous determinants responsible for the environmental effects of agricultural production and processing are significant, there are also influences coming from outside the agricultural sector. These include economic and environmental policies pursued nationally and internationally.

80. The principal indirect causes - that is, the exogenous determinants of environmental impact of agricultural production and processing - are many. They include the level of economic development and the extent of poverty, the macroeconomic framework including monetary/fiscal policies, exchange rate policies, sectoral policies and debt pressure; international market conditions including price levels and trade and agricultural policies; the legal framework, in particular property rights; environmental regulations not only in the producing country but also in the consuming country in the form of quality requirements and product standards.

1. Level of economic development and the extent of poverty

81. The human, financial and material resources a country has at its disposal to deal with ecological concerns and economic problems are closely linked to its level of economic development. This concerns, in particular, the skills of the labour force, the level of research and development, the presence of an efficient infrastructure and administration as well as the country's ability to earn foreign exchange. The ability to design and implement policies to protect a country's environment depends quite significantly on all these elements. Moreover, as many, if not most, ecological problems are of an interdisciplinary and complex character, their resolution requires a comprehensive and coordinated approach by Governments, the business sector and the general public. The approach must take into account the interrelationships among and between the determinants of environmental impact. Higher economic development generally impacts positively on the capacity to master this complexity.

82. The case studies identify rural poverty to be both the cause and the consequence of environmental degradation. In a situation of under-employment, farming is often the only recourse to escape starvation. Nevertheless, if the income that can be earned from farming is inadequate, farmers will reduce inputs or migrate to areas with more promising perspectives, like new forest frontier areas. Both reactions to poverty, however, aggravate environmental problems.

83. Poverty also undermines farmers' efforts to take care of their own health. They usually know what pesticides to use, what quantities to apply and the safe methods of application. However, where such criteria entail additional costs, experience shows that many farmers, in particular poor ones, have tended to ignore the guidelines in order to avoid any additional costs. Sometimes lack of appreciation of the consequences of not abiding by the guidelines is a factor. Proper training would help but this, too, is clearly tied to economic sufficiency.

2. Macro-economic framework

84. Governments resort to policy measures such as subsidies, tax incentives, export taxes, price controls, physical output targets and foreign exchange controls, to name but a few of the instruments which shape the scale and methods of commodity production and, indirectly, bear on its effects on the environment. Fiscal policies, exchange rate policies and the consequences of debt pressure are also major aspects of the macroeconomic framework.

85. Governments have generally intervened in agricultural commodity markets through taxation affecting the profitability of cocoa, coffee and rice production. Selective credit policies were used in Brazil to encourage contour terracing of coffee plantations and to restrict credit allocations to areas considered agro-ecologically suited to coffee. In the case of cocoa, in the 1970s and 1980s, directed credit facilities in Brazil encouraged the adoption of a technical package based on extensive applications of pesticides, fungicides, herbicides and even arboricides. Yields proved sensitive to credit availabilities.

86. Thailand had imposed, until 1986, three different export taxes on rice: the rice premium, an export duty and obligatory sales to Government at below market rates. As a consequence, domestic prices of rice fell to half the international level. Curtailed revenues constrained the use of agricultural inputs - which, up to a certain point, seems to offer more environmental advantages than disadvantages - but also aggravated poverty and undermined the maintenance of crops and arable land.

87. Agricultural pricing is affected by foreign exchange policies. When a currency is over-valued and the domestic marketing system does not intervene, the producer of export products receives less domestic currency in real terms from international trade. The effect of this on the environment is similar to that following the underpricing of production. During the decade up to 1987, the loss to Nigerian producers of agricultural products attributable to currency over-valuation equalled more than 60 per cent of the revenue from crop sales. Conversely, currency overvaluation in effect subsidizes imported inputs such as agrochemicals and so can induce excessive use. The impact that reduced agricultural prices have on the environment is ambiguous. In some cases reduction in the intensity of input use may be good although if land prices subsequently become depressed this, in turn, reduces the value of investments in farmland development or soil conservation. This may discourage farmers from

levelling, terracing, draining or otherwise improving their land. Moreover, increased poverty can have wide-ranging negative consequences for the environment.

88. During the recessionary period that followed the boom in commodity prices and production of the late 1970s, most developing countries removed growth stimuli such as subsidized credit, tax and land concessions with a view to reducing fiscal and external imbalances. Often this implied a reduction in public and social investment. Moreover, debt pressure forced Governments to adopt liberal exchange rate policies and encourage the production of tradeables. There was pressure to expand output. Although the depressing impact of these measures on world commodity markets is clear, the impact on the environment is not as readiy quantifiable and would benefit from further research.

89. While it may be suggested that recession may be more environmentally benign than malign (it lowers resource use) the case studies on cocoa, coffee and rice show that this has not necessarily been the case. Among the specific environmental effects of recessionary tendencies described in the studies were: higher vulnerability to attacks from pests and disease owing to financial inability to protect crops adequately ; disinvestment in environmental control technology, particularly in processing; and abandonment of arable land or diversification into cash crops with distinctly more negative environmental effects (substitution of corn, tomatoes, bananas and natural rubber for cocoa and coffee, for instance).

3. International market conditions

90. International market conditions determine the environmental effects of commodity poduction in various, if inconclusive, ways. Firstly, market prospects influence the scale of production, export volumes and foreign exchange revenues. Secondly, international market conditions and structures can encourage or discourage the degree of processing. For example, tariff and non-tariff barriers (in particular consumption taxes, in the case of coffee and cocoa) affect the degree of processing attained in the producing country.

91. Depressed prices may induce producers to increase production volume - be it in an extensive or intensive way - with direct environmental effects. Whether producers diversify into other more or less environmentally harmful products; or leave the land idle (with severe ecological and social effects) such as rural exodus, these alternatives also have implications. Finally, provided that producers are not shielded from the world market, international commodity markets determine the profitability of the individual producer and thus influence the level of expenditures on environmental protection. Insufficient maintenance and rehabilitation of agricultural land runs the risk of provoking serious soil degradation and pest problems, these latter often entraining excessive agrochemicals applications.

4. Legal framework

92. The legal framework, in particular the land tenure system, is another exogenous factor affecting the environmental impact of agricultural production. Several studies pointed to land-ownership and tenure systems as a major constraint for long-term ecologically oriented agricultural development. As long as farmers' security of tenure is of a short duration, they can hardly be expected to take the long view and invest in the sustainability of their farm systems. In many developing countries, agricultural land is occupied and farmed

Box 5.

Environmental effects of the cocoa crisis in Brazil

Although cocoa productivity improved rapidly in Brazil during the 1970s, the period since 1980 has witnessed declining yields. This phenomenon can be laid to several causes: the fall in international prices coupled with drought; increased input and labour costs; accelerating national inflation; credit restrictions; serious indebtedness among growers; and worker layoffs. The appearance of the witches' broom disease in 1989 threatened even further growers' prospects for recovery, as they watched trees die, unable to afford the extraordinary labour costs necessary to prune the infected branches. Finally, the 1992/93 crop suffered spectacular outbreaks of black pod rot, necessitating investment in copper solution treatments which growers could ill afford.

Stimulated by public policy, dwindling yields were compensated in the 1980s by an expansion of cocoa area in the order of no less than 38 per cent. This was accompanied, however, by financial losses owing to plummeting prices since the mid-1980s. Production credit has shrunk since several export firms declared bankruptcy in 1990. The result has been a continuing substitution of cocoa plantings by other land use, chiefly pasture for grazing which threatens not only the cocoa industry itself, but also the Atlantic Forest ecosystem. Some growers are now selling timber from their forest reserves to pay off debts. Deforestation and illicit timber trade are commonplace, but there is also an increase in permits granted to exploit forests by the federal Government. The sustainability of forest resources in the cocoa zone of Bahia has been positively correlated with cocoa prices. Between 1971 and 1990, as cocoa prices declined, the area of forest cleared and sold as timber increased.

With the current crisis, many cocoa growers are offering timber for exploitation, principally derived from trees of lower quality, such as shade trees in cocoa stands. Marginal cocoa growers had retained primary forest fragments as a soil bank, in the expectation that, with future improvement in relative prices, they could invest in cabrucas within these patches. These last valuable remnants of the Atlantic Forest are now falling to the axe.

Rural unemployment has likewise been the bitter fruit of the financial and environmental crises affecting the cocoa industry. As many as 200,000 "permanent" workers, lacking employment security of any kind, had been forced out of work by mid-1992 in the Bahia cocoa zone, making the rural exodus dramatically evident.

without legal land titles. In Thailand, for instance, such a system represents a proportion of over 40 per cent of agricultural land. Moreover, especially in rice production, it is common that a large portion of the land is farmed by those who rent fields on short-term contracts.

5. Environmental regulations

93. Environmental regulations exist in all countries covered by the case studies. Norms for use, conservation, protection, improvement and control of natural resources and the environment are thus specified. The legislation, however, has not proved easy to implement, principally on account of problems caused by weak intra-governmental coordination, the lack of definition of responsibility among federal, state and municipal authorities, absence of

adequate resources and prevalence of corruption. In some cases, when laws were enforced, fines established one or two decades previously were applied; these were often ridiculously low and thus ineffective as sanctions to alter behaviour. Evidence suggests that command and control, although enforceable only with difficulty, rather than economic incentives, has been the main means to enforce legislation so far.

94. There have also been serious problems with the utilization of some principal tools of environmental regulation, such as environmental impact assessment. The difficulties were both of a conceptual and practical nature. The case studies pointed out that most environmental regulations were explicitly or implicitly concerned with large production units only. Annex III provides further information on the use of environmental impact assessment as a tool for environmental policy, as mentioned in the case studies.

6. Consumer preferences

95. Quality requirements and product standards in consuming markets very often compel producers to ship flawless produce, for which they obtain better prices. The guarantee of top quality and imperishable agricultural products is often obtained at the cost of malign environmental effects. Many product standards and the demand for high quality leave the producers with little option but to apply pesticides and preserving agents excessively and preventively. Currently consumers would seem to be a lower priority to the ecological conditions of production rather than other qualities.

IV. CONCLUSIONS

96. The following conclusions are derived from findings based on selected case studies of national experiences concerning a limited number of products. Therefore, they must be considered only preliminary. It would be desirable to test their validity and if necessary make adjustments following further research and analysis of other products and other countries, including developed ones. Similar work on the minerals, forestry and fisheries sectors would probably shed light on the links between the commodity sector and the environment. Understanding these connections would contribute substantially to improving the design and implementation of local, national and international policies and measures for fostering sustainable development in the commodity field.

(a) All producing countries are concerned about environmental protection and sound management of their natural resources. However, this concern should not be limited only to the countries producing commodities where environmental degradation is an actual fact or a potential risk but should be shared by the whole international community, in particular, consumers interested in the conservation of natural resources and the protection of the global environment as well as in ensuring sustained supplies of the commodities in question.

(b) The case studies show that cocoa, coffee and rice are either produced or could be produced in such a way that the environment, particularly the natural resource base, is not harmed but even improved. Whether production is, in practice, so organized is determined by a set of economic, technical, social and legal factors, some of which are inherent in the production process (endogenous) and some external (exogenous) to it. Policies and measures promoting sustainable development in the commodity field therefore need to address both types of determinants.

(c) In general, adverse environmental effects could be prevented and environmentally preferable techniques and practices could be adopted with minimal risk to the level of production. This is a critical factor for producers dependent upon crop revenue for their livelihood. Such an approach would ensure sustainable production, assist in solving some social and health problems and, in some instances, even cut costs. Although many environmentally preferable techniques already exist, there is room for progress by agricultural scientists, including through the adaptation of, and improvement in, traditional practices. Designing and implementing appropriate national and international programmes and policy packages is the key. While they need to be targeted to the specific determinants, account must be taken of the complex web of interrelationships.

(d) The specific environmental effects of commodity production and processing differ from commodity to commodity and from country to country. Systematic information and analysis on, in particular, the linkages between the determinants and the effects are at best sketchy. Information must be sought, analysed and disseminated widely. The effectiveness of policies and measures at both the national and international levels, aimed at improving natural-resource management and environmental protection, can be considerably increased as this knowledge expands.

(e) The specific context of each country, in particular the extent of poverty, has implications for constraining implementation of policies and measures aimed at controlling environmental impacts. In spite of these differences, much could be learned from an exchange of experiences and dissemination of information not only on technical issues but also, and perhaps more importantly, on policy aspects of sustainable development in the commodity field.

(f) Policies and measures should be aimed at (i) removing disincentives to practices that are favourable to sustainable development in the commodity sector; and (ii) introducing appropriate incentives at local, national and international levels. In addition to market-based policies, regulatory, command and control measures have a place, but given the poverty in developing countries' commodity sectors, and fundamental difficulties in the enforcement of regulations, positive incentives and persuasion seem more appropriate than regulation and fines.

(g) According to the case studies and their respective conclusions, the following key policies and measures should be implemented at the national level in developing countries:

(i) Analysis of the environmental effects of envisaged policies should be made an integral part of policy-making. Agricultural policies should focus not only on the improvement of productivity in the short-term but also on the conservation of natural resources. When macroeconomic policies imposed by development exigencies are likely to lead to environmentally harmful results, specific counteractive measures should be taken.

(ii) In countries where agrochemical use causes environmental problems, subsidization of such inputs ought to cease progressively and selectively and the funds so liberated be shifted to technical advice and extension services designed to develop and promote environmentally preferable production techniques.

(iii) Farm-management systems based on appropriate local research, and combining pest and soil fertility management with crop rotation, intercropping, waste recycling and appropriate crop diversification, should be encouraged through training and the provision of directed credit.

(iv) Hazardous pesticides of the World Health Organization (WHO) categories I (extremely and highly hazardous) and II (hazardous) should be banned.

(v) Land-tenure systems should be reformed if they discourage, for example because of their short-term nature, investments in the protection of natural resources. Policies discriminating against small producers should be avoided.

(vi) Cooperative arrangements among the relevant offices of the administration should ensure resolution of environmental problems including those which do not fall neatly into the purview of specific administrative departments. Technical cooperation, particularly in the context of UNDP's Capacity 21 programme, has an important role to play in this respect.

(vii) Effective and efficiently-funded and manned extension services which, above all, aim to demonstrate the economic benefits to be derived from environmentally preferable production practices, are an essential requirement for success of the above measures.

(h) International support could contribute crucially to the spread of environmentally preferable production techniques in developing countries. This support could be of a technical, financial and for commodities which are subject to international trade, commercial nature. The priorities change from country to country.

(i) Technical support could be scientific or administrative, but in either case it should aim to develop human resources in developing countries.

(A) Scientific technical assistance would help in research into assessing the environmental impacts of commodity production, developing environmentally preferable techniques as well as new product strains requiring less inputs which could potentially harm the environment, and improving the utilization of waste and environmentally harmful by-products.

(B) Administrative technical assistance could focus on improving the capacity of developing countries to design and implement policies promoting environmentally preferable production. This would include such areas as assessing the environmental implications of economic and commercial policies as well as identification of policy requirements, including macroeconomic and commercial policies, for achieving desired environmental goals; the creation of administrative structures to follow-up, implement and enforce the policies; and the establishment of the necessary infrastructure for human resources development in all of the above areas, but especially, effective extension services.

(ii) Financial support would enable the developing countries to

undertake the necessary investments to change established production methods, in addition to facilitating activities of a technical nature. Such investments, which many developing countries could ill afford themselves under present economic conditions, would cover both infrastructure and human resource development. For revenue foregone during adjustment before the new production methods bear fruit, bridging finance might be required to ensure the livelihood of the producers during the adjustment process. "Debt for nature" swaps could be envisaged for attaining a variety of environmental objectives.

(iii) Commercial support should, foremost, involve mechanisms to enable developing countries to attain pecuniary benefits from the adoption of environmentally preferable techniques, including the utilization of potentially polluting waste products. This is, in fact, the essence of the internalization of environmental externalities; that is, the provision of compensation for local or global environmental services rendered by producing the particular commodities and for undertaking efforts to improve the environmental impact of such production. Mechanisms and actions which could be envisaged in this respect include: the implementation of eco-labelling schemes which focus on environmental issues in the producing countries themselves and designed cooperatively by the producing and consuming countries; the inclusion of environmental objectives in international commodity agreements and arrangements; and the establishment of other international commodity-related environmental arrangements. The pursuit of such mechanisms for providing positive market-based incentives may be fraught with difficulties which must be solved multilaterally at the international level. Otherwise serious difficulties, including injustices, could arise. In the search for implementable mechanisms both the producing and the consuming country Governments will need to participate along with industry and non-governmental organizations. Such cooperation should also aim at promoting demand for products produced under environmentally sound conditions.

(iv) Any barriers to trade in environmentally preferable products should be removed and product standards which encourage environmentally harmful production practices (such as a high use of agrochemicals) should be altered.

(v) In general, deterioration of international market conditions is detrimental to protecting natural resources. The sound management of natural resources is one more reason for preventing market conditions which are disastrous for producers. Excessive instability in the world markets of products consumed domestically (such as rice) leads to a high priority for self-sufficiency and, potentially to the environmentally undesirable conequences of monoculture.

(i) Trade in agrochemicals banned in the developed countries should cease.

(j) The issues are complex and there is much work to be done by the various international organizations in their areas of competence and by other researchers. Synergies may be gained from cooperation, in particular between

policy-oriented and science-oriented groups. For example FAO's efforts to explore environmentally preferable technologies in agriculture as well as UNIDO's and UNDO's work on such technologies in processing industries are crucial elements of fosterning sustainable development in the commodities field. The emphasis given to environmental considerations in World Bank lending also has important implications as does the attention paid to the environmental concerns of developing countries in OECD's work on environment and trade, and on development assistance.

Notes

1. The World Commission on Environment and Development, Our Common Future, Oxford University Press, 1987, p.43.

2. This frequency distribution is used only for illustrative purposes and in no way implies any distinction among products or producers as more or less "green".

3. In spite of its position as the world' s leading rice exporter, rice production in Thailand is mainly limited to the rainy season crop. In so doing less agrochemical inputs are required because the soil of the paddies is enriched by legumes planted during the dry season.

Annex I

Rice eco-farming in China

1. The concept of ecological farming was officially introduced in China in 1984 through Government document 64, which stipulated that agricultural areas must be protected from environmental pollution and destruction as part of the country's overall environmental protection programme. Currently there are more than 1,000 eco-farming demonstration villages throughout the country; moreover, the number is growing rapidly owing to the programme's success in increasing the yield per unit and in providing additional sources of food and income.

2. Thus far, the most successful forms of rice eco-farming are the combination of rice production with pisciculture, with duck-raising, with azolla farming, and with dryland crops. A common feature prevailing all the combinations, like other eco-farming patterns, is integrated pest and disease management. The environmental benefits of rice eco-farming include the following:

Weed control. Aquatic weeds compete with rice plants for soil nutrients. Weeds are excellent food sources for both fish and ducks, so when rice is intercultured with fish or with ducks, the proliferation of weeds is weakened. In the experimental paddies in Guangdon Province, as much as 85 per cent of the weeds were estimated to have been consumed by fish. Under the rice/azolla system, weed growth is inhibited by the more dominant azolla which then becomes an organic fertilizer in the next crop cycle.

Soil conditioning. The presence of fish in the paddy improved soil nutrient composition and increased soil aeration. Phosphorous, potassium and nitrogen contents rose by 16, 50 and 10 per cent respectively; in addition there was a slight increase in soil organic matter. Eco-farming paddy soil also aired better than the conventional paddy soil after drainage.

Water quality. The presence of fish and other aquatic animals in the paddy was found to increase the oxygen content of the water. Moreover, a conscious effort on the producer's part to keep the water clean for the fish by minimizing agrochemical inputs further reduced the risk of contamination.

Pest and disease control. Pest attacks and disease damage were proven to be less severe in rice eco-farms. Improved soil condition, cleaner water, and more thorough soil aeration inhibited the spread of plant diseases, while the appearance of plant-eating insects such as rice leaf hopper, rice leaf roller, rice sheath blight decreased with the presence of spiders, wasps and other natural enemies. Land-use factors such as rotation between rice and dryland potential to minimize the carry-over of crop-specific diseases and pests.

Residual toxins. With the more rational use of agrochemicals, the amount of residual toxin found in rice and other co-products produced ecologically was found to be negligible.

Erosion protection. Simple engineering projects undertaken in connection with eco-farming, such as widening and raising of embankments, digging of trenches for fishes and the making of ridges for rice, were also believed to contribute to the strengthening of land formation and optimial water-use. Despite the 1988-1989 drought in Loess Plateau, which destroyed the region's agricultural production, harvests at the eco-farming trial sites in Wenxi County, Shanxi

Province remained at a reasonable level. Incidents of soil erosion and rapid water run-off in Dongganqin village have decreased since the inception of eco-farming activities and soil protection measures.

Besides the ecological benefits cited above, eco-farming is especially easy and attractive for the average farmer to adopt because it is essentially based on traditional agriculture; it has been proved to increase crop yield and income sources. In Zhejian Province, for instance, rice yield rose only 10 per cent but total paddy income doubled because of the additional fish. Results from Guangxi Province, the site of the initial farms for rice/fish production, were even more encouraging. Between 1986 and 1989, rice yield increased by 85 per cent to 15.438 kg/ha, while total production value almost tripled because of the fish harvest, which averaged 536 kg/ha in 1989.

Furthermore, eco-farming produce bears the Ministry of Agriculture's coveted "green food" seal which denotes produce grown on officially designated "green food areas" under ecologically harmless conditions, and guaranteed to be agrochemical-free. It must have passed rigid quality control. Only produce from eco-farming units exhibits this seal. So far this represents only about 5 per cent of the total food marketed. Despite the fact that these products are generally higher-priced than products from conventional farms, domestic demand continues to rise in line with increasing health-consciousness in China.

The current official agricultural policy is to promote eco-farming actively. The Ten-year National Economic Development Plan, approved by the People's Congress and promulgated by the Government in 1991, includes provisions for "continuing the environmental protection projects and eco-farming trials". Specifically, it contains plans for the Ministry of Agriculture to expand eco-farming experimental areas to a total of 3.5 million hectares by the end of the century from the current area of 2.2 million hectares. It was estimated that in 10 years' time, there would be over 30 million hectares of agricultural land operated under the eco-farming system.

Under the plan, the expansion will be implemented jointly by the Ministry of Agriculture and the county-level government. Development planning will be formulated and implemented by a multi-discipline work team, both from within and outside the region. Each county will also be equipped with an eco-farming service centre engaged in monitoring environmental conditions and ensuring product quality, research and development work, and training. It will also include the creation of model projects to demonstrate research findings and to provide training samples.

There is still a serious shortage of capital necessary to convert conventional farms into eco-farming units and to train interested farmers on the appropriate eco-farming technology. Most of China's farms are small-scale family-operated units; the initial investments necessary to purchase stocks and improve irrigation are often beyond the family's budget. Moreover, eco-farming requires additional skills and technological knowledge for which farmers would need intensive training. There is also the still prevalent belief among farmers that higher dosage of chemical inputs brings higher yield and income. Use of agrochemicals in Chinese agriculture is relatively recent and many farmers have still not experienced, nor become aware of, the long-term consequences of synthetic fertilizer and pesticide use.

Annex II

Regime and regulations for use of agrochemicals

The survey of environmental regulations in the countries studied disclosed that the regimes for use and import of agrochemicals have various common features but also a good number of specificities. These may be summarized as follows:

In Brazil, production, marketing and use of pesticides require prior registry with the federal Government to determine the degree to which they may endanger the environment. Registry is not permitted if antidotes are not readily available for those substances that may cause disease such as cancer, genetic mutations or hormonal disturbance, or which may cause severe environmental damage. Products must be sold with correct labelling giving full information on the dangers of pesticide use, along with precautions and instructions in case of accidents. The Govenment can cancel pesticide registration if the environment, natural resources or public health are damaged or endangered.

The Federal Environmental Protection Agency of Nigeria considers agricultural chemicals to be one of the 14 problem areas within the framework of its National Policy on the Environment. The latter requires that the use, storage, transportation, marketing, sale and disposal of agrochemicals be regulated and an up-to-date register of approved agrochemicals with guidelines for their use be kept. The Environmental Protection Agency also monitors agrochemical residues, provides "Safe Use of Pesticides Guides" which specify maximum permissible levels of pesticides, mounts programmes to develop environmentally sound alternatives such as organic fertilizers, and encourages Integrated Pest Management (IPM) practices and the development of crop varieties which require less or no agrochemicals.

The Government of Indonesia has banned the use of 57 hazardous chemical pesticides and has discontinued any subsidy on pesticides. Methods of Integrated Pest Management (IPM) have been introduced as part of an overall plant protection and pesticide minimizing approach. In 1990, some 50,000 farmers were trained throughout an entire season in their own fields.

Since 1980 Thailand has cooperated with FAO in the Inter-country Programme on IPM for rice. It is aimed at strengthening surveillance and plant-protection-service units as well as introducing early-warning systems. The country has, however, not yet decided to implement IMP policies on a large scale.

In the Philippines, IPM was adopted officially by the Government as its strategy for crop protection in 1986 (to date, it has been limited to rice, maize and cabbage). On the basis of experience in Indonesia, the Philippines currently organize courses for more than 1000 municipal trainers who will conduct farmers field schools. A support network for IPM is being established as well. On the regional, provincial and municipal levels, field officers and programme coordinators are to be trained in agro-ecosystem analysis and management, so that they can manage resources and decide on interventions supportive of the IPM programme.

In Costa Rica, pest and disease control have been declared activities in the public interest. Since 1982, the sale and application of fungicides containing arsenic has been confined to the months of February to June. The

same decree has also mandated the mixing of such fungicides with zinc-based products in order to diminish the absorption of arsenic and lead by the coffee plant. Since 1990, the Government has taken several steps to ban the import, storage and use of arsenic-based fungicides. A manual published by the Cooperative Program ICAFE-MAG provides detailed instructions on the techniques for control of weeds and pests affecting the coffee plant.

El Salvador has several laws regulating the registry and trade of pesticides. It is compulsory to register the names of pesticides every three years, however, there are no defined norms which regulate the use of these pesticides. The Salvadorian Institute for Coffee Research has issued a manual on the safe use of agrochemicals which, in addition to the use of other chemicals, describes alternative measures for pest control.

Annex III

Utilization of Environmental Impact Assessment

The review of environmental regulations in the countries where case studies were conducted revealed that Environmental Impact Assessment (EIA) was an explicitly mentioned aspect of these regulations in the following countries:

In Brazil, EIA is compulsory for the following activities: agropastoral establishments of over 1000 ha, activities leading to significant deforestation, activities and agro-industrial facilities which run significant environmental risks, any activities in environmentally critical areas. The National Environmental Council requires that public hearings (as a forum for participation by individuals or groups) be an integral part of the impact assessment and thus the licensing of a project.

In Indonesia there is a Central Commission on EIA which furnishes technical guidelines. EIA is mandatory for every activity which has a potential environmental impact. This concerns, in the cases of cocoa and coffee, any plantation of 500 ha or more, activities opening up virgin forest or rain forest of 25 ha or more, plantation activities of a size of 100 ha or more in the upper course of a river and processing plants capable of treating produce stemming from 500 ha or more of arable land. Depending on the stage of the project, the Government requires (a) information regarding the environment for activities being planned, (b) provision of environmental evaluation for activities already in progress and (c) an environment management plan or environment observation plan for managing and monitoring environmental effects of activities being carried out.

In Thailand and the Philippines, EIA guidelines have been developed, inter alia, for agro-industries, dams and reservoirs. Assessment is compulsory for the larger processing industries and irrigation schemes. In Thailand, compilation of EIA is done by registered consultancy companies and designated universities.