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INFLUENCE OF INTERNATIONAL MARKETS ON ECOLOGICAL SUSTAINABILITY OF AGRICULTURAL PRODUCTION

a conceptual model

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TABLE OF CONTENTS

I. SCOPE OF THE STUDY

1. The aim of this paper is to formulate a conceptual model for the analysis of links between international market influences on the sustainability of agricultural production.

2. The paper is an updated and revised version of some parts of an earlier study (Kox & Stellinga 1991) which was commissioned by the UNCTAD Commodities Division. The UNCTAD project focussed on the links between international market conditions and the intensity of resource use in the production of primary commodities in four commodity sectors. The project is started to provide a basis for policy proposals which will ensure that international commodity trade promotes sustainable development. Apart from our contribution on agriculture, three companion papers were written fishery (Kaczynski 1991), forestry (Hpay 1991) and mining (McKendry 1991).

3. As sketched by the Brundtland report (WCED 1987) a dual relation exists between environment and development. Economic growth and the quality of growth are influenced by the ecological issue. At the same time ecological devastation in many developing countries is amplified by poverty-led behaviour and by the need to secure foreign exchange. Debt servicing problems and adjustment policies force countries to increase agricultural export volumes. Agriculture as a major economic sector, as an important export sector[1)], and as a sector with intensive natural resource inputs, deserves close attention in this respect.
From policy viewpoint it is important to have a clear view of how international market changes have their impact on the sustainability of national agricultural systems. National instruments may fail to deal adequately with the fact that international trade creates a spatial and time gap between the production of negative environmental side effects of production and the consumption of net outputs. It becomes more and more obvious that a set of internationally operative regulatory instruments must be created. For such attempts to be successful it is inevitably to carefully study the influence of international market structures on the integration of environmental externalities.

4. The spectrum of relations between international market structures and environment for all types of agricultural production forms such a complex and wide-ranging subject that some limitations are applied in this report. Firstly, the analysis mainly focuses on the reaction of the agricultural *production* system to changes in market conditions (e.g. prices changes). No attention will be given to the reaction of the demand for agricultural products to the same changes. A consequence of this limitation is that price elasticity of demand and income elasticity of demand are assumed to remain constant. Though, more probably than not, this assumption is incorrect for many agricultural products, it would require additional research to establish its effects on resource use and environment. However, it can be argued that most environmental effects occur in the production phase rather than in the consumption phase, so that this self-limitation does not prohibit a view of the most essential problems involved.

A further limitation concerns the range of agri-ecological production systems that could be treated. A general conceptual framework is sketched for the relation between international market structures and their environmental consequences in agriculture. These interrelations are studied in more detail on the basis of a number of case studies. A selection criterion was that they were exemplary for certain agricultural regions, product types, and production conditions.
Finally, domestic government policy has an important potential role in reducing environmental externalities. In order to do so, governments have to reconsider their agricultural policy, because current measures - e.g. regarding product prices and agricultural inputs, tax (dis-)incentives, rural credit, extension services, and regulation of land tenureship - sometimes contribute to environmental destruction in the agricultural sector.[2)] In this report government policy as such is no specific object of study. Nevertheless, where domestic government policies interfere with the line of causation between changes in international market conditions and environmental pressure in agriculture, this topic cannot be ignored.

5. The definition of agricultural sustainability is a subject in itself. Our approach is inspired by the Brundtland Commission's concept of *sustainable development*: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987:43). Our third chapter discusses at some length how to derive an operational definition for sustainable agriculture from this general notion of sustainable development. The concept of 'international market influences' which is also central for our analysis, will be operationalized in chapter IV.

6. This report consists of the following parts. Chapter II deals with the characteristics of resource use and environmental problems in the agricultural sector. Agriculture is treated as a physical transformation process that is influenced by market stimuli as well as cultural and social conditions. Chapter III operationalizes the concept of sustainable agriculture, from a static and a dynamic point of view. Chapter IV sketches a model for analyzing the influence of changes in international market structures on the sustainability of a given national agrcultural system. In Chapter V it is tried (at some length) to put some flesh on the conceptual bones. The influence of international market changes on agricultural resource use is sketched for six characteristic agri-ecological systems. In the final Chapter VI the usefulness and applicability of our conceptual framework is discussed on the basis of the preceding six case studies.

II. RESOURCE USE AND ENVIRONMENT IN AGRICULTURAL PRODUCTION

This chapter deals with the agricultural production cycle in general, and the ecological problems which may result (or enter) in the different moments of the cycle. The agricultural contribution to ecological problems are of two types: pollution emission and depletion of natural resources. With regard to emission of pollutants special attention will be given to external inputs of chemical fertilizers and pesticides. A major form of resource depletion in agriculture occurs in the form of land degradation, especially erosion.

The agricultural input-output system

7. Like other primary commodity sectors, agriculture strongly depends on the use of natural resources in its production process. In a technical sense, the agricultural production process can be conceived of as a cyclical transformation process in which inputs are systematically combined to produce certain combinations of vegetable or animal outputs.[3)] The agricultural transformation process generates vegetable and animal products for industrial processing, or for direct human or animal consumption. Inputs consist of human labour, animal traction, industrial inputs (machinery, tools, agrochemicals), selected outputs from earlier agricultural production cycles (seeds, compost, manure), energy carriers, infrastructural investments, and, finally, a complex mix of natural resources.
Natural preconditions (resources) enter the transformation process either in crude or in human-shaped form: soil, surface water, ground water, air, climatic conditions, micro and macro organisms, race and species characteristics (biodiversity). A characteristic element is that most natural preconditions enter the transformation process as an indivisibility, as an undivided totality. Parts of this totality will effectively be used, while other parts will not.

8. At the end of each agrarian production cycle the stock of natural resources that entered production, may or may not be reproduced in its original quality and quantity. If no complete reproduction takes place part of the stock of natural resources apparently has been used-up. Examples of this phenomenon are soil degradation, exhaustion of ground water basins, consumption of fossil energy, destruction of micro organisms, and outward shifting of the agricultural frontier so that natural landscape areas (wetlands, rainforests) are reduced.
Production inputs for next production cycles will be affected, when depletion of natural resources occurs. Other, formerly unused sections of the stock of natural

resources will have to make up for the depleted stock. Alternatively, additional labour and man-made inputs are necessary to compensate for degradation of the stock of natural capital, e.g. various sedimentation techniques to reverse an erosion process, or application of artificial fertilizers to keep the nutrient balance of the soil up to level. Natural resource depletion may as well affect other sectors, like for instance in the case of degradation of touristic attractiveness of the rural landscape.

9. Part of the net marketable output re-enters the agricultural production process. The use of seeds and offshoots in subsequent production cycles is probably the best example of this feedback flow. In mixed farming systems, products of the livestock sector (manure) are used as inputs in arable farming, and vice versa. Apart from in-farm use of marketable outputs several feedback loops exist for products which are not sold in outside markets. Materials like straw, mulch products, compost, and manure are recycled within the agricultural sector, either for soil fertilization, construction, harvest protection, or energy generation.

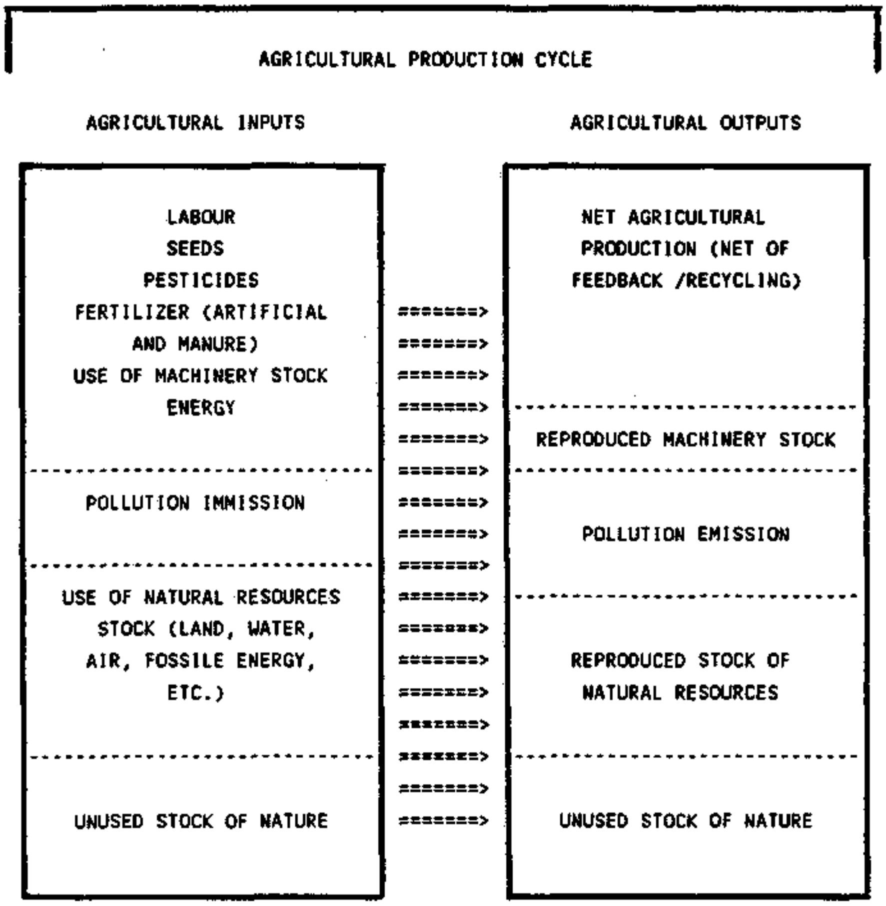
10. Apart from marketable agricultural outputs the production process results also in side-products which do not have a positive market value, but whose use value is definitely negative, e.g. pollution of air, surface and ground water, salinisation due to irrigation, solid waste products. This category of side products are designated as *pollution emission*. Many of them are closely attached to and affect the quality of natural media like air, water and soil. Agricultural pollution typically originates from a large number of geographically dispersed sources, spread over an extensive area (IEEP 1991). Production of crops is often linked with abundant use of chemical fertilizers and pesticides, especially when production units are large.[4)] A part of these agrochemicals persists as residues in agricultural produce. Another part (nitrates, phosphate) ends-up in surface and subsoil water flows. In intensive cattle ranching minerals-enriched cattle feed eventually causes harmful sedimentation of heavy metals in production areas, rivers and ground water. When not neutralised by additional productive activities (pollution abatement), the emitted pollutants enter subsequent production cycles of agriculture, agro-industry, or other economic sectors. They will ultimately affect animal and human food chains.

11. To the extent that pollutants enter the agrarian production cycle jointly with other inputs, this pollution 'feedback' is labelled *pollution immission*. Pollution immission negatively influences the effectivity of other inputs and the quality of the

next 'vintage' of agricultural outputs. Agriculture is more vulnerable to external pollution than many other economic sectors, especially where aerial pollutants and water pollution is concerned. To neutralise (parts of) the pollution immission the agricultural production cycle in the narrow sense has to be preceded by additional production activities, like cleaning and filtering of irrigation water, or sprinkling lime to neutralize soil acidification caused by acid rain or excessive nitrate disposals.

Chart 1

Diagram of resource use and environmental relations in the agricultural production cycle



12. The elements of resource use and environmental relations of the agricultural sector which have been described so far, are pictured as a diagram in Chart 1. The proportions of various sections of the chart are purely at random. Both inputs

and outputs consist of heterogeneous quantities. For quantification and aggregation a monetary dimension would have to be assigned to all these heterogeneous quantities.[5)] So far only direct input and output relations of the agricultural production cycle have been described. Cumulative ecological effects of one unit of net agricultural produce will be larger, though. To calculate these it is necessary to quantify resource use and pollution emission caused by all intermediary production. In a broader environmental perspective these cumulative effects should be considered as well, but this report will concentrate on the agricultural sector as such.

Intensity of external input use

13. With respect to input intensity a wide spectre of agricultural production systems can be identified. We will here concentrate on two extreme types of agricultural input-output systems, between which many intermediary forms exist:

* *high external inputs system of agriculture* (abbreviated: HEIA), characterised by high agro-industrial inputs (hybrid seeds, fertilizers, pesticides) per acre, high degree of mechanization, and high input of fossil energy.[6)]
* *low external inputs system of agriculture* (abbreviated: LEIA), characterised by just occasional application of agro-industrial inputs, low degree of mechanization, predominantly using human and animal energy, limited use of fossil energy (mainly for transport and fuelwood), high degree of local recycling.

An input is called 'external' if it is supplied by other economic sectors, outside agriculture in a strict sense. For the analysis of agri-ecological production systems it is important to also consider inter-regional flows. In a regional analysis, inputs delivered by other agricultural production regions are also regarded as external inputs. The direct use of natural resources (land, water[7)], and air) by a regional agricultural system will be considered as internal inputs.

14. HEIA systems of agriculture are often found in large-scale agricultural enterprises, intensive dairy farms, bio-industrial production units and greenhouse horticulture, while LEIA will be more typical for small-scale farming, extensive cattle ranching, agriculture in marginal or mountainous areas, subsistence farming and modern types of ecological farming. HEIA types of agriculture are more frequently encountered in OECD countries, while LEIA systems are relatively more customary in developing countries.

Application of HEIA types of technology in developing countries is typically linked to either export-oriented production or to Green Revolution programmes. The latter programmes were widely embarked on since the mid-1960s in Latin America and Asia, and much less in Africa. The programmes were centered around introduction of improved, high-yielding varieties of wheat, maize and rice.[8)] Green Revolution programmes, also called 'agricultural modernization', increased the dependence of farmers on packages of non-agricultural inputs, including seeds (often hybrids), fertilizers, pesticides, irrigation and mechanized equipment. Green Revolution technology was especially used by medium and large farmers. Small farmers often preserved traditional agricultural methods, due to financial constraints. LEIA types of technology are therefore mostly found with small farmers.

15. Tempting as it may be to regard all LEIA types of agriculture as ecologically preferable to HEIA, such an *a priori* conjecture does not hold. Some LEIA types of agriculture exhaust the natural resource stock they use in production, so that their 'internal' use of direct available (unpriced) inputs results in unsustainable agriculture. Especially on the more marginal tropical soils (e.g. parts of Sahel-Sudan zone) external inputs are required to maintain the nutrients balance of the soil (Breman 1990). Nevertheless, from a strictly ecological perspective it seems safe to assume that HEIA types of agriculture will generally pose a heavier environmental burden than LEIA types.[9)]

16. HEIA production systems are often promoted for their high productivity in terms of land and/or labour. However, productivity comparisons between HEIA and LEIA production systems are misleading as long as only partial comparisons are made. Although partial measures provide insights into the efficiency of an input in the production process, they mask many factors accounting for observed productivity growth. Partial approaches to productivity measurement are very sensitive to both the composition of outputs and the relative intensity of various inputs (Ehui & Spencer 1990). A growth in labour productivity over time may, for instance, simply be the result of the substitution of direct labour by external inputs, or be the result of the realization of economies of scale. A comprehensive productivity measurement requires that the full social and environmental costs of both technology types are taken into account. Not only the costs of external inputs and capital, but also the costs of resource depletion (e.g. soil nutrients) and of pollution emission should be included.[10)] Moreover, on the output side, comprehensive productivity measurement will not only valuate directly saleable outputs, but also replenishment of soil nutrients,[11)] enhanced resistance to non-agricultural erosion

processes, improved soil microbiological properties, improvements to landscape value for tourism, and other improvements to the stock of natural resources. When these factors are included, the pattern of productivity differences between HEIA and LEIA systems could well become completely different.

Distribution of ecological effects of agriculture in time and space

17. Environmental externalities of agricultural production can manifest themselves nearly instantly, e.g. in the case of a major pesticide contamination. More often, however, effects are lagged in time, like in the case of gradual contamination of water resources, soil erosion, super-saturation of the soil (e.g. with phosphor), and exhaustion of soil fertility. These lagged effects occur in indirect forms. They can be major causes of 'natural' catastrophes, like land slides, floods, animal diseases, forest fires, or sinking ground water levels. More important, they can appear in the form of a slow process of falling agricultural yields. This in turn may cause rural impoverishment, departure for urban areas, and depopulation of rural areas.

18. Most negative ecological externalities of agricultural activities will *nolens volens* be consumed by the rural communities in the producing areas (e.g. Blaikie & Brookfield 1987). International trade creates a spatial and time lag between consumption of agricultural products and absorption of the direct environmental consequences of their production. Only a small part of the harmful ecological side effects trickles down along the international trade chain to commodity-importing countries. This may be in the form of pesticide residues in agricultural commodities. Such residues make themselves felt as health hazards for harbour, transport and manufacturing workers and, ultimately, also for consumers in importing countries. Some environmental effects of agricultural production pass national borders, like SO_2 emissions (contributing to acidification of rain), pollution of rivers, seas and oceans. We will now pay attention to four major ecological problems associated with agricultural production: pollution caused by the application of fertilizers and pesticides, land degradation, and contribution to diminished biodiversity.

Fertilizer use and environment[12)]

19. The use of (artificial) fertilizer has a great impact on agricultural production yields. Current application levels of artificial fertilizers vary widely across production regions, ranging from 20 kilogram per hectare in Africa to 225 kilogram in Western Europe (cf. Annex I, Table 1). At the level of countries even

larger differences exist, also within continents. While Mali applied 6.4 kilo per hectare in 1988, Egypt used 400 kilo. Fertilizer consumption has grown most in countries with low application levels. Most remarkable is the growth of fertilizer consumption in Asian countries. However, large inter-country differences in fertilizer application continue to exist.
Use of chemical fertilizer not only differs between countries, but also between crops. In OECD countries they are widely applied in all sectors of agriculture. In developing countries artificial fertilizers tend to be used more in production of cash crops than in food production. Low and moderate intensity of fertilizer use is mainly found in developing countries' food production.

20. Fertilizer application does not necessarily cause environmental problems. Up to a certain level its application will only generate higher agricultural production per hectare.[13)] This is particularly the case where soil fertility is low by past depletion of the soil, or where the local nutrient balance of the soil has been disturbed by whatever reason. Beyond a certain threshold level further growth in fertilizer use per hectare creates environmental problems. Every addditional ton of fertilizer use per hectare will then tend to aggravate the problems of N(nitrogen)-leaching and P_2O_5(phosphate)-runoff. This contributes to the pollution of ground water and drinking water with nitrate, and the eutrophication of inland and marine surface waters by phosphate. Moreover, the extra use of phosphate and compound fertilizers attributes to increasing heavy metals concentrations in the soil. Over the past decades there has, for example, been a steady increase of cadmium in the soil in developed countries, which in itself creates health risks and ecological damage.[14)]
The threshold level does not depend on absolute per-acre fertilizer use only. To find water and soil contamination effects of fertilizer use, several additional factors should be included, like soil type, climate, topography, depth to ground water and other hydro-geological properties. The potential threat of fertilizer accumulation in water bodies - the leaching vulnerability - is a function of all these factors. In a US study the potential water contamination risks due to fertilizer use was calculated for ten important crops.[15)] The results are reproduced in Table 2 of Annex I. It is shown that in the USA the average leaching vulnerability is highest for peanuts, followed by cotton, rice and soya beans. Combining this risk factor with average fertilizer application rates per crop, rice, peanuts, tobacco and corn rank highest for water contamination risks.

21. The main question related to the environmental impact of chemical fertilizers is up to which level they can be applied without doing irreversible or unacceptable harm to the environment. Global food production must increase in order to feed a world population, which - according to current projections - by 2025 will be more than double its 1977 level.[16)] In order to reach this goal either areas of arable land have to be extended and/or yield per area unit has to be increased at a global level. Possibilities for extending arable areas without damaging consequences for natural environment are limited, so that further nutrient inputs (N, P_2O_5, K_2O) in agriculture will be necessary.[17)] Fertilizer use is, therefore, immediately associated with the world food problem.
It is beyond question that agriculture in many regions cannot do without artificial fertilizers to maintain both food production levels and the nutrient balance of the soil. Given negative environmental consequences associated with over-intensive use of fertilizers, it is important to assess whether, and to what extent alternative farming systems can be introduced that still maintain or increase agricultural output. The use of biological processes for fertilization -nitrogen-fixing plants, crop rotations, use of trees as 'nutrient pumps', and recycling of organic waste (e.g. IFOAM 1989) - could be extended far beyond current levels. The FAO has started to promote integrated plant nutrition systems (IPNS), which combine an intensive use of biological processes with a restrained and more efficient use of mineral (chemical) fertilizers (Blackwell 1991; FAO 1991). The high cost of fertilizer relative to the cost of labour in developing countries means that sustainable farming systems should make maximum use of recycled nutrients within the farm with simultaneous minimization of the bought-in fertilizer. At a global level, most efforts are, however, still spent on expanding the use and production of chemical fertilizers. World fertilizer demand is growing steadily. Most governments of developing countries with fast growing populations view expansion of domestic fertilizer production and additional imports from the world market as a *conditio sine qua non* for maintaining and raising agricultural output.

22. Discussion of environmental problems in fertilizer production is usually limited to the production of fertilizers itself and often does not include environmental problems and resource use in mining and production of raw materials and intermediate products. In an overall assessment also transport costs should be included. Related to the latter point questions can be asked about the environmental rationality of exports of nutrients in the form of animal feed components such as soybean meal or cotton seed and the subsequent import of chemical fertilizers to restore the level of nutrients in the soil. An overall assessment of the environ-

mental impact and resource use related to the application of fertilizer in agriculture must include all phases of mining, production and transport, while it should also account for the important amounts of fossil energy which are often[18] used in fertilizer production.

Pesticide use and environment[19]

23. Pesticide use increased dramatically over the last decades, particularly in large-scale modern agricultural production where most of the produce is destined for export. Insect pests are inherent in large-scale monocultures, which destroy the natural balance that would keep them in check. With cultivation of a limited range of plant varieties over large areas, as is often the case with modern high-yielding varieties, plagues can have widespread, disastrous effects. When traditional varieties are used, plagues are limited in scale, due to the large diversity cultivated. Many agricultural export crops are grown in large-scale production units. Moreover, export crops are often highly concentrated in some agricultural areas. These three aspects -large production scale, regional concentration, and reduced diversity of varieties- often coincide in the case of export production, which makes it especially vulnerable for pests. As a consequence, a high propensity to apply pesticides is found here.[20] The costs of pesticide application sometimes amount to 40 per cent of total production costs (Blackwell 1991).

24. Pesticides differ with regard to the level of toxicity and their environmental persistence. Environmental threats by pesticide use in agricultural production include potential contamination of ground water and surface water, its consequences for micro-organisms, accumulation in animal and human food chains, downgraded bio-diversity, and direct health hazards caused by the preparation and application of pesticides. Organochlorines such as DDT, aldrin, dieldrin, endosulfan, heptachlor, and chlordane accumulate in agricultural soils, ponds and river bottoms, and animal tissue, and are taken up by plants or released by soil organisms to poison further. Furthermore, many organochlorines prove to cause cancer in laboratory tests, and/or cause infertility. Organophosphate pesticides, like parathion and malathion, though often more toxic and accounting for more than 80% of acute poisonings in Central America, break down relatively quickly when introduced into the environment (Faber, 1991).

25. The use of pesticides leads to its own propagation in the form of ever higher application doses, of ever stronger pesticides, and of greater frequency of application, since it stimulates pest resistance and also destroys natural enemies of pests.

So pesticide use often induced a resurgence of both target and secondary pests, and, in doing so, it did not boost agricultural production over the longer term. Apart from doubts on their long-term biological effectivity, many commentators agree that over-application of chemical inputs (fertilizer and pesticides) is widespread. Due to sales promotion, improper information on necessary application rates, and subsidized prices, the agricultural use of agrochemicals is often extended beyond the level which is micro-economically rational (Pearce et al. 1990; Spruijt 1988).

British agronomists calculated that reducing herbicide use by 28%, fungicide use by 80%, use of plant growth regulators by 61%, and nitrogen-based fertilizer application by 40% resulted in a cereal yield loss of only 0.8 tonne/hectare and had no impact on gross margins.[21)] Evidence exists to support the case for a more rational use of pesticides, even without a complete change-over to a pesticide-free agriculture. An illustrative case stems from Indonesian agriculture. Indonesia became self-sufficient in rice in 1983 thanks to the success of the high-yielding, early-maturing, stress-tolerant, multiple-disease resistant IR36-variety, introduced in 1976 by the International Rice Research Institute (IRRI). This variety is cultivated in more than half of the rice area of the world, and requires intensive use of fertilizer and pesticides. Up till 1985 the Indonesian government subsidized pesticides, to a level of 40 per cent of the price. In 1985 Indonesian rice harvests were at risk when the numbers of brown-planthoppers, an important rice-pest, multiplied quickly. The brown-planthoppers were apparently more resistant to pesticides than their natural enemies, such as the wolf-spider, which tended to be eradicated. A change in policy in 1986 was the result, when the government banned 57 broad-spectrum pesticides and reduced pesticide subsidies, despite opposition from transnational chemical corporations. In close co-operation with FAO Indonesia became the first developing country to include Integrated Pest Management (IPM) in its government policy. An emergency extension programme was developed to teach farmers to recognize and protect pest predators. The progamme was successful, as damage declined sharply in 1986/87 and an ecological balance was reestablished. Yields in IPM areas proved higher than before, with lesser ecological damage, and areas infected with the brown-planthopper were diminished by half. In the first year of operation pesticide use was cut by 65 per cent, while yields continued to rise. The Government saved much expenses on pesticide-subsidies.[22)] Similar reports came from Nicaragua were in the early 1980s the use of DDT and parathion was diminished by 40 per cent as result of a well-planned campaign for integrated pest management.[23)]

Land degradation

26. Land is the major natural resource used in agricultural production cycle. Agriculture and related human activities in rural areas have several implications for the quality and quantity of the available stock of land. Land degradation can take several forms: e.g. erosion, modification of horizon structure, partial removal of fine particles, pan formation, podsolization, compactization, changes in hydrology, impoverishment of vegetation, salinization, and acidification. These physical changes result in a decline in capability of the land to satisfy a particular use. This will become manifest, *ceteris paribus*, in the form of lower agricultural yields (crops, livestock, useful vegetation). For analytical purposes it is necessary to distinguish between land degradation that occurs through human interference and natural processes that would have occurred anyhow. 'Net' land degradation (cf. Blaikie & Brookfield 1987) in a given time period is the combined result of:

* natural degrading processes (e.g. leaching, compaction and erosion of the soil, changes in plant cover and hydrological regime, changes in soil and water chemistry);
* human interference (soil exhaustion by agriculture, ploughing, deforestation for firewood and agricultural extension, etc.)
* natural reproduction (new soil formation, restoration of nutrient status under rest periods, vegetation formation);
* restorative management (land management by man, e.g. improvement of nutrient status, terracing, mulching, contour cropping).

The effect of agriculture and land management activities on land quality will be influenced by two qualitative characteristics of a given land system, its *sensitivity* and its *resilience*. Sensitivity refers to the degree to which a given land system undergoes changes due to natural forces, following human interference. Resilience[24)] concerns the ability of land to reproduce its capability after interference and determines the necessary human efforts to that end. Land systems with high sensitivity and low resilience easily degrade, do not respond to land management and should not be interfered with by agricultural (and other) activities. Otherwise, depletion of this natural resource will be unavoidable.

27. Erosion is probably the most studied aspect of land degradation. Erosion due to agriculture not only depends on sensitivity and resilience of a given land system, but also on cultivation characteristics of different agricultural uses. In general, perennial crops can play an important role in preventing soil erosion. A study of the US Department of Agriculture calculated average erosion intensity of

ten major US crops. Table 3 of the statistical annex (Annex I) reproduces these data. A remarkable figure in this table is the intensity of erosion caused by tobacco cultivation. Cattle ranching also forms a cause soil erosion in many arid zones, often due to overgrazing (Myers & Tucker 1987). The United Nations Environment Programme estimated the total global cost effects of desertification in arid zones at $ 26 billion annually as a consequence of lost agricultural and livestock productivity (UNEP 1981, quoted in Ahmad et al. 1989; Mortimore 1989). Several studies have been made of economic implications of erosion (cf. Dasgupta & Maeler 1989). In Mali forgone farmer's incomes due to soil erosion are estimated at $ 31 - 123 million annually, which is equal to 4-16 per cent of agricultural GDP (Bishop & Allen 1989). On-site costs of soil erosion in upland areas in Java are estimated to amount $ 320 million annually, or three per cent of agricultural GDP. Counting the costs caused by downstream sedimentation of eroded soils would add another $ 25-90 million (Magrath & Arens 1987). Soil erosion and falling ground water levels in their turn cause desertification (Mortimore 1989; Pearce et al. 1990).

28. An aspect that deserves special attention in relation to land degradation problems is the issue of land distribution. In developing countries the areas with fertile soils and good farming properties, like river delta areas or valleys, are often owned by medium and large farmers or plantation companies. These areas often have a positive sedimentation balance, so that farmers can afford to pay relatively little attention to erosion prevention. Farmers often apply relatively large-scale and HEIA-oriented technologies. Green Revolution technology was principally designed for the better, i.e. more fertile, flatter and often irrigated, soils of the tropics and subtropics, even though these soils represent only approximately one-fifth of the total agricultural area (De Groot 1992).
On the other hand, the vast areas with less fertile soils and inferior farming properties, like mountainous areas, hill slopes, semi-arid zones and rainforest-related colonization zones, tend to be farmed by small, poorer farmers. It implies that the latter cultivate the most erosion-prone areas. In order to make farming ecologically sustainable in these areas one needs to undertake relatively more anti-erosion works as a percentage of annual labour input. Bad economic conditions (low prices, high input costs), and seasonal or permanent labour migration to higher wage opportunities can cause a disregard of anti-erosion works. Under such conditions labour efforts may be solely directed to direct crop-oriented labour (sowing, weeding, harvesting) rather than to activities that sustain agricultural production in the longer term. A skewed land distribution, with marginal lands

allocated to marginal-income farmers, can, therefore, under certain economic conditions have particular harmful effects on soil erosion.

Commercial seed inputs and biodiversity

29. A natural resource asset that commonly enters agricultural production as an unpriced common input is biodiversity, i.e. the availability of a wide specter of genetically-different micro-organisms, plants and animal species. Traditional farming systems use local plant varieties or at least varieties that have been improved on the basis of local varieties. Seed production is often an integral part of annual production. In HEIA systems, however, seed inputs are increasingly purchased from specialist firms, several of which are large multinational companies. These firms sell seeds that have been improved by combining genetic inputs from various geographic areas, deliver high yields, or have other special characteristics. By selling hybrid seeds, which cannot be used for subsequent in-farm seed production, seed suppliers guarantee a steady stream of demand. Currently, the value of worldwide agricultural use of seeds is estimated at $ 31 billion. Slightly more than half of this amount consists of commercial supplies by specialist firms.[25)] The use of plant species from an ever smaller genetical base tends to diminish genetical diversity in agricultural areas, so that many varieties which are perfectly attuned to local climate and soil, but have a lower yield per annum, may gradually disappear. This generates a process of genetic erosion and diminished biodiversity. The process is aggravated - also with regard to microbiological species and wildlife animals - by the use of herbicides, insecticides and fungicides, which are sometimes supplied in a package deal with the seeds.

Agricultural input suppliers increasingly sell integrated packages of seeds (often hybrids, or specially treated, sometimes by DNA recombinant techniques), fertilizers and pesticides.[26)] Transnational corporations increasingly incorporate both agrochemical input businesses and seed businesses in an attempt to develop integrated packages of genetically engineered seeds which should be used in combination with (their) specific agrochemical inputs in order to obtain optimal production yields. Their long-term aim is to use genetic engineering to by-pass the slow process of traditional plant-breeding and to develop crops with new characteristics such as better yield and quality, controlled ripening and higher resistance to pests and diseases, while farmers will procure more inputs from them (Cookson 1990). If attempts in this technology direction are successful, a larger part of world seeds inputs for agriculture will be dominated by a relatively small number of suppliers.[27)]

III. SUSTAINABLE AGRICULTURE

30. Sustainable development has become a fashionable catchword and is often loosely used to cover various contents (cf. Lélé 1991). A definition which has gained wide adherence is the one adopted by the Brundtland Commission (WCED 1987:43) according to which it is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". A key element in this definition is the issue of *inter*generational equity according to which a trade-off may exist between the needs of current and future generations. It concerns two problems, the first of which is the depletion of non-renewable natural resources like minerals, fossil fuels, biodiversity, soil structure, complex ecosystems and natural landscapes.[28)] The second trade-off between the needs of current and future generations exists when costs associated with current consumption are shifted forward to the future. Several types of pollutive behaviour in agriculture, like gradual poisoning of subsoil and ground water by chemical residues, would reflect this attitude of 'enjoy now - pay later'. To the extent that transborder ecological effects are involved, the distribution of country contributions to these cumulative effects cannot be overlooked. The claim of developing countries that current and past generations in a number of wealthier (mainly OECD) countries have taken a more than proportional share from the world's stock of depletable resources, and contributed more than proportionally to international pollution problems, is hardly challenged. Since the Brundtland definition stresses the needs of both the future generations and the present generation, it also regards the issue of *intra*-generational equity. The existence of large inequities *within* the current generation with regard to possibilities to fulfill current needs, cannot be ignored. A very skewed international distribution of income prevents large sections of the current generation from fulfilling even their basic needs. The consequence of the Brundtland definition is that it entails a possible trade-off between production increases to fulfill the needs of the current poor - even when this causes additional pressure on the natural environment - and preservation of the natural resource base for future generations.[29)]

This trade-off in the basic concept of sustainability is reflected in the existence of two camps in the definition of sustainable agriculture. In the literature two approaches can be distinguished:

(a) Definitions that start from *technical and economic characteristics of an agricultural input-output system*. According to Conway (1985) "sustainability is the capacity of a system to maintain productivity in spite of a major disturbance, such as caused by intensive stress or a large perturbation". Lynam & Herdt (1989) define sustainability as "the capacity of a system to maintain output at a level approximately equal to or greater than its historical average, with the approximation determined by its historical level of variability. [So that a sustainable system is one] with a non-negative trend in measured output". A similar approach is found in Ehui & Spencer (1990) who consider a system sustainable if the index of intertemporal total factor productivity (defined in terms of the productive capacity of a system over time, with incorporation and valuation of changes in common property resources) is not decreasing.

(b) Definitions that start from wider *socio-economic issues of agricultural development*. A CGIAR report (CGIAR 1988) defines sustainable agriculture as "the successful management of resources for agriculture to satisfy the changing human needs, while maintaining or enhancing the quality of the environment and conserving natural resources". An ASA committee considers that agricultural activity sustainable "that, over the long term, enhances environmental quality and the resource base on which agriculture depends; provides for basic human foods and fiber needs; is economically viable and enhances the quality of life for farmers and society as a whole" (American Society of Agronomy 1989:15). According to De Groot (1992:6-7) and Conway & Barbier (1990:40, 158) sustainable agriculture refers to the least possible degree of conflict between ecological sustainability, productivity, stability, and equity.

The *type b* definitions of sustainable agriculture incorporate a multitude of cumulative conditions which relate to the function of agriculture in society. In this way the concept tends either to become vague, if loosely interpreted, or unattainable, if strictly interpreted. Cumulative conditions, like in the case of the afore mentioned ASA definition, will more probably than not conflict with each other. If no decision criterion is provided for weighing conflicting conditions one can only conclude that sustainable agriculture will hardly ever be attained. In *type a* definitions this dilemma is less of a problem, but is not completely eliminated. If economic and ecological characteristics of an agricultural input-output system are treated alike, it is implicitly assumed that there is substitutability between the two elements. It would imply, for example, that a lower degree of ecological sustainability - e.g. in the form of higher input intensity of unpriced, depletable natural resources, or higher pollution intensity - can be compensated for by a higher productivity in terms of commercial inputs and outputs. However, such a substitutability would only exist if reference can be made to perfectly homogeneous quantities. If this is not the case - which is indeed doubtful (cf. Section 16) - it is

better to treat ecological and economical conditions separately.
We prefer to consider ecological production conditions as physical constraints for the agricultural input-output system. We consider an agricultural system as sustainable if the following seven ecological constraints are met:

* the nutrient status of the soil is left intact (or is restored);
* pollution emission (by fuel gases, agrochemicals) is absent or neutralized in the agricultural sector itself;
* on balance no encroachment into natural landscapes, like wetlands, natural forests, and mountainous regions, takes place. Agricultural extension in one area may be compensated by new reservations (wild areas) where wild animals can reproduce and live undisturbedly;
* no contribution is made to endangering biodiversity;
* no contribution is made to depletion of fossil energy or other nonreproducible (mineral) stocks;
* no land erosion takes place due to agricultural activity;
* the resilience of the local ecosystem is left intact.

Our definition of sustainable agriculture is thus fairly unambiguous and deals only with the ecological constraints for agricultural production. It lends itself for multicriteria analysis.[30)] In agricultural development, however, tradeoffs can be necessary with other objectives for the agricultural sector, like contribution to food security, foreign exchange generation, efficiency, and equitability with regard to incomes and land distribution. Such tradeoffs are of course necessary and real, but they better belong to the area of agricultural policy, rather than being from the very outset ingrained in the definition of sustainable agriculture.

Agricultural change and sustainability

31. Till now sustainable agriculture was defined as a set of constraints. In a static analysis sustainable agriculture will only exist if all the stated conditions are met; otherwise, agricultural production is unsustainable. In a dynamic context one has to review whether a given process of agricultural change makes agricultural production more or less sustainable.
The use of a multi-dimensional criterion in a dynamic analysis complicates such sustainability evaluation. A given change in agricultural practices may work out differently on the extent to which all seven constraints of our sustainability are met. The extreme cases, where the scores on all constraints simultaneously improve or deteriorate, are relatively simple. Even if the score on only some constraints improves while remaining neutral on others, it could be called a change

for improved sustainability. A problem arises, however, when a change in agricultural method causes diverging trends with respect to two or more of the seven constraints. It is highly problematic to valuate the diverging trends in terms of a single, homogeneous dimension (cf. Section 12). As a consequence there will be a number of borderline cases where the ecological effect of agricultural change processes should be considered undetermined.

32. For the discussion of processes of agricultural change our unit of analysis will be the physical production unit (the farm, a local agricultural production system), rather than a product or crop. We distinguish between two relevant types of agricultural change: (*i*) in the physical *level of production*, and (*ii*) in the applied *methods and technology*.
In practice, these two types of change will jointly occur, but for analytical purposes they can be treated separately. Other processes of agricultural change are mostly reducible to these two elementary processes of change. For instance, the shift between market production and subsistence production may have far-reaching ecological consequences. This shift can be 'decomposed' to changes in the level of production, and in the technology used. Also, other processes, like the substitution between crops and/or cattle-related activities, are only relevant for our analysis to the extent that they influence the intensity of resource use. Changes in the composition of farm output will, therefore, not be treated as a separate case, but as a sub-case of a change in agricultural technology.

33. Increasing or reducing agricultural the production level without changing production methods and production technology, will supposedly affect the level of environmental pressure (resource depletion, pollution). An increase in agricultural production with constant technology[31] can occur via extension of the agricultural frontier (encroachment into formerly non-agricultural areas), or via reuse of fallow lands. Similarly, a decrease in agricultural production (without change in agricultural technology) can come about through putting arable land to fallow (or non-agricultural uses), or by decreasing both livestock numbers and grazing acreage. This formulation implies that land input is taken as the benchmark. But due to the assumed complementarity of inputs, labour input could be used as well. In empirical analysis it is useful to use the most constraining input factor. In some cases this will be the availability of labour power, as has been argued for Subsaharan African agriculture by Dommen (1992).

34. Changes in production technology occur by: (*A*) altering the share of output that is used as input in subsequent production cycles (nutrients recycling, mixed farming); and (*B*) by alteration in the set of non-agricultural inputs that are used to make a certain output: labour, fixed production equipment, (tractors, farming machinery), external inputs (seeds, agrochemicals).[32)]

A type *A* change in technology is a crucial aspect of the shift from subsistence agriculture to market-oriented agriculture. A transition from mixed agriculture to mono-product forms of agriculture often also implies changes of the first type. Agricultural modernization as promoted under Green Revolution schemes implied both changes of the first and the second type: increasing dependence on market-supplied inputs and increased dependence on non-agricultural inputs.

Technical change in agricultural production had to a large extent an 'embodied' character, i.e. it was particularly associated with the purchase and use of intermediary inputs from outside the sector. A change-over from LEIA to HEIA systems of agriculture represents the case of a more than proportional increase of purchased external inputs relative to other inputs. Mechanization forms a sub-case of a LEIA - HEIA transformation (more use of perennial production equipment, fossil energy). Production becomes more labour-intensive when more labour (longer working hours, using more farm workers) is applied relative to other purchased inputs.[33)]

In the history of agricultural technology several forms of sustainable agriculture have been developed: shifting cultivation with application of fallow periods, several forms of mixed farming (in which both cultivation and grazing were rotated in relation to each other, while livestock manure formed a precious source for soil fertilization), slash-and-burn methods with long fallow periods to allow recovery of sensitive tropical soils, terracing techniques, and wet rice cultivation systems. These agricultural practices have mostly been the result of trial-and-error methods, combined with centuries of cultivation experience. They resulted in systems of technology which were highly adapted to local natural conditions.

The last decades technology developed in industrialized countries has been widely introduced in 'developing' countries as the way to obtain increases in agricultural production levels and productivity. In this process local knowledge was often all too easily discarded.[34)] It is now more widely recognized that the results were not always desirable, and after some decades of green revolution and 'chemicalization' (industrialization) of agriculture, environmental issues are evidently gaining importance on the agronomical research agenda. At the frontier of agricultural technology many traditional techniques for sustainable agriculture are being reevaluated and supplemented with innovative elements. Increasing attention is given to the development of non-chemical forms of pest management (integrated pest management, biological pest management), biodegradable pesticides, integrated plant nutrition systems with 'green' fertilizers to (partially) replace chemical fertilizers, introduction of low-input varieties, mulching, integration of cultivation, grazing and forestry (agro-forestry), contour ploughing techniques; optimalization of irrigation techniques so that better use is made of available water resources. Experiments show that from a technical point of view agriculture without input of chemical pesticides is well feasible. Such pesticide-free agricultural methods become increasingly sophisticated, often on the basis of renewed attention for traditional cultivation knowledge (cf. Kox & Stellinga 1991: annex II; Vereyken 1991). Agronomic and agrobiological knowledge on these issues grows quickly, due to current shifts in research priorities. Knowledge gaps as to the technical feasibility of forms of agriculture which are ecologically sustainable are expected to disappear soon.

35. Summarizing, we hitherto discerned four basic types of changes in agricultural activity which are pictured in Chart 2:

1) increase of the level of agricultural production with constant technology;
2) increase of external inputs per hectare or per hour of labour (less LEIA-oriented, more HEIA-oriented);
3) reduction of the level of agricultural production with constant technology;
4) decrease of external inputs per hectare or per hour of labour (less HEIA-oriented, more LEIA-oriented).

The x-axis of Chart 2 depicts an index of the production level, while the y-axis represents an index of increasing HEIA orientation. The numbers associated with the arrows coincide with the four types of change.

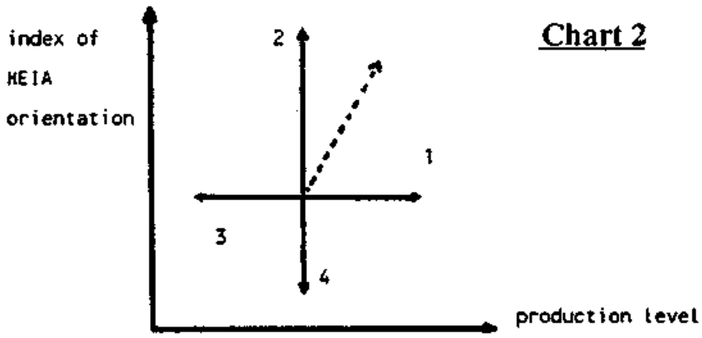


Chart 2

A dominant direction of change in modern (Green Re'olution) agricultural technology is circumscribed in Chart 2 as an outward shift between the directions 1 an 2 ('northeast bound').

The importance of the baseline situation

36. The sustainability issue is always connected with a certain baseline situation which is used as point of reference. An overall characterization of the ecological effects of agriculture in a region should therefore include both the direction of change of agricultural activities, and the static characterization of the total agricultural situation in that region. For example, it is possible that newly introduced agricultural activities in a region are in themselves ecologically neutral (no further deterioration) or even improve the ecological situation (less pollution, restoration of soil fertility), while the totality of agricultural production still remains unsustainable. In a drastically degraded natural area more efforts will be needed to re-establish an ecological balance than would be the case elsewhere.

37. This is best illustrated by looking at the type of agricultural change represented by arrow 3 in Chart 2. At first sight, one would perhaps expect the negative ecological effects to be reduced. Though indeed the probability of this being the case is above 50 per cent, a closer look reveals that such a conjecture does not necessarily hold. Let us suppose that a decrease in the level of agricultural production, by keeping technology constant, occurs, and that land is returned to the free forces of nature. Then it depends on the intensity of previous land degradation and the self-restoring capacity of the area whether the on balance ecological effects are positive. Normally, with cultivated area being cut back, land put to fallow, or livestock populations being reduced, a process of natural reproduction of the capability of the soil takes place. During rest periods the nutrient status of the soil will in many cases be restored. There will be new vegetation formation and sometimes new soil formation. Meanwhile agricultural pollution emission becomes less, so that the overall effect on the environment is an improvement. However, whether this scenario becomes true, depends also on the resilience and sensitivity (cf. section 26) of the land system. The sensitivity of the soil may be such that prior agricultural activity has fundamentally degraded these land systems. If this coincides with a low restorative capacity, only very long fallow periods could perhaps restore the land's original capabilities (to arrive at ecological neutrality). If, however, degraded lands which have a high sensitivity for erosion are left to the free forces of nature, the ultimate result may well be an ecological deterioration due to

subsequent erosion processes.

38. The environmental effects of the four main types of agricultural change that have been summarized in section 35, are not *inherently* positive or negative. It depends on the characteristics of the baseline situation in each production system whether a given agricultural production method is appropriate or not. A method that is perfectly attuned to production situation *A*, may cause serious environmental degradation in production situation *B*. This problem makes it impossible to establish an unconditional link between processes of agricultural change and the subsequent ecological effects.
What can be done, at a conceptual level, is to list the most relevant agri-ecological scenarios. Pollution and resource use effects will be grouped together.[35)] The requirements and tolerance margins of the ecological system in the baseline situation are always decisive. Each type of agricultural change can affect pollution emission and depletable natural resources in a positive, neutral, or negative way. Since our definition of sustainable agriculture requires that environmental effects of agricultural production are *not* negative, positive effects and neutrality can be grouped together under the label *ecologically benign*. We can now construct a matrix of eight main environmental scenarios (Chart 3). The matrix is to be read row-by-row, starting with the four basic types of agricultural change. Whether or not the resulting agricultural practices are sustainable depends on their appropriateness for local conditions.
In Chart 3 the most likely scenario for each category of change is put in italics. Due to the strictness of the sustainability criterion for agricultural methods the probability that more agricultural production (without taking further provisions) will produce scenario B is less than 50 per cent, so that A is the most likely scenario. Similarly, the most likely scenario for more intensive use of external inputs is C. The third row in the matrix (a decrease in agricultural production at constant technology) is a special case, as was argued in the preceding section. The resilience factor of the soils that are laid fallow, ultimately determines whether this practice fosters sustainability or not. In many semi-arid areas or on hill slopes, for instance, natural erosion processes can further degradate the capacity of the land system. Nevertheless, scenario F is supposed to be the most generally valid case. In the case of increased LEIA-orientation the nature of the regional baseline situation is even more decisive with regard to appropriateness. No *a priori* probability value can be attached to scenarios G and H.

<u>Chart 3</u> Environmental scenarios for changes in agricultural activity

DIRECTION OF AGRICULTURAL CHANGE	AGRICULTURAL PRACTICES APPROPRIATE FOR LOCAL AGRI-ECOLOGICAL CONDITIONS ?	
	PRACTICES NOT APPROPRIATE	PRACTICES APPROPRIATE
1. INCREASE IN AGRICULTURAL PRODUCTION BY CONSTANT TECHNOLOGY	**A.** *Ecological effects negative*	**B.** Ecological effects benign
2. MORE INPUT-INTENSIVE AGRICULTURAL PRODUCTION (HEIA+)	**C.** *Ecological effects negative*	**D.** Ecological effects benign
3. DECREASE IN AGRICULTURAL PRODUCTION BY CONSTANT TECHNOLOGY	**E.** Ecological effects negative	**F.** *Natural restorative processes (positive ecological effects*
4. LESS INPUT-INTENSIVE AGRICULTURAL PRODUCTION (LEIA+)	**G.** Ecological effects negative	**H.** Ecological effects benign

IV. A CONCEPTUAL MODEL FOR THE INFLUENCE OF INTERNATIONAL MARKET CONDITIONS ON AGRICULTURAL SUSTAINABILITY

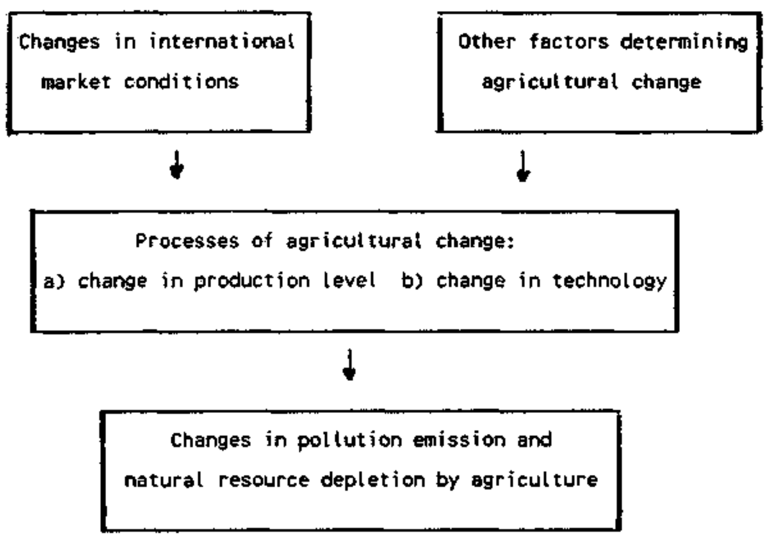
39. The preceding two chapters gave a general overview of the agricultural input-output system in relation to ecological issues and analyzed the relevant types of agricultural change. Building on these elements we can now proceed with the central issue of this paper: how do changes in international market conditions affect resource use and environmental effects in agriculture? To arrive at meaningful answers we will first split up the problem in its constituting causal elements as pictured in Chart 4. Along the lines of this explanatory model, we will first divide the complex central question for this report into three sub-questions:

I How do changes in international market structures relate to other causes of change in agricultural activities?

II How do influences from the international market affect agricultural production?

III How do the selected categories of changes in agricultural activity affect pollution emission and resource depletion?

Chart 4 Basic explanatory model



Causes of change in agricultural activity

40. For a clear understanding of processes of agricultural change it can never be sufficient to look at one causal factor only. To derive changes in pollution emission and natural resource use directly from changes in international market conditions would be even more problematic. Therefore, the latter factor must be considered as being one in a set of determining factors. A multiplicity of factors can invoke changes in agricultural activities:

(a) population growth and associated food demand;
(b) changes in social organization like tenure systems, land entitlements, and ownership relations;
(c) technological innovations in agricultural production techniques;
(d) changes in government policy towards agriculture, e.g. with regard to prices, subsidies, marketing boards, extension, and national food security in general;
(e) activities by pressure groups (ecological movements, consumer organizations, and trade unions);
(f) economic pressures by international suppliers of external inputs;
(g) changes in international market structures and conditions for agricultural outputs.

Though recognizing the importance of factors (a) through (e), they will deliberately be assumed constant here. To analyze all these lines of causation is beyond the scope of this paper. According to our initial question we will concentrate on the two last factors (g and f). Since major suppliers of external inputs (agrochemicals, seeds, production equipment) are often international companies, their policy can in a broad sense be considered as part of international market conditions. This holds especially for most developing countries. So, in this respect factors (f) and (g) can be taken together as '*changes in international market conditions*'. Given changes in international market structures will be taken as a starting point for analyzing their eventual environmental consequences in agriculture.

Market structures and changes in international market conditions

41. Before analyzing the influence of international agricultural markets, it is useful to characterize them in terms of their competitive process. The role of market prices in the competitive process differs among various market structures. In *free* markets supply levels may hectically respond to price changes, and vice versa. In markets with *oligopolistic buyers* (oligopsony) changes in demand volume

by the oligopsonists are more important. In international markets that are largely controlled via vertical integration of limited numbers of large international companies, company strategies are far more important than international market prices. Such market structures are referred to as *closed*, because a small number of parties control both supply and demand.[36] *Segmented* markets ('partly open, partly closed') are those where an important part can be regarded as 'closed' while the rest of international supply and demand is handled more freely, e.g. by commodity exchanges. Finally, the role of price competition can be considerably reduced by government interventions (tariffs, non-tariff barriers). Such market structures are labelled *controlled* - or from a free marketeer's viewpoint 'distorted' - markets. This last market characteristic may to some extent overlap with other criterions. For example, markets can be both controlled/distorted and at the same time be characterised by oligopolistic buyers. Controlled/distorted markets prevail in several international markets for food products, particularly as a consequence of US and EC agricultural trade policy. As an example of this classification 33 international commodity markets (including nine minerals, and forestry products) are clustered in terms of the prevailing competitive situation in Table 4 of the Statistical Annex.[37]

42. Five relevant types of change in international market conditions will be distinguished. The *first* and most obvious case is that of relatively sharp price changes[38] resulting from either supply or demand shocks (or speculative transactions) within a given market structure. When a downturn in agricultural export prices persists for some years, it will have consequences for debt servicing capacities. This, in its turn, urges a growth in export volume and hampers imports of agricultural inputs. The *second* case relates to growing consumer demand for agricultural quality products that have been produced according to high health and/or ecological standards. *Thirdly*, important developments may occur in the way markets are controlled/distorted, be it in the form of quotas, tariffs, or phytosanitary requirements. Shifts in the involvement of large international companies in the production phase of agricultural commodities (e.g. investment in plantation or contract farming) forms the *fourth* relevant category. A *fifth* type of change is represented by the case where pressures by international input suppliers cause a shift in agricultural technology and working practices.

This list is not exhaustive, but contains the most essential changes in international market conditions. The consequences of each category of market changes will now be treated in more detail. Description of the lines of causation closely follows

Chart 5, a flow chart which integrates most preceding elements of the conceptual framework. In Chart 5 the causality direction flows from the top (changes in market conditions) to the bottom, inducing one or more of the four main types of change in agricultural activity (as distinguished in section 35). For a complete picture of the eventual ecological effects Chart 3 with its eight ecological scenarios is complementary to Chart 5.

Considerable change in international market prices

43. A considerable change in international (often dollar-denominated) export prices for agricultural products in principle affects all those involved in the export chain: exporters, trading companies, companies that have farmed out part of their production, farmers, plantation owners, and governments. When equal bargaining positions would prevail, all parties would see their incomes changed by the same proportion. However, due to differences in bargaining power some parties will cash a larger share of international price increases, or pass on a more than proportional share of price decreases to other parties. For instance, companies may be able to pass on a more than proportional share of price decreases to their suppliers. Similarly, plantation companies may react to decreasing prices by forcing down plantation wages or economize on expenses for inputs. Governments that account for a considerable share in agricultural export earnings - by taxes or directly via parastatals, marketing boards, export monopolies - can adjust their share in export earnings.[39] So, a number of intermediary stations exist between world market prices and incomes at farm level. Especially small farmers tend to have weak bargaining positions in an export chain. This means that they will bear nearly the full burden of international price decreases, while cashing only a part of price increases. In the next sections the intermediary complications of bargaining powers in an export chain are ignored and it is assumed that a change in world market prices cause a similar change in farmgate prices.

For clarity's sake it is mentioned here that farmgate prices in itself are not decisive in major production decisions by the producers, but the net income to be obtained by farmers. The difference between farmgate prices and the cost of production, together with the production risks involved, will determine the choice of crops, the level of agricultural production, and the choice of technology used in production. The net income of producers depends on the relative prices of inputs (land, labour, capital and external inputs) and outputs. For agricultural export commodities, the share accruing to the farmers of the export price, is crucial.

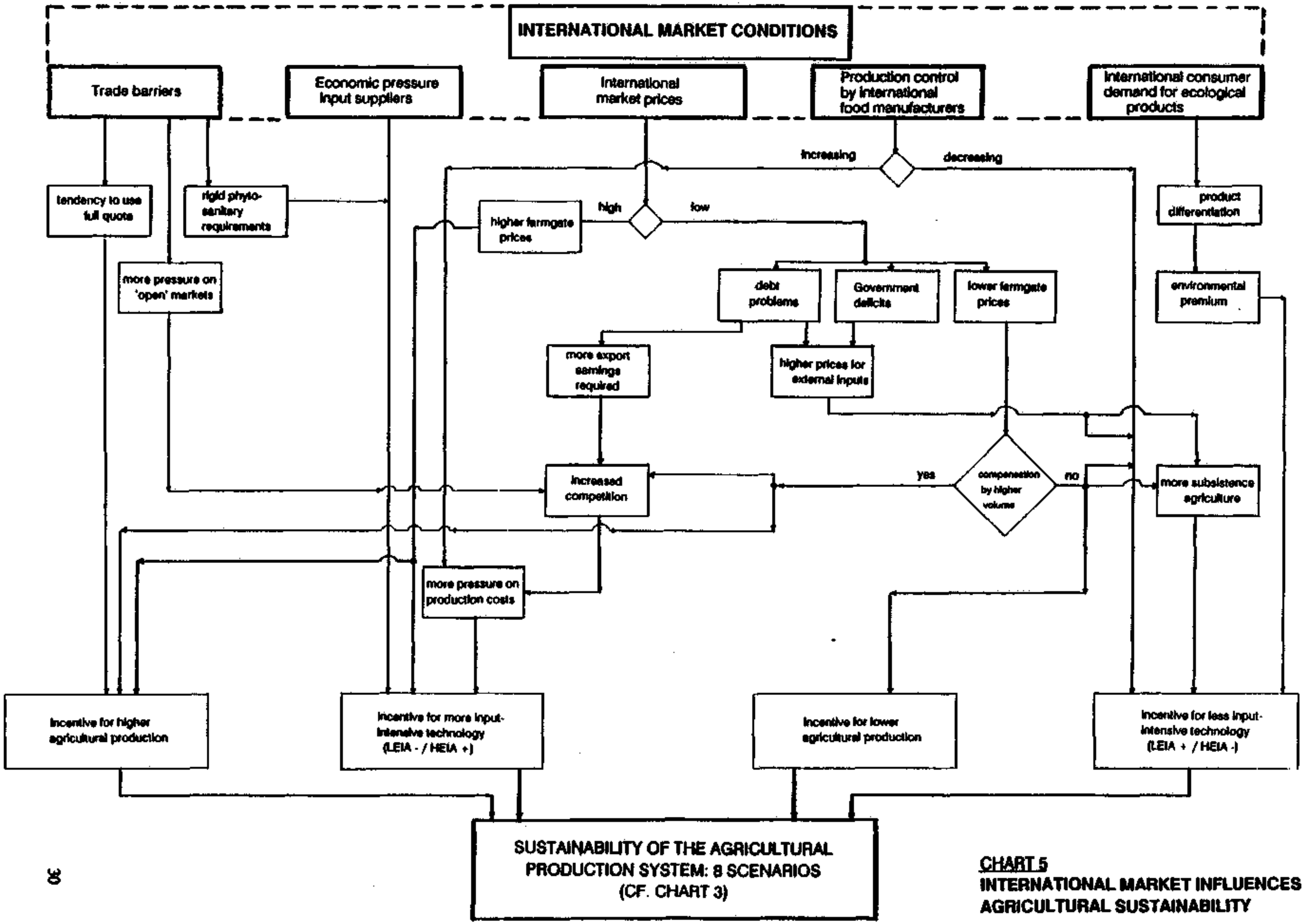


CHART 5
INTERNATIONAL MARKET INFLUENCES ON AGRICULTURAL SUSTAINABILITY

44. If international developments cause a *higher* farmgate price for product A that is dominant in a certain region, this will stimulate a higher production level. The production technology will not necessarily be altered. Growth occurs through larger cultivated areas, larger herds, more labour and more use of external inputs. Associated pollution will increase as well, while cultivation or grazing areas tend to further encroach natural landscapes. The latter effect will not occur when (crop) substitution takes place, so that areas which were previously cultivated with other crops, are converted to cultivation of product A. However, by this development regional monoculture tendencies will be enhanced, thus increasing the vulnerability for pests, and, consequently, the use of pesticides. Of course, environmental consequences depend on the nature of the agricultural methods applied, but the likelihood that the ecology is negatively affected by more pollution and/or natural resource depletion will be significant.

An increase in farmgate prices may also invoke a larger use of external inputs by relaxing the financial constraint that hitherto prevented producers from buying external inputs. Consequently, agricultural methods would become more HEIA-oriented.[40)]

45. The causal chain from a *lower* international price is more complex. Three first-order effects can be discerned. An initial effect will be a fall in farmgate prices. How farmers will react to this depends on their situation. Since they will have been accustomed to some price variation they will probably not immediately respond in their production and investment decisions. When the price decrease appears not be of a short-term nature, they tend to lower production and investment for this product. If diversification into other cash crops is not a viable alternative, environmental pressure tends to be reduced. Otherwise it depends on the comparative ecological characteristics of both products what will be the overall environmental effect.

In regions dominated by monocultures where alternative income opportunities are lacking, the farmer's response will be different. They tend to increase production in order to compensate lower income margins by higher volumes.[41)] Monocroppers will not continue this response infinitely when prices remain falling. Below some price level they will completely step out and - as will often be the case in developing countries - shift to subsistence agriculture. Subsistence agriculture - due to budget constraints - often makes few use of external inputs. LEIA agriculture will gain importance. To the extent that external inputs (like pesticides) are substituted by more labour use, the environmental consequences are positive. However, it can also imply unsustainable exhaustion of the soil structure and erosion. No generalized statement can be made *a priori* about the ultimate environmental consequences of increased subsistence agriculture, though it often coincides with rural poverty and population pressure that strain the use of local natural resources.

A second main effect of a fall in international prices is its depressing effect on government incomes. If government deficits increase, cuts in subsidy programmes for agricultural inputs (fertilizers, pesticides) become likely to take place. In countries where adjustment programmes of IMF and World Bank are implemented such subsidy cuts often form part of the adjustment package. Lower subsidies for agricultural inputs increase procurement costs for farmers and induce farmers to apply more LEIA-oriented agricultural methods.

A third effect of lower prices occurs through its balance of payment effect. If a period of low export prices for agricultural commodities lasts for some years it aggravates debt servicing problems. In many developing countries a dominant response has been the curtailment of imports. Imports of foreign manufactured inputs for the agricultural sector (agrochemicals, machinery, spare parts) are hampered, so that they become less available and more expensive. This also contributes to more LEIA-oriented agricultural methods.

46. Serious debt servicing problems in countries whose export earnings depend to a large extent on one or a few agricultural commodities, produce a similar reaction to price decreases as in the case of monocrop farmers: when export alternatives are not available they tend to produce more rather than less of the product. The period of low prices since 1980 urged many countries to export larger volumes of agricultural commodities in order to finance their import needs and debt. Readjustment pressure by IMF and World Bank strengthened this type of behaviour.[42)] In slowly or hardly growing world markets increased export earnings for a country can only be arrived at by increasing the country's share in the international market. Because a competitive edge requires a low cost price level and therefore high productivity, an incentive exists to increase agricultural yields by using more external inputs. Export agriculture will become more HEIA-oriented. If import constraints are operative for agricultural inputs, the export agriculture sector tends to be treated with marked preference at the cost of (food) production for the domestic market. The domestic food sector will be forced in a more LEIA-orientated direction.

International consumer demand for ecological quality products

47. A hesitant, but steady growth can be registered in the demand for agricultural products that have been produced under ecologically sound conditions. Such quality niches in demand, often stemming from middle and high income consumers in OECD countries, are related to avoidance of health hazards, especially in regard to pesticide residues.[43)] In this market segment a willingness to pay for ecological quality products exists. It offers importing companies (trading companies, manufacturers) an opportunity to fetch a price mark-up ('environmental premium'), so that it becomes profitable to sell such quality products. Large food retailing companies in OECD countries grasped this demand tendency and, where necessary, organized the international supply lines for such products by themselves. To the extent that this demand tendency persists or even gains further momentum, transnational manufacturers, importers or large food retailing companies will increasingly set ecological quality standards for agricultural products.[44)] In the longer run they will have to pass on parts of the environmental premium to persuade farmers to apply ecologically more sound methods and apply less, or less toxic agrochemicals. Farmers are remunerated for employing ecologically-sound methods. This tendency presents a growth opportunity for LEIA-oriented types of agricultural production.

Changes in 'controlled' international markets

48. Competition in international agricultural markets is to a large extent distorted by market intervention of major OECD countries. US agricultural policy and the Common Agricultural Policy of the EC have far-reaching consequences for world agricultural markets. They influence both agricultural export opportunities and domestic food security policy in many developing countries, by protecting their home markets and practising subsidized dumping of their agricultural surpluses at the world market.

For developing countries market access in principal markets are negatively affected by tariff and non-tariff barriers. Though tariff barriers still play an important role, and especially for manufactured agricultural products, non-tariff barriers have become relatively more important since the GATT Tokyo Round. Export of manufactured agricultural products to the EC countries, the USA and Japan are seriously hampered by a policy of tariff escalation for processed products.[45)] Non-tariff barriers (NTB's) have many faces, like import licensing, quotas, preferential tariffs, 'voluntary export restraints', and (phyto)sanitary regulations.

Introduction of NTB's can affect agricultural production in exporting countries in several ways, depending on their form and the conditions they contain. Generalized statements about their environmental effects do not make sense, therefore. Nevertheless, we can follow three cases.

* If a preferential tariff is levied on quota-exports, while additional export volume is charged a much higher tariff, commodity exports tend to be reduced to the quota volume. Agricultural production diminishes, but before this happens producers will seek alternative export outlets. Competition in 'open' export markets becomes more intense. To gain market share there, prices and cost levels come under pressure. To boost productivity an increase in the use of external inputs ('HEIA-orientation') will often be the result.

* If the quotum level exceeds current export levels a tendency will arise to use the full quota with their attractive tariff rate. Agricultural production levels will increase.

* Current phytosanitary regulations in a number of countries are very strict in terms of surviving pests in agricultural export shipments. Such regulations thus tend to reinforce the application of insecticides, fungicides and herbicides. A relaxation of phytosanitary import requirements will probably lower pesticide use in exporting countries, while a tightening of such requirements has the opposite effect.

<u>Production policy of large international food manufacturers</u>

49. In international agricultural markets which are characterized by oligopolistic buyers, or which are (wholly or partly) 'closed' due to vertical integration by large international food manufacturers, sudden shifts in the procurement policy of these firms may strongly affect exporting countries and their farmers. These large international food processors can arrange their primary commodity input by free market contract (via commodity exchanges), by hierarchical control (contract farming, outgrower schemes, subcontracting), or by complete vertical integration (direct investment in plantations). In the first option farmers are left free in their production decisions and in the production methods they wish to apply. In the second option farmers lose part of their freedom of decision in exchange for guaranteed sales conditions. In this situation the outcontractor often contractually prescribes production methods, like pesticide spraying, and sometimes even supplies (credits for) such external inputs. In the third option the food processor invests in plantations and acquires full responsibility for the choice of production methods. Ample evidence suggests that, relative to small farmers, plantations apply more agrochemical inputs, mechanized equipment, and fossil energy for traction and transport. With each further step in direct production control by large international firms, the HEIA-orientation of methods tends to increase.

Pressures by international input suppliers

50. A final category of international market influence is represented by sales promotion efforts of suppliers of agricultural inputs. Worldwide concentration in important agricultural input industries is often very high and sales promotion plays a crucial role in the competition process. Ten major multinational corporations (Ciba-Geigy, Bayer, ICI, Rhone Poulenc, Du Pont, Monsanto, Dow/Elanco, Hoechst, BASF and Shell, all with sales of $1 billion or more) account for 77% of world pesticide sales, totalling $21.5 billion in 1989.[46)] Pesticides forms an important growth sector for the chemical industry. In 1988 and 1989 world market sale grew by 3% each year. For the years 1990-1995 growth is expected to be lower, with forecasts ranging from 1 to 3% per year. Reductions in the use of pesticides are expected for the EC, USA and Japan, while the developing countries constitute the major growth markets. For Brazil (already a major consumer) and India growth rates of over 5% a year are expected in the early 1990s.[47)]

The combined sales efforts of these companies (including their influence on extension programmes) represent a formidable force behind the promotion of agricultural techniques and working practices that make intensive use of external inputs. They spent, for instance, in 1988 $ 55 million on promoting rice pesticides by advertizing, while the rice insecticide market for the nine main rice producing countries amounts to approximately $ 350 million (Blackwell 1991). Agricultural input suppliers increasingly sell integrated packages of seeds (often hybrids, or specially treated, sometimes by DNA recombinant techniques), fertilizers and pesticides (cf. Section 29).

V. MARKET STRUCTURES, RESOURCE USE AND ENVIRONMENT IN SELECTED AGRI-ECOLOGICAL SYSTEMS: CASE STUDIES

51. In this Chapter we present six case studies which are selected in order to provide relevant examples of the relationship between international market structures and the resource use intensity and environmental effects of the production concerned. By including different types of agricultural products and production systems, which are not restricted solely to commodity production in the developing world, we hope to present a sufficiently wide spectre in order to provide a fruitful basis for the discussion of the central issue of this report. The case studies are the following:

(A) the livestock sector in Botswana,
(B) cotton production in South Mali,
(C) tapioca production in Thailand,
(D) cocoa production,
(E) the Dutch agricultural sector, and
(F) gum arabic production in Sudan.

52. The case studies intentionally do not include qualitative judgements as to the *developmental* sustainability of the production of the commodity in question, or of the type of agricultural system concerned. Firstly, the issue of food security in relation to the production of export commodities must be taken into account, before the agro-economic desirability of the production of the commodity in question can be assessed. But secondly, the socio-economic, political and cultural situation of the producing region in question would have to be taken into account as well to make such judgements possible. In this respect the participation of the communities involved and the situation with regards to feasible alternative employment and income opportunities can be mentioned. But the working conditions of farm labourers on plantations, of farmers (male, female or children which may have to provide unpaid child labour) must then also be discussed. These questions are considered to be outside the direct scope of this report.

A. LIVESTOCK IN BOTSWANA

Description of the agricultural product and the production region

53. Botswana is a land-locked country in Southern Africa in the semi-arid zone, with sparse, erratic rainfall and recurring periods of drought. Two-thirds of the country consists of the semi-desert Kalahari (the 'Sandveld'), a very vulnerable natural environment. The eastern area has more rainfall and accomodates 85 per cent of the population and 80 per cent of the cattle. The Okavango delta, an inland swamp in north-western Botswana, is one of the most remarkable wildlife areas of the world. Botswana achieves high growth rates and is ranked in the World Bank classification as a lower middle-income country. The major part of the high growth rates accrue from the boom of the mineral sector (diamonds, copper-nickel and coal). Livestock, and mainly cattle, is the most important agricultural sector. Meat exports come second to diamonds as export revenue earnings.

Botswana's number of cattle increased from just over one million at the time of independence in 1966 to some three million in 1981. The number was reduced to approx. 2.5 million in the last major drought from 1982 to 1986, and is growing again since then. Sustainable herd size is estimated at 1 to 1.5 million head of cattle.[48)] Cattle-ownership is very skewed. According to official statistics 110 commercial ranchers (representing 0.2 per cent of all cattle-owners) own the same number of cattle as the 28.500 traditional owners (representing 55 per cent of the cattle-owners). In reality cattle distribution may be even more unequal, as the wealthier farmers have better access to water and fodder subsidies in years of drought, and the mortality rates for their herds were subsequently lower in the last major drought than for the herds of smaller owners. 45 per cent of households are estimated not to own any cattle at all. Many cattle are owned by absentee owners in towns, and the large cattle owners are politically very influential. Cattle have a high cultural importance and perform many functions (such as a form of savings, old age insurance, status symbol, a valuable asset which can be turned into cash) in Botswana's society. In other words, cattle have more than economic significance.

Resource use of Botswana's livestock sector

54. There are two major environmental/resource use problems connected with Botswana's livestock sector.

A. Overstocking of cattle, i.e. animal numbers in excess of the range's carrying capacity, on fragile soils has led to overgrazing and land degradation. Overgrazing appears to be common throughout Botswana. The spread of boreholes into the

Kalahari, has led to the disappearance of perennial grasses and to bush encroachment in the area around the boreholes. The scarcity of accessible water causes pressure on groundwater levels. Most studies agree that, though the absolute contribution of overstocking to range degradation cannot be assessed, improved range management is required. The environmental problems related to overgrazing were exacerbated by the years of drought.

B. Cattle conflict with wildlife in terms of competition for grazing resources, water and through the effects of veterinary cordon fences on migratory animals. Though there is controversy as to the exact amount of interference with migration patterns of wild animals by the erection of cattle fences and their contribution to mortality, nobody denies this interference. In 1981 plans were made to erect a fence in the Western part of the Okavango to separate domestic catlle from wildlife, in order to control foot-and-mouth disease and meet EC-requirements. As wild buffaloes harbour foot-and-mouth disease, they can spread the disease to cattle. Recently there was a controversy between people from the Okavango District and the government over plans to divert water from the Okavango to the Orapa diamond mine and over the extension of the buffalo fence, which would enable livestock to spread further into the Okavango. For the inhabitants of the Okavango district wildlife and the swamps (e.g. in the form of fish and tourism) form their main source of income.

Another feature of this conflict between cattle and wildlife is the extensive programme to combat the tse-tse fly in Northern Botswana. There has been controversy about the use of dieldrins and other insecticides, such as DDT. Also here, the danger is that if the Okavango delta is freed of the tse-tse fly, human beings and cattle will move in, which subsequently can result in desertification of the marginal lands.

Constraints to sustainable livestock production

55. Government support for the livestock sector is extensive. Government policy directly encourages livestock ownership through fiscal incentives to overstock. As losses in agriculture may be written off against income from other activities, there is no incentive to manage herds to maximize pre-tax gains. Furthermore, inputs like veterinary fences and veterinary services in general, are subsidized, and extension services, research and slaughterhouse facilities are also provided by the government. Moreover prices tend to be lowest at the onset of the dry season, providing no incentive to sell at that point, despite the fact that it would avoid cattle making demands on the rangeland environment at its most susceptible time (Pearce et al. 1990: Ch.7).

Botswana's cattle industry also received substantial international loans. The World Bank in particular has been blamed for making available $18 million in loans for the livestock industry aimed at increasing exports (Inger 1991; and Payer 1982).

The Tribal Grazing Land Policy (TGLP) of 1975 aimed to improve cattle management and herd productivity, to protect the small cattle owners and those who have no cattle at all, and to control overgrazing on the common land by privatizing part of the common land, under leasehold arrangements. Most commentators agree that the policy failed due to lack of ranch development (fencing and water supplies), poor supervision of herds due to absenteeism, the continuation of traditional management practices and the continued application of 'dual rights'. TGLP ranchers did not give up their rights to the communal land, whereby they could degrade their leasehold land and then move their cattle on to the common land and wait for the overgrazed land to restore itself. By doing so, ecological pressure on the communal lands was further aggravated. Furthermore, hardly no land has been set aside as reserve lands. Moreover, the assumption of the TGLP that the lands to be fenced into ranches were 'empty' proved to be not correct. These lands proved to be populated and already had boreholes, causing those herds to be moved into the remaining communal areas (Inger 1991).

"It seems clear that only a policy which effectively addresses the use and land tenure rights of cattle owners, and which deals with the incentives to overstock, can succeed. (...) But if *communities* could be given rights of exclusion over defined areas of grazing land, then the principle of communal land tenure can be preserved while avoiding the worst excesses of open access resource use. Indeed the aim should be to establish common property in its true sense, as a form of defined communal ownership, and prevent *de facto* open access use whereby anyone can lay claim to grazing rights."[49)] The Botswana National Conservation Strategy, sponsored by the United Nations Environmental Programme (UNEP) and the International Union for the Conservation of Nature (IUCN), which took some ten years before finally being approved by Parliament, does not look too hopeful either in this respect:

"*Rangeland pasture degradation*. Of all the issues, this is recognized to be the one which is the hardest to resolve. In relation to that degradation which is caused for by over-stocking of livestock, the solutions have generally been known for a considerable time. However, many of them run counter both to traditional customs and to the right of Batswana [the inhabitants of Botswana, H.K./R.S.] under the Constitution. Progress in implementing such solutions is likely to be slow. Nonetheless, they are included as part of the overall package, since Government is, in principle, committed to solving the problem in the longer term."[50)]

A 1990-policy paper by the Ministry of Agriculture of Botswana proposes that this should take the form of allowing individuals to fence in the communal areas, which would mean a further de facto transfer of communal lands into private hands. This proposal, it is feared, could result in a land grab by the larger cattle owners. The policy paper recognizes that there is hardly any difference between traditional communal and ranching on TGLP-farms, and recognizes the need to abolish dual grazing rights. It does not, however, commit itself to any action in the latter aspect.[51)]

The influence of international market structures of beef on resource use and environment in Botswana

56. The state-owned Botswana Meat Commission (BMC) operates abattoirs in Lobatse, Maun and Francistown and has a monopoly over meat-exports. Some 70 per cent of beef production is exported to the EC at prices considerably higher than world market prices. Botswana beef receives preferential treatment under the Lomé Convention. EC imports of beef from Botswana representing less than 0.5 per cent of consumption, constitute a negligible quantity for the EC. Under Lomé IV (1989) Botswana's quotum was set at 18,916 tonnes of beef and veal (Fourth ACP-EEC Convention, signed in Lomé on 15 December 1989). Lomé allows a 90% import levy rebate, on the condition that Botswana imposes an export levy of the same quantitude. In February 1980 a short outbreak of foot-and-mouth disease resulted in the closure of the EC-market to Botswana beef, which lasted until January 1981. Botswana can generally meet the strict EC regulations, and has an advantage over other Lomé signatories. Some ten per cent of beef exports go to South Africa, also at prices above world market levels. Despite Botswana's membership of the Southern African Customs Association (also comprising South Africa, Lesotho and Swaziland), beef exports to South Africa are restricted by quota.

Botswana pursues a policy of increasing domestic value-added in the livestock sector. At Lobatse a cannery for corned beef and a tannery, with a capacity of 1,200 hides a day, were opened in 1980. Shortly afterwards, a pet food cannery started production. (In London (U.K.) BMC operates a cold store.) Another cannery is operated at Maun abattoir. The Botswana Vaccine Institute, producing foot-and-mouth vaccines, became operational in 1982, and exports a considerable part of vaccine production.

BMC is highly profitable, and the bulk of the profits are distributed to the suppliers of the cattle. The funds accruing to Botswana by the EC import levy rebate (in the form of export levies) are also distributed to cattle owners: the preferential treatment under development co-operation therefore mainly benefits the larger cattle owners and in fact constitutes a subsidy to them (Veenendaal & Opschoor 1986). Apparently, the European Community attempted to persuade Botswana to use these funds for environmental protection measures aimed at redressing the environmental problems related to the livestock sector in Botswana (Van Amstel et al. 1987: 66). Up till now these attempts met with no success.

Discussion of the Botswana case

57. Botswana's environmental problems related to the livestock sector are not caused by low commodity prices, on the contary, the relatively high prices due to the preferential exports to the EC and to South Africa seem to have contributed to these environmental problems. These formed an incentive to increase herd sizes. Pearce et al. (1990) contend that resource conservation considerations suggest a lowering of these administered prices and a reduction in the subsidies and tax allowances. Others, however, doubt that lowering the commodity price, will lead to a substantial reduction in the total number of cattle (Veenendaal & Opschoor 1986; interview D. Inger).

It may be argued that due to the large proportion of exports under preferential prices, Botswana benefits more from the EC-Lomé convention, than it is hurt by the consequently lower prices it receives for the rest of its exports due to the depressed world market prices, which result from the subsidized beef exports of the EC. The over-dependence on the EC-market for beef exports poses great risks for Botswana's livestock sector if the European outlet were ever reduced, or even cut-off altogether. The EC became self-sufficient in the eightees; protection of the EC market from imports and guaranteed internal prices, artificially higher than world market prices, led to a substantial surplus production, which are exported with export subsidies.[52)]

Since the current, favourable export markets for Botswana's beef, contributed to the environmental problems under consideration, policy measures must attempt to redress the environmental damage caused by the overstocking of cattle. Government policy up till now has not been successful in addressing this issue. EC pressure to divert at least part of the benefits accruing to Botswana thanks to preferential access into the EC away from the cattle owners and into environmental protection measures has not been successful either. It has been commented, that maybe the EC did not try hard enough.

Failure to take appropriate measures, may in the longer run lead to forced reduction of cattle and to less productivity of the herd. The danger, therefore, is that due to short term encouragement of beef exports, in the longer term trade may become endangered through environmental problems caused by present export production. It may be feared that the main burden of environmental problems will be more severe on the poorer sections of the population (Veenendaal & Opschoor 1986). Cattle density on communal grounds reached alarming proportions, which also had consequences for the non-cattle owning population. As was already mentioned, the smaller cattle owners suffered more in the last drought, than the richer cattle owners.

B. COTTON PRODUCTION IN SOUTH MALI: RESOURCE USE AND ENVIRONMENT UNDER INTENSIFICATION OF AGRICULTURE

Description of the agricultural product and production region

58. Cotton is one of the most important agricultural export earning commodities for developing countries, together with sugar, coffee, natural rubber and cocoa. Large scale production of cotton is known for the extensive use of pesticides in production.[53)] In several West African countries cash-crop production of cotton was stimulated in the 1950's and 1960's by the CFDT (Compagnie Française pour le Développement des Textiles). National 'cotton companies' formed after independence, further stimulated cash-crop cotton production, with continued support of the CFDT. An 'integrated approach', whereby the development of cotton production was promoted in all its aspects. The following services were provided:

* extension services,
* organization of the supply of inputs (such as, fertilizers and pesticides) and (both seasonal and investment) agricultural credit,
* introduction of improved plant varieties and new techniques,
* provision of equipment,
* purchase and processing of cotton,
* marketing (including exporting) of fibre, cotton seed and cotton cake.

An important aspect was the guaranteeing of a season's price and of marketing outlets. The national cotton companies worked through village associations, which gradually take over more and more of the activities of the extension workers (Mahdavi 1985). Cash-crop production of cotton was set up according to 'crop intensification'-methods, and included the use of fertilizer, pesticides, agricultural machinery and appropriate techniques. E.g., row cultivation and single cropping were introduced, which made the use of draught animals and mechanization possible and allowed that different crops were given different (fertilizer and pesticide spraying) treatment. In the case of cotton, it was recommended to apply 50 to 100 kilograms of fertilizer per hectare, and use pesticides, weed killers and mechanized weeding.

The introduction of new agricultural techniques destroyed deeply rooted traditions which had allowed societies to survive and develop in an environment often hostile and difficult to control. E.g. the habit of interplanting had been a rational response to local circumstances (Mahdavi 1985:8). It ensured that the land was in use over the longest possible time, that harvesting would be spread out and more manageable, that risks of adverse weather and pests were spread over several crops, and that advantage was taken of the fact that certain plants complement one another and control soil erosion when they are grown together. Furthermore, the women who were responsible for sowing and weeding could keep an eye on their babies while working.

Gradually, the cotton companies developed into 'integrated rural development institutions', set up literacy and health care programmes, started distributing food-crop seeds and expanded extension work to include these and other crops (forage crops) and improved stockraising as well. Technology introduced for the production of cotton were used for other agricultural activities as well.

Resource use in cotton production in South Mali

59. CFDT started operations in two districts in South Mali (Ségou and Sikasso) in 1964. In 1974 the state organization CMDT (Compagnie Malienne pour le Développement des Textiles) was formed. Productivity increased considerably, especially in the cultivation of cotton. The area on which maize, sorghum and millet were cultivated expanded considerably as well (Sada Sy & Yero Bah 1985). The CMDT had followed the same approach, as described above. In this case not only cash crop production of cotton was stimulated, but the cultivation of maize as a cash crop was stimulated as well. CMDT made inputs (fertilizer and improved maize varieties) available through credit in kind. For cotton, the guaranteed price was made known before the agricultural season, and input delivery, production credit in kind and output marketing channels were well developed (Berckmoes et al. 1988). The CMDT is at present responsible for total rural production, including animal husbandry. Rural development as such has become the final goal: crop diversification, public health, literacy, erosion control and the position of women

are all receiving attention (Breman 1990: 279).

In South Mali soil fertility is a major physical constraint on the growth of agricultural production. Therefore yields are lower than theoretically possible. Demographic pressure leads to high level of food (and income) requirements for the population, which in turn also results in overexploitation of the natural environment. The traditional method to restore soil fertility, the slash-and-burn production system with long fallow periods, was abandoned. Slash-and-burn is still practiced, but the fallow periods are shortened; actual area cultivated is significantly higher than the 20% which can be cultivated under the slash-and-burn method without degrading and eroding the soil (Berckmoes et al. 1988). The agricultural activities of the CFDT and the CMDT were backed up by research, which was, among others, directed at protection of the fertility of the soil (Sada Sy & Yero Bah 1985).

A farming systems research study in the Sikasso-district of South Mali (Berckmoes et al. 1988) stated that assured food-self sufficiency can be combined with less desertification, and intensified crop and animal production. A better integration of these two forms of agriculture is required for this. In the area studied larger farmers considerably expanded their cultivated area from 1978 to 1983. At the same time they intensified crop production through the use of chemical inputs, and especially fertilizers, which are thought to be a prerequisite for sustainable agriculture in South Mali and other Sahel areas, since it can improve soil fertility, or keep it at sufficient levels. The nutrient balance of the soil is negative and manure did not prove to be the solution: even if all possibilities of increasing manure production were used, then the amount of manure would not even cover a third of what is needed. Therefore, soil fertility can only be maintained by additional imports of nutrients into the agro-ecological system, or by decreasing the cultivated area. Alternatives to fertilizer, like for instance agro-forestry, are -as in many other developing countries- more expensive to implement.[54)]

Production of the other food crops grown in the area (sorghum, millet and some rice and groundnuts) remained LEIA-oriented (with no application of inputs). The largest increase in cultivated area was due to the expansion of cotton cultivation. Another development was the accelerated investment in draught animals. Animal traction further contributed to the expansion of cultivated area. The attempts to increase cereal and cotton production by intensifying production methods is put forward as evidence that cash crop production (in this case of cotton) can be the motor for agricultural development. It was proved that artificial fertilizers -overcoming soil fertility constraints- could be used cost-effectively in cotton production.[55)] Increased revenues from cotton production contributed to the expansion of the use of animal traction. The intensification of production led to excellent yields in 1982.

The farming systems research study noted that the group of the larger farmers were best capable of implementing the desired type of agricultural intensification. Economic risks had become higher due to the increased dependency on resources external to the farming system, which are outside the control of the farmers. Their larger financial, labour and animal traction resources enable them to respond more rapidly to changes by altering their production strategy than smaller farmers. In practice, they also have much more access to arable and grazing land. The position of small farmers, especially those that do not dispose of animal traction, is much more difficult, as most of them are not self-sufficient in food and are much more limited in production (strategy) alternatives. Their position is imminent to become more marginalized (Berckmoes et al. 1988). Breman (1990) also notes a growing inequality between (groups of) farmers.

Constraints to sustainable cultivation of cotton: international market conditions and government policy

60. Since 1983 the area planted with cotton was further expanded, but the application of chemical inputs decreased. At first, two low production years, caused by unfavourable rainfall, induced the farmers to lower production risks by reducing production costs per unit area. The more LEIA-oriented farming practices were further reinforced by a deterioration of the cotton price vis-à-vis input prices in subsequent years.[56)] Higher prices of pesticides and fertilizers on the local market and a fall in world market prices for cotton fibre in the mid eightees, caused CMDT to change its policy to one aimed at limiting the cotton area.[57)]

The substantial deterioration of the external debt situation of Mali -increasing by more than 500% in the decade up to 1986- will have contributed to the CMDT change of policy (Unctad 1989: table 43a). As there were no alternative cash crops, evasion by farmers of the area targets for cotton production were likely, by compensating reduced inputs per unit area through a further expansion of the area planted. This had a -further- negative impact on grain yields as well.

As of 1986 CMDT also stopped commercializing cereals, when the cereal market was liberalized. The guarantee price for maize was abolished. Production credits for maize, which had to be repaid at the moment of sale of the crop, were no longer made available. Fertilizer for maize could only be bought against immediate payment. Application of fertilizer subsequently diminished for maize production as well (Berckmoes et al. 1988).

In Mali the whole cotton grain is bought by one central factory, which separates the cotton fibre and the by-product cotton seed. Since all the nutrients of the cotton are in the cotton seed, and not in the fibre, sustaining of the nutrients balance of the soil can be achieved by keeping the cotton seed in the agro-ecological system. In many countries, including Mali, cotton seed is often sold outside the country as animal feed. In Mali farmers can buy back the cotton seed, but recently richer livestock farmers near urban areas buy most of the cotton seed. The reason for this is the implementation of donor financed projects, which promote intensive livestock rearing aimed at producing milk for supplying urban areas. Richer farmers seized this opportunity by investing in dairy cattle. Under the terms of the dairy programme, the cotton factory is obliged to sell the cotton seed at unremunerative prices to dairy farmers, and furthermore the dairy farmers obtain an artificially high price for the milk. The donor funded dairy programme is therefore based on two 'artificially' favourable prices. But the result is that the cotton seed is not used in South Mali, and is therefore not kept in the agro-ecological system there, which in turn leads to more pressure on the nutrients balance (interview, H. Breman). Exports of peanut cake outside the region has the same effect (Breman 1990).

Discussion of the South Mali cotton case

61. As information about the environmental consequences of the use of pesticides was not available to us at the time of writing, no absolute conclusions can be drawn as to the environmental sustainability of cotton production in South Mali. Also from an equity point of view questions can be raised about the direction intensified agricultural production is taking. The larger farmers responded favourably to the intensification of cotton and maize production in the area concerned. The smaller farmers could make considerably less use of increased external inputs.
If we limit the discussion to the use of fertilizer then the case of cotton production in South Mali is an example where the relationship between developments on the world market and the use of inputs -and in that sense the sustainability of agricultural production as well- can be shown. Several experts consider the use of chemical fertilizers necessary for overcoming soil fertility constraints in agricultural production in South Mali, since manure production is not in sufficient supply. The CMDT had encouraged cash crop production and application of external inputs for the production of cotton and maize, and not for other food crops. More HEIA-oriented production proved to be cost-effective for the farmers as long as price guarantees and institutional support (attractive credit facilities, extension services, marketing channels) were provided. Due to lower world market prices for cotton, the use of fertilizer in cotton production was reduced to a level below the quality

required to maintain the nutrient balance of the soil and limit the process of desertification. In the production of maize the amounts of fertilizer used were reduced as well due to the liberalization of the cereal market and the subsequent fall in prices, which also put in jeopardy the assurance of food-self sufficiency (Berckmoes et al. 1988).
World market prices for cotton fibre are outside the control of Mali. Domestic cereal prices can be controlled, but liberalization of the cereal market made an end to guaranteed prices. Risks are therefore great that when prices for agricultural products are low the nutrients balance of the soil in South Mali will deteriorate further, if cultivated area is not reduced. Furthermore, use of cotton seed as animal feed in dairy production meant to supply urban areas, means that the nutrients are not kept in the agro-ecological system of South Mali. Use of subsidies for application in both food crop and cash crop cultivation might be helpful in this respect, alongside with proper extension and regulatory methods. When farmers are guaranteed satisfying income levels, government agencies can better make demands about desired agricultural practices. More HEIA-orientation would in this case be beneficial for the environment.

C. TAPIOCA PRODUCTION IN THAILAND

Description of the product and the product region

62. Tapioca, also known as cassava or manioc, is a major source of human nutrition in the tropics. In the Northeastern Region of Thailand, however, it is grown as a cash crop, mainly for export to the EC where it is used as an animal feed component. Thailand has a dominant position on the world market for tapioca, with approx. 80% of world exports, half of which is exported to the European Community.
Tapioca production increased dramatically from the mid 1960s onwards and covers an area of 1.5 million hectares, or 7% of total agricultural land. Including those involved in transport, trade and processing, some five million people are -directly or indirectly- dependent on tapioca for their livelihood. Yearly production is about 20 million tonnes of tubers, or approx. 8 million of the exported tapioca

pellets. Almost all tapioca is produced on small farms of less than 6.5 hectares. Income from tapioca represents 40% of total income for the average farmers, up to 80% for the poorest who have few other sources of income. Tapioca is the most secure and profitable crop for the often very poor farmers concerned. Other income alternatives outside agriculture are virtually absent in Northeast Thailand (Van Amstel et al. 1986).

Resource use in the tapioca production of Thailand

63. Tapioca production is well suited for the marginal soils in the Northeastern area of Thailand. This is because it still gives a reasonable crop on the very poor soils, does not need much water and can survive periods of drought; it does not require much specific knowledge, nor high investments, and has a flexible harvesting time and labour requirements fit in well with other crops. Furthermore, tapioca production appears not to have been a major cause of deforestation in the region: forest areas were opened up by logging companies or was the result of uncontrolled cutting for firewood and charcoal production (Van Amstel et al. 1986). Continuation of tapioca production means that farmers do not have to move away to newly deforestated lands as would have been the case when alternative crops were grown: i.e. other crops would need a larger area to be farmed. Moreover, tapioca probably contributes less to erosion of the soil than alternative crops, and scattered evidence suggests that planting of other crops would accelerate decreasing soil fertility. When tapioca exports would become impossible, environmental problems in the area very likely will increase. Experiments aiming at diversification of farming activities in Northeastern Thailand appear not to be very successful up till now. However, current production methods for tapioca production in Thailand further exhaust the already marginal soil, and production can still not be described as sustainable. Permanent cropping gradually takes out the remaining nutrients from the soil, and it would take long fallow periods for soil fertility to recover. Productivity of the soil decreases and yields fall after some years of permanent tapioca production, to remain fairly constant for a longer period beyond that point.(NIO-Association 1990). Production of tapioca could be made sustainable by using sufficient amounts of fertilizer and by anti-erosion measures.[58)]

Constraints to sustainable cultivation

64. The land tenure system is such that few farmers have legal rights to their land. Therefore, they have hardly any incentive to use more sustainable farming practices and to improve the quality of the land. Soil conservation or improvement

by fallow periods or application of fertilizers at the moment are too expensive for the farmers concerned. Us· of fertilizers increases production costs. Since the price of tapioca is mainly linked to EC-grain prices and outside control of the producers, it will only result in higher income margins for the farmers, if increases in tapioca output is higher than the costs of the required inputs. Furthermore, experiments in the area did not unequivocally prove that application of fertilizer leads to higher yields in the short term (NIO-Association 1990). Therefore, risks involved for the farmers concerned are great. The conclusion is, that, though production of tapioca could be made (more) sustainable by using sufficient amounts of fertilizer and by anti-erosion measures, the incentives for the farmers are very limited indeed.

The influence of international market structures on resource use and environment

65. Production of tapioca in the Northeastern Region of Thailand and its subsequent export to the EC as one of the animal feed components, is a direct, but unforeseen, result of the (levy structure of the) Common Agricultural Policy of the EC. When the EC introduced guaranteed prices for cereals in 1963, animal feed producers in the EC intensified their search for grain substitutes. A mixture of tapioca and soyabean meal -with respectively 6 and 0 per cent import tax- proved cheaper than both imported maize (which has higher import levies) and domestically produced cereals. Cash crop production of tapioca on the poor soils in Thailand meant that many poor farmers could obtain an income. It can be argued that the tapioca trade from Thailand to the EC is the curious result of EC-protectionism. Main importing country traditionally is The Netherlands, where tapioca is used in intensive livestock rearing, especially pigs and -to a lesser degree- poultry.

Tapioca production in Thailand is all but completely exported, as it is not the local staple food (rice). Exports grew from 250,000 tonnes in 1960 to approx. six million tonnes in 1984 and reached new record heights of respectively 8.5 and 10 million tonnes of tapioca pellets. in 1988 and 1989 (Toepfer International 1990/91). The last few years tapioca became the second most important agricultural export revenue earner for Thailand, next to rice exports.

As EC (surplus) production of cereals increased, the costs of buying, storing and exporting the surpluses grew as well. The European Commission responded by decreasing domestic cereal prices, which subsequently led to a price cut of tapioca, and by trying to lower imports of animal feed components. For tapioca from Thailand, the second response first took the form of an informal agreement to lower exports, which proved to be unsuccesful. It was followed by a formal so-called 'Voluntary Export Restraint Agreement' for the period 1982-1986, with quota diminishing from 5 million tonnes to 4,5 million tonnes. In subsequent Agreements the quota are set at an average of 5.25 million tonnes a year, allowing for some flexibility in individual years. For example, in the current period 1991-1994 there is an annual maximum quantity of 5.75 million tonnes a year. Loss of export income to Thailand for the period of the first Agreement (1982-1986) has been estimated at US$ 750 million. Some compensation was given by an aid package designed to promote diversification and to identify new market outlets for tapioca. There are indications that lower prices for tapioca lead to relatively stronger reduction of income share accruing to farmers. Apparently, other parties involved in the chain of production, processing, transporting and trade have stronger positions than the farmers and shifted the margin reduction to them.[59)]

Some three quarters of tapioca imports from Thailand into the EC goes through Rotterdam Port, which has a dominant position in imports of animal feed components. International trade in tapioca from Thailand is dominated by a handful corporations, of which Krohn and Alfred Toepfer from Germany are traditionally the most important ones. Other foreign companies include Granaria (the Netherlands), and Cargill (USA). The share of indigenous companies increased to more than 30 per cent of Thai exports in 1984.

Tapioca is -contrary to other producing areas- not produced in Thailand for immediate human nutrition, but predominantly for use as raw material in feedstuffs production and for industrial use. Since tapioca is not used in animal feed manufacturing for local use -it cannot compete with local alternatives-, almost all produce is exported. Thailand tries to find alternative markets for its tapioca and the Government uses an 'export bonus system', whereby quota for exports to the EC are linked to export transactions concluded with other countries. Other importing countries include, Japan, South Korea, Taiwan, and the Soviet Union (Toepfer International, 8-2-1990). These alternative markets are very instable, as tapioca competes with maize, and exports are largely non-remunerative.

Tapioca offers possibilities for industrial processing. For example, it can be processed into starch and starch derivates, to be used in the food, paper, textile and furniture industries, and high-grade starch is used in medicine production. Thailand attempts to increase domestic value added, as is shown by several projects directed at local industrialization on the basis of tapioca. USA agribusiness company Cargill and the Dutch starch company Avebe are involved in local tapioca starch factories in Thailand.

Discussion of the Thailand tapioca case

66. Tapioca or cassava is a 'perfect' crop for poor soils. It can be seen as 'the

last product in the chain of agricultural production on marginal soils'. In the case of Thailand its labour requirements combine easi'" with rice production, the main agricultural product, and returns for the farmers are relatively secure and positive. Although the relationship between tapioca production and the environmental consequences in Thailand is not straightforward and simple, current production methods further exhaust the already marginal soils. Tapioca production in Thailand can, in that respect, not be described as sustainable.

Production of tapioca could be made more sustainable by using sufficient amounts of fertilizer and by anti-erosion measures; in that case the soil can even be restored to such an extent, that it can become suitable (again) for producing other crops.[60)] Giving farmers legal rights to their land, strengthening their social position, increasing credit facilites, and subsidizing fertilizers appear necessary to provide them with an incentive for more sustainable farming practices. Institutional measures should further be taken to make sure the inputs concerned are properly used. Attempts to increase domestic value added by local processing can only lead to more sustainable tapioca production if it can be made sure that this surplus is put to use for sustainable agricultural production, and is not appropriated by middlemen, industry and multinational traders.

Since at the moment environmentally better alternatives for tapioca production do not exist for the farmers, and since stopping exports would condemn a few million people to deeper poverty, solutions will necessary be on a long term basis. Stopping the trade evidently does not end the environmental externality caused by tapioca production. Suggestions have been put forward to use EC funds for stimulating (research into) more appropriate forms of land-use and forest exploitation, and for developing a strong local industry on the basis of tapioca production (Van Amstel et al. 1986; interview Bunders & Van der Sande).

Thailand's tapioca production remains highly dependent on exports to the EC and is therefore vulnerable to changes in EC policies. As was shown by the introduction of 'voluntary' export quota in 1982, Thailand has little influence over the direction of these changes. Further price reductions for cereals are discussed in the EC. This will have direct effects on prices paid for imported tapioca. Liberalization of international agricultural trade would also lead to lower EC cereal prices. As feed costs represent approx. two thirds of production costs in intensive livestock rearing in The Netherlands, extensive (bio)technological research is being undertaken to increase the efficiency of the conversion process of animal feeds into meat. This research also enhances the reciprocal substitution of different components of animal feed. Both developments may lead to a further downward pressure on tapioca prices. As environmental consequences of intensive livestock rearing in the Netherlands are extensive, demand for tapioca may also diminish due to the introduction of national environmental measure·

D. RESOURCE USE AND ENVIRONMENT IN COCOA PRODUCTION

Description of the product[61)]

67. Cocoa is one of the most important export commodity crops of developing countries. Almost 80% of production is concentrated in six countries: Ivory Coast, Brazil, Ghana, Malaysia, Nigeria and Cameroun. In the 1980's Ivory Coast became the largest producer by raising production from 180,000 tonnes in 1970/71 to 840,000 tons in 1988/89, at that time 30% of total world production. In the last decade a new region is establishing a firm position in the cocoa market: South East Asia, with Malaysia and Indonesia becoming important cocoa producing countries. It can be expected that South East Asia will strengthen its position further, and even that this region might bypass West Africa as main cocoa producing region (Chalmin 1990:10-12). Approximately 80% of consumption is concentrated in North America, Western Europe and Japan, with another 10% is consumed in Eastern Europe.

Resource use in the production of cocoa

68. Production of cocoa is very dependent on weather conditions and is in principle unstable. Large differences exist in resource use in cocoa production between countries and within countries from farm to farm. The main determining factor of present resource use in the production of cocoa appears to be the ownership structure of the land. We will concentrate here on the two extreme types of agricultural input-output systems, HEIA and LEIA (cf. Chapter II, sections 13-16). In cocoa production these take the form of as smallholder production and plantation production. Cocoa production in Brazil and Malaysia is dominated by plantation production, although smallholder production does exist. Smallholder cocoa production is dominant in Ivory Coast and Ghana, although also some cocoa plantations exist.

The most important asset in **smallholder cocoa production** is the availability of family-labour, and cocoa cultivation can in the first place be described as labour intensive. The possibility to use unpaid family labour results in manual weeding, instead of using herbicides. Other agrochemicals are not used at all or at a low intensity level. They are often too expensive for the farmers, or, if the farmers can afford to buy them, not available. In many producing countries the distribution infrastructure for inputs is inadequate. Ivory Coast is the main exception to this rule. Due to the guarantee-price system for cocoa smallholder farmers generally could afford the use of fertilizers and chemicals, which made the organization of reliable distribution channels for inputs worthwile. But even in Ivory Coast the use of chemical fertilizers and pesticides is significantly lower than compared to 'plantation-countries' such as Malaysia and Brazil.

Generally **cocoa production on plantations** is characterized by the application of large volumes of chemical fertilizer and pesticides. Often agressive agrochemicals are used, which, although banned in Europe and the USA, are still for sale in Brazil and Malaysia (ICCO 1990: 27). Reliance on intensive use of chemicals partly reflects the search to save on labour costs. Standard average labour requirements per hectare per year on cocoa-plantations have been estimated at approximately 80 working days. Between 20 and 40 days have to be spent on weed control, fertilizer application and the spraying of agrochemicals (Wood and Lass 1987).

An important contributing factor to the use of agrochemicals is the cultivation of high yielding varieties and clones (hybrids). The higher the level of hybrid plantings, the higher the necessity to adhere to strictly prescribed regimes of fertilizer and agrochemicals. Table 5 of Annex I gives data for the percentage of area under hybrids for the main cocoa producing countries. Malaysia and Brazil, with the highest levels of hybrid planting are also known for the high levels of pesticide spraying. Industry sources indicate that the area planted with hybrids is increasing. In 1986/87 just under 1 million hectare, representing 21,7% of a world total cocoa acreage of 4.5 million hectare was under hybrids; in 1988/89 this had grown to 1.15 million hectare (25% out of 4.6 million hectare).

Government policy is co-determining factor in resource use in cocoa cultivation. Especially important are the pricing and marketing policy (guaranteed farm-gate prices and export pricing), extension services, credit facilities and research. The government of Ghana actively stimulates moderate use of pesticides. Spraying of pesticides was carried out by trained personnel of the Extension Services Department of the Ghanaian Cocoa Board. Despite protests from large agrochemical companies, only two carefully selected types of pesticides may be used alternately in order to prevent pests from becoming resistant. Under the Cocoa Rehabilitation Programme (starting 1987/1988), pressure by financing institutions such as the World Bank led to 40,000 employees in the Cocoa Board being declared redundant, including large numbers of extension personnel. As a consequence spraying will in the future have to be done by untrained farmers. Accidents and pesticide poisonings are expected to increase. Stopping altogether of pesticides application, enabling the pests to spread more freely than before, could be another result. The quality of cocoa (both the physical qualities such as moulds, size, weight, and the taste) is highest where buying structures of governmental bodies stimulate these aspects. Where plantation cultivation prevails, cost control receives the main emphasis by producers. As a consequence, Malaysian fermentation and drying techniques are inferior to the labour-intensive techniques used by smallholders in Ivory Coast and Ghana. To improve Malaysian methods would require longer fermentation and drying periods and hence more labour costs. This would increase cost components which are already higher than the African ones. Buying policies of trading, grinding and confectionary companies indicate that they are only marginally interested in raising quality. Their first priority -apart from abundant supply at low prices at an acceptable quality- is product consistency in terms of bean size and composition, as homogeneity improves processing efficiency.

Grading in West African countries, when done, is controlled by Cocoa Marketing Boards. Their policies differentiate prices according to the quality of the beans delivered by farmers. The buying practice of private trading companies in Brazil shows the opposite: they do the grading in house, and farmers do not have any experience in grading. Trading companies can pay the same (or even lower) prices for both good quality beans and for medium or bad quality beans. In practice, the price does not so much depend on quality, but on the need for cash and the possibility to store harvests - which work to the detriment of smallholders. Inconsistent pricing policies and less attractive prices than in Ivory Coast led to a diminishing of the area cultivated with cocoa in other West African producing countries. Also in Brazil no guarantee price for smallholders exists and credit facilities are difficult; often the farmers are forced to sell their crop before harvesting. In recent years, many smallholders had become so indebted that they had to sell their land. CEPLAC estimates that the share of cocoa production by smallholders dropped from 60% in 1980 to 25% in 1990.[62)]

Constraints to sustainable cocoa production

69. Due to low prices for many commodities, several countries dependent on the export of one or a few agricultural commodities have encountered problems in

the pursuit of agricultural policies. The dominant tendency of the last few years has been to reduce the influence of (para)statal bodies in agriculture. In Nigeria the Cocoa Marketing Board was abolished in 1986/87. The Ghanaian Cocoa Board was trimmed in 1987/88 and more privatization steps will come. The government of Ivory Coast prepares personnel cuts and privatization of parts of the Caisse de Stabilisation for 1992. This already happened in Brazil, where the labour force of the CEPLAC (the parastatal organization supporting cocoa production) has been reduced by more than 50 per cent. As a result the influence of trading, processing and confectionary companies on how cocoa is produced will be strengthened. This development will probably have negative effects for environmentally sound agricultural practices.

Though present low prices of cocoa led plantation managements in some cases to cut down on the use of fertilizers and pesticides, this is just a short-term reaction, which will be reversed when prices restore themselves. At higher cocoa prices, production increases due to higher fertilizer and pesticide inputs, will become attractive again.[63)]

Attractive guarantee prices (independent of short-term world market price fluctuations) made cocoa the most attractive crop for farmers in Ivory Coast. Stable internal prices led the farmers to substantially extend the area planted with cocoa: from 880,000 hectare in 1976 to 1,355,000 hectare in 1986. This expansion resulted in the loss of primary virgin forests. Yields per hectare grew with more than 40% due to the use of hybrids, fertilizers and pesticides. The current low world market prices for cocoa and the pressure to reschedule its public debt forced the Government of Ivory Coast to reduce the internal guarantee price with 50 per cent. Consequently, the next crop was 714,000 tonnes as compared to 849,000 tonnes in the previous harvest (ICCO, June 1991). As cocoa is a perennial crop, the ultimate reduction of production volumes is still uncertain.

<u>The influence of international market structures on resource use and environment in the cocoa production</u>

70. The value of world cocoa trade accounts for approximately $4 - $5 bln. Cocoa prices tend to fluctuate. Presently, world market prices are at their lowest level since 1975; with 1985 prices being almost two times higher. Both production and consumption volumes have risen over the last 30 years. The growth in production is a clear trend over the years, but is not stable for all consecutive years. The steep fall in world market-prices is mainly the result of seven consecutive years of rising production; with world consumption growing at a lower level. End-of-season stocks rose from approximately 26.2% of total world grindings in 1983/84 to

67,4% in 1990/91 (Cf. Table 6, Annex I).
Concentration levels in various parts of the cocoa production and consumption chain are very high.[64] One result of this continuing concentration process in the cocoa and chocolate sector is that fewer market parties obtain more power and influence over producers and governments involved. An attempt in the last few years by the largest producing country, Ivory Coast, to support prices by withholding its cocoa crop from the market (30% of total world production), failed. Traders and processing companies succeeded in shifting their supply to Malaysia and Indonesia, although the quality of their beans is inferior to those supplied by Ivory Coast. Big grinding companies discovered how they could still supply the confectionary and food industry with cocoa of an acceptable quality, based on a mix of lower quality beans. Especially when no intermediate organizations exist in the form of Government Marketing Boards or farmers' co-operatives prices obtained by farmers for their crop do not necessarily depend on quality, but on the need for cash of the farmers.

Discussion of the cocoa production case

71. Changes in agricultural practices that stimulate environmentally sounder cocoa production can not be expected to result directly from higher prices. Where plantations reduced the level of pesticide use in their effort for cost cutting, higher prices will lead to a return to higher pesticide use. Higher world market prices might induce plantation companies to search for even higher production yields and productivity. The consequence might well be an even higher level of chemical inputs.
Where smallholder cocoa production prevails, production methods of cocoa generally are more environmentally sustainable. Since low prices push them out of the international market, a sufficient price level to guarantee their incomes is a condition for sustainable development. The bargaining power of smallholders is such that they will probably receive only a very small part of the rise in world market prices, if at all. The power of trading companies and the processing industry is concentrated to such an extent that the outcome of selling/buying operations between many thousands of smallholders and a very oligopolistic industry is heavily biased in favour of the latter. Therefore, higher world market prices must be supported by a number of other measures. These will have to include efforts to strengthen the market positions of farmers, either in the form of farmers' co-operatives or of parastatal marketing bodies. In this respect also extension services, marketing and credit facilities, and enforcement of input regulating policies (pesticides), can be mentioned. A system of guarantee prices (at farmgate level)

can offer the conditions for stable cocoa cultivation. A problem encountered with such a system is that prices tend to become unflexible.
Active government involvement probably is required to stimulate policy-oriented research on better seedlings, on integrated pest control (biological forms of pest control), on economic use of cocoa-byproducts, and on intercropping with other crops in order to minimize dependency on a mono-crop.

The mainstream tendency at present, however, points in the other direction. The only optimistic aspect is that there is so much at stake for the highly concentrated industry that they are probably under growing pressure to take quality aspects more into account. In this sense, the industry may be a possible lever for the introduction of (more) sustainable forms of agriculture. Quality aspects include here the environmental consequences of resource use in cocoa production as well as pesticide residues in production. This implies the need for market pressure from consumer groups in coalition with organizations of farmers and agricultural labourers, which are mostly exposed to prevailing unsound agricultural practices. This, in turn, presupposes growing consumer-awareness of the actual situation in the total cocoa and chocolate production chain.
A research-policy, linked to an adequate extension infrastructure, gives governments important instruments to promote sustainable agricultural practice, by which it can control the resource use in such a way that this prevents negative environmental impacts. Aspects of this policy are issues such as pest control, good pruning and maintenance practices, harvesting and first processing techniques, grading and classification techniques.

E. UNSUSTAINABLE AGRICULTURE IN THE NETHERLANDS

Description of the agricultural production region

72. Before the introduction of artificial fertilizers conserving soil fertility was the crucial aspect of Dutch agriculture. In the Middle Ages the three-course system was employed in which every three years the land was allowed to lie fallow and weeds were ploughed under. Animal manure was the most important agricultural product, since it enabled farmers to shorten unproductive fallow periods. After 1550 efforts directed at shortening the un-productive fallow period included

alternating arable farming and grassland, and crop rotation, the cultivation of mangel, clover, vetch and beans (Berenschot 1990; Swinnen & Tollens 1989:47). Previously, all rules and laws to conserve the existing stock of forests in the Netherlands had proved to be insufficient, since over-population led to over-exploitation. In the Veluwe region the laws became ever more severe. Ultimately, the penalty for the first offence was exile, for the second offence a hand was chopped off, while the death penalty stood for the third offence. However, as people had no choice (meaning they could not follow the rules and regulations), the Veluwe was stripped of its forests in the end. In this situation of over-exploitation of resources caused by over-population, policies directed at resource conservation simply were not feasible.[65]

Mainly due to the advent of fertilizer after 1870, large parcels of previously uncultivated land could be transformed into agricultural land. Since then Dutch agriculture has a tradition of increasing intensification, mechanization, technological innovations, and reliance on external inputs. Dutch agriculture became more and more independent of nature; methods and materials were developed to alter the natural conditions of agriculture. Artificial fertilizer, biocides, soil improvement, irrigation and drainage techniques, seed and embryo manipulation and hormone treatments can be mentioned in this respect. Greenhouse agricultural production completely controls climate, water, nutrients and culture bed. Dutch fertilizer use per hectare is among the highest in the world (Cf. Table 1 of Statistical Annex).

The development of a strong institutional framework, characterized by strong links between research, extension and education activities, played a central role in this process. A concentration process took place in the agricultural trading and processing sector. Government policy actively supported the agricultural sector. The creation of a large market and guaranteed prices under the Common Agricultural Policy (CAP) of the EC led to further increases of Dutch agricultural production. Together, these factors led to a form of agriculture directed at ever increasing production per unit. Government subsidies aimed at developing larger scale, specialized farming production units. Still, according to OECD standards, farming units are relatively small-scale. While agricultural land is scarce and very expensive in the densily populated country, Dutch agriculture paradoxically contains strong elements of a 'bulk-orientation'.[66]

Developments in the livestock sector (cattle, pigs, and poultry) exemplify environmental problems caused by intensification. Imports of compound animal feeds components like soya bean, tapioca, cotton seed cake, and citrus pulp, gave a strong impetus for intensive livestock rearing.[67] The strong competitive position of the Dutch livestock sector derives in part from the nearness of Rotterdam harbour; transport costs for imported animal feed components are low. It has been calculated that the Dutch intensive livestock sector, which uses 80,000 hectares, makes use of *5 million* hectares of agricultural land in the Third World and the United States of America.[68)] More than half of livestock produce (meat, eggs and dairy products) is exported to other EC countries and elsewhere. In 1987 the agricultural sector (including horticulture) contributed to 4 per cent of national income, and contributed significantly to exports with a trade surplus of Dfl. 10 billion (some $5 billion).[69)]

Resource use in Dutch agriculture

73. Environmental effects associated with Dutch agriculture are so widespread that the modern agricultural system has been described as bearing no relation to the natural eco-system and as having become aggressively hostile to it.[70)] Agriculture contributes to acidification, phosphorus pollution caused by manure and artificial fertilizers, dispersement of biocides and heavy metals (copper and cadmium), aridity caused by increasing water extraction, disappearance of plant and animal species, levelling of landscape and to changes in climate.[71)] Soil erosion occurs in a few regions, and phosphates cause eutrophication of surface waters (De Ploey 1989:127; Hofman & Verloo 1989:160) In a number of areas the soil already has become super-saturated with phosphorus. Heavy metals such as copper have accumulated in the soil, and the government has in the meantime reduced the norm of maximum content of copper in compound feed for fattening pigs. Pesticide use per hectare is very high, especially in the cultivation of potatoes, flower bulbs, but also in greenhouse horticulture. It has resulted in the disappearance of several plant and animal species.

To a considerable extent environmentally negative effects can be traced to an increasing dependence on external inputs, and to the disappearance of 'cyclical' production processes. Especially important are the 'broken' chains in nitrogen and phosphorus, which resulted from the growth in agriculture and the development of specialised enterprises. There is widespread agreement that Dutch agriculture is characterized by the over-dosage of chemical inputs. One reason is that labour is more expensive than artificial fertilizer and pesticides, but another is that up till recently the mentality of most farmers was 'if it does not do any good, it does not do any harm either'.

Government policy and alternative production systems

74. Dutch government aims to reduce pollution emission, which currently

exceeds absorption capacity of the eco-system. In the National Environment Plan (NEP) an attempt is made at evaluating the external costs associated with the agricultural sector. Other policy papers target the closing of the mineral cycles as much as possible: ammonia emittances should be reduced by 70 per cent and pesticide use by 50 per cent in the year 2000. A recent study (1991) by the National Institute of Public Health and Environmental Protection (RIVM) indicates that policy measures taken up till now, will not lead to the reductions aimed at.

In a recent consultant study (Berenschot 1990) an assessment is made of what the effects of the conversion of the entire Dutch agricultural sector to the biodynamic (BD) method. The basic principle of biodynamic agriculture is that an agricultural enterprise functions optimally when production is hardly dependent upon external input. Objective of the study was 'to assess the economic feasibility of BD agriculture by comparing the economic and environmental aspects with current agricultural methods and by weighing the BD model against policy principles, as laid down in the NEP.' Sustainable agriculture is taken to encompass both ecological and economical sustainability. Not all environmental damage has been quantified in the study, as a complete evaluation of all external costs attributable to the agricultural sector has not yet been completed. It is expected that increasing understanding will result in a greater costs for environmental damage.

Environmental costs of current agricultural practices are estimated at Dfl. 6.1 billion per year, based on the costs of restoration. The NEP aimed at a reduction of environmental costs attributable to the agricultural sector by Dfl. 1.8 billion per year. Conversion of the entire Dutch agricultural sector to the BD method, would reduce emissions of ammonia by 76%, of nitrogens by 85% and of phosphorus by 99%, and chemical biocides would not be used at all. Comparing current agricultural methods with agricultural practices conforming to the NEP-scenario and with biodynamic (BD) agriculture, resulted in the data shown in Table 7 of the Statistical Annex. Note that gross production values under BD agriculture are significantly lower than under current practices. Labour costs would be higher under BD agriculture.

The Berenschot study concludes that the aims of the environmental policy would be fully realised under BD agriculture, as no (internal or external) costs remain from environmental damage attributable to the agricultural sector. The economic result *at the farm level*, however, is lower than under current agriculture and under the NEP scenario. As enterprises become increasingly liable for environmental damage, e.g. by internalising these costs in the forms of levies on manure production, on the use of chemical inputs, and on energy use, BD agriculture will become increasingly attractive to individual farmers, however.

The influence of international market structures on Dutch agriculture

75. Exposure of a more sustainable Dutch agriculture to the world market will certainly create additional problems. When international trade becomes more liberalized, Dutch agriculture has to become more competitive. In such a situation, a majority of farmers would not voluntarily increase their current production costs by extensifying their production by laying land fallow, by using less manure, by introduction of more *natural* production methods.[72)] It has been proposed to invoke the 'infant industry'-clause in case the Dutch agricultural sector would convert to sustainable production methods, since it would require much additional research and development to drastically change the current technological trajectory. Temporarily supporting such a form of agriculture, for instance for a period of five or ten years, has been mentioned in this respect.

Discussion of the Dutch agriculture case

76. The Dutch agricultural system has a tradition of ever increasing reliance on the use of external inputs. Government policy and the creation of the CAP stimulated growing intensification and specialization of agricultural production units. Applied technological research, extension and education played a central role in this process. As a result Dutch agriculture became more and more independent of natural cycles. It has been described as aggressively hostile to the natural ecosystem. Environmental costs of current agricultural practices are estimated at approximately US$ 3 billion per year, based on the costs of restoration. A conversion of the entire agricultural sector to biodynamic agriculture would mean that environmental policy goals of the Dutch government would be fully realised. Internalising external costs of environmental damage into production costs *at the farm level* BD agriculture will become more attractive to individual farmers. A major constraint is that the whole institutional framework of Dutch agriculture at present is directed to increasing intensification and productivity. For agriculture to become sustainable again, it is necessary to drastically change the whole current 'technological trajectory'.

F. THE SPECIAL ROLE OF GUM ARABIC FROM SUDAN[73)]

Description of the agricultural product and the production region: gum arabic production in Sudan - resource use and environment

77. A wide climatic variation exists in Sudan, the largest country in Africa. The northern part of the country is desert or desert-like. In the south an equatorial climate exists with high rainfall and humidity. Dependence on natural resources in the north is sensitive, as soil fertility is threatened by wind erosion and rainfall erosion as well and as there are recurrent periods of drought. Recycling of bio-mass residues and animal waste is essential to sustainable agriculture, given the general absence of artifical fertilizer. Evidence on desertification is controversial, but indications suggest that the general trend in the quality of land, and hence land productivity, is downward. Agricultural output has been sustained only because of increases in the cultivated area. Political instability has been high. Pearce et al. (1990) comment that a lengthy period of political stability is Sudan's greatest need if any semblance of sustainable development is to be achieved.

The acacia senegal ('hashab') tree is distributed widely in the Sahelian-Sudanian zone and is to be found in Mauretania, Senegal, Mali, Nigeria, Chad, Ethiopia, Somalia and Sudan. The trees are very tolerant to temperature and rainfall variation, and provide a useful buffer against desertification. The trees produce a gum that has a large number of uses. The trees have important positive environmental functions as well. The lateral expansiveness of the roots make them highly valued for their soil stabilizing functions. The tree further acts as a buffer against wind erosion and decreases water runoff. They encourage grassy growth in the immediate vicinity, and for this reason they are widely seen as an integral part of any programme to rehabilitate or augment silvo-pastoral systems. Furthermore, the trees are favoured sources of fodder for livestock. As gum production takes place with trees aged 4-15 years, the older trees become suitable for fuelwood.

The gum from the acacia senegal tree, a zero-calorie polysaccharide, has important qualities. It is highly soluble in water, is a good emulsifier, has low viscosity, is non-toxic, non-polluting, odourless and flavourless. Properties of gum arabic include anti-crystallization, providing a protective film, adhesive, thickener, emulsifier, suspensoid and flavouring. Gum arabic is used in confectionary production, beverage manufacture, the pharmaceuticals sector, litography and photograpy, and pesticide production.

The main competiton of gum arabic comes from various types of (modified) starch (in the confectionary, beverage and flavouring markets) and dextrins, cellulose esters and other synthetic polymers (in pharmaceuticals). Most substitutes appear to contain some portion of gum arabic. Substitution is feasible in most uses, but there is a premium on the use of high-quality arabic gum in offset litography processes and demand is likely to be inelastic in uses which rely on the zero-calorie characteristic.

Gum production provides a convenient source of seasonal employment and income, especially in regions were off-farm income opportunities are limited, as the gum is collected in the dry season. For nomads the harvested gum from untended trees also provides a useful supplementary income source.

Constraints to sustainable gum arabic production

78. In the case of gum arabic economic development and improvement of the quality of the environment can be fully consistent with one another. As there are indications that supply elasticity of gum arabic is high, increases in producer prices most likely lead to short-term supply increases by the tapping of the existing stock of trees. Favourable producer prices set by the Gum Arabic Company (GAC), which has a monopoly over exports, -together with the end of the drought- contributed to increased production in the years 1984/5 to 1987/8, and led to short-term income increases for the producers. The producer share of the export price was raised by the GAC (to approx. 70% in 1987/8) in an effort to raise the rewards to farmers in light of large-scale damage to the stock of trees in the 1984/5 drought.

Price incentives for arabic gum do not necessarily lead to higher investments in the form of new tree plantings. More planting is needed for longer-run, more permanent income opportunities and in enhancing the environmental benefits arising from the hashab tree. Planting decisions, however, are heavily affected by the poverty of the producers, the process of desertification contributing to their poverty. Farm communities, led by motivations of short-term survival, will not likely consider the benefits accruing from planting hashab trees, which yield arabic gum only after a gestation period of 4-5 years. By not planting them, environmental degradation gets aggravated and further poverty in the longer-run results. Pearce et al. (1990) conclude that this 'environmental-poverty trap' is the single most important reason for not leaving anti-desertification decisions to the market.

Therefore, apart from raising producer incomes, other policies are necessary. This can include improved handling, transport and storage to raise quality. A further reducing of the share of the final export price taken by non-producers can also be considered. In this respect, the monopoly of the GAC has been discussed, as has taxation policy of the government. Especially significant in this respect is the share taken by local merchants, which can amount 13-16 per cent of the final export price. Due to the unavailability of other sources of credit to farmers, they are forced to engage in a form of sharecropping with the merchants, who charge extremely high implicit rates of interest, reportedly often of the order of 50-75 per cent per annum. A concerted effort to supply rural credit would assist in breaking the environment-poverty trap.

Apart from the unavailability of good credit facilities, another constraint is the land tenure system. The situation of land use and property rights is confusing. The implementation in 1984 of the Islamicization of law in Sudan is thought to have contributed to this fact. Evidence indicates that the largest obstacle to securing credit is the lack of well-defined rights of the farmers to their land and the trees and crop that are on it. Lending to small farmers is highly risky, due to lacking legal collaterals.

<u>The influence of international market structures of gum arabic on resource use and environment in Sudan's gum arabic production</u>

79. Most gum arabic traded is supplied by Sudan (approx. 80% of world exports); other suppliers being Nigeria and Senegal. Sudanese exports amounted to 24,200 tonnes in 1984/5, and 16,000 tonnes 1986/7, with a FOB (free-on-board) value of $80, resp. $ 70 million. A major market is the United States, which accounted for an estimated one-third of all the gum arabic exported.

Marketing of Sudanese gum arabic exports is a monopoly of the Gum Arabic Company (GAC), which fixes the price. The ready availability of substitutes with varying degrees of price and quality competitiveness influences decisions about supply price, and the GAC tries to set the world price accordingly. A major problem is the unreliable supply, which suffers major setbacks in years of drought (1972-1975 and 1984-1985). Production supplies ranged from 11,300 tonnes in 1984/5 to 30,000 tonnes in 1986/7. The GAC attempts to regulate supply through the holding of bufferstocks. The search for substitutes has been intensified in the last period of drought, which may have permanently damaged part of the export outlet for gum arabic.

<u>Discussion of the Sudan gum arabic case</u>

80. The acacia senegal ('hashab') tree which is found in the Sahelian-Sudanian zone performs both very important economic and positive environmental functions. Gum production provides a convenient source of seasonal employment and income, for farmers and nomads, especially in regions were off-farm income opportunities are limited. A major problem is the considerable variations in sup-

ply, among others caused by recurrent periods of drought. Search for substitutes of gum arabic, such as various types of (modified) starch, was intensified during the last drought. This may ultimately lead to gum arabic becoming a specialty ingredient, e.g. for use in offset litography, which will be purchased in very small volumes only.

There is evidence that higher producer prices lead to short-term supply increases by the tapping of the existing stock of trees. Investment in the planting of new trees (which yield arabic gum only after several years), is important for longer-run, more permanent income opportunities and for enhanced environmental benefits accruing from the tree. Investment is hampered by the poverty of the producers, who are motivated by short-term survival strategies. This is an example of the 'environmental-poverty trap', whereby environmental degradation and poverty enforce each other on the longer-run. Therefore, it seems improper to leave anti-desertification decisions to the market. Important constraints in this respect are the unavailability of good credit facilities and the lack of well-defined rights of the farmers to their land and the trees and crop that are on it. These two constraints reinforce one another as well.

VI. CONCLUSION: DISCUSSION OF THE ANALYTICAL FRAMEWORK ON THE BASIS OF THE CASE STUDIES

81. The analytical framework developed in Chapters III and IV attempts to disentangle the complex relationships between changes in international market conditions and the ecological sustainability of agriculture at a local level. The six case studies in were presented in order to provide relevant examples of these relationships and will be used to evaluate the usefulness of the analytical framework. Although no exhaustive test of the model can be expected on the basis of six case studies only, we will discuss the relevancy of the distinctions made in the analytical framework.

The next sections will deal with the following questions:

* Is the distinction of agricultural change in four **basic types** (cf. Chart 2) sufficient for describing the most relevant types of change?
* Do the eight **environmental scenarios** (summarized in Chart 3) adequately describe the ecological consequences of agricultural change?
* Do the predicted **probabilities of these environmental scenarios** (Section 38) correspond with actual practice?
* Are the **five major types of changes** in international market conditions (Section 42) the most relevant ones or should other international factors be included?
* Are **causal trajectories** between changes in international market conditions and types of agricultural change adequately described in Chart 5?

82. Each of the six case studies presented in the foregoing chapter described an agricultural production system, its pollution emission and/or resource use, the most constraining factors for sustainable production, and in particular the influence of changes in (international) market conditions on sustainability. The commodities discussed in the case studies represent three of the international market structures distinguished in Section 41.[74)]

One case study focused on agricultural production on the basis of a specific crop (cocoa). This case represented the only example of an oligopolistic buyers market. Four case studies dealt with regional agricultural production systems (Botswana, South Mali, Thailand, and Sudan) in relation to a specific international product market. Cotton and gum arabic markets can be considered as 'generally free' commodity markets, while the market for beef and tapioca can be described as controlled/distorted markets. The case study on Dutch agriculture, where the intensified, specialized agricultural production unit is dominant, did not center on a specific commodity. It described a national agricultural system that operates within the structure of the 'controlled and distorted' EC agricultural market. The three options presented in the case study, continuation of the current situation, the 'NEP' (National Environment Policy)-option and the biodynamic-option, are separately dealt with.

83. The division of agricultural change in four basic types proves indeed to be useful for the description of the most relevant types of change. The cases of Botswana (production enlargement at constant technology), South Mali before 1985 (area enlargement, combined with higher input intensity), South Mali after 1985 (lower input intensity, together with area enlargement), and Dutch agricultural growth (increased HEIA-orientation) all fit reasonably well in the scheme. The cocoa case described two different production situations. A shift between the two main forms of production appeared to coincide with a shift from more HEIA-orientation (plantations) to more LEIA-orientation (smallholders), and vice versa.

The need for close examination of the baseline situation is illustrated by the fact that in several cases (Botswana, Thailand, the Netherlands) constant production levels, given current non-sustainable production technology and methods, contribute to natural resource depletion. And since the framework is developed in order to discuss the dynamic aspects of the relationship between agriculture and environment, a clear distinction should be made between the characterization of the **existing situation** of agricultural production and the **direction of change** in the agricultural activities.

While current Dutch agricultural practices are unsustainable, the two alternative options discussed above are both changes for the good. One option (the 'NEP'-option), however, can still not be characterized as leading towards completely sustainable agricultural production, while the other, the biodynamic option, could. It is clear that not always absolute judgements can be made, as agricultural methods can, in real life, be described as more or less sustainable than other methods. The 'NEP'-option, apparently, represents a borderline case.[75)] The cases on the Netherlands, South Mali and Thailand suggest that also changes in the level of nutrients recycling could be included in the list of basic agricultural change processes. In the first case an import surplus of nutrients poses environmental problems. In the latter two cases, cotton seed and tapioca exports appeared to be important forms of nutrient leakage. Therefore, the construction of material balances, quantifying the export and import of nutrients for regional agricultural systems appears to be useful.

84. On the basis of the case studies it appeared that the ecological consequences of agricultural change are quite well described by the set of eight **environmental scenarios**, summarized in Chart 3. However, the cases of cotton production in South Mali and of cocoa production in West Africa show that it is problematic to lump together natural resource depletion (nutrient status, erosion, reduction of primary forests) and pollution emission by agriculture. It can thus be necessary to treat both ecological elements separately.

Scenarios leading to more pollution emission and/or resource depletion:

Scenario A: where an increase in agricultural production at constant technology leads to more pollution emission and/or resource depletion: Botswana case; Thailand case; increase in cocoa production on plantations.

Scenario C: where more HEIA-orientation (more input-intensive) agricultural production leads to more pollution emission and/or resource depletion: current Dutch agricultural growth pattern; shift from smallholder to plantation production of cocoa.

Scenario E: where a decrease in agricultural production at constant technology leads to more pollution emission and/or resource depletion: a decrease of gum arabic production in Sudan.

Scenario G: where more LEIA-orientation (less input-intensive) agricultural production leads to more pollution emission and/or resource depletion: cotton production in South Mali (with the proviso made as to the environmental effects of the use of pesticides) in the period after 1985.

Scenarios leading to less pollution emission and/or resource depletion:

Scenario B: where an increase in agricultural production at constant technology leads to less pollution emission and/or resource depletion: an increase in gum arabic production in Sudan

Scenario D: where more HEIA-orientation (more input-intensive) agricultural production leads to less pollution emission and/or resource depletion: cotton production in South Mali (with the proviso made as to the environmental effects of the use of pesticides) in the period up to 1984; tapioca production in Thailand IF the nutrient basis of the soil would be kept at level due to sufficient use of external inputs in the form of fertilizer.

Scenario F: where a decrease in agricultural production at constant technology leads to less pollution emission and/or resource depletion: decrease in livestock production under current practices in Botswana, IF natural restorative processes are still possible; decrease in cocoa production on plantations.

Scenario H: where more LEIA-orientation (less input-intensive) agricultural production leads to less pollution emission and/or resource depletion: the biodynamic scenario of Dutch agriculture; shift from plantation to smallholder production of cocoa.

85. Do the predicted **probabilities of these environmental scenarios** correspond with actual practice? In Section 38 it was stated that both an increase in agricultural production and more intensive use of external inputs would most likely result in negative ecological effects, and that a decrease in agricultural production at constant technology would probably have positive ecological consequences. The predicted probabilities of these environmental scenarios converge with actual findings in four of the six cases, i.e. for livestock production in Botswana, for tapioca production in Thailand, for plantation production of cocoa, and for the growth pattern of Dutch agriculture. The case of gum arabic contradicts the predicted pattern: more production would enhance ecological conditions, while less production causes more erosion.

The case of cotton production in South Mali does not fit well into the predicted pattern. This is partly caused by the fact that, as argued above, pollution emission problems and natural resource depletion problems cannot always be lumped together, since agricultural change may affect both incongruously. Before 1985 more pesticide use probably caused more pollution (which would coincide with the prediction), while at the same time more application of inorganic fertilizer improved the nutrient status of the soil (which does not coincide with the prediction). For the period after 1985 when world market prices for cotton caused a change in government policy and led towards a more LEIA-orientation an inverse effect on ecological variables took place. It appears justified that in Section 38 no predictions were given for the most probable ecological effects of an increased LEIA-orientation of agriculture.

86. The case studies presented show the influence of the five **major types of change in international market conditions** identified in Section 42 on the resource use and environmental effects of the agricultural production concerned. Especially, price changes and changes in the way markets are controlled/distorted appear to be important in this respect. The cases, however, also indicate that some factors could be given more explicit attention. The importance of international loans for agricultural projects becomes clear a.o. in the livestock case (Botswana) and in

South Mali, where intensive dairy farming was promoted. Current policies of international lending organizations tend to increase the level of commodity production. Adjustments programmes prescribed by IMF and World Bank contributed to a deterioration of extension programmes and the dismantling of state marketing boards. In cocoa production in West Africa this led to more unco-ordinated pesticide application, loss of expertise, and more short-term oriented behaviour of small farmers.
The gum arabic case showed the importance of (potential) substitution policies by major international processors. As argued in Chapter I of this report, we paid little attention to substitution on the demand side, which may be the consequences of changes in relative commodity prices. As this factor influences several commodity markets, this issue should, therefore, be given explicit attention.

87. The **causal trajectories** between changes in international market conditions and types of agricultural change depicted in Chart 5, cannot but simplify the complex relationships existing in reality. The cases suggest that the most important causal relations are fairly well covered by the model developed in Chapter IV, but also that other variables could be included:

a. domestic government policies towards agriculture: effectivity of seasonal management of production (e.g. herd sizes), definition of property and land tenure rights of small farmers (Botswana, Thailand), integrated rural development, input pricing, stabilization of farmgate prices (South Mali), agronomic research support (the Netherlands), rural credit for investment in perennial crops (Sudan), and purchase of inorganic fertilizer (Thailand).

b. domestic policy with regard to management of public commons (e.g. wildlife areas and common grazing rights in Botswana);

c. domestic distribution of income, cattle stocks (Botswana) and land: In Botswana a small group of large cattle owners is generally thought to be very influental politically. In South Mali large and small farmers reacted differently to Green Revolution schemes of the CMDT; only the larger farmers (could) adopt the different cultivation practices proposed.

88. Summing up, the analytical framework presented in Chapters III and IV identifies the main causal links between international factors, processes of agricultural change, and their ecological effects. It can be helpful in identifying international constraints to sustainable agriculture. Further refinement is possible by separating pollution effects and resource depletion effects. Extension of the model is possible by including the effects of domestic policy interference.

NOTES

(1) In the low-income countries (excl. India and China) and the lower-middle income countries agricultural exports accounted for approximately 30 - 32 per cent of total merchandise exports in 1989. For the twenty severely indebted middle income countries agricultural commodities represented 29 per cent of total merchandise exports (World Bank 1991:234-235).

(2) See, for instance, Gillis & Repetto (1987); Le Prestre (1989).

(3) Depending on the unit of analysis that is favoured, an agricultural cycle can either be a crop (from sowing to harvesting), a calender year, a crop rotation cycle of several years, or even - like in the case of shifting cultivation - the multi-annual period (including the fallow periods) between the moment that a farming household leaves a certain cultivation area and the moment that the households starts cultivating it again.

(4) This holds, inter alia, for large-scale production of crops soya, cocoa, coffee, cotton, tobacco, rubber, and sugar beets.

(5) Valuation of environmental damage is complicated by three problematic aspects. Firstly, ecological effects have no natural unity of measure. This specially applies to the subjective appraisal of the natural environment (Bartelmus 1989). Secondly, environmental effects both have the character of externalities and of public goods: they represent no private property, are not sold in markets and their value cannot be assessed in a direct way. The third and perhaps most important aspect is that ecological effects, due to their complexity, uncertainty, and to the far from complete knowledge about the complex ecosystems, can hardly be forecasted (Turner 1988). Many ecological relations have a non-linear character, which means that sudden vehement reactions can occur after many years of small, gradual changes in some ecological variable. In this context the resilience of a natural environment is important: up to a certain extent small changes in ecological conditions can be absorbed without substantial losses in its functioning, but beyond this point sudden collapses can occur. For instance, many years of neglect for soil structure can suddenly result in massive land slides in mountainous areas. Similar, but less understood are the links between long years of mono-cropping and sudden deterioration of harvests due to plant diseases. Incomplete knowledge means that pivotal change factors may be undervaluated. On methods for measuring the costs of environmental damage a growing amount of literature has come into existence. Cf. e.g. Nash & Bowers 1988; Ahmad 1981; Hufschmidt & Hyman 1982; Hueting 1987).

(6) This includes direct use of fossile energy for traction (transport, mechanised equipment), heating, cooling, or lighting at a farm-level. Furthermore, long-distance transport of products, product conservation and production of inputs often also require large amounts of fossile energy.

(7) In non-rainfed agricultural systems it is questionable whether water supply can be regarded as an internal input of agriculture in a strict sense. For instance, water supply for irrigation systems may be supplied by utility companies (state or private).

(8) In South and Southeast Asia alone, the acreage planted with such varieties expanded from 26,000 in 1965-'66 to around 61 million in 1982-'83 (Ascher & Healy 1990:33-34).

(9) Cf. Goldschmidt 1978; WCED 1987; Balancing the future 1991.

(10) Since heterogeneous quantities are involved such comprehensive productivity comparisons require that all

quantities are reduced to the same dimension (e.g. energy or money). The use of changes in index numbers only masks the valuation issue, since weights in input and output composition have to be assessed anyway. Accounting for pollution emission requires a valuation (in money or energy terms) of additional efforts that would be necessary to neutralize such pollution. Similarly, to account for resource depletion requires that either the denominator (output) or the numerator (costs) of the productivity quotient be corrected for costs involved in producing alternatives to the depleted resources. The use of land prices as proxy for local resource depletion is only adequate under the assumption of perfect land markets, including perfect foresight as to the economic implications of depletion for the landowner. Approaches to measuring total agricultural productivity are developed, inter alia, in Christensen (1975), Capalbo & Antle (1988) and Ehui & Spencer (1990).

(11) Replenishment of nutrients can be a result of agricultural practices like green manuring or application of trees and shrubs as 'nutrient pumps', which fix atmospheric nitrogen and recycle nutrients. Dommen (1992) and Ehui & Spencer (1990) describe agricultural production systems where such 'secondary' outputs of agriculture represent a large part of total output.

(12) In writing the sections on fertilizer use the contribution of Hans Heerings (SOMO) is gratefully acknowledged.

(13) According to a major fertilizer producer: "Generally, long-term experiments show that the yield level obtained without any fertilization is of the order of 25 to 45 per cent of the optimum yield under current agriculture. This is what natural fertility can support. In such systems the removal of nitrogen, phosphorus and potassium wil be about 15-35, 5-15 and 10-25/kg/ha per year. Nitrogen is supplied through nitrogen fixation by legumes, algae and bacteria and by precipitation, while phosphate and potash are supplied by weathering of soil particles. Circulation on the farm of nutrients in organic materials like manure, compost, etc., is not a net input unless animal feeds (e.g., concentrates) are brought in from outside" (Norsk Hydro 1990:94).

(14) In some agricultural areas (e.g. the Netherlands) these problems have been aggravated by a regional oversupply of animal manure with additional heavy metals concentrations. The latter stem from additions in animal feed.

(15) Tobey (1991) used an index of leaching vulnerability and absolute per-acre nitrogen use for ten major US crops, each based on national averages for the USA.

(16) In 1977 the world population amounted to 4.1 billion, in 1989 it is estimated at 5.2 billion, by 2000 it is estimated to reach 6.2 billion, and projections for 2025 arrive at 8.5 billion. Data are from: World Bank (1979: Annex Table 18; 1991: Annex Table 26).

(17) In Linnemann et al. (1979:7-11,21-71) it is estimated that the global area of arable land in 1965 (1427 million ha.) represented only 39 per cent of potentially suitable agricultural land. Wide regional differences in the use factor were found. The use factor ranged from more than 70 percent in Southern Asia, Japan and Western Europe (88%) to 32 per cent in China, 27 per cent in Tropical Africa, and 18 per cent in Latin America. According to this study the largest potential increase in world food production would come from an increase of agricultural yield per hectare. The study recognises, however, that cultivation of the non-used areas, irrigation, fertilizer use, application of pest control measures, and other yield-increasing measures cannot be without ecological consequences: "the ecological implications of such a massive expansion of agricultural production remain rather uncertain" (p. 8, p. 20, and p. 358).

(18) Other sources, like hydro-energy, which do not exhaust natural reserves, are used as well in some countries.

(19) In Appendix II of Kox & Stellinga (1991) the environmental consequences of pesticide use are further elaborat-

ed on.

(20) In Brazil, for instance, agricultural export production accounts for almost all pesticide use in the country. Total sales approximated almost $1 billion in 1989. The vast majority of it is used in the production of soya, citrus fruit, sugar-cane, and coffee (European Chemical News, September 17th 1990). In Central American countries export production of cotton is often considered as the most ecologically destructive crop - rivalled perhaps only by extensive cattle ranching - due to the extensive use of pesticides and its contribution to deforestation. For export production of bananas, cotton and sugar in Central America extensive use is being made of pesticides (Faber 1991). In Guatemala an estimated 80 kilograms of insecticide per hectare cultivated with cotton are applied each year, and the frequency of applications (often in the form of 'chemical cocktails') has risen from 8 to 40 times a year in the last two decades (Multinational Monitor, January/February 1991).

(21) European Chemical News, October 1st, 1990.

(22) Data from World Bank (1990); Pearce et al. (1990); Spruyt (1988); Blackwell (1991).

(23) Chemistry & Industry, September 16th 1985.

(24) Sometimes the concept 'carrying capacity' is used as alternative for resilience. 'Carrying capacity' is basically a static concept that refers to the maximum environmental burden (created by wildlife, farm animals and/or people) that a given land system can endure in a given period without losing its regenerative capacity. The concept of resilience, however, is not oriented at the maximum chargeability. It refers to the dynamic characteristics of a land system. Because of its more general nature we prefer to use the concept of resilience.

(25) Worldwide trade in seeds is estimated at $ 16 billion per year, but farmers plant an additional $ 15 billion worth of seeds which they save from their own crops (Cookson 1990).

(26) Cf. Ruivenkamp 1989; Kenney & Buttel 1985; Kumar 1987; Biotechnology and Development Monitor 1989/91; Cookson 1990.

(27) This move towards more HEIA-orientation is not in itself a consequence of new technologies like biotechnology. The same technologies often are also applicable in the context of more LEIA-oriented production systems. An example forms the use of biotechnology innovations for developing LEIA-oriented technology trajectories and application by small-scale farmers (e.g. Bunders 1990).

(28) The division between renewable and non-renewable is somewhat elusive. Many so-called 'free gifts of nature' are in principle renewable, though sometimes only at a limited scale and in the long term, if enough productive and resource efforts are spent to their reproduction. Non-renewability therefore is not always an absolute criterion, but one that relates to the necessary investment of time and resources, to the current technological frontier, and to the scale of reproduction possibilities. By these criteria mineral deposits, fossile fuel deposits, clean oceans, tropical rainforest, natural wetland areas, ozone layer, biological diversity, etc. can all be considered as non-renewable natural assets. To some extent this is illustrated by the fact that some authors regard tropical timber and rainforests as a renewable resource (El Serafy 1989:11), while others regard it as a non-renewable resource. According to Gillis et al. (1987:522) it is not yet certain that tropical timber can be regarded as a renewable resource, like for instance is true in the case of most coniferous timber varieties. This incertainty stems from the long growth cycle (40-150 years) for many popular tropical hardwood varieties, the vulnerable ecology of tropical rain forests, and widespread lack of success - except in case of teak - of attempts to regenerate the logged varieties. Sometimes (e.g. Van den Bergh 1991) the term semi-renewable resources is used for resources like tropical forests, land, oceans, and atmosphere, which can be regenerated under very strict conditions or long periods (relative to human

lifetime).

(29) This trade-off between the current and future generations could, of course, be alleviated by international income redistribution.

(30) Cf. literature in Nijkamp, Rietveld & Voogd (1990) and Van Pelt (1992).

(31) Constant technology implies that input coefficients remain unaltered, and that there is no substitution between inputs, so that inputs enter the production cycle in the same relative proportions (complementarity). The absolute level of production increases or decreases proportional with the change in input levels. Production increases with constant technology imply an identical rate of growth of all inputs, so that even at a higher production level their relative proportions are the same as before.

(32) Though a change in the share of pollution and waste per unit of gross output would by some be considered as a form of technology change, we will treat it as a consequence of technology change.

(33) In Third World countries, an increase in labour intensity is often the consequence of constraints with respect to the capacity to buy external inputs. It will presumably often coincide with increased LEIA-orientation. It can be appropriate to distinguish between short-term oriented labour efforts (sowing, weeding and harvesting) and longer-term oriented labour efforts (needed for maintaining soil fertility, construction of anti-erosion works, irrigation works, and landscape preservation). The latter type of labour efforts would more properly be treated as capital investment, investment in 'landesque capital'. In an input-output approach both types of labour input must be treated separately, due to the different functions they perform.

(34) Policy makers in both developed and developing countries as well as in multilateral organizations often suffered from this 'Western technology bias'. An evaluation of livestock projects financed by Dutch development aid described the main cause for their failure as such: "The learning process did not follow the order one logically would expect. One did not start with small-scale, simple projects, that were geared to local livestock practices, and -on the basis of experiences gained therein- subsequently develop the projects and introduce technological modernizations. Instead, one followed the reversed order". (Cited in Stellinga 1990:22).

(35) For reasons of simplification, pollution emission and resource depletion are taken together. Changes in both variables do not necessarily move in the same direction. For example, a given change in agricultural activity, like more fertilizer use, may cause more pollution emission, but less resource depletion. Taking these possibilities into account would double the number of possible scenarios. For the sake of simplicity and transparancy both criteria are taken together. This is well defendible, since our definition of sustainable agriculture is stated in terms of a set of cumulative conditions. In the example mentioned, the agricultural production system would still be considered as unsustainable.

(36) Bananas, for example are to a large extent produced, traded and even transported by a small number of vertically integrated companies. Policy changes of such large international companies (e.g. investment in plantations, introduction of outgrower schemes, relocation of processing plants) may have large influences on agricultural practices.

(37) The data in Table 4 refer to the mid-1970s and should therefore be updated. Nevertheless, this type of market classification facilitates a description of international market influences on agricultural production.

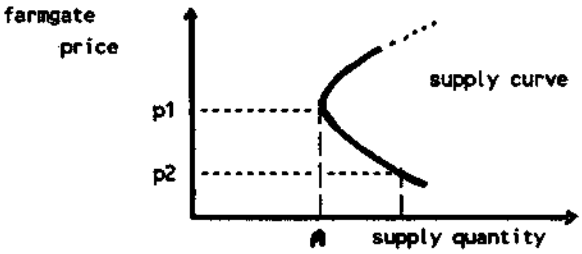
(38) It depends on the nature and stability of the international product market what the criterion for sharp fluctuations is. In a volatile market a 10 per cent change in dollar-denominated export prices is normal, and will probably

not induce supply volume changes. But in a stable market with price that only fluctuate in long-term cycles, the same 10 per cent price change may well invoke sharp supply reactions.

(39) In African countries marketing boards allowed a considerable margin between world market prices and the prices farmers received. By adjusting their share in prices governments can, in principle, temporarily absorb hectic price shocks in the world market and stabilize farmgate prices. Though it retards supply accomodation to changed demand conditions, incomes of farmers are stabilised. Marketing boards have, however, also been used as a taxing instrument rather than as a price stabilisation instrument. The Ghana Cocoa Marketing Board is a case in point, as reported by Gersovitz & Paxson (1990).

(40) The latter effect would be enhanced indirectly by increasing foreign exchange earnings that facilitate the purchase of foreign agricultural inputs. (Moreover, prices of foreign inputs denominated in local currency will diminish when the local currency appreciates vis-à-vis foreign currencies). If the government shares in the price gain it contributes to less government deficits and more opportunities for government programs to stimulate extension programs, and programs to distribute and subsidise agricultural inputs.

(41) This type of behaviour of monoculture producers who lack short-term alternative income sources, could be described by a kinked supply curve. Above a point (A) the supply increases with an increasing price; this is the orthodox case. When prices falling below p1, however, the supply quantity will also increase, but now with falling prices; this could be labelled the perverse supply case. The point (A) reflects the level at which the constraint of lacking income alternatives of the mono-croppers becomes operative. When prices fall below p2, the producers will completely turn their back to the market, and will probably end-up in subsistence agriculture. Consumers and/or commodity traders are evidently the beneficiaries of this type of producer's behaviour.



(42) IMF conditions for stand-by credits often included prescriptions to increase commodity export earnings, thus contributing to further international supply imbalance and depression of export commodity prices. In a basic policy document on Sub-Saharan Africa the World Bank calls on countries to increase their agricultural exports in spite of depressed world markets. "If Africa's economies are to grow, they must earn foreign exchange to pay for essential imports. Thus it is vital that they increase their share of world markets. The prospects for most primary commodities are poor, so higher export earnings must come from increased output, diversification into new commodities and an aggressive export drive into the rapidly growing Asian markets" (World Bank 1989:13).

(43) Similar developments are taking place in the market for tropical hardwood. A consumer boycot for non-sustainable tropical timber products is imminent or has already begun in a number of European countries (United Kingdom, Netherlands).

(44) At present manufacturer's product standards are more related to product consistency (quality uniformity), due to the process technology characterizing many food manufacturing activities.

(45) Many commodity-exporting countries tried to shift towards downstream activities in the production chain

(industrial processing of agricultural products, like canning or other forms of preparation) in order to improve their export earnings. Tariff escalation in OECD markets is an important reason why such vertical diversification efforts show meagre progress. It exists, inter alia, in the case of processed cocoa, coffee and tea, processed beef and fish, preserved vegetables and fruits, refined sugar, processed cereals, manufactured tobacco, leather and leather products, yarn and woven fabrics. An enlightening example is that of vegetable oils, where the raw material receives a duty-free treatment in the EC, while a 25 per cent tariff applies to margarine. Though smaller than for most-favoured-nation tariffs, GSP and other preferential rates for a number of products also possess an escalated structure. Even preferential ACP tariffs granted by the EC have a degree of escalation, e.g. for coffee, vegetable oil and tropical fruits. (Cf. UNCTAD 1989: Ap.10/11).

(46) European Chemical News (September 17th 1990); Blackwell (1991).

(47) European Chemical News, September 17 1990; Blackwell.

(48) Studies quoted in The Financial Times, 28-9-1989.

(49) Pearce et al. (1990: Ch.7). Developments in Botswana are a typical example, whereby 'common property resources' are encroached upon through increased commercialization of agriculture and privatization of (part of) the communal areas (Blaikie and Brookfield 1987: 195). Tribal and extended family obligations and communal management of the grazing lands was replaced by individualistic and competitive behaviour, with degradation of the land as a result.

(50) Botswana National Conservation Strategy, Government of Botswana, December 1990 (quoted in: Inger 1991).

(51) Data from interview with D.Inger (Rural Studies Promotion, Botswana).

(52) In Ivory Coast, Senegal and other West African countries, deep frozen meat from the EC, is, due to these export subsidies, significantly cheaper at local markets, than fresh local or regional meat supplies (OECD/CILSS, 1990). Proponents of sustainable trade point to these detrimental effects of EC agricultural policy with respect to beef export subsidies, and call for an end to subsidized exports (HIVOS et al. 1991: 7-8).

(53) In Central American countries export production of cotton has been described as 'the most ecologically destructive, rivalled perhaps only by cattle.' (Faber 1991) Between 1956 and 1980 land devoted to cotton increased by more than 2,000 per cent in Guatemala, contributing to a significant loss of forests and widespread pesticide contamination of people and the environmnent. By the 1970's, Guatemala had the highest levels of DDT in mother's milk and human flesh, 185 times higher than the limits set by the World Health Organization. An estimated 80 kilograms of insecticide per hectare are applied to cotton each year, also causing pest resistance. Applications have risen from 8 to 40 times a year in the last two decades. Pesticide runoff flowing into rivers and oceans contaminates fisheries and drinking-water supplies. Farmers and consumers are exposed to the chemicals and an average of over 1,000 pesticide poisonings per year were reported in the 1980's (Multinational Monitor, January/-February 1991). Similar findings are reported for the cotton production in other Central American countries, such as El Salvador and Nicaragua (Faber 1991). In El Salvador pesticides account for more than 50 per cent of production costs (IPS, 5-7- 1988). In some areas of California purchases of pesticides made up 40 per cent of farmers' outlay in 1987 (The Economist, 6-6- 1987). US companies try to develop fast-growing hybrid cotton and cotton varieties that are more insect resistant and herbicide tolerant (Agribusiness Worldwide, January/February 1989). A more indirect result of large-scale cotton production in Central American countries was that excluded peasant farmers often moved onto marginal agricultural lands, such as the steep hillsides or the nutrient-poor rainforests soils. This resulted in further deforestation, declining fallow cycles, severe soil erosion and land degradation, watershed destruction, critical fish, wildlife, and woodfuel shortages, declining food production and increased poverty

(Faber 1991). In the Soviet Union, extensive irrigation of cotton fields contributed to the drying up of Lake Aral, and the consequent disappearance of fish and other forms of life, which is considered to be one of the world's major ecological disasters (IPS, 16-01-1990).

(54) Data from Berckmoes et al. (1988) and from interview with H. Breman (Centre for Agrobiological Research, CABO, Wageningen).

(55) Data from interview H.Breman (Centre for Agrobiological Research, Wageningen).

(56) The average cotton price in 1986 was 34% lower than 1984 prices (Commodity trade and price trends, 1987-88 edition, The World Bank, 1988).

(57) Since 1986 world market cotton prices show an upward trend (Brown 1991). It is not known to us, whether or not the CMDT consequently changed its policy regarding cotton production.

(58) Data from interview with J. Bunders and Th. van der Sande, Department of Biology, Free University, Amsterdam.

(59) Van Amstel et al. (1986) mention in this respect that 50% of Rotterdam c.i.f.-prices accrue to the farmers, while more recent figures give a 33% share (NIO-Association).

(60) Data from interview J. Bunders and Th. van der Sande, Department of Biology, Free University, Amsterdam.

(61) In writing the sections on resource use and the environment in cocoa production the contribution of Paul Elshof (SOMO) is gratefully acknowledged.

(62) Interviews with CEPLAC employees held by Paul Elshof in spring 1991.

(63) Variable production costs for plantation production are higher than for smallholder production, as plantation companies substituted labour for the use of external agrochemical inputs. The level of world market prices determines whether or not the extra costs for these inputs are worthwhile to be spent in cocoa production.

(64) About 55% of total world grindings (the primary processing phase), of cocoa beans in 1990/91 is concentrated in Western Europe and North America, while only 32% took place in developing countries. A few multinational companies dominate world grindings. Approximately 35% of total world grindings (representing some 800,000 tons of cocoa beans) is done by Grace Cocoa (subsidiary of WR Grace), Cargill, Cacao Barry (subsidiary of Sucres et Denrées), Van Houten International and ED&F Man/Gill & Duffus. They own grinding factories in Europe, North America and in production regions like Brazil, Malaysia/Singapore and penetrate the industry in other countries like Ivory Coast, Ecuador and Indonesia. Apart from the specialist grinding companies a high volume of grindings is done by the big confectionary companies such as Nestlé, Hershey and Cadbury.
During the last ten years international trade in cocoa beans and cocoa products has become even more concentrated and presently only a few big trading companies dominate the trade. Cargill, ED&F Man, Van Houten International and Sucres et Denrées control together more than 50% of the cocoa trade.
Also in the production of chocolate high levels of concentration exist. At world level only five companies supply between 70 and 80 per cent of total consumption: Nestlé, Mars, Philips Morris (which took over Jacobs Suchard), Cadbury, Hershey. Two companies, Hershey and Mars, together have a market share of more than 70 per cent of the USA market. In the UK three companies, Cadbury, Nestlé/Rowntree and Mars, control about 80% of the market. A recent development is that confectionary companies purchase (part of their supply) directly from producers, in order to secure supply at low prices and to avoid too large a dependence on only a few big trading

companies.

(65) Interview with H. Breman, Centre for Agrobiological Research, Wageningen.

(66) The dairy sector can serve as an example of the production-orientation of Dutch agriculture. The policy of the co-operative companies dominating this sector was, at least until recently, not very marketing oriented, but directed instead at acquiring scale economies in production, input procurement and product sales. Farmers' co-operatives hardly aimed at marketing high value-added products or the development of top-level branded articles (Stellinga, 1989).

(67) The European Community is by far the most important party in world trade, as it imports often considerably more than 50% of the different animal feed components.

(68) Study as quoted in P. de Jaeger (1991).

(69) Labour employed in the agricultural sector in 1987 amounted to 256,000 labour years (or 5.4 per cent of the total labour volume). Total production value amounted to Dfl. 33.5 billion. Dairy production amounted to Dfl. 8.8 billion, intensive livestock rearing to Dfl. 6.9 billion, flowers and floral nursery products to Dfl. 5 billion, and the remaining horticultural enterprises contributed almost Dfl. 4 billion (as quoted in Berenschot 1990: 10-11).

(70) A consultant study even concluded: "The effects of acidity on the environment from too much ammonia from manure, manure pollution by over-fertilization, diffusion of biocides and heavy metals, aridity and stench became more noticeable. Poisoning of the environment leads to the disappearance of plant and animal species and to total deterioration of the quality of life." (Berenschot 1990: 9)
Though being one of the major polluters, the agricultural sector itself also suffers from pollution immission from other sectors. E.g. milk from certain regions has been prohibited for sale due to high dioxine levels caused by the burning of refuse. Like elsewhere in Europe, products became radioactively contaminated due to the Tshernobyl-nuclear power-station disaster in the Soviet Union.

(71) Emissions in 1987 amounted to 277,000 tonnes of ammonia, 242,000 tonnes of nitrogens, 78,000 tonnes of phosphorus, 1,300 tonnes of copper and cadmium, and 18,000 tonnes of chemical biocides (Berenschot 1990).

(72) A.M. van der Woude, as quoted in: De Volkskrant, 30-1-1989.

(73) The section on arabic gum is mainly based on Pearce et al. (1990: Ch.6). Use has been made of RAFI (Rural Advancement Fund International) Communique, Gum Arabic, Case study, September 1986.

(74) The closed market type and the partly open, partly closed market type were not represented.

(75) The cases provide more examples of the fact that not always absolute judgements can be made with respect to the sustainability of the agricultural systems. A proviso was made for both cotton production in South Mali and for smallholder cocoa production in West Africa regarding the environmental effects of the use of pesticides. Furthermore, it is clear that even if smallholder cocoa production in West Africa in itself could be described as sustainable, the loss of primary virgin forest due to area extension for cocoa production cannot be described as representing a sustainable environmental scenario.

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STATISTICAL ANNEX

Table 1

Consumption of fertilizer[a)] (kg) per hectare of arable land and permanent crops, in selected regions

Region	1961-65	1988	% growth
World	27.9	98.7	253
Africa	4.7	20.0	325
Mali	0.2 b)	6.4	3100
Egypt	109.9	400.1	264
N. & Central America (tot.)	41.2	83.7	103
USA	52.2	93.6	79
South America (total)	8.4	41.1	389
Brazil	9.1	47.5	422
Asia (total)	11.8	114.8	873
China	13.2 c)	262.2	1886
India	3.7	65.2	1662
Indonesia	8.4	112.8	1243
Western Europe (total)	117.2	225.4	92
France	133.9	311.6	133
Netherlands	534.9	649.8	21

Notes: a) kilogram of nutrients (nitrogen N, phosphate P_2O_5, and potassium K_2O). b) 1967. c) FAO estimate.
Source: FAO Fertilizer Yearbooks 1978,1989.

Table 2

Nitrogen use and potential threat of fertilizer accumulation in water bodies, for selected crops in the USA

Crop	Use per acre (lb) weighted by leaching vulnerability (1)	Nitrogen use per acre, 1987 (lb) (2)	Average leaching risk (1)/(2) (3)
1. Tobacco	.. a)	164	.. a)
2. Rice	49	131	0.37
3. Peanuts	46	83	0.55
4. Corn	40	122	0.33
5. Cotton	27	73	0.37
6. Sorghum	22	72	0.31
7. Wheat	20	61	0.33
8. Barley	14	44	0.32
9. Oats	7	23	0.30
10. Soybeans	7	19	0.37

Note: a) vulnerability index not applied because regional production data were not available. Source: Tobey (1991:92).

Table 3

Erosion intensity of selected crops in the USA, national averages

Ranking	Crop	metric tons per acre
1.	Tobacco	12.0
2.	Soybeans	7.1
3.	Corn	6.6
4.	Peanuts	6.4
5.	Sorghum	4.4
6.	Oats	4.2
7.	Cotton	3.7
8.	Wheat	3.2
9.	Barley	2.8
10.	Rice	0.2

Source: USDA Soil and Conservation Service, National Resource Inventory, USDA, Washington 1982.

Table 4

Nature of primary commodity markets, 1973-75 average (in US$ bln.)

GENERALLY FREE		CONTROLLED / DISTORTED		CLOSED		OLIGOPOLISTIC BUYERS		PARTLY OPEN, PARTLY CLOSED	
Oilcake	2.4	Wheat	9.3	Phosphate	1.5	Coffee	4.3	Wood, wood products	7.1
Cotton	3.7	Sugar	8.0	Iron ore	3.8	Oilseeds	3.2	Copper	7.0
Wool	2.5	Beef	3.7	Bananas	0.7	Veget. oils	3.6	Aluminum	2.0
Hides/leather	2.8	Maize	5.7	Bauxite	1.5	Tobacco	2.1	Nickel	0.8
Nat. rubber	2.6	Rice	2.0			Cocoa	1.4	Lead	0.8
Tin	1.2	Wine	1.9			Tea	0.8	Zinc	1.3
Hard fibers	0.2	Citrus fruit	1.2						
Jute	0.2	Butter	1.3						
Pepper	0.2								
TOTAL	15.8	TOTAL	33.1	TOTAL	7.5	TOTAL	15.4	TOTAL	19.0

Source: L.N.Rangarajan (1978).

Table 5

Selected data on cocoa production, 1986/87

	period	area (1,000 ha)	% hybrid	yield kg/ha	total production (1,000 ton)
Cameroon	1986/87	453	11.3	292	132
Ivory Coast	1985/86	1,355	14.8	428	580
Ghana	1986/87	910	14.1	251	228
Nigeria	1986/87	470	33.6	213	100
Brazil	1986/87	708	48.7	505	357
Indonesia	1986/87	124	n.a.	345	43
Malaysia	1986/87	315	100.0	530	167

Source: Economist Intelligence Unit (1989).

Table 6

Selected market data for cocoa: annual production, grindings, price, stocks

Cocoa year	Production	Grindings	Stocks	Price
	....	1,000 tonnes	....	($ US/ton)
1960/61	1,172	1,002	467	494
1970/71	1,554	1,420	493	586
1980/81	1,691	1,558	668	2,099
1985/86	1,972	1,841	633	2,149
1990/91	2,406	2,274	1,532	1,208

Source: ICCO, June 1991

Table 7

Comparing actual data for the Dutch agricultural sector with two alternative approaches: implementation of the National Environment Plan (NEP) and conversion to Bio Dynamic methods (BD)*)

(amounts in Dfl. bill.)	Actual	NEP	BD
Gross production value	32.6	29.0	19.8
Value added	14.3	13.0	11.8
Labour costs	10.6	10.0	11.9
Capital expenditure, etc.	6.7	6.4	5.7
Environmental costs for enterprises	0 -	1.5 -	0 -
Economic result at farm level	- 3.0	- 4.9	- 5.8
Environmental damage	6.1 -	3.3 -	0 -
Sectoral result including environmental damage	- 9.1	- 8.2	- 5.8

Note: *) The data presented in Table 7 show that the economic results of the agricultural sector are negative, if the market values for labour and return on capital are used. This negative result shows that the farmers accept hourly wages and returns on invested capital which are lower than average Dutch market values.
Source: Berenschot (1990: 37).