Background Paper 1: **Agricultural Biodiversity**

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INTRODUCING THE SIX BACKGROUND PAPERS

The *FAO/Netherlands Conference on the Multifunctional Character of Agriculture and Land* (MFCAL) will take place in Maastricht, the Netherlands from 12-18 September, 1999. Discussion will be based on a series of specially-prepared case studies and two main technical documents - *Issues Paper: The Multifunctional Character of Agriculture and Land* and *Taking Stock of The Multifunctional Character of Agriculture And Land.*

The six Background Papers in this volume provide an additional source of information and reference. Their purpose is to stimulate thought and to illuminate the very real value of what could be called "the MFCAL Approach" for the study and analysis of specific subject areas and themes. They also demonstrate the two-way value flow, showing how the MFCAL Approach can be enriched through reference to specific examples, but similarly, highlighting the valuable contribution that the approach can make to individual subject areas and issues.

The production of the papers has been overseen and coordinated by the Executive Bureau of the Conference. Each paper has been prepared by an independent group of authors and technicians from within and beyond FAO. Indeed, in providing these papers, it is important to note that the designations employed and the presentation of material do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations or the Ministry of Agriculture, Nature Management and Fisheries, The Netherlands, concerning the legal status of any country or its authorities or concerning the delimitation of its frontiers or boundaries.

We are certain that each paper provides a valuable contribution to the ongoing development of our understanding of the Multifunctional Character of Agriculture and Land and to the discussions at the Conference in September.

For reasons of both cost and time, it has not been possible to translate the six Background Papers. Summaries in French and Spanish will be available on the internet prior to the Conference in Maastricht (http://www.fao.org/mfcal) and will be available at the Conference venue.

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Most importantly, thanks must go for the people who acted as technical focal points for the production of the six individual documents (FAO, unless otherwise indicated): Linda Collette (**Agricultural Biodiversity**); Gustavo Best (**Bioenergy**); Dominque Lantieri and Francois Lemmans (IFAD) (**Drylands**); Terri Raney and Jeff Tschirley (**Environment, Trade and SARD**), Eric Kueneman, Michael Zoebisch(ICARDA), John Dodds (ICARDA) (**Research and Technology**) and Wulf Klohn (**Water**). They all embraced the challenge with enthusiasm, efficiency and utmost professionalism.

A large and distinguished team from within FAO, the Ministry of Agriculture, Nature Management and Fisheries, The Netherlands, throughout the CGIAR System and from a number of universities and research institutions provided important inputs to the Background Papers. Their individual contributions are recognised in the individual acknowledgements of each paper.

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Sustaining the Multiple Functions of Agricultural Biodiversity.
Background Paper 1: Agricultural Biodiversity:

SUMMARY

The present paper reviews the relationships between agricultural biodiversity and the functions of agro-ecosystems at different spatial and temporal scales. Selected examples are used to highlight the multiple functions of agricultural biodiversity and its links with rural livelihoods in a range of ecological and economic settings.

Agricultural biodiversity encompasses the variety and variability of animals, plants and micro-organisms that are important to food and agriculture, which result from the interaction between the environment, genetic resources and the management systems and practices used by people. Plants and animals, both wild and cultivated, have been combined, modified and managed by people for millennia, in complex and diverse agricultural systems. Agro-ecosystems necessarily include, by definition, people and their institutions, as well as the agricultural biodiversity that they use and influence through their diverse range of social goals and definitions of well being.

In the first part of the paper, the multiple functions of agricultural biodiversity are discussed in terms of its contributions to food and livelihood security, production and environmental sustainability, and rural development.

Dynamic and complex livelihoods usually rely on plant and animal diversity, both wild and in different stages of domestication. Different types of agricultural biodiversity ("cultivated", "reared" or "wild") are used by different people at different times and in different places, and so contribute to livelihood strategies in a complex fashion. Understanding how cultivation, herding, fishing, collection, use and marketing of different types of agricultural biodiversity are differentiated by wealth, gender, age and ecological situation is essential in order to evaluate their overall economic value.

In addition to contributing to environmental sustainability, agricultural biodiversity helps sustain many production functions both in low external input and high input-output agriculture. Available evidence is summarised for the following functions: decomposition and nutrient cycling, biomass production, soil and water conservation, pest control, pollination and dispersal, biological diversity conservation , climate, water cycling and influence of agricultural biodiversity on landscape structure.

In addition to its contribution to food and livelihood security, agricultural biodiversity can provide a basis for eco-tourism and the regeneration of localised food systems and rural economies.

In the second part of the document, underlying causes of agricultural biodiversity losses are summarised in order to identify some of the actions and, policy and institutional reforms needed to sustain agricultural biodiversity and agro-ecosystem function:

The neglect of indigenous knowledge, local institutions and management systems. Local knowledge and practices can offer striking examples of active conservation and sustainable use of agricultural biodiversity.

One of the most fundamental causes of agricultural biodiversity loss, both past and present, is the active promotion and spread of the *blueprint approach* to development. Typical expressions of this are industrial agriculture and the closely related Green Revolution, focused on maximising commercially important yields and productivity through the use of monoculture systems and uniform technologies.

Corporate interests are increasingly reflected in research, development and distribution of seeds, livestock and other technologies that directly affect agricultural biodiversity.

Inequitable tenure and control over resources. A significant cause of agricultural biodiversity loss is linked with the inequitable access to, and control over, land, water, trees and genetic resources. Denying

rights of access and resource use to local people severely reduces their incentive to conserve resources and undermines local livelihood security.

Market pressures and the undervaluation of agricultural biodiversity play a significant role in the loss of agricultural biodiversity. The expansion of global markets and recent patterns of trade liberalisation have a homogenising effect on agricultural biodiversity by standardising food production and consumption. Policies for harmonisation of standards that accompany the globalisation of markets are strong forces undermining efforts for the sustainable use of local agricultural biodiversity and local adaptations. The multiple functions of ecosystems are difficult to value in economic terms, and indirect ecosystem function values and the economic and social values of biodiversity to rural people have been largely underestimated by outside professionals.

Demographic factors such as the expansion of human populations and large migrations are often partly responsible for agricultural biodiversity losses in new "frontier" areas such as forests, coastal zones, mangroves and grasslands.

Options for sustaining agricultural biodiversity and its functions are presented in the concluding part of the paper with a rationale for each series of proposed actions:

Expanding knowledge on the dynamics of agricultural biodiversity. Knowledge about agricultural biodiversity and the processes enhancing or eroding it is the basis of national and international policy making and determines which kinds of management regimes prevail. However, much is uncertain and unknown about the structure and multiple functions of agricultural biodiversity. Investments are therefore needed to improve and expand our knowledge about agricultural biodiversity and its functions.

Increasing effective use of agricultural biodiversity in food and fibre. Agricultural biodiversity performs vital functions in agriculture, land and water use. Future global food security is dependent on harnessing and sustaining agricultural biodiversity and its many functions, from the farm plot to the landscape level. National sovereignty and food security ultimately depend on a wide choice of agricultural technologies and development options from genetic to ecosystem levels.

Promoting local adaptive management of agricultural biodiversity. Variation within and among agro-ecosystems is enormous, and calls for far greater appreciation of local farming practices and knowledge used by rural people to manage agricultural biodiversity in forests, wetlands, fields, rangelands, coastal zones and freshwater systems.

Supporting local participation in planning management and evaluation. Land use planning should enable local people, especially the poor, to define their priorities and needs.

Transforming bureaucracies and professional practice. Local adaptive management of agricultural biodiversity and large-scale participation challenge bureaucracies to shift from being project implementers to new roles that facilitate local people's analysis, planning, action, monitoring and evaluation.

Strengthening local rights and security of tenure. There is a need to provide a legal framework within which a devolved management of agricultural biodiversity can operate effectively, especially in respect of resource tenure.

Reforming trade-related policies, markets and economic incentives. Economic instruments such as trade policies, markets, subsidies and economic incentives are key to sustaining agricultural biodiversity and its multiple functions. A multilevel and systemic approach to economic transformation will often be needed to reform trade, taxation and public spending aimed at sustaining agricultural biodiversity and its multiple functions.

The Multifunctional Character of Agriculture and Land: the energy function.
Background Paper 2: Bioenergy.

SUMMARY

Agriculture is intrinsically multifunctional in character. Furthermore all agricultural activity and related land use leads directly to other non-agricultural functions ranging over social, environmental, economic and cultural goods and services, which can result in significant benefits or costs. However, there is abundant evidence that, beyond food security, the multifunctional character of agriculture makes significant contributions to achieving rural development, energy and environmental sustainability at local, national, regional and global levels. An improved and more systematic understanding of this "multifunctional character" can lead directly to even greater benefits. The significance of this multifunctional character constitutes a major issue for contemporary policy-makers and practitioners alike. This document is an attempt to assess the energy function of agriculture.

The role of agriculture as an energy consumer related to the energy needs for irrigation, fertilisation, transport, processing and conservation is quite well documented, even if it is still necessary to view the energy/food nexus more systematically. The role of agriculture as a major energy producer is rarely recognised or put into practice. Growing consideration of global climate change and increasing awareness of the potential of biomass energy as a motor for rural development have triggered new attention. This study draws from these new concerns and understandings.

Bioenergy production and use is an important agricultural activity particularly in many rural areas of developing countries. Combing both traditional and modern forms, biomass energy currently provides about 55EJ (equivalent to 25 million of barrels/day of oil), equivalent to approximately 14% of the world's energy. It is the single most important source of energy for developing countries as a whole, and accounts for 34% of total energy provision. Indeed, in many developing countries it represents over 90% of total energy use. Although levels are predictably low in developed and industrialised countries, it can still account for as much as 20% of total energy use in some of these countries. Much of this energy originates from various types of agricultural and forestry residues, although in the future various types of energy crops and plantations are expected to provide the main source.

Biomass was the main source of energy prior to the early 20th century. During the last few decades however - the so-called "oil era" - biomass energy has been relegated and largely ignored by policy makers and energy planners alike. Current trends indicate that the amount of bioenergy used remains stable (or even growing) with an increased use in industrial countries such as EU members and USA, as a result of mainly environmental reasons rather than for energy considerations. Since the early 1990s, the increasing interest in biomass for energy has been manifested in most energy scenarios showing biomass as a potential major source of energy in the 21st century, ranging from 59 to 145 EJ by 2025. This expected increase of biomass energy could have a significant impact for agricultural development.

Despite the high energy intensity of agriculture in industrial countries, in global terms the agricultural sector consumes little energy in comparison to other industrial sectors. In fact, in many developing countries inputs levels are very low. This means that: i) by adopting western patterns of agricultural modernisation would lead to higher level of energy use, ii) the potential of C mitigation in agriculture from decreased energy use is much smaller than other sectors. The combined potential of agricultural systems for mitigating CO_2 has been estimated at between 0.94 and 2.53 PgC/year compared to present global emissions of 7.0 PgC/yr.

In the short to medium term, residues will continue to be a major sources of bioenergy and thus would have less direct implications for agriculture than would be the case if large scale energy crops and plantations were established on agricultural land. Guidelines for residues use are urgently required in order to determine what "is" and what "is not" renewable to ensure maximum environmental advantages, as has been done with energy forestry/crops/plantations. The large-scale use of animal manure for energy is questionable because their non-energy uses may have greater value, except in

specific circumstances where surplus manure poses environmental problems for agriculture such as in Denmark where surplus manure is treated to produce biogas and also fertiliser as a by-product.

Energy technology has been improved over the past two centuries to meet certain economic and also environmental criteria but not for sequestering C. Large-scale use of bioenergy, when it reaches market maturity, offers the most effective alternative to C sequestration. The conventional view that use of biofuels were often a cause of land degradation, deforestation and health hazards, is not supported by evidence. For example, health hazards of biofuels are a more direct consequence of cultural practices, underdevelopment and poverty than to the nature of biofuels themselves. Most of these negative impacts could be eliminated by improved socio-economic conditions such as better housing, and improved technology such as improved cooking stoves.

Agricultural development has been highly unequal around the world, stemming in part, from differing levels of socio-economic development, resource endowment, climatic conditions, policies, etc. In many developing countries a major reason has been the lack of political support to farmers for, for example, infrastructure, markets, R&D and extension, despite the fact that agriculture is often the main source of livelihoods for the majority of the population. Some of these shortcomings are now being addressed through more consultation with the farming community, greater recognition that traditional farming knowledge has a role to play, that modernisation of agriculture needs good technical skills, the role of women in food production, etc. There is also greater recognition of the potential role of bioenergy in socio-economic development and in food production. Bioenergy can be a large (if normally secondary) source of employment and income for many farmers in remote rural areas. The potential implications of large-scale production and use of bioenergy for the rural economy are significant and thus should not be overlooked.

Climate change and its potential implications for agriculture poses many questions for which there are still very few answers. Stated simply, not enough is known to make any meaningful predictions. Much more long-term research is needed before any unequivocal recommendations can be made. The intricacies of land availability, food and fuel competition are being addressed more seriously, and it is now more widely accepted that land availability is not at the heart of the problem but agricultural mismanagement, waste, land tenure, policy interference, etc, are more crucial problems. The potential role of bioenergy has been addressed more seriously since the early 1990s when global concerns such as environmental pressures, privatisation of the energy sector and concern with sustainability started to arise.

Farmers have demonstrated their capacity for change and innovation if they see clear opportunities. With proper support (extension services, infrastructure, financial, etc.), farmers will be able to produce far more food and energy, provided that the necessary changes are put in place. It is important to remember that production of food and energy in agriculture are mutually interrelated and complementary. Bioenergy programmes, when coupled with agroforestry and integrated farming, can improve food production by making energy and income available, where it is needed, in a more environmentally and sustainable manner.

However, bioenergy production is a complex issue that depends of many and varying factors. Bioenergy should not be regarded as a universal panacea for solving agricultural and energy problems in rural areas, but as an activity which can play a significant role in improving agricultural productivity, energy supply, the environment and sustainability. Its final contribution will depend on a combination of social, economic, environmental, energy and technological factors. The multifunctional character of agriculture and land, and its potential role in bioenergy production should receive greater recognition, together with the need for positive political encouragement, and socio-cultural adaptations.

Drylands and the MFCAL Approach.
Background Paper 3: Drylands.

SUMMARY

This paper reviews processes, patterns and trends of agriculture and land use in drylands areas. It also explores the extent to which an approach directed at the multifunctional character of agriculture and land – the MFCAL Approach - can help address the greatest challenge facing drylands, namely combatting desertification. The discussion opens with a review of the MFCAL Approach leading to the design of a simple referential matrix which provides the basis for subsequent analysis. Attention then turns to the related themes of drylands and desertification, focusing on the implication of these issues for both dylands countries and drylands populations. The paper then assesses the field experiences of various partners world-wide using case studies collected from both two separate databases - the *FAO/Netherlands MCS Database* and the IFAD project database. The analysis identifies the key factors shaping both success and failure in drylands areas and extracts key lessons for the future sustainable development of drylands and for combating desertification. Finally, the paper translates these findings into a preliminary set of normative guidelines and recommendations for improved project cycle management in drylands and for heightened coherence in policy formulation and decision-making process.

The MFCAL Approach incorporates a willingness to recognise the wide-ranging contributions and influences of agriculture and related land uses and to emphasise the diversity of functions as an effective resource and asset. The present paper analyses the relevance and applications of the MFCAL approach to drylands.

Characterised by limited water, soil and biodiversity resources, drylands have traditionally enhanced the multifunctional use of agriculture and land as a priority and as a matter of basic necessity. However, increased pressure from natural and human factors exacerbated the process of land degradation in drylands, raising dramatic issues on the sustainability of current land use patterns and farming systems, as well as on the quality of rural livelihoods in the concerned areas.

All land use options described in the paper, including food production, cash crops, range farming, exploitation of wood products, nature conservation, tourism and mineral extraction, show multiple interactions, trade-off and impacts according to site, time, scale and a combination of influencing factors.

Particular attention is also given to the desertification issue. It is shown that both causes of desertification and strategies to combat desertification can be usefully analysed using an MFCAL approach.

This general review is followed by the assessment of 51 case studies and success stories, applying the MFCAL analytical framework and selected from the *MCS Database*, developed as part of the Stock-Taking component of the preparatory process leading to the FAO/Netherlands Conference on the Multifunctional Character of Agriculture and Land and the *IFAD Project Database*. These case studies represent a wide range of scenarios in terms of geographical location, implementing agencies, production system and scale of intervention

Two case study types typologies based on what is perceived as the major priority issues: (i) the development of favourable socio-economic conditions ensuring food security, poverty alleviation and appropriate policy and institutional framework (*human-driven approach*) , and (ii) the preservation of the natural land capital and the development of environmentally-sound land management systems able to mitigate the effects of land pressure and to provide economic development and benefits for a wide-range of stakeholders (*resource-driven approach*).

The case studies demonstrate that whatever priority objective is chosen, the effective results and impacts largely depend on the actions carried out and on a combination of internal and external influencing factors taken in due consideration during the project cycle and which cover most functions contained in the MFCAL approach, even if they are not part of the initial objective of the project. They

particularly stress the importance of the social cohesion function through stakeholders' participation in planning and managing the land resources, of the economic development function through the necessity of appropriate financial and technical services able to boost local initiatives, of the knowledge function through the necessity of integrating traditional knowledge with innovative technology and of the policies and institutional function through appropriate actions to regulate land tenure and agricultural prices.

Although prioritisation and appropriate targeting are widely considered as necessary steps in the first place, the performance and the positive impacts of the projects are strongly improved by recognising the diversity of functions as an effective contribution to the development of sustainable land use patterns and by applying a flexible approach in addressing the issues at stake. The cases studies also confirm that the multifunctional character of agriculture and land is intrinsically related to the characteristics of drylands natural, social and economic environments. Optimisation of land resources, which remains the real challenge of these regions, is strongly dependent on the range of functions these limited resources can effectively generate.

The paper analyses the extent to which the MFCAL approach can improve the common methodologies used for project management (e.g. logical framework) and help to harmonise the variety of sectoral and functional policies optimising the institutional, legal, organisational and financial mechanisms in place in the recipient countries.

It also summarises some of the opportunities and the risks of the MFCAL approach, stressing the potential added value that it represents by offering a wide common framework applicable at both the micro and macro levels, by focusing on problems or functions rather than sectors, and by allowing to identify in a flexible manner complex links, synergies and gaps occurring in development programmes of drylands.

In conclusion, the paper recognises the potential utility of the MFCAL Approach. It also underscores however, the need to further refine the approach and the need to test it in the real world, at both macro and micro levels, in order to assess its operational usefulness for the sustainable development of drylands.

Environment, Trade and SARD: Concepts, Issues and Tools.
Background Paper 4: Environment and Trade.

SUMMARY

The 1992 Earth Summit, the 1994 WTO Agreements, the 1996 World Food Summit and numerous multilateral environmental agreements comprise the major international frameworks that influence national policies in the areas of international trade, environmental protection and sustainable agriculture and rural development. These agreements and declarations have set in motion a dynamic process that is not yet entirely consistent or coherent in balancing the objectives — environmental, economic and social — of the world's diverse nations. While it is clear that countries and groups within countries differ sharply in their interests and priorities, it is imperative that the international community seek common ground in addressing these crucial challenges. Toward that end, this paper reviews the role of trade policy in SARD, discusses the framework of international agreements and understandings in which the trade-environment-SARD debate is being pursued, and explores some of the concepts and tools underpinning the debate. The paper the highlights some of the key issues of concern for developing countries and concludes by identifying some of the principles underlying an effective policy framework for trade liberalisation and environmental protection within the context of SARD.

Research and Technology and the Multifunctional Character of Agriculture and Land. Background Paper 5: Research and Technology.

SUMMARY

The paper defines research activities carried out at the CGIAR centres within the context of the multifunctional character of agriculture and land (MFCAL). Ways are described in which technologies and knowledge generated by the centres are applied in collaboration with national program partners, which contribute to a range of key functions, namely food security, natural resource management (including environmental husbandry), socioeconomics, policy and institutional strengthening. Technologies developed by the centres already have a significant impact in the different functions of agriculture. Specific research activities undertaken at respective centres are outlined as an illustration of how the research agenda of the CGIAR Centres take account of MFCAL. These activities cover a wide range of subjects and issues, reflecting the crucial and complex linkages between agriculture and related land-use.

There are two main roles for research: (i) To contribute to the proper understanding of the interactions and interdependencies of agricultural production systems, the farming communities and the socio-economic and socio-political framework, and (ii) to use this understanding for the development of appropriate technologies, which improve production systems' outputs at the land user's end, and which are environmentally sustainable.

The vast diversity of agricultural systems and environmental conditions demand more location-specific solutions. Agricultural research has contributed significantly to the development of well-accepted technologies, such as agroforestry and intercropping systems which provide soil protection, expand the diversity of agricultural production and contribute to improved income generation. Also, significant progress was made, through research, in developing sloping agricultural land technologies (SALT) which permit the sustainable and productive use of steeplands in densely populated regions. Progress has also been shown in policy research. A number of countries have revised their land-use and environmental policies to ensure sustainable utilisation of limited agricultural resources. All these technologies and strategies aim at addressing the multifunctional character of agriculture and land, tapping potentials and recognising limitations of the biophysical and socio-economic environment.

However, there is a need for new and better-adapted technologies, which keep pace with changing overall conditions, developments and environments. The complexity of agricultural land use demands more comprehensive, accessible and user-friendly information and communication systems. These are important prerequisites to facilitate improved cooperation and interdisciplinary research. Improved tools for agro-ecological characterisation, in conjunction with geographical information systems (GIS), will help identify and locate 'hot spots' of land-use areas of concern and enable extrapolation of technologies to other areas of similar characteristics. To fine-tune existing generic technologies to location-specific requirements is another challenge for agricultural research, and establishing the limits of carrying capacities of different agricultural environments.

The multifunctional nature of agriculture is already embodied in the mission of the Consultative Group for International Agricultural Research (CGIAR) to strive for poverty eradication, food security and sustainable agricultural development while conserving the natural resource base. It is reflected in research activities undertaken at the International Agricultural Research Centres (IARCs), although not defined categorically within the context of MFCAL.

The Contribution of Blue Water and Green Water to the Multifunctional Character of Agriculture and Land. Background Paper 6: Water.

SUMMARY

Water is vital to agriculture. It is a central ingredient of the multifunctional character of agriculture and land. This paper explores both the multiple contributions that water makes to agriculture and also, some of the different ways that it supports the multifunctional character of agriculture itself. In particular, the paper examines the extent to which agriculture contributes to food security, improved environmental management and food security. The analysis builds heavily on the so-called MFCAL approach. This approach is built on the recognition of the multiple functions of agriculture beyond food production

The paper examines four questions:

- What amounts of *green* and *blue* water are appropriated in different types of agriculture and by various crops and other vegetation
- What are the tradeoffs between agricultural and other water uses
- What is the significance of urban expansion for water use in agriculture
- What are the pre-conditions for agriculture in various regions of the world in terms of climate and availability of plant nutrients. What particular forms of agriculture is most viable in different regions and water regimes.

The annual water requirement necessary to achieve food security varies between 1000 and 2000 m^3 per person and year. This water is provided by rainfall ("green water") and may, where rainfall is deficient, be supplemented with irrigation ("blue water"). The process of producing biomass is highly water consuming and returns water vapour to the atmosphere – water actually used by vegetation, whether natural or agricultural - is not returned to the river basin. There is no substitute for water in the photosynthesis process.

The combination of poverty and a large and growing population in relation to available water resources constitutes a major challenge with regard to food security and is also detrimental to the development of a viable multifunctional agriculture. The water challenge is compounded in some countries by the fact that a large share of the annually renewable "blue" water resource is already utilised. In some countries, there are simply no more easily accessible sources to exploit. In other countries, the financial, environmental and social costs associated with dams and withdrawals contribute to a reduction in rate of exploitation.

Producing more with less water can only be achieved if the water that is available for agriculture is used more efficiently and productively. The main principle must be to minimise the unproductive evaporation and to optimise the productive transpiration. In rainfed systems, water harvesting techniques and water conservation are important to make better use of the "green water". Irrigated agriculture has to cope with a growing demand for "blue" water and also arable land, labour, etc., from industries and urban areas.

The amount of water in soil depends, apart from climate, on texture and structure. Deep sandy soils typically contain large amounts of water. Given the comparatively slow movements, this water is sometimes seen as a stock of water, part of which is easily available and of great value during droughts. Clay soils, despite low hydraulic condictivity, contain less amounts of easily available water. From a physiological point of view they are drier than sandy soils.

Land use has a significant impact on the water balance. Large-scale changes in land in vegetation cover affect the size and temporal distribution of the various water flow components in a basin. The

greater the biomass of the vegetation, the more water will be consumed, with a corresponding decrease in streamflow.

The amounts of water that are required to produce various crops differ significantly. It is relevant to note that, as long as water supply is subsidised, the farmer has little interest in comparing crop water requirements and the economic return for different agricultural products. Growing demand for water from other sectors will put increasing pressure on the agricultural sector to use water more efficiently and to use it for crops that have strong demand by users.

In large parts of the world where, owing to climate and soil conditions, yields are quite low and access to markets is poorly developed, short-term increases in production will probably have to be secured through site-specific farming strategies where a combination of water harvesting, plant nutrient management, adaptation to topographical features, etc., is the only realistic approach in the foreseeable future.

In semi-arid regions where irrigation is unfeasible, inter-cropping and complex crop rotations are the only viable options. Nitrogen-fixing crops are important and a combination of leguminous crops and cereals may sometimes reduce the risk of pest attacks. In the tropics, a mixed system has the advantage of providing a vegetation cover over the soilsurface for a longer period, with evident benefits for the water balance.

In arid regions, plant productivity per year is rather low and can normally be increased only if water is added through water harvesting or irrigation. Since the arid and semi-arid regions are also characterised by significant variations in terms of annual and seasonal rainfall, the occurrence of intermittent droughts are exacerbating challenges in agriculture. A vicious circle easily develops where a harsh climate leads to low plant productivity which leads to low organic matter contents. Nutrient and micronutrient deficiency is a common agricultural problem.

In the temperate and most of the sub-tropical regions the situation is more favourable to the build-up of a complex multifunctional system. However, there is a great variability in intensity of production. Agriculture is part of the highly industrialised western community and agriculture is itself more or less an industry. The agricultural landscape has high diversity and in many parts of the industrialised world has high aesthetic value.

Agriculture conserves, by its own presence and production of plant and animal biomass, traditional social and cultural as well as biological values. It is difficult to estimate the long-term consequences of the rapid change of the global market but it will surely not only have deep influences upon international relationships and upon the national scene. A free market system without the present system of subsidies will provide incentives and create new systems of production. It is an open question whether the multifunctional character of agriculture and land can further develop when competition on a free market is the driving force of change.