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# WORLD FOOD PRODUCTION THROUGH A SUSTAINABLE AGRICULTURE

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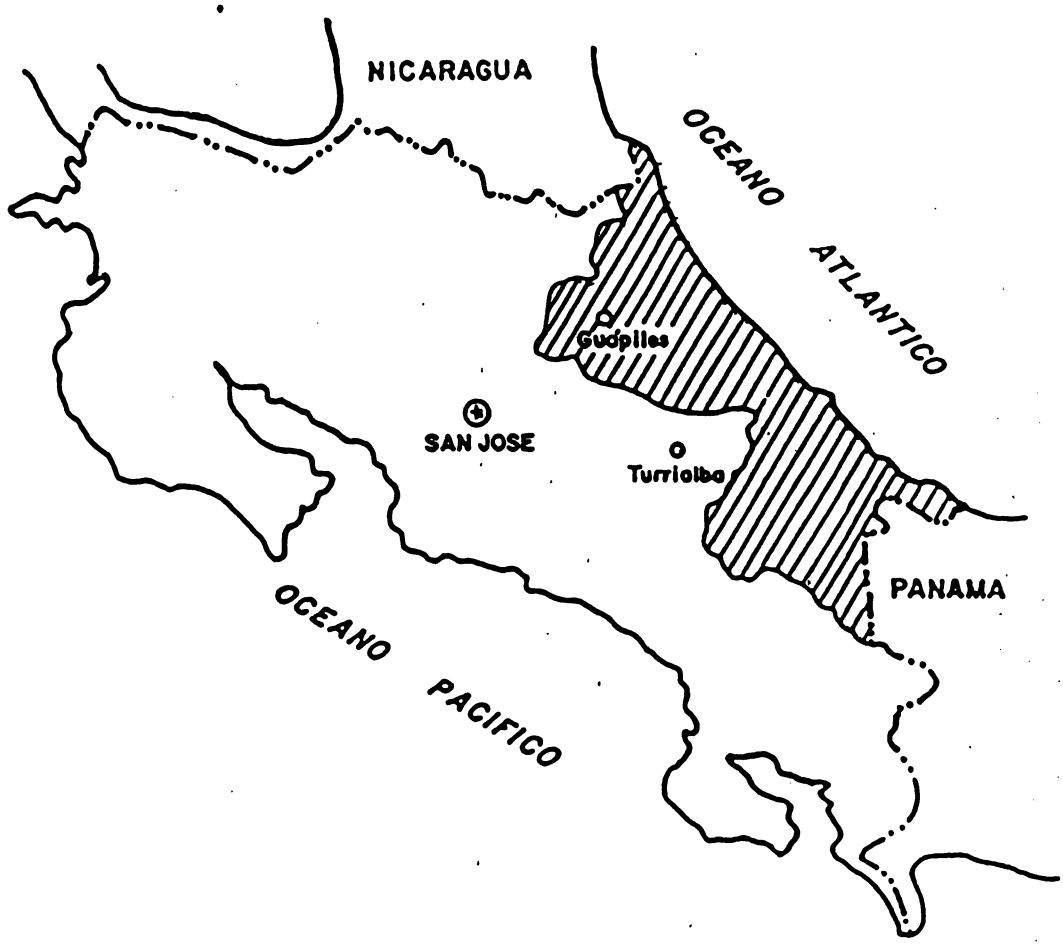
The Atlantic Zone Programme (CATIE-AUW-MAG) is the result of an agreement for technical cooperation between the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), the Agricultural University Wageningen (AUW). The Netherlands and the Ministerio de Agricultura y Ganadería (MAG) of Costa Rica. The Programme, that was started in April 1986, has a long-term objective multidisciplinary research aimed at rational use of the natural resources in the Atlantic Zone of Costa Rica with emphasis on the small landowner.




Location of the study area.

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**SUMMARY**

**Prof. Rabbinge was invited to participate in the Round Table session of the REDCA Conference in Panama September 2-6 (1991) regarding sustainable land use.**

**In his paper he presented concepts for sustainable landuse, based on broad studies realized in Europe. The presentation was prepared to enable comparison with concepts developed in the US and in the South.**

## I. CONCEPTS, PERSPECTIVES, OPTIONS FOR CHOICES

No issue has been discussed so intensively in various gremia in many developed and developing countries as "sustainable agriculture".

The term "sustainable agriculture" is something as a general accepted ultimate goal or a credo, it gives a nice feeling and it unifies people in their belief that we are working for a good objective. The absence of a clear definition enables anyone to have his own interpretation. There are some that consider "sustainable" not a particular form of farming of this or that piece of land, but emphasize that what has to be sustained is the capacity of people, countries and the world to support decent livelihoods. An important implication of this view is that not the way of farming be it external inputs intensive or extensive is important, but more how much labour is required and what are the possibilities to maintain farm employment at such a level that decent livelihoods for farmers and their employees is guaranteed. Labour replacing techniques and inputs such as tractors, threshers and weedicides - which substitute cash purchases for employment, and at the same time require more skilful management to sustain the environment - are then not desirable and there is a strong presumption against any subsidy to such inputs or to research on them.

In fact this perspective of sustainable livelihood may result in an inefficient use of inputs and resources, which may result in a continuation of a decrease of potential to support the still growing number of people under poor circumstances. The implicit choice to prevent labour substituting measures may cause the elimination of yield promoting measures and thus result in the promotion of inefficient farming, both in terms of output per input and in labour efficiency. Thus the chance to improve farm income is virtually absent and this may lead away from the envisaged objective of promotion of sustainable livelihoods of many. This example illustrates the need to be clear and explicit in the formulation of objectives.

Agriculture should be both productive and sustainable. This implies that from the ecological viewpoint renewable resources are maintained, non renewable resources are used with foresight and that the intrinsic value of the environment is recognized, and from the socio-economic viewpoint farm families make a decent living and that the increasing and changing demands for agricultural products are satisfied at affordable prices. The goals and boundary conditions are qualitatively formulated and this may help to reach consensus between groups

of people representing different interests, but it does not bring clearness in the way farm policy and agricultural policy should take place.

A political, rather than a scientific, debate is needed to reach conclusions on how conflicting objectives of productivity and sustainability are more or less achieved. The outcome of such a debate depends on political and ideological views rather than on biotechnical or technical-economical possibilities and limitations. It is, however, the task of science to rationalize the debate and distinct facts from opinions and beliefs. Too often the 'sustainability' issue has led to mystification and conservation of strategies and methods that are contra productive in the sense that they lead away from agronomic, socio-economic and environmental goals.

To achieve that role of making discussions transparent and distinct between ideological, normative preferences and biotechnical, technical-economical possibilities and limitations methodologies have been developed that are used in the project of CATIE, the Ministerio de Agracultura y Canaderae of Costa Rica (MAG) and the Wageningen Agricultural University in Costa Rica. Sustainability gets than hands and feet. Various concepts of sustainable agriculture and sustainable development can be worked out with that methodology. It makes also very clear that it is impossible to formulate on basis of scientific insights one definition of sustainable agriculture. The role of science is modest, but important, it does not develop one blueprint for a sustainable agriculture but it offers possibilities, shows what options are possible and how ideological preferences can be transferred in operational strategies.

## II. RESOURCE MANAGEMENT

For ages the need for more food for an increasing world population have been met by using more agricultural land. When population numbers were limited sustainable farming systems in the sense that they were continued for ages, were developed. Examples of such systems are shifting cultivation in tropical forests, and rainfed, bunded rice production in Asia.

However, in most situations productivity demands overruled sustainability demands, so that soil resources were over exploited. Vast areas of once good agricultural land have been lost or damaged by wind and water erosion, exhaustion or salinization. Well known examples are the bare hills in the Mediterranean region, the saline soils in the Middle East, the mining for nutrients of the commons in Western Europe and the destructive dust storms in the 1930's in the USA.

It is only in this century that various methods were developed by which overuse of agricultural land could be prevented. The slow increase of productivity during centuries as a result of better agricultural methods accelerated in this century and green revolutions

occurred. The first green revolution in the industrialized western world took place during and shortly after World War II. This revolution, a discontinuity in increase of productivity, from a rate of between 2-5 kg grain equivalents per ha per year to 80-200 kg grain equivalents per ha per year was due to innovations from various disciplines: Better water management and timeliness enabled by mechanization, improved soil fertility by the use of inorganic fertilizers, a better control of weeds, pests and diseases through the use of biocides and better varieties with higher harvest index and more resistance against pests and diseases. The high increase in productivity per unit of acreage was combined with an even higher increase of labour productivity, due to mechanization, other agronomical methods such as chemical weed control and better farm structures and organization.

For example the production of one ha of wheat in The Netherlands required about 370 hours per ha in the beginning of this century, whereas nowadays 10-15 hours per ha is used in North-Western Europe and in the USA and Australia even less, not more than 8 hours per ha. Yield levels in the Netherlands changed from circa 1100 kg $ha^{-1}$ in 1900 to 7500 kg $ha^{-1}$ at present, so that labour productivity increased circa 200 fold. Similar increases in productivity are found in other crops such as potato, rice, maize, onion.

The green revolution in the western industrialized world was combined with a decrease in number of mouths to be fed, and although diets became more luxurious with, more meat, the production increase was so high that net import of food in Europe until the eighties changed in a surplus of food in the European Community nowadays. That creates difficulties for the common European agricultural policy - that will not be discussed here - and may affect the agricultural development in developing countries as food surpluses of the E.C. are dumped on the world food market where developing countries try to sell their most important products, i.e. agricultural products. The EC policy therefore affects the agricultural development in the developing world. Thus again policy decisions are needed in the industrialized world to stimulate the agricultural and therewith further development in many third world countries.

The first green revolution in the industrialized world was followed by a second green revolution in many developing countries. Again productivity per unit of acreage and per man increased considerably from about 2-5 kg $ha^{-1}$ $yr^{-1}$ before 1968 up to 125 kg $ha^{-1}$ $yr^{-1}$ (De Wit, 1987) in the seventies and eighties. Despite an almost three-fold increase in the third-world population since 1945, global food shortages have been averted and the occurrence of famines have been reduced in both number and size. The green revolutions have enabled an improved food situation in the world although the world population increased from 1 billion inhabitants at the beginning of this century to 6 billion inhabitants nowadays. The increase in numbers continues, especially in the developing world. To feed all those people a considerable increase in foodproduction is necessary, not only due to increase in number of people but also due to increase in income and thus change in diet.

The possibilities are still there. There are still large areas that could be reclaimed in some parts of Africa and of South-America, but in many regions of Asia most of the land that is suitable for some form of agriculture is already in use. The possibilities for increasing productivity per ha are still very large, as agricultural production takes place in situations where water and/or nutrients are limiting in part or the whole growing season. About 99% of agricultural production takes place far below potential levels. In developing countries most agricultural production takes place at levels below 30% of what is potentially possible. In potential the possibilities for increasing production are still very large in most countries of South and Central-America and Africa, that the increase in population size could be met.

The increase in production per unit of area and per man requires an increased use of external inputs from the industrialized sector of the economy. Large scale reconstruction and reallocation of land in regions with agricultural perspectives is for that reason needed. This will lead to changes in the landscape and may affect diversity of the environment, but it will not necessarily lead to a reduction of efficiency of resource use. On the contrary when production will be concentrated in well endowed regions and overuse of inputs is prevented optimal production systems may be developed in which efficacy and efficiency of inputs is optimized and negative environmental side effects are minimized.
In the often too intensive agricultural production systems in North-Western Europe this would mean in many cases a reduction of inputs per harvest whereas in the majority of agricultural production situations elsewhere an increase of inputs is needed. However this is due to the big distance between Best Technical Means and Best Economical Means.
Recent analysis of De Wit 1990 confirms the notion that the so called law of diminishing returns is absent in agriculture when the combination of inputs for various purposes is mixed in the proper way. On the contrary the efficiency of resource use increases with increasing yield. This does not hold unlimited but it is definitely true at the lower end of production levels.

This would lead to the conclusion that for environmental reasons such as minimization of emission of nutrients or maximization of outputs per unit of input concentration of agricultural production in well endowed regions should be advocated. For technical reasons this may be optional. Thus a proper crop rotation, in general terms not too narrow rotations, in arable farming and as a consequence per crop high yields and properly applied inputs will lead to optimal use of inputs. This may be defined as Best Technical Means. However in practice it pays often to use more than technically optimal inputs as the economical optimum may be at higher input levels than technically speaking. This is for

example the situation in grass growing for annual farming in The Netherlands. There it pays to have a considerable overuse of inputs in technical terms. This overuse enables the farmer to spend less attention and time for proper crop management. To bring Best Technical Means and Best Economical Means in those situations close to each other an increase of the costs of inputs seems necessary, or a lower price for the end product is needed. To quantify such relations better for various crops and various production systems adequate agronomic and agrobiological research is needed.

## III. CONVERGING AND DIVERGING DEVELOPMENTS

In detailed studies on the agricultural policy in the EC it was shown that the distribution of production in the various regions is increasing in skewness. The well endowed regions are producing a more and more increasing part of the total production volume. When a maximum is set to this production, say self reliance, to facilitate entrance to the world market for developing countries and production costs determines the distribution of the production over the community this skewness increases and this would mean further marginalisation of less endowed regions. In the EC this would mean that given the continuation of the increase of productivity per unit of area, for the reasons mentioned above (distance between actual and potential production and a higher efficiency at higher production levels) the total amount of cultivated land in the EC will decrease with at least 30 percent of the agricultural land in the EC before the turn of the century. Some figures may illustrate this: At this moment the EC has $128.10^6$ ha of cultivated land and $12.10^6$ farmworkers. Within twenty years this will decrease to minimally $30.10^6$ and maximally $70.10^6$ and $2.10^6$ and $7.10^6$ farmworkers. Marginalisation of agriculturally less endowed regions is not a new phenomenon. Contraction of agricultural areas took also place in the 10th and 17th century in many areas of Europe due to decimation of population numbers due to pest epidemics. Recently abandonment of vaste tracts of lands in for instance the USA confirm these developments. This fact that there are regions where agricultural production continues to increase and regions where agriculture disappears as an important source of income has divergent consequences for the sustainability of agriculture. Both in economic and in ecological terms. Continuity in economic terms is impossible for all those who find a living in agriculture nowadays in the less endowed regions. Off farm employment and stimulation of other economic sectors seems the only way to go. Still for ecological continuity farming or other land use seems necessary to prevent degeneration. Ranching, forestry, nature development and conservation are probably although very extensive, both in terms of labour as in other inputs, feasible options. In this way a bimodal agricultural production situation may occur, on the one hand intensive, highly productive and environmental clean agriculture, on the other very extensive, low productive and also environmental clean

agriculture, which is more a form of land conservation.
This phenomenon of bimodality in agriculture will take place on all scales, be it at country level, regional level, or supranational level. The continuity of agriculture and maintenance of environmental integrity seems best guaranteed in this way. To guide such developments and to see in what way too fast developments can be mitigated by government policy or support; scenario studies at various scale levels are needed. The first and second green revolution know like each revolution its victims; as developments in the near future will be as radical as during the last decennia, policy makers should be aware of this and act adequately. This may mean that support of agricultural development in agriculturally less enclosed regions on the cost of production in well endowed regions may be necessary for political reasons. This will go at the expense of efficient resource use, but other objectives such as socio-economic convergency or political stability may be very well worth it.

## IV SUSTAINABILITY AND AGGREGATION LEVELS

Sustainable development in agriculture requires insight how to produce and manage resources at various aggregation levels. Most discussions on sustainability take place at the crop level. Detailed analysis on nutrient uptake, nutrient use and functioning of crops, the role of weeds, pests and diseases, water management etc. are done for different crops. This crop level dictates the types of disciplines involved in the design and development of crop systems that minimize inputs per unit of output, minimizes pesticide input per unit of product and maximize output per unit of labour. Much plant physiological knowledge, agronomical knowledge, soil fertility studies, irrigation studies, breeding, crop protection studies and to integrate this all production ecological studies are needed. Such insight and knowledge may lead to technically speaking optimal use of inputs and maximization of outputs per unit of input. However, it should be not one issue activity but a whole integrated crop management system. One issue management systems are not profitable and acceptable for the farmers.

Cropping system level.
A second level of aggregation is the cropping systems level. At that level the rotation and/or mixing of crops is considered. To minimize external inputs per unit of output not too dense cropping systems should be used. Again various disciplines, such as agronomy, crop protection and soil science should contribute to the development of various cropping systems.
However, in many cases the biotechnical possibilities and limitations do not determine the production but limitations and possibilities at farm level are more important determinants.

Therefore studies on farm level are very important. How are agronomical measures determined, p.e. socio-cultural considerations, labour division, tradition and other factors may govern decision making rather than biotechnical efficiency or pure economic goals. To integrate biotechnical, socio-economical studies at this level various procedures and methods have been developed.

A synthesis of disciplines and a synthesis of concepts is needed for that reason. Farming systems research may contribute there, especially in developing countries where the variation in farming systems is so very big. Proper analysis and description of farming systems is necessary to enable the development of strategies and methods that are tailored to the specific needs of various farming systems. Agronomists working on the crop level have the tendency to overestimate the possibility to change agronomical measures as they are not familiar with the background of agronomical systems in which tradition, property rights, religion and other not biotechnically determined factors play such an important role. Very often there is the idea that due to lack of knowledge farm systems operate below optimal levels. That is very often not true. For example pastoralists in the Sahel region exploit the excellent pastures in the North of the Sahel at the border of the Sahara during the short rainy season by a yearly transhumance and survive the rest of the year in the South of the Sahel, where little feed but sufficient drinking water is available during the dry season. This herding system is labour intensive, but measured by production per unit surface the most productive system that can be visualized under such agro-ecological circumstances (Bremon, 1982). Any attempt to improve production by introduction of other techniques will fail when the introduction of external production resources is not considered. This holds also for a better integration of transhumance in the North with arable farming in the South, if this would be socially acceptable to begin with.

This example demonstrates that any intervention or proposal for change should be based on a detailed analysis of as well the biotechnical and socio-economic characteristics, possibilities and limitations of the present systems as well as good evaluation of the potentials for change. The latter should include the need for external resources and thus both a micro-economic evaluation as a guestimate of how world markets develop are needed.

Farming systems operate at regional levels. At that level other analyses are needed. Again clear formulation of various concepts of sustainability are needed. It should be formulated explicitly what agrotechnical, socio-economic, environmental and spatial objectives are distinguished. These objectives should be formulated in such a way that they can be made operational. It should be made clear from the very start which part of the rural economy is taken into account. Such studies may help to rationalize decision making at the regional level and to design various strategies for development. Examples of such programs are scarce. However at some places in south-east Asia, western Africa and central America efforts are made to develop such methodologies. The agricultural research centers at Wageningen and the

agricultural university contribute to such studies and collaborate with various local research institutions. The need of such studies is amplified by the emphasis on environmental issues, the tendency to move more and more into marginal agricultural land with more and more environmentally hazardous developments and the need to have a good guidance in agricultural and other developments in the regions.

The last level at which additional studies are urgently needed concerns the national/supra national level. At that level international political interests and objectives dominate. However such developments determine the possibilities of lower levels. They determine "the weather" under which the regions must function. To prepare themselves to this, strategic studies are needed. These studies should demonstrate the space for choices local governments possess and make clear how various issues such as environmental objectives determine the limits for decision making.
In The Netherlands such studies on the European level have been done by the Dutch Scientific Council for Government Policy. (WRR, 1989, 1990)

## V. WORLD FOOD SITUATION AND RESEARCH OBJECTIVES

As said above the world food situation has improved considerably during the last decades although the world population has drastically increased. Famine and hunger occurred in many parts of Asia in the fiftios and sixties, but has diminished from an absolute shortage of food to local distribution problems. Nevertheless the increase in number of world inhabitants and the increase in income will require an enormous increase of world food production in the coming decades.
This increase is only for a small part gained by extension of agricultural production area but should mainly take place through increased productivity per ha. There are two reasons for this; 1. environmentally it is hazardous to develop marginal agricultural land, 2. the higher efficiency of outputs per input at high production levels. This does mean that we should continue to do research on agricultural productivity. Not just increase of productivity but increased productivity with a clear emphasis on higher efficiency of inputs. Thus agricultural research would serve not only agrotechnical aims but also environmental aims.
Many organisations that sponsor agricultural research are aware of the hazardous developments in marginal areas; over-exploitation as a result of poverty tend to emphasize research in these areas. However as requests for food is considerable, it would be unwise to concentrate on studies on improving agriculture in these least endowed regions. Many problems in these regions are not much different from those in the regions which are better

off, but only more severe. Accordingly, much of the agricultural research in these areas, which is in general much more difficult, is more readily applied elsewhere, so that their comparative advantage does not increase and marginalisation continues. This may be a reason for the small contribution of research towards mitigation of inequity. Changes in less endowed or marginal regions require more political decision making than agricultural research directed to these areas. This does not mean that these areas should be without research.

No, on the contrary. However, the world food situation is best promoted by research directed to increases in productivity.

Regional development and research for agriculturally less endowed regions should concentrate on socio-economic studies including various scenarios for development of those areas. It should become clear what additional economic activities may help to overcome the problem of off farm employment which is urgently needed in many of those areas.

## VI. RESEARCH ISSUES AND PRIORITIES

The subjects discussed above gave in a nutshell the need for various types of research to develop sustainable agriculture at various places. On all aggregation levels studies oriented to sustainable agricultural systems should be started or continued. Conceptualisation, quantification and exploration of possibilities, options and limitations form the backbone of such studies.

REFERENCES

BREMAN, H. 1982.
In: Penning de Vries, F.W.T. et M.A. Djitèye
La productivité des pâturages sahéliens.
Pudoc, Wageningen ISBN 90 220 0806 1

de WIT, C.T., HUISMAN, H., RABBINGE, R. 1987.
Agriculture and its environments: Are there other ways?
Agricultural Systems 23 (1987) 211-236.

de WIT, C.T. 1990
On the efficiency of resource use in agriculture.
Liber Amicorum, Dept. Theoretical Production Ecology

WRR 1989
Rural areas in Europe.

Internal Publication Wetenschappelijke Raad voor het Regeringsbeleid