SUSTAINABLE DEVELOPMENT OF AGRICULTURE, FISHERIES, AND FORESTRY

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Contents

1. Introduction
2. Major Issues in Sustainable Development of Agricultural Production
2.1. Yield Increases
2.2. Variability of Yields
2.3. Short Arable Rotations
2.4. Limited Resources
3. Control Systems for Pests, Weeds and Diseases
3.1. Development and Steps towards Pest Control Systems
3.2. Scientific Background of Disease and Pest Control Systems
3.3. Basics of Decision Making and Risk Assessment
3.4. Organization and Operation of Pest Control Systems
4. Practices for Improvement of Soil Fertility
5. Environment Protection and Sustainable Development of Agriculture
6. Food safety and Sustainable Agricultural Development
7. Effects of Agriculture on Biodiversity
Glossary
Bibliography
Biographical Sketches

Summary

Major issues of sustainability from the perspective of agricultural development are further increases in crop yields without affecting the environment. Those increases have to be realized by improvements in husbandry, plant protection and plant protection. Pests control systems are an integral part of this approach and must be based on a thorough understanding of the ecology of pests and beneficial species and their interaction with the crop as well as environmental impacts and human interferences. Knowledge about these interactions forms the scientific background of pest control systems and comprises such essential elements as population dynamics and epidemiology of pests and beneficial organisms just in the same way like investigations in the field of pest – crop loss – relationships. To be able to handle this knowledge and further adept it to practical needs specific tools for decision making are necessary. The process of decision making must evaluate the given pest situation (by surveillance and sampling tools), the forecast of pest development (determining the further impact of climatic and host factors e.g. modeling population dynamics and epidemiology of

pests), the forecast of damage (tools and decision criteria based on economic damage thresholds) and the record of successful control measures.

More sophisticated control systems also consider two levels of application. First the regional level with the purposes of monitoring the pest presence or absence (e.g. warning system), and second the farm level with the target to promote and clarify the above described process of decision making. Therefore, they are stronger connected to information needs and organizational structures, which are often provided by co-operation between state and private funded enterprises. Control systems emphasize the growth of a healthy crop with the least possible disruption to agro-ecosystems, minimizing the farmers risks and encourages natural pest control mechanisms. In this way they do achieve economic and environmental sustainability and are associated with modern integrated pest management (IPM) concepts. Soil fertility, which is an important component of sustainable agriculture, can be improved via various means of husbandry like the growth of fodder crops and the application of organic fertilizers. Based on the concept of sustainable development all changes in agricultural practices have to be assess by looking at the different dimensions of sustainability, at least the economic aspects of changes have to be considered. This poses special problems in areas like food safety and biodiversity.

1. Introduction

Sustainable Development is a concept, which incorporates the social, economic and ecologic dimensions of regional and global development. This concept is based on the responsibility for future generation and has its political roots in the discussion on the global development in relation to environmental protection. From a scientific point of view sustainable development is based on considerations in forestry sciences first mentioned in Germany in the 18th century, which focused on sustainable harvest. At that time it was defined as an annual harvest equivalent to the annual re-growth in a forest which thus allows a long term use of a particular area.

In recent years the concept has been extended to various other sectors apart from agriculture, forestry and fisheries and is now considered as a global issue and guideline for international political discussions and decisions. This widespread international recognition has first been achieved with the so called “Brundtland-Report” published in 1987. The next milestone in the discussion and implementation of the concept of sustainable development was the world summit in Rio de Janeiro in 1992, which led to the signing of the Agenda 21 by a great number of political leaders.

In this Document the political leaders of the world agreed to promote a global sustainable development. Following this summit the concept of sustainable development was e.g. incorporated in the work of the UN with the establishment of the Commission of Sustainable Development (CSD) and various activities of the Food and Agricultural Organization the UN (FAO). Since those first conferences and the establishment of the different international organizations and bodies the concept of sustainable development has become a major issue in a great number of different political areas from rural and urban development to education and gender issues.

For the areas of agriculture, forestry and fisheries the concept of sustainable development is now focused on the measurement of developments via indicators and the political implementation of different means to allow a more sustainable development. The quality of indicators, however, varies tremendously. Economic indicators are mostly easily established and agreed upon because such indicators have been used for international and national benchmarking for decades. More difficult is the question of indicators for ecological parameters. In general, indicators for abiotic parameters like nitrogen balances, soil erosions, soil compaction etc. are not as critical to establish in comparison with appropriate indicators for biotic parameters like biodiversity. The quality of indicators for social development depends on the scale of comparisons. National indicators like literacy, school attendance, education, work load etc. are better established from a scientific point of view then indicators to compare single farms. The next important step for the establishment of a sustainable development is the combination of the different separate indicators and thus the three dimensions of sustainability. A great number of interactions and interrelations affect the response and make comparisons of systems either in agriculture, forestry or fisheries notoriously difficult. Another intrinsically difficult aspect of the concept of sustainable development is the pledge to care for future generations, which imply an almost infinite responsibility. From a scientific point of view this claim is almost impossible to incorporate into concepts or models.

The question remains: What is the real scientific and political innovation of the concept of sustainable development following almost 100 years of discussion on environmental protection, economic development as well as social and human rights issues especially in relation to the third world? The answer lies in the consequent combination of the three dimensions. The concept of sustainable development tries to give guidelines for environmental protection and incorporates the economic and social consequences and this view applies to all dimensions. Such a concept relates to almost all aspects of global and local human development. It is easy to call for but very difficult to establish and consequently to administrate.

Agriculture, forestry and fisheries play a central role in the concept of sustainable development, because unlike other sectors of the economy, those three areas have close relations to all three dimensions of sustainable development. Agriculture and forestry, for example, require a great proportion of the fertile land area of the earth and thus affect environmental parameters in a global scale. Agriculture, forestry and fisheries including the food sector are important economic parts of the global economy and the living conditions all around the globe are affect by the situation of primary production. This importance of agriculture, forestry and fisheries has therefore played a great role in the discussion on sustainable development. The agenda 21 has a number of chapters dealing with those areas and also various indicators of sustainable development are based on parameters which have a close relation to agriculture, forestry and fisheries. Additionally the long term aspect of sustainable development relates closely to the concept of soil fertility as a typical feature of agricultural and forestry production.

With respect to the concept of sustainable development some aspects of agricultural production require special attention, because they have long term effects with consequences for all three dimensions. Important is the development of soil fertility, the

effect of pesticide application and plant protection as well as the productivity of agriculture, forestry and fisheries.

2. Major Issues in Sustainable Development of Agricultural Production

The most important issue in the discussion of the concept of sustainable development in relation to agricultural production is the need for further yield increases in the future without affecting the environment. Until very recently the answer to this question was solely based on the expectations of the future development of the world population and the consumption patterns of this population. Up to now it would have been easily possible to produce sufficient food even for a growing population of up to 9 or 10 billion people if the consumption of meat would be decreased. With the exception of crisis even this development is highly unlikely. In contrast, the developing economies in Asia have drastically shown that the consumption patterns change in the opposite direction with more meat consumption and thus an unprecedented demand in cereals in countries like China, Indonesia and Thailand. Additionally the world population increases, which amplifies this development.

On a global scale, it is almost impossible to substantially increase the acreage used for agricultural production, however, in some areas potential for an increase exists. Especially in areas with set aside programs some increase in the areas used for agriculture production is possible, which applies to the European Union. Higher yields with a constant input of fertilizers and pesticides translate into a more efficient use of the limited resource soil. This would, however, limit the pressure on natural ecosystems.

Given the current high price level for fossil fuels another competition becomes increasingly important, the competition between the production of food and the production of biomass for energy. In a number of areas in the world it is currently more economically feasibly to produce energy from agricultural crops like sugar cane in Brazil or corn in the US then to produce crops for food. If this trend further continues – and it seems to be very likely – much more pressure will be put on the limited resource soil. Any further prediction of the future development of agriculture production and the major issues in relation to sustainable development is therefore strongly based on supply and demand and the price development of the energy sector. This makes predictions even more difficult.

2.1. Yield Increases

Agriculture around the world is characterized by enormous yield increases in all major crops. From the perspective of sustainable development it is imperative to further increase the yields with as little negative effect on the environment for various reasons. Mainly it is necessary to feed a growing population but also to set aside land for environmental reasons. If the current yield increase can continue in the future is hotly debated among scientists. Based on empirical data from the yield development on a country by country basis it can be shown, that the yield increase has diminished in the last decades.

How difficult a forecast of the future yield development is, can be exemplified by

looking at older projections. In the 1950ies plant breeders estimated the potential for increasing wheat yields approximately around a further 20 percent. In reality the yield increase has been 50 percent and record wheat yields are now fivefold compared with the time 50 years ago. A mayor reason for this yield increase in cereals like wheat, barley and rice is the change in the so called harvest index. This index describes the relation between the total above ground biomass of a crop and the harvested biomass. In wheat and rice this index has increased from 0.3 to 0.5 in the last decades, whereas the total biomass has not changed a great deal. Plant breeders are skeptical if this development can continue in the future and therefore other morphological changes in the architecture of crops are in the focus now.

2.2. Variability of Yields

A mayor issue for a sustainable development of agriculture in the future is variability in time and space. Yields, without any question, are important, however, it is not only the average yield but also the variability from year to year which affects profitability and efficiency of farm operations. Those differences in the efficiency determine a great proportion of the environmental effects of agriculture production. Each misconception about the yield potential inevitable causes a higher nitrogen balance and leads to nitrate pollution. The better such a variability is managed, the smaller are the effects of agriculture production on the environment.

One possibility to deal with this year to year variability is the use of crop models; however, most of those models have been developed with a scientific focus and have not been widely applied to practical agriculture. The quality of the models varies, with most advances developments in the major crops wheat, maize and rice. Other crops have attracted only limited attention. The importance of the year to year variability seems to increase due to the changing weather conditions in the context of climate change, although data on this hypothesis is still quite scarce. Apart from the variability in time the variability in space is a major issue in relation to sustainable development in agriculture. Technical developments in satellite positioning have improved the situation in this area.

2.3. Short Arable Rotations

The history of arable farming systems in the last 100 years shows a decrease in the number of crops grown. Various attempts have tried to counteract this development; however, those attempts have mostly been unsuccessful. Currently maize, wheat, rice dominate in most arable areas of the world. The reasons for this development are mainly the higher yield potential of the crops mentioned as well as a great number of uses and production chains suitable for those particular crops. In consequence the plant breeders and the chemical industry concentrate on this limited number of crops, which further intensifies this development. Crops with a limited acreage face difficulties from the marketing side. The last consequence is the lost knowledge in practical farming and agriculture research. Currently this development is happening with legume crops in northern Europe.

The concentration on such a limited number of crops has dramatic ecological

consequences, since the entire ecosystems – weeds and pests - which relate to these crops also vanish. On a landscape scale this means a reduction in biodiversity. Such an example underlines the need for a broad social discussion on situation of agriculture production, because the consequences of a further decrease in the number of crops grown will have consequences for the entire society.

2.4. Limited Resources

The use of corps for the production of biomass has to comply with regulations of good agriculture practice and criteria for sustainable production. The trend to a small number of crops should be reversed; however, the current situation shows a completely different tendency with further increases in the acreage of maize in Europe. Critical is the long term development of soil fertility and soil carbon content in relation to the growth of energy crops. If energy production is the main target, a complete use of the above ground biomass is necessary, which increases the challenge to manage the soil organic balances. In the long term other limited resources will gain more importance. For example phosphorus is limited and forecasts are quite dramatic. Given this development it is important to close nutrient cycles on a farm but also on a regional level.

3. Control Systems for Pests, Weeds and Diseases

The use of chemical plant protection products is the most criticized husbandry technique in today's agriculture. Connected to the criticism are examples of the poisoning of man and animals as well as the side-effects of chemical plant protection on the ecosystem or the natural balance in total. In these discussions it is often denied that the world-wide harvest losses by diseases and pests are enormous, with dramatic consequences for global food security. For example, in rice up to 83% of their potential yield would be lost. Despite plant protection measures in wheat an average of 36% of the possible global harvest is lost each year. Averaged over all crops, it would rise to 50% without plant protection activities. Therefore plant protection makes a important contribution for food security of people and farmer's income. On the other hand it is imperative that plant protection needs to be improved.

In total, crop protection today pursues three objectives:

- Safe supply of food, livelihood from harvest to harvest and optimum income per unit land or input,
- Minimize effects on mankind and nature, and
- Improve plant protection in all its facets (Methods, products and management).

In this understanding, crop protection implies options ranging between the two extremes of total loss of crop and hazards to man and environment. To avoid losses and effects on man and nature, and at the same time to achieve an effective and economic control of diseases and weeds a comprehensive strategy is needed. In this sense pest management today is commonly understood as a methodology to reduce pest and diseases intensities in order to avoid crop and yield losses and environmental hazards. Pest management systems are setting the framework towards this goal.

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Biographical Sketches

Olaf Christen, born in 1961, has studied agriculture science at the Christian-Albrechts-University in Kiel, Germany and earned a PhD in Agronomy in 1990 with the focus on preceding crop effects on winter cereals. From 1991 to 1992 Olaf Christen has worked as a postdoctoral fellow in the Department of Agronomy and Soil Science, at the University of New England, Armidale, Australia. Since 2000 he holds the chair of Agronomy and Organic Farming at the Martin-Luther-University in Halle-Wittenberg, Germany. His main research interest includes farming and cropping systems, sustainable agriculture, biodiversity in agricultural landscapes and oilseed rape agronomy.

Wolfgang Heyer studied agriculture from 1969 to 1972 at the Martin-Luther-University in Halle (Germany), with the specialization in plant protection, particularly in integrated pest management (IPM). In 1976, he received his PhD from same University. He wrote his thesis on ecological investigations of the cereal leaf beetle in the central parts of Germany (life cycle, population dynamics, damage capacity). The results were used to create a monitoring system for the whole country, including computer based simulation models for cereal leaf beetle dynamics in winter wheat fields (PESTSIM OUL). This was followed by five years research work on pests in tropical bean stands in the Caribbean (computer aided

pest prediction, damage thresholds, monitoring instructions). Recent work at Halle University is mainly concerned with studies on beneficial arthropods in agricultural land, with the aim of their possible protection and support for increasing their population. Additionally, these ecological results form a basis for evaluation of farming systems with special focus agro-ecological questions and biodiversity.