OPPORTUNITIES AND CONSTRAINTS OF ORGANIC AGRICULTURE
A SOCIO-ECOLOGICAL ANALYSIS

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About the course

This course is part of the 1999-2000 Socrates/Erasmus Programme on Ecological Agriculture. The two weeks’ summer course theme is on Human Context of Organic Farming. The second week is dedicated to Economic and Social Impact of Ecological Farming Systems. It is within this second week that the present course on Opportunities and Constraints of Organic Agriculture – A Socio-Ecological Analysis is offered (Viterbo, 24 July 2000).

The objectives of this course are:

- to understand opportunities and constraints of organic agricultural systems in different agro-ecological and socio-economic settings;
- to analyse trade-offs among the agronomic, ecological, economic and socio-political performance of organic agricultural systems.

The learning approach relies on stimulating students’ skills to place their agronomic knowledge into an inter-disciplinary framework of analysis with a view to evaluating all aspects of farming systems.

Suggested reading


Website: [http://www.fao.org/organicag](http://www.fao.org/organicag)
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ORGANIC AGRICULTURE

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1. INTRODUCTION

1.1. Shifting the agricultural paradigm

In the past decades, agricultural development paid little attention to available local resources, both natural and human endowments. Agricultural practices focused on short-term productivity that required external inputs and on establishing uniform systems (i.e. monocultures). The benefits of specialization are based on "economies of scale" where mechanization, specialized know-how and marketing are involved and on exploiting comparative advantages of the local production situation. The resulting simplification has a pronounced effect on field and farm-level diversity and environmental side effects (pollution and loss of environmental services). Environmental resources and indigenous knowledge have been disrupted and today, agriculture can hardly be defined as sustainable.

Natural resources management is the result of human interactions with ecosystems. Depending on farmers’ skills, agriculture can generate either synergistic or antagonistic effects on both the human and natural environments. The economic contribution of agriculture (i.e. providing food and livelihoods) can only be maintained if its base (i.e. natural resources) is preserved and their functions (environmental services) are enhanced. There is also need to re-direct efforts TO human skills and social resources to create a favourable environment for agriculture.

Sustainable agriculture development needs a paradigm shift from segregation to integration, that is a move from focusing on single, isolated parts of agricultural systems (disciplinary reductionism) to perceiving all parts in their full context (interdisciplinary holism). It explicitly recognizes that it is the users of resources, not the stocks of natural resources, that are the focus of management.

1.2. What is sustainable agriculture?

Sustainability is an issue of A system's performance over time. In order to "measure" the performance of a system (even only in qualitative terms), one must define its boundaries and the relationships of their constituent components: there are internal components and external influences as well as inputs and outputs which cross boundary lines.

In agriculture, a system could vary from the soil system, to the cropping system, farming system, watershed system, and national agricultural system. Since the biophysical and socio-economic conditions are constantly changing, sustainability is more of an evolving concept than a set of fixed rules. Issues of sustainability must be addressed in relation to values, power relationships, time and space: sustainable for whom? for what? and for how long?
We strive to describe the complex world we live in by arranging the information available to us under simplified schemes intended to facilitate our understanding of the relationships among individual components and to help us organize our actions. Developmental processes could be depicted by classifying resources in the following four broad categories:

- **Human resources**: stock of human knowledge and skills, philosophy, ethics, religion, health, nutrition and education, labour;

- **Social resources**: complexes of norms and codes of behaviour that shape human interactions and persist over time by serving collectively valued goals. It includes formal institutions (e.g. public institutions, non-governmental and private organizations, training and educational institutions, including universities, research institutes) and informal ones (e.g. village committees, community groups), as well as traditions, formal laws and regulations, democracy, good governance, civic actions, equity, social cohesion;

- **Economic resources**: human-made goods generated via economic activities, including income flows derived from the various assets, technologies and infrastructure; and

- **Natural resources**: non-renewable and renewable natural resources and environmental services, including the self-purifying services of renewables.

A system may be considered sustainable when all individual livelihoods are secured without compromising the ability of future generations to secure their needs from the same natural resource base. The various resources cannot fully be substituted among each other but are complementary. For example, producing more of a supposed substitute (human-made resource) physically requires more of the very thing being substituted for (natural resource). Sustainability (or unsustainability) can be evaluated by the sum of the various resources where the degree of use, exchange and trading among them will vary according to the values given to each. The interactions between resources and degree (and acceptance) of their substitutability ultimately depends on acceptability of trade-offs between resources.

### 1.3. What is the objective of ecological agriculture?

Ecological agriculture aims at improving agricultural production and post-production while conserving the regenerative and reproductive capacity of the natural resource base, and thus, avoiding the cycle of rectification of error. It is based on traditional ecological understanding and combines results of modern science of natural processes. Hence, ecological agriculture is about maximizing use of knowledge of natural processes. Criteria for ecological agriculture need to consider technical performance, efficiency, impact, resource use, availability, and user preference.

Ecological agriculture should fulfil the following requirements in order to be environmentally sound, non-consumptive, economically viable, socially just, and culturally compatible, that is:

- meet the demands of local geography, particularly climate and topography;

- enhance and build on natural processes, mainly through organic recycling such as nutrient recycling, nitrogen fixation, and pest-predator relationships;
increase biodiversity and genetic heterogeneity;

- generate only non-accumulative and biodegradable waste and by-products;
- require low-energy consumption, preferably using renewable resources and recycling more of their wastes and products;
- use local materials and energy;
- require available capital investment and affordable maintenance;
- build on locally understood technologies and use proven techniques to reduce the incidence of failure;
- involve local people in its introduction and development and use existing or easily adaptable skills;
- be accessible to, and self-reliant among farmers and rural people, and adaptable to their management capacities.

1.4. What constitutes organic agriculture systems?

Ecological agriculture includes, but is not limited, to organic agriculture. Organic agriculture is the most regulated form of ecological agriculture as it adheres to legally defined standards and norms of production, processing and labelling. In organic agricultural systems, biophysical production factors are intimately linked to socio-economic and institutional factors. Organic agriculture represents a continuum from the farm to the consumer table.

Production and post-production parameters include:

- land and water management in mixed plant and animal systems that combine land use, tillage, shelter zones, hedges, pastures, agro-forestry, and water use;
- soil fertility management combines eco-physiology, nutrient cycling, crop rotation, inter-cropping, and generation and recycling of organic matter;
- crop production combines crop selection, propagation, and organic pest and weed control;
- animal husbandry combines appropriate feeding strategy, veterinary practices, and stocking rates;
- farm resources involve sourcing renewable energy, labour and mechanization;
- production handling involves adequate storing, processing and transportation to minimize losses and preserve quality.

Socio-economic and institutional "infrastructures" involve:

- regulatory framework (voluntary or mandatory) and supporting policies that include aid schemes and instruments to pay producers (especially small operators), develop diverse marketing structures, promote regional development, provide information and legal definitions;
- standards and norms that govern inspection, certification, labelling and accreditation practices;
- research that defines agenda for organic research, provides links with mainstream agricultural research institutes, promote farmers participation and in-situ research;
community development that targets farmers associations for self-regulatory mechanisms and national networks;

- market structure including outlets, opportunities and comparative advantages, price and demand, organizations, cooperatives and unions (of farmers, processors, retailers, consumers, and sellers/supermarkets), production-consumption structures, and marketing networks;

- consumer education related to production processes and products quality;

- consumer spending power to support ecological production.

A shift to organic agriculture brings about significant change:

- first, the composition of the inputs changes. Together with a reduction in the use of synthetic fertilizer and pesticides, an increase of other inputs can occur, such as organic material, labour and machinery.

- at the same time, rotations change, affecting yields and yield variability, total production and income (both present and future).

- this, in turns, influences food security, and the natural environment.

- those changes are often influenced by, and influence, social changes within the community.

Farmers would need to evaluate all the above issues to determine their likelihood of success in organic agriculture.

1.5. Why do we need a socio-ecological analysis?

Organic agriculture prospers on diversified farms with complex interactions. It links agro-ecological specificity with socio-economic diversity. Currently, most policies actively encourage farming that is dependent on external inputs, exogenous technologies and foreign expertise, which consider only the biophysical criteria of an agricultural systems.

Agro-ecosystems are currently defined on the basis of rainfall and temperature, which may be relevant for the evaluation of single crop production opportunities. The complexity of agro-ecosystems is largely based on farmers’ decisions, both at individual farmer and farming community levels. Whereas the harvested components are directly linked to the way agro-ecosystems productivity is measured and evaluated by the farmer in the short run, the non-harvested components play a key role in the functioning of agro-ecosystems, its sustainability and long-term productivity, and its function to other parts of society at large (see Table below).

Organic management includes environmental functions of land use as well as a strong human dimension, namely: farmers’ ability to predict future markets, the farming communities’ characteristics that determine local markets, market integration, the local economic and social forces that dictate which crops will be grown and when, opportunities for unskilled labour and migration flows, and a host of state variables and attendant dynamic rules and regulations of access.

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<tr>
<th>Component of non-harvested biomass</th>
<th>Agro-ecosystem function</th>
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<td>Trees</td>
<td>Shade</td>
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<td>Aesthetics</td>
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<td>Habitat for diverse biodiversity of fauna, flora and microbes</td>
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<td>Wind breaks</td>
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<td>Litter (with similar functional attributes to crop residues)</td>
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Effect on local and catchments hydrology  
Maintenance of soil fertility (e.g., *Acacia albi*)

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<th>Weeds and cover legumes</th>
<th>Capture of plant nutrient excess (e.g., in the fallow period)</th>
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<td>Protection of soil surface against splash erosion, improved infiltration</td>
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<td>Habitat and resources for associated biodiversity (beneficial soil organisms, pests, pathogens and their control agents)</td>
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<td>Resources for soil organisms mediating soil processes</td>
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<td>Nitrogen fixation by legumes</td>
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<td>Creation of micro-climate and reduction of wind speed of boundary layer</td>
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<td>Entrapment of wind and water-borne sediment</td>
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<td>Dung from domestic stocks increases plant nutrient availability</td>
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<th>Crop residues</th>
<th>Effect of mulching on soil temperature and moisture</th>
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<td>Protection of soil surface against splash erosion, improved infiltration</td>
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<td>Nutrient carry-over between crops</td>
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<td>Microbial products promoting aggregate stabilization</td>
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<td>Maintenance of soil organic matter</td>
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<td>Dung from domestic livestock</td>
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<th>Roots</th>
<th>Building soil structure</th>
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<td>Creation of macropores and water conduits</td>
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<td>Contribution to soil organic matter</td>
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<td>Nutrient carry-over between crops</td>
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<td>Resources for beneficial and plant pathogenic soil organisms</td>
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(Vandermeer *et al.*, 1998)

It is the "human space" where people live and derive resources for a fully reproductive life that delimits "socio-ecological" zones, and therein lies the entry point for sound management of natural ecosystems. Socio-ecological land units are therefore the basis for rural and agricultural activities since they determine land rights and natural resource use. Actions at this level imply an infinite number of decisions, which are taken by users of "local spaces". The challenge is to couple the legitimate needs and interests of individual users with the collective interest for sustainable development, including the health of transboundary natural ecosystems.
the evaluation of land use options. The issue is therefore a matter of understanding relationships, recognition and anticipation of trade-offs, assessment of benefits and alternatives and identification of appropriate management interventions. Farming objectives and management skills are a key to the identification of the course of action.

2. ISSUES IN ORGANIC AGRICULTURE

2.1. Ecological dimensions

The flow of energy (that involves biological and non-biological agents) drives the carbon, oxygen, nitrogen and phosphorus cycles. Nutrients are pumped through the system by the action of photosynthesis and are again made available for recycling by the action of decomposers. Nutrients are constantly being removed or added; adding more natural substances or synthetic materials than the ecosystem is able to handle upsets bio-geochemical cycles.

For example, the nitrogen cycle is characterized by fixation of atmospheric nitrogen by nitrogen-fixing plants, largely legumes (i.e. symbiotic bacteria living in association with leguminous), root-noduled non-leguminous plants, free-living aerobic bacteria, and blue-green algae. In agricultural ecosystems, the nodulated legumes of approximately 200 species are the pre-eminent nitrogen fixers. In non-agricultural systems, some 12 000 species are responsible for nitrogen fixation.

*Environmental services that are vital to agriculture include*

- **Soil forming and conditioning.** A substantial amount of invertebrates (earthworms, millipedes, termites, mites, nematodes, etc.) play a role in the development of upper soil layers through decomposition of plant litter, making organic matter more readily available, and creating structural conditions that allow oxygen, food and water to circulate.

  For example, the amount of soil worked over by earthworms is tremendous: 4-36 tons of soil passes through alimentary tracts of the total earthworm population living on an acre in a year! Termites are the only larger soil inhabitants that are able to break down the cellulose of wood. Termites play a major role in tropical soils where there are also soil churners; they move as much as 5 000 tons of soil per acre in constructing their complex mounds (allowing better rain penetration in soil).

- **Waste disposal.** A succession of micro-organisms occurs in the detritus, involving namely bacteria and fungi as well as detritus-feeding invertebrates, until organic material is finally reduced to elemental nutrients. Ecosystems recycle, detoxify and purify themselves, provided that their carrying capacity is not exceeded by excessive amounts of waste and by the introduction of persistent (synthetic) contaminants.

  For example, the nutrient-filtering function of mangroves can be compared to that of oxidation ponds of conventional wastewater treatment plants.

- **Pest control.** Predation is not just the transfer of energy whereby one organism feeds on another organism but also complex interactions among predator-prey populations. If a portion of the prey is not available because of environmental discontinuities (a typical case in agriculture), the self-regulating balance will be dampened. Inter-specific competition keeps more pests in check than we ever could by using pesticides.

- **Biodiversity.** An ecosystem stability (or instability) depends on the results of the competition between different species for food and space. Predation ameliorates the intensity of competition for space and increases species diversity. The nature of inter-specific competition and its effects on the species involved is one of the least known and most controversial areas of ecology.

- **Beneficial associations.** Symbiosis of plant roots with mycorrhizal fungi plays a most important role in temperate and tropical forests in absorbing nutrients, transferring energy and reducing pathogen invasions. Parasitism is used in the biological control of insects. Other symbiotic combinations include animal/fish/tree species (e.g. agroforestry, varietal diversification).
• **Pollination.** 220 000 out of 240 000 species of flowering plants are pollinated by insects.

• **Carbon sequestration.** The capacity of biomass in sequestrating carbon is receiving an increased attention with the aim of reducing (in the long term) climate change. Where no tillage is practised, soil contributes to retaining carbon. As organic agriculture favours minimum tillage (for better retention of water, nutrients, and biodiversity), the carbon retention potential of soils is becoming an important issue.

• **Habitat.** Although by definition, habitats provide shelter and food, many ecosystems have functions often discounted. For example, hedgerows around a field provide habitat for over-wintering of beneficial arthropods.

**Natural resources**

**Land.** Organic farmers build on environmental services by using several techniques to prevent erosion (e.g. land consolidation and levelling) and enhance soil fertility. Soil structure is improved through nutrient mining (by deep rooting crops), improvement of nutrient availability with mycorrhizal and optimal nutrient recycling, specific crop rotation and manuring strategies (e.g. manure, compost, crop residues, legumes and green manures), and other natural fertilizers (e.g., rock phosphate, seaweed, wood ash). Minimum tillage avoids soil compaction. Integrating trees and shrubs conserves soil and water and provides a defence against unfavourable weather conditions such as winds, droughts, and floods.

**Water.** Maintaining water quality requires good knowledge of ecological processes (e.g. consolidating or developing vegetation that help water self-purification) and applying farm practices that avoid pollution and use little water (e.g. minimal use of irrigation, prevention of water evaporation losses). Due to the change in soil structure and organic matter content under organic management, water efficiency is likely to be high on organic farms. Efficient harvesting and use of water also controls salinization and waterlogging.

**Genetic material.** Preservation of agro-biodiversity is indirectly addressed by organic agriculture since this form of agriculture relies mostly on endemic biodiversity that is resilient to local ecological stress (e.g. drought). The emphasis of seeds and breeds used in organic agriculture is on local suitability with respect to disease resistance and adaptability to local climate. The availability of suitable genetic material (e.g. GMO-free), its selection, rearing and distribution is often a constraint.

2.2. Agronomic dimensions

**Fertilizers and pesticides.** Decreasing the use of synthetic fertilizers and pesticides goes together with increasing other inputs. These inputs can be bought or produced on the farm (such as manure), others come in the form of knowledge about actions to be taken (e.g. timing of planting or best rotational combinations. The change in the combination of inputs may change the effectiveness of certain processes, which influence farm output, such as the cycles of water, nutrients, energy and knowledge (inter-generational). Crop protection relies on natural pest controls (e.g. insect pheromones, plants with pest control properties) or by enhancing self-regulation.

For example, a primary pest may be avoided by planting at a time when the insect cannot complete its life cycle, even though that results in a certain decrease in yield due to non-optimal conditions in other aspects such as heat; a secondary pest could stop after abandoning the use of pesticides and natural predators return.

**Crop rotation.** Crop rotation is required under organic certification programmes and is considered to be the cornerstone of organic management. Crop rotation is a valuable tool for weed control, maintenance of soil structure and organic matter, recycling of plant nutrients, contribution to overall species and habitat diversity, preventing erosion (application of cover crops), green manuring, and pest and disease control. Inter-cropping, after-cropping, alley-cropping and mixed cropping are spatial and temporal alternations chosen according to crop and soil-specific cycles and needs. Agricultural pests (fungi, insects, and weeds) are often specific to the host, and will multiply as long as the crop is there. Manipulation of crops between years (management by rotations) or within fields (strip-cropping) is therefore an important tool in the quest for management of pest problems. The lack of use of synthetic fertilizers and pesticides leads to restrictions in choice of crops. The loss in (present) income through a change in rotation is to some
degree reflected in, and compensated by, the decrease in input costs. The success of an organic farm depends on the identification of end-uses and/or markets for all the crops in the rotation, as few farmers can afford to leave fields fallow. Wide adoption of organic agriculture is expected to change markets due to the likely prevalence of rotational crop products.

**Energy:** Energy in all its forms, including labour, is one of the most important agricultural inputs. Energy is required at all points of the food production chain: land preparation, planting, harvesting, transport, processing, irrigation, agro-industries and rural services (e.g. cooking, heating, and lighting). On organic farms, mechanization is often replaced by labour, especially for weeding and harvesting in highly diversified systems. Chemical fertilizers (that are produced using a high level of non-renewable energy) are substituted with organic matter, nitrogen fixing-crops or green manuring. Indirectly, using natural rather than synthetic fertilizers saves non-renewable energy and nitrogen leaching is minimized.

Disadvantages in discarding synthetic fertilizer must be considered as well: energy needs can escalate if thermal and mechanical weeding or intensive soil tillage is used and, in some cases, organic farmers burn to clear land which reduces fertility. Many resource-poor farmers do not have access to livestock manure, often an important fertility component. Sometimes sewage sludge is used, which may contain pathogens and other contaminants. Inappropriate management of energy inputs used in organic agriculture may be detrimental to the environment: over-manuring of nitrogen has several side effects such as leaching (hence affecting water quality), stimulation of plant diseases and discouraging biological N-fixation. Environmental standards are expected to reflect local conditions so that pollution is minimized. In fact, restrictions on the number of livestock or amount of manure to be used per unit of land are not exceptional.

**Diversification.** Organic agriculture requires a diversity of crops and livestock. Many indigenous food crops (e.g. yam, sorghum, millet, oil palm, cashew, mango) have been supplanted by monoproduction of cash crops. Food crops, pseudocereals (e.g. amaranth, buckwheat, chenopods), grain legumes (e.g. adzuki, faba, hyacinth beans) and other under-utilized plants, many of great value, can be reintroduced through crop rotations. This contributes to whole farm health, provides conservation of important genotypes, and creates habitats for beneficial species. Animal husbandry on organic farms focuses on manure production and the roughage and waste to food conversion capacity of animals.

**Stability and resilience.** A system resilience is its ability to overcome perturbation and to recover its function to former levels once the perturbation is removed. Resilience is of particular value to farmers in terms of risk and productivity of the system. In organic agriculture in general, a diversity of crops is grown and different kinds of livestock are kept. This diversification means that the risk in variation in production is spread, as different crops react differently to climatic variation, or have different times of growing (both in the time of the year and in length of growing period). There is therefore less chance of a bumper year for all enterprises on organic farms (likely to coincide with relatively low prices). Also, there is less chance of low production for all crops and livestock simultaneously. This contributes to food security and stability of food supply.

**Yields.** Factors determining yields include plant varieties and knowledge on how to manipulate biological processes within agricultural systems. The management system is a major factor in the degree of yield and financial variability. Another factor, which makes a difference in yields, is the time and length of the growth period of a crop. Exogenous factors such as climate are important.

For example, due to slow mineralization of nitrogen under cool growing-conditions, crops on northern organic farms have a shortage of nitrogen early in the season. However, in countries where low soil temperature is not a limiting growth factor, as in many developing countries, this factor should not prove significant.

Although yields on organic farms generally fall within an acceptable range, yield comparisons depend on the systems involved. Organic agriculture yields are lower than yields of intensive external input agriculture. The latter, however, also results in considerable losses of nutrients and environmental quality as well as in food surpluses, which are exported with subsidies. Experiences of organic production in ecosystems with low-productivity potential demonstrate the potential to double or triple average yields. The results are of course due to very low initial yields on these lands but such conditions correspond to many countries of the developing world. If similar results were to be achieved in the less endowed regions of the world, present food deficits could be partly resolved. In any case, increased yields are
more likely to be achieved if the departure point is a traditional system, even if degraded, rather than a modern system.

**Total farm production.** It is important to consider not only yields, but also whole farm production. The total production on the farm is the yield multiplied by the area in the different crops or that used for livestock (usually measured per unit of area). When measuring production, one also needs to be aware of the concept of net production, especially relevant in developing countries. This refers to the net production of specific inputs, such as the costs of nutrients.

For example, it is very easy to increase the yield of a cow by feeding her concentrates. The question is, however, whether it was worth the extra input. This can be determined by an assessment of the net returns to farming.

It should be realized that, during the conversion process, yields might be lower and investments higher than at a later stage when the organic farm has been established. The net returns to farming can therefore be lower in such a period than later.

### 2. 3. Economic dimensions

**Farm income.** The suitability of an agricultural system depends on its profitability, if that concept includes all aspects which affect farmers’ welfare.

For example, low return of a marketable crop as compared with another farming system may mean very little if inputs are also low, or if the farmer can harvest other products which can be grown simultaneously in the one system, but not in the other (such as fish with irrigated rice when no pesticides are used). In addition, relative incomes can change drastically with changing input or output prices.

In developed countries, the financial cost of inputs (excluding labour) on organic farms can be lower than on many non-organic farms, although the magnitude differs between enterprises and countries. The difference is generally greatest in those enterprises where inputs can be readily substituted by low-cost alternatives, as fertilizers by nitrogen-fixing crops or green manure. For those inputs where substitutes are costly, such as labour cost for weeding, differences in expenditure on input between organic agriculture and other systems tend to be relatively low, or costs on organic farms can be higher. In situations where inputs are subsidized, as fertilizers and pesticides have been in a number of developing countries, the financial returns on organic farms may not be as attractive. Similarly, not counting the environmental and health costs of such inputs means that organic agriculture is under-valued.

The legal transition to organic agriculture takes two to three years during which products cannot be sold as organic. Initial loss of yields, extent to which inputs were used under the previous management system, and the state of ecosystem degradation are often constraints that can be easy to survive only if financial support is given to farmers. Hence, the degree of support during transition, and sometimes in the first years following the transition period, are important factors in farm economics. When organic agriculture performance on the environment is rewarded (e.g. through support to conversion), organic agriculture is as profitable as conventional agriculture.

**Markets.** Reliable market information, quantity and regularity of supply, and comparative advantages are key to tapping market opportunities. Output prices are subject to quantity of supply and consumer willingness to pay premiums for organic products (often at prices 20 percent higher than conventional products). Entering lucrative markets entails inspection, certification and labelling of produce, the cost of which being somewhat expensive. Factors such as farm size, volume of production, and efficiency (or availability) of certification organizations determine inspection costs. Often, small farmers cannot afford certification costs, and care should be taken for not marginalizing small producers.

**Food security.** Food security is not necessarily achieved through food self-sufficiency. Consumers’ demand for organically produced food and sometimes impressive premiums provide new export opportunities for farmers of the developing world. Returns from organic agriculture have the potential, under the right circumstances, to contribute to local food security by increasing family incomes. Organic agriculture can contribute to local food security in several ways. Organic farmers do not incur high initial expenses so less money is borrowed. Synthetic inputs, unaffordable to an increasing number of resource-poor farmers due to decreased subsidies and the need for foreign currency, are not used. Organic soil improvement may be the only economically sound system for resource-poor, small-scale farmers.
This characteristic of the production process on organic farms means that organic farmers are less dependent on external inputs (e.g. fertilizers, credit), over which they may have little control, thereby increasing local food security.

2.4. Social and institutional dimensions

Land tenure. Protecting soils and enhancing their fertility (land stewardship) implies ensuring productive capacity for future generations. However, in the quest to improve soil quality for the future (probably the single most important factor to determine whether farmers are interested in the issue) is whether they will benefit from the change. Security of land tenure is, therefore, an extremely important factor in this respect. If land security is not guaranteed, there is little reason for farmers to invest in a method that will bring them income in the future rather than immediate rewards.

Labour. If compared to large-scale mechanized agricultural systems, organic systems appear more labour-intensive. Using no external inputs requires that fertilizers and pest control methods be internally produced using labour intensive techniques. Labour requirements tend to be high on some organic farms (e.g. plantations), on organic farms where labour-intensive methods are used (such as strip farming, manual weeding, composting), and in low ecological potential areas that use techniques that require significant labour (such as Zai planting pits).

The timing of labour requirement throughout the year is an important aspect of labour. Care should also be paid to on-farm multiple activities (e.g. agro-tourism, processing) and off-farm labour time as often part of the family income comes from non-farm and off-farm activities. Another important issue to consider is not the quantity of labour, but the quantity of output per unit of labour, or labour productivity. While organic agriculture is likely to generate good labour productivity, labour return depends on the available amount of labour at farm household level. Often, the increase of costs of labour to produce extra units of crops is higher than the increase in outputs.

In many areas, labour is a critical constraint in agricultural production, especially when considered on a seasonal basis. Achieving high levels of labour use may not be physically possible or economically viable on small-scale farms in developing countries and may also add to household drudgery, especially for women. This is also true for cash-poor farmers and those supplementing their incomes with off-farm work. Labour and total costs are generally lower on private organic farms. In the developed world, labour scarcity and costs may deter farmers from adopting organic management systems. However, where labour is not such a constraint, organic agriculture can provide employment opportunities in rural communities. Furthermore, the diversification of crops typically found on organic farms, with their various planting and harvesting schedules, may result in more work opportunities for women and a more evenly distributed labour demand which helps stabilize local/regional employment.

Justice. The concept of "fair trade" implies a concern of the buyer for social justice for those who work in agriculture, especially with regard to a "fair wage". In fair-trade projects, traders ensure that producers receive a minimum return for their produce irrespective of the actual market price. At present, certification that guarantees fair trade does not necessarily imply organic production. Organic certification organizations favourably consider inclusion of "reasonable wage conditions". Improving the situation of women is recognized as an important issue within organic agriculture. The social environment of the workers engaged in organic agriculture, namely their working conditions and environment, often results in improved housing situations and childcare facilities. Availability of work, gender distribution of labour and access to knowledge are key considerations in organic agriculture.

Attitudes and perceptions. The single biggest constraint to the development of organic agriculture is that most people in all kinds of areas (including scientists, researchers, extension officers and politicians) strongly believe that organic agriculture is not a feasible option to improve food security. For this reason, very few farmers can obtain information about this management system, even when they inquire about it. If those who make policy decisions on the allocation of resources, such as for research and extension, are not aware of the possibilities of organic agriculture, no positive consideration towards this farming system can be expected.

Investments and benefits. The advancement of organic agriculture to date has to a large extent been due to private investment. This has been in the form of consumers’ willingness to pay for organic commodities (price premiums) and farmers’ readiness to experiment and innovate, despite the risks involved with such on-farm research. Many of the inputs used in organic agriculture are public goods (such as knowledge about practices) which can be used without
impeding use by others. Hence, there is little private interest in promoting particular inputs, which are used in organic agriculture. Organic management, which relies on local knowledge of complex interactions and variations of conditions carries an enhanced potential for more equitable distribution and access to productive resources, namely land.

**Knowledge.** Empirical knowledge of natural processes takes a long time to consolidate itself. Traditional knowledge can be improved through selective introduction of results of modern science in areas such as energy flows and biogeochemical cycles, biotic and abiotic factors, which regulate plant development, renewable energy technologies, and management techniques. The integration of traditional technologies with emerging technologies would lead to an improvement of traditional technologies in terms of: i) cost per unit; ii) productivity per unit of factor input; and iii) quantity and quality of output.

**Research.** The conservation of ecological foundations (soils, aquifers, forests, biodiversity, and the climate systems) is essential for continuous advances in crop and animal productivity. Conventional research on management of natural resources for agriculture (i.e. soil, water, biological resources, and related nutrient and energy balance) is not responding to farmers’ needs. To be successful, agricultural innovations should be based on an interactive process between farming communities and agricultural research institutions. Applied and adaptive agricultural research could be successfully implemented through location-specific and/or on-farm research, jointly with rural and tribal families, where partnerships, extension, and communication are integrative parts of the process of research and knowledge sharing.

**Community participation.** Engaging in organic production means experimenting new techniques, introducing different management of labour time, investing efforts in different management of space, adapting and refining solutions to change, comparing different options with farmers that have similar conditions, and making appropriate choices. This can only be achieved through farmers’ participation in research and its application. This on-farm research component can support rural communities, and generate new knowledge that will benefit all farmers. Consistent labour needs, combined with the enhanced capacity of the land and protection of water associated with organic agriculture, may encourage people to permanently locate and thus reinvigorate rural communities. The establishment of cooperation between farmers is instrumental in helping farmers to become a stronger and more independent partner in the agro-business environment. In addition, providing a critical mass for renewed rural community structures sets an end to the isolation of farmers, thus increasing the viability of rural life. Most importantly, various forms of cooperation within the food chain are necessary to overcome the gap between farmers and consumers.

**Self-reliance.** Within organic agriculture, the use of locally available inputs is encouraged. The effect on the local community of such a form of agriculture is, therefore, likely to be greater than when inputs are imported from outside the community. In those cases where synthetic fertilizers and pesticides are imported, adoption of organic agriculture techniques means a decrease in imports, decreasing the need for foreign currency and credit. The site-specific nature of organic agriculture also means that indigenous species and knowledge, so often discounted, are of great value. In many places, this knowledge has been eroded with the introduction of high external input agriculture, promotion of monoculture, and selection of "improved products." Farmers may readily welcome a management system close to their own traditions and not driven solely by a production ethic.

**Policies and regulations.** Norms, standards, inspection and certification in organic agriculture have been established and remain enacted by the private sector. Recently, a number of countries have established guidelines, regulations and policies to assist producers to respond to the growing demand for organic food and to control fraudulent practices. Favourable policies and institutional structures are important incentives to the adoption of organic agriculture. Where supportive government policies are lacking, and especially where inspection organizations are unavailable (or need to be imported at high expense), interested communities need to mobilize and organize themselves to procure necessary inputs and to access markets.

### 3. CONCEPTUAL FRAMEWORK FOR THE SOCIO-ECOLOGICAL
ANALYSIS OF ORGANIC AGRICULTURAL SYSTEMS

Market food prices frequently fail to reflect the true cost of production, as they do not internalize environmental and societal costs of production. The pursuit of short-sighted economic gain, coupled to the lack of awareness of the long-term implications of unsustainable agricultural practices undermines the basis of agricultural production. Management in time and space of interactions between ecological, economic and social variability is lacking for sound decision-making.

Governments, farmers and consumers make their decisions according to the information available to them. Sound information on the status of renewable resources, natural resources dynamics, land-use and tenure patterns, socio-cultural knowledge and conditions are necessary to chose among different agricultural production systems and invest resources such as capital, labour, markets structures and support services.

3.1. Information collection

Biophysical and socio-economic parameters allow the understanding of social dynamic of farming and resource-use systems. Information collection of agro-ecological, economic, social and institutional parameters needs to cover: i) the state of resources; ii) resource management efficiency and where possible, iii) anticipated opportunities and constraints.

3.1.1. Agro-ecological parameters

State of resources

- land: availability of land and soil quality and productivity (e.g. structure, texture, mineral and organic composition, water holding and exchange capacity);
- water: water quality and hydrology (water supply, hydric balance and soil occupation);
- biodiversity: ecosystem and species diversity, distribution and abundance;
- ecosystems: habitats and ecological relationships that determine productivity, presence of special ecosystem or species, biomass, primary and secondary productivity, eco-regulation (degree of pest and disease occurrence, pest predator presence), carrying capacity of the system (e.g. stocking rate);
- climate: winds, rainfall, and climate variability.

Resource management efficiency

- flows of organic matter and nutrients: nutrient balance (excess, depletion), quantity of organic matter, organic matter recycled internally, ratio of internal and external nutrient inputs, macro- and micro-nutrients in soil, ratio of on-farm feed production and imported feed;
- water: water quality and water balance;
- biodiversity: number and quantity of crop and animal varieties and species, crop rotation index, composition of


micro- and macro-soil life, pest incidence, resistance in genetic resources and needs for pesticide use;

- productivity: genetic potential of crops/breeds to yield, growth and yields (e.g. plant height, tillers length, days of maturity, duration of crops, etc.);

- climate: creation of micro-climates, emissions from livestock;

- energy: ratio of renewable and fossil energy used, ratio of internal and external energy inputs used, and ratio of labour substitution to mechanization.

**Anticipated opportunities and constraints**

- crop protection strategy: which pests are common, what is the cause, what can be done to avoid them within available resources;

- access to material which can be used in compost and mulch, availability of other materials such as rock dust;

- import needs: organic fertilizers and pesticides, seed/breed, water, energy;

- pollution and degradation to be mitigated and means available;

- long-term productivity: the effect of present production on the soil and biodiversity and implications for future yields;

- added valued: contribution of livestock to the farm, benefits from trees and biomass, resilience.

**3.1.2. Economic parameters**

**State of resources**

- availability of capital, degree of financial autonomy and level of investment;

- financial incentives: government economic support during and/or after conversion, preferential conditions of credit, tax reduction;

- existing storage, handling, processing and transportation facilities for organic produce;

- cost of inspection and certification to total production;

- market opportunities: domestic and international markets, level of price premium, volume, quality and regularity of supply, comparative advantage.

**Resource management efficiency**

- use of production factors: value of produce compared to production costs, production per hectare, per unit of water, per farm worker, per unit of capital;

- number of on- and off-farm activities that contribute to farm income;

- ratio of the value of external inputs and the total production value;

- investment in enterprise development (e.g. equipment and infrastructures).

**Anticipated opportunities and constraints**

- assessment of economic variability: risks and variability of yields in good and bad years, market price change,
government intervention, exchange rates;

- evaluation of non-natural resources needed, such as capital, machinery and tools;
- total production of all enterprises (not only of the main enterprise);
- total net return: income from main crop and other crops and livestock, minus the cost of the inputs used for the production;
- return on capital: a balance between additional return (including also reduction in costs) and extra costs (including also revenue foregone).

3.1.3. Social parameters

*State of resources*

- human assets in term of skills (and training needs);
- labour requirements (quantity and timing of labour) throughout the year;
- people expected to derive livelihoods (income) from the enterprise;
- land tenure and conditions of resources access;
- gender desegregated access to resources and benefits;
- income distribution and gender division of labour.

*Resource management efficiency*

- labour intensity per hectare and unit of produce and labour productivity;
- total food availability per family compared to consumption requirements.

*Anticipated opportunities and constraints*

- degree of risk;
- rural employment and migration patterns;
- household food security and nutrition;
- degree of self-reliance.

3.1.4. Institutional parameters

*State of resources*

- existing laws, standards for organic production, processing, inspection and labeling;
- availability of government support: research, technical assistance, training and support to marketing;
- availability of inspectors and certifiers (domestic or international);
- contacts with organic processors, distributors, traders and retailers;
- marketing outlets: farm gates, home delivery, specialized shops, supermarkets, and export markets.
Resource management efficiency

- community structures (e.g. farmers’ associations) for self-certification;
- farmers cooperation and exchange of information;
- on-farm research: degree of farmers participation in experiments and percentage of farmers adopting and replicating experiments;
- number of farmer representatives in government discussion fora.

Anticipated opportunities and constraints

- difficulty to comply with rules and standards;
- insufficient access to support services;
- good governance;
- social cohesion.

3.2. Analysis

Availability of natural and human resources differ from location to location. Hence, the practicality of certain practices, their opportunities and constraints, will vary considerably between localities. It is not sufficient to consider the variables within a single dimension. In fact, the performance of each of the agro-ecological, economic, social and institutional dimensions involves trade-offs among them.

Management options should not only aim at optimizing agronomic performance but also at optimizing the ecological and social performance of the system. For example, maintaining soil fertility offers the choice between applying compost or green manuring: if organic material and labour are available, the first option is the one that can perform better on the agro-ecological, economic and social fronts.

3.3. Setting objectives

It is through a mental process that farmers take decisions, based on their own ideas and values, and accepting responsibility and consequences of their choice. It is therefore necessary to place the analysis of agro-ecological, economic, social and institutional parameters within a wide context of goals.

Different priorities express different attitudes towards nature, society and the ethical decisions involved. In line with these differences, different values (expressed as priorities) will have specific consequences on equity, economy and environmental sustainability. Farming objectives such as environmental and landscape restoration, rural development...
and local food security or export markets orientation will entail different priorities and value systems.

For example, farmers deriving part of their income from off-farm activities could afford longer crop rotations to enhance environmental quality at the expense of economic performance. A farmer with pressing income and food needs and available working force will opt for more intensive use of land and excess water pumping for food production. An enterprise engaged in crop exports will prefer to purchase organic inputs to maximize its crop monoculture on the whole farming area, thus foregoing diversified crop production and animal husbandry on the farm.

Specific farming objectives have to be set in light of identified needs, opportunities and constraints. It is with a specific objective in mind that farmers decide on what to produce, how much to produce, and how best to produce. Objectives and constraints of stakeholders at the micro-level (e.g. farmer or community) should be integrated with those at the macro-level (e.g. policy, markets) and different types of trade-offs evaluated.

4. CONCLUSION

Organic agriculture seeks to optimize the primary efficiency of agro-ecosystems, in compliance with local environment conditions and social needs of a region. Over-stressing any single natural or human production aspect of any sub-system might lead to deterioration of the balanced efficiency of the whole system. Optimizing the synergy of soil-crop-animal and man interactions is therefore the foremost challenge.

Farm systems evolve and change through time, in response to their own logic, as well as to the changes, which occur in the society within which they are immersed. Often agricultural innovations are rejected because of socio-cultural constraints to their adoption, but become rapidly adopted if the economic circumstances change (e.g. capital, labour availability, markets, general economic developments, new support services). Complex agro-ecosystems change rapidly as a result of farmers’ decisions based on their perceptions of opportunities and constraints. Societal demand for environmental quality and value-added food products (such as consumer demand for organic food) is already directing producers and decision-makers choices towards sustainable agricultural systems.

Socio-ecological analysis of farming systems allows farmers and decision-makers to understand problems, issues and trade-offs, weigh outcomes of alternative actions to a chosen set of objectives, and make an appropriate decision. Decisions that maximize equity, productivity and environmental sustainability will contribute to moving towards sustainable development.