TECHNOLOGY INNOVATION PLATFORM OF IFOAM

IFOAM TECHNOLOGY INNOVATION PLATFORM TIPI

Technology Innovation Platform of IFOAM (TIPI)

A Global Vision and Strategy for Organic Farming Research

First Draft, October 12, 2014

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List of abbreviations

ABA	Brazilian Association of Agroecology
ACIAR	Australian Center for International Agricultural Research
ADB	Asian Development Bank
AfroNet	African Organic Network
ANSOFT	Asian Network for Sustainable Organic Farming Technology
ARNOA	Asian Research Network of Organic Agriculture
ASEAN	Association of Southeast Asian Nations
ASTI	Agricultural Science and Technology Indicators
AU	African Union
CAP	Common Agricultural Policy
CAPSA	Center for Alleviation of Poverty through Sustainable Agriculture
CCFD	Terre Solidaire
CGIAR	Consultative Group on International Agricultural Research
CMS	Cytoplasmic Male Sterility
CORE Organic	Coordination of European Transnational Research in Organic Food and Farming Systems
CO_2	Carbon Dioxide
CSA	Community Supported Agriculture
DOA	Department of Organic Agriculture
DOK trial	Biodynamic-Bioorganic-Conventional Agricultural Trial
EC	European Council
ECO-PB	European Consortium for Organic plant breeding
EIP-AGRI	European Innovation Partnership for Agricultural Productivity and Sustainability
EU	European Union
EOA	Ecological Organic Agriculture
ERA-Net	European Research Area Network
FAO	Food and Agriculture Organization of the United Nations
FiBL	Research Institute of Organic Agriculture
GHG	Greenhouse Gases
GFAR	Global Forum for Agriculture Research
GIZ	German Federal Enterprise for International Cooperation
GIZ IS	GIZ International Service
GMO	Genetically Modified Organisms
GTZ	German Technical Cooperation
GOMA	Global Organic Market Access
HAL	Horticulture Australian Limited
HIVOS	Dutch Humanist Institute for Cooperation
HNV	High Nature Value
IAASTD	International Assessment of Agriculture Sciences and Technology for Development
IP	Integrated Production
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICT	Information and Communication Technology
IFAD	International Fund for Agricultural Development
IFOAM	International Federation of Organic Agriculture Movements
IFOAM EU	International Federation of Organic Agriculture Movements European Union
IFPRI	International Food Policy Research Institute
INTA	National Institutes for Agricultural Research
IOL	German Institute of Organic Agriculture
IRRI	International Rice Research Institute
ISOFAR	International Society of Organic Agriculture Research
ISSA	Iranian Scientific Society of Agroecology
KACA	Korean Agricultural Cooperative Agency
KOFA	Korean Organic Farmers Association
KSA	Kingdom of Saudi Arabia

LEISA	Low External Input Sustainable Agriculture
MEA	Millennium Ecosystem Assessment
MENA	Middle East and North Africa
MEP	Ministry of Environment Protection
MOA	Ministry of Agriculture
MOST	Ministry of Science and Technology
NARI	National Agricultural Institute of Papua New Guinea
NACF	National Agricultural Cooperative Federation
NPOF	National Project on Organic Farming
NOAM	National Organic Agriculture Movements
NOARA	Network for Organic Agriculture Research in Africa
NODP	National Organic Development and Action Plan
NORA	National Organic Research Agenda
NORAD	Norwegian Agency for Development Cooperation
OACC	Organic Agriculture Center of Canada
OFP	Organic Farming Project
OFPA	Organic Foods Production Act
OFRF	Organic Farming Research Foundation
OMRI	Organic Materials Review Institute
ORC	Organic Agriculture Research & Development Center
OREI	Organic Research and Education Initiative
OTARE	Organic Trust Australia - Research and Education
OWC	Organic World Congress
PAR	Participatory Action Research
PGS	Participatory Guarantee Systems
PFI	Practical Farmers of Iowa
PhilRice	Philippine Rice Research Institute
POETCom	Pacific Organic and Ethical Trade Community
ProGroV	Productivity and Growth in Organic Value-chains
R & D	Research and Development
RDO	Rural Development Office
SARE	Sustainable Agriculture Research and Education
SATNET	Sustainable Agricultural Technologies and Improved Market Linkages in South and Southeast Asia
SCAR	Standing Committee on Agricultural Research
SDC	Swiss Agency for Development and Cooperation
SEPA	China State Environmental Protection Agency
SIDA	Swedish International Development Cooperation
SINAB	Sistema d'Informazione Nazionale sull'Agricoltura Biologica
SOAAN	Sustainable Organic Agriculture Action Network
SOCLA	Sociedad Cientifica de Agricultura LatinoAmericana de Agroecologia
SOFA	Saudi Organic Farming Association
SPC	Secretariat of the Pacific Community
SyProBio	Systèmes de Production Biologique diversifiés
TIPI	Technology Innovation Platform of IFOAM
TFP	Total Factor Productivity
TP	Technology Platforms
TP Organics	European Technology Platform for Organic Food and Farming Research
TEEB	The Economics of Ecosystems and Biodiversity (TEEB)
TOA	Towards Organic Asia
TOFA	Organic Alternative for Africa
WHO	World Health Organization
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environmental Programme
UNIDO	United Nations Industrial Development Organisation
USDA	United States Department of Agriculture

1. Executive summary

Organic agriculture world-wide offers the promise of a future to produce and distribute food and other farm products in a healthy, ecologically sound, truly sustainable and fair way. The full benefits of organic agriculture are just now being realized—from ecosystem services to the provision of healthier food - yet, to reach its full potential organic farming needs to address many challenges. While organic agriculture has grown in strength and is in the most favorable position it has ever been in with respect to market conditions, government policies and international institutional support, it still does not have adequate resources to continue its expansion.

The Technology Innovation Platform of IFOAM (TIPI) has developed a vision and an agenda to advance organic agriculture through research, development, innovation and technology transfer. TIPI's vision recognizes that current technologies based on heavy use of external inputs that are toxic and pollute the environment come with a price. Investments in ecosystem services and the development of technologies that are productive, stable, adaptable, resilient, and fairly shared are much more likely to sustain the world's population in a rapidly changing environment. Sustainable pathways to innovation will require engagement of all stakeholders in a science-driven multi-disciplinary approach. Such an approach seeks to

(1) Empower rural areas,

(2) Provide eco-functional intensification that produces food and ecosystem services, and

(3) Provide food for the health and well-being available to all.

Organic agriculture must build the capacity to fulfill the world's food needs for the entire population if it is to fulfill its mission.

The new paradigm proposed by TIPI is founded upon a whole systems approach, the engagement of farmers, researchers and other practitioners in a co-innovative approach; and open access technologies that are readily adapted to local conditions. While there are barriers and bottlenecks that will need to be overcome for this vision to be realized, TIPI calls upon the organic community to support its 14 point action plan to advance organic agriculture in a forward-thinking and innovative way.

2. About TIPI, the Technology Innovation Platform if IFOAM

The Technology Innovation Platform of the International Federation of Organic Agriculture Movements (TIPI) is a research action network of the International Federation of Organic Agriculture Movements (IFOAM) that has been initiated by the Research Institute of Organic Agriculture (FiBL) in collaboration with other research institutions around the world.

The kick-off took place at the BioFach World Organic Trade Fair (BioFach) February 2013 in Nuremberg, Germany with researchers and stakeholders from all over the world present. TIPI's mission is

- to engage and involve all stakeholders that benefit from organic agriculture research;
- to set a global research agenda for organic food and farming;
- to foster international collaboration in organic agriculture research;
- to facilitate exchange of scientific knowledge of organic food and farming systems; and
- to disseminate, apply and implement innovations and scientific knowledge consistent with the principles of organic agriculture.

TIPI is unique as the global Technology Innovation Platform for organic research of all stakeholders. It seeks to co-operate with regional, national and transnational technology platforms and research networks like the European Technology Platform for Organic Food and Farming Research (TP Organics), Sociedad Cientifica de Agricultura Latino Americana de Agroecologia SOCLA in Latin America, as well as national platforms.

It seeks to work constructively and positively with all organizations that are involved in organic agriculture research, technology development, and innovation. In particular, TIPI will help IFOAM bringing together and mobilizing different organizations working on organic research issues. TIPI promotes continuous discussions which will be led with related stakeholder driven research platforms such as on animal welfare, agro-ecology, agroforestry, landscape, climate change adaptions and mitigation, soil and nature conservation. TIPI aims for an open and intensive knowledge exchange, information dissemination and strong communication running its webpage[1] and using international organic research archives. In general, the membership is open to all stakeholders with an interest in advancing organic agriculture research. TIPI welcomes organizations and individuals to represent farmers, processors, traders, suppliers, consumers, scientists, state, foundations, individual donors and civil society. Full and supporting TIPI member organizations are listed at the TIPI website.

As a platform within IFOAM, TIPI is an informal network and sector group that is self-organizing and self-governing. The members are able to develop its purpose, terms of references, goals, strategies and activities.

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[1] www.organic-research.net

3. General introduction to organic agriculture

Organic farming[2] is based on the idea of practices that are environmentally friendly, animal welfare oriented and geared towards improving the living conditions of farmers. To strive for close-to-nature farming is a central piece of the farmers' own concept. Beyond agricultural practices and their technical and economic bases, organic farming was and is a life model and thus has always included important aspects of social reform, philosophical lifestyle and of a 'new social movements'. The principles of ecology, health, fairness and care of the International Federation of Organic Agriculture Movements (IFOAM) encompass this comprehensive thinking (IFOAM n.d.).

In the beginning, organic farming started without public financial and technical support. The pioneers promulgated organic farming as an alternative model to intensive, specialized and partially industrialized – 'anonymous and soulless' – food production (Rusch 1968; Meadows et al.1973). The economic exchange of the pioneer farmers with consumers, among themselves and with up- and downstream businesses were predominantly personal and direct. Products were sold from farm to farm or hand to hand, or in some cases traded on a restricted level. In the cities, food coops were started, organic stores opened farmers markets and box schemes appeared (Heldberg 2008).

Organic agriculture and food processing is regulated by an elaborate code of conduct which goes back to pioneers in Europe, in the United States and Asia. Farmer associations have defined private standards and labeled food since mid of the 20th Century. In 1980, IFOAM introduced the first global organic standards.

Early governmental regulations were introduced in a few European countries and in several US States in the 1970s and 1980s. In 1991, the European Commission put in force the regulation on organic agriculture and in 2002, the United States Department for Agriculture (USDA) enacted the National Organic Program. Currently, 88 countries have organic regulations and 12 countries are drafting regulations (Huber & Schmid 2014).

Private bodies, such as IFOAM, governmental authorities through bilateral negotiations and agreements, and international organizations, such as the CODEX Alimentarius of the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) have worked to harmonize standards for organic foods. Growth is occurring in all regions; however, demand for organic products is mainly in North America, Japan and Europe. The most important agreement is the 2012 arrangement between the European Union and the United States. Globally, these two standards account for over 90 percent of all organic sales.

While organic food markets are well organized in developed regions, the organic sector is still in its infancy in most developing countries. These countries often lack a robust domestic organic sector and are dependent on the production of export-oriented commodities. These value chains are often subject to third-party inspection and control by external organic certification bodies accredited by agencies in the importing countries. Participatory Guarantee Systems (PGSs) rely on mutual control within a farm community or group of farmers, may create a viable system to build local markets.

First private research institutes came up in the 1970's in Europe. From 1990 on, market growth and economic success of the farmers attracted a new generation of farmers and governments started to fund research. Applied research for organic agriculture started in Western Europe and the USA. Later, Canada, Brazil (and other South American countries), China, South Korea and India started to catch up. Meanwhile, organic agriculture research has raised a global interest although is still marginal in its size and quantity. As a rough estimate, less than one per cent of

[2] Any system that uses organic methods and is based on the Principles of Organic Agriculture as 'Organic Agriculture' and any farmer that employs such practices and such systems as an 'organic farmer' regardless of whether the products are marketed as organic or not. Biological, biodynamic, permaculture, agroecological or natural farming etc., are also considered consonant with organic agriculture methods and approaches. Organic farming is not exclusive to any form of land and/or resources ownership nor is it restricted to the size of a farm (IFOAM n.d.)

the annual food and agricultural research spending of 49 billion US dollars of public and private donors is used for the specific solutions and contexts of organic farming (Tittonell 2013; Beintema et al. 2012; Niggli et al. 2008). The gradient from the leading countries to those where organic farming research is not a priority, is huge. The potential for mutual learning and information exchange is therefore great.

In 2007, the European organic stakeholders started to develop a vision for organic food and farming research followed by a research strategy and an action plan on how the strategy should become implemented (Niggli et al. 2008; Padel et al. 2010; Schmid et al. 2009). The process was driven by the Technology Platform TP Organics. Technology Platforms are a common scheme of the European Commission to let stakeholders participate in the research agenda setting. The main target of this process was the European Commission, as funding of multinational research projects in the field of agriculture is important in the European Union (EU). The number of open calls with a focus on technical restraints and opportunities of organic agriculture has considerably increased in the consequent Research Work Programs of the EU due to the work of the multi actor research platform of TP Organics. It has significantly raised the profile of organic farming and its research community and has led to a stronger acknowledgement of organic agriculture as an ecological and farmer driven intensification strategy.

In international agriculture and food research on the other hand, the profile of organic agriculture is still not sufficiently high. Furthermore, the work done so far by TP Organics cannot be automatically extrapolated for other parts of the world. Despite these gaps, the contribution of organic agriculture to raise the productivity of farms in developing countries, to increase livelihoods of small family farms persevering in subsistence agriculture and to enhance the attractiveness of rural areas are potentially interesting to be looked at. An especially important question is the adaptation of organic principles to tropical, subtropical and arid zones. Furthermore, the attitude of bottom-up innovation, farmer-to-farmer learning and farmer-to-consumer value added generation – typical for organic food and farming systems – might offer partial solutions to current global challenges.

The Technology Innovation Platform of IFOAM (TIPI) will not repeat the activities conducted so far in the European Union but integrate them. Its main focus is on the integration of all activities in Europe, the North and South American continent, Africa, Asia and Oceania. It emphasizes not only the role of organic food as a successful niche market but chiefly the potentials which can be taken from organic agriculture to address trade-offs between productivity and the sustainable use of the environment and limited resources. Trade-offs also exist between productivity and social/ethical aspects of farming, Furthermore the profit sharing in the food chain is distorted to such an extent that sustainable farming is gravely counteracted.

The work on a global vision, a strategic research agenda and an action plan will be a participative process of all organic stakeholders and related communities such as fair trade, small holder farmers, environmentalists and different traditional farming communities like pastoralists or other indigenous movements. Scientists will be one stakeholder group of many others. It is not the goal of TIPI to become a platform of scientists only; their interests are represented by the International Society of Organic Agriculture Research (ISOFAR[3]).

This report is the first draft written by the international board of TIPI for a wider consultation among the organic stakeholders, presented at a workshop at the IFOAM International Congress in Istanbul, October 2014. Istanbul should build the momentum for a subsequent global implementation of the action plan with the goal to boost organic agriculture research in all regions of the world and to give input in international organizations and their high level conferences.

[3] www.isofar.org

Box 1: Key facts and figures of organic agriculture

The latest data on organic agriculture show a continued growth of the organic agricultural land and of the market; however there are substantial differences in development in the continents (Willer & Lernoud 2014)

- There were 37.5 million hectares of organic agricultural land in 2012.
- The regions with the largest areas of organic agricultural land are Oceania (12.2 million hectares) and Europe (11.2 million hectares). Latin America has 6.8 million hectares followed by Asia (3.2 million hectares), North America (3 million hectares) and Africa (1.1 million hectares).
- Currently 0.9 percent of the agricultural land of the countries covered by the survey is organic.
- Some countries reach far higher shares: Austria 19.7 percent, Sweden 15.6 percent, Estonia 15.3 percent, Switzerland 12.9 percent, and Germany 6.2 percent.
- There were more than 1.9 million producers in 2012.
- Thirty-six percent of the world's organic producers are in Asia, followed by Africa (30 percent) and Europe (17 percent).
- The countries with the most producers are India (600'000), Uganda (189'610), and Mexico (169'707).
- Latest research from Organic Monitor finds international sales of organic food and drink approached 64 billion US dollars in 2012.
- Growth is occurring in all regions; however, demand for organic products is mainly in North America and Europe. Organic product sales are projected to continue to rise in the coming years.
- In 2012, the countries with the largest organic markets were the United States, Germany, and France.
- The highest per-capita consumption was in Switzerland, Denmark, and Luxembourg.
- The highest market shares were reached in Denmark, Switzerland and Austria.

4. Strengths, weaknesses and potentials of organic farming

4.1 Introduction

At present, agriculture faces the unprecedented challenge to secure food supplies for a rapidly growing human population while seeking to minimize the adverse impacts of agriculture on the environment and reduce the use of non-renewable resources and energy. A shift towards sustainable agricultural production entails the adoption of more system-oriented strategies, which include farm-derived inputs and productivity based on ecological processes and functions (Garnett & Godfray 2012). Sustainable agricultural systems also involve the traditional knowledge and entrepreneurial skills of farmers (IAASTD 2008). System-oriented sustainable practices include organic farming, Low External Input Sustainable Agriculture (LEISA), and agro-forestry. In addition, a few elements of agroecology - such as integrated pest management, integrated production (IP), and conservation tillage - have been successfully adopted by conventional farms as well.

4.2 Strengths of organic agriculture

4.2.1 Multi-functionality - the most characteristic feature of organic agriculture

Organic agriculture produces both commodity and non-commodity outputs and addresses ethical concerns like animal welfare and the livelihoods of farmers and farm workers (fair trade). Hence, it is a predominantly multi-functional concept of agriculture. Public goods - or non-commodity outputs - as provided by organic farms have been comprehensively reviewed by several authors (Tittonell 2013; Schader et al. 2012; Rahmann et al. 2009; Niggli et al. 2008; Scialabba et al. 2002; Stolze et al. 2000). The different meta-analyses all confirm in a consistent way that organic agriculture can be characterized as a multifunctional and system oriented agriculture.

In the case of Switzerland, calculation with a comparative-static mathematical programming model showed that state support schemes for organic farming (direct payments) are equally cost-effective at achieving environmental policy targets as the combination of different targeted and tailored agri-environmental measures (Schader et al. 2013). It also reveals that specific agri-environmental measures like ecological compensation areas (e.g. hedgerows, field margins with wild flowers, and extensive grassland) are more cost-effective when implemented on organic farms than on non-organic farms.

4.2.2 (Bio)diversity on organic farms

Diversity is an important driver for the stability of agro-ecosystems (Altieri & Nicholls 2006) and hence, for a continuously stable supply of food. At the farm level, organic farmers often practice diversification by producing several different commodities, both livestock and crops, and by processing and marketing them directly.

Comparative biodiversity assessments on organic and conventional farms reveal 30 percent higher species diversity and a 50 percent greater abundance of flora and fauna in organic fields (Rahmann 2011; Bengtsson et al. 2005; Hole et al. 2005; Fuller et al. 2005). The higher biodiversity applies to different taxonomic groups, including microorganisms, earthworms, weeds and wild flowers, insects, mammals, and birds (Hole et al. 2005; Kragten & de Snoo 2008; Kragten et al. 2008; Wilson et al. 1997; Wickramasinghe et al. 2003; Gabriel & Tscharntke 2007; Holzschuh et al. 2007; Gabriel et al. 2006; Frieben & Köpke 1995). In regions where the number of organic farms increased, the diversity and abundance of bees grew considerably, which contributed to the pollination of crops and wild plants over larger areas (Rundlöf et al. 2008). Most of the studies indicate that the diversity of species on organic farms is predominantly the effect of the ban of pesticides, herbicides, and fast-release fertilizers. Furthermore, diversified crop rotation and non-chemical weeding have a positive effect on the species diversity of organic farms (Rahmann 2011; Hole et al. 2005). Sufficient semi-natural landscape elements like hedgerows, fallow-ruderal habitats, and wildflower strips are additional measures used by organic farmers to stabilize pest populations (Zehnder et al. 2007).They belong to the toolset of organic farmers in order to make crop production more resilient.

The most recent hierarchical meta-analysis of 184 observations from 94 individual studies confirmed that the species richness was increased on organic fields by 34 percent, on average, compared to conventional fields (Tuck et al. 2014). This effect has been robust over the last 30 years. Quite obviously, the heterogeneity of these results is big. The positive effect of organic agriculture is greater in intensively farmed regions and in regions dominated by arable crops. Not all taxonomic and functional groups and crops profit from organic farming, but a significant majority does.

4.2.3 Lower negative environmental impacts

The high dependence of conventional farming on chemical fertilizers, herbicides, and pesticides has caused considerable environmental damage. Meta-analyses comparing the environmental impacts of organic and conventional farming show that organic farms are likely to have lower nutrient losses as well as lower ammonia emissions per unit land (Tuomisto et al. 2012; Gomiero et al. 2011; Stolze et al. 2000; Drinkwater et al. 1998), but not necessarily per ton food produced, because of the lower yields. As both nutrient losses and ammonia emissions are relevant indicators for local and regional eutrophication (Dahlgaard et al. 2012), these negative environmental externalities cannot be compensated by higher yields.

Other nutrient elements like potassium and phosphorous, are not found in excessive quantities in organically managed soils, which increases their efficient use (Mäder et al. 2002). Since synthetic herbicides and pesticides are not applied on organic farms, leaching and run-off effects are likely not to occur. The only pesticides used in organic agriculture that cause residues in soils are copper fungicides. They are used in horticultural crops such as potatoes, grapes, hops, and a few vegetables at annual rates of 3 to 4 kg of copper per hectare. The replacement of copper fungicides by breeding of disease resistant varieties and by easily degradable botanicals has a high priority in national and European Union organic research.

4.2.4 Stable soils – Less prone to erosion

Fertile soils with stable physical properties have become the top priority of sustainable agriculture. Thus, the essential conditions for fertile soils are vast populations of bacteria, fungi, insects, and earthworms, which build up stable soil aggregates. There is abundant evidence from long-running field studies that organic farms and organic soil management lead to good soil fertility. Compared to conventionally managed soils, organically managed ones show a higher organic matter content, higher biomass, higher enzyme activities of microorganisms, better aggregate stability, improved water infiltration and retention capacities, and less susceptibility to water and wind erosion (Edwards 2007; Fließbach et al. 2007; Marriot et al. 2006; Pimentel et al. 2005; Reganold et al. 1987; Reganold et al. 1993; Siegrist et al. 1998; Mäder et al. 2002).

4.2.5 Carbon sequestration

Organic farmers use different techniques for building soil fertility. The most effective ones are fertilization by animal manure, by composted harvest residues, and by leguminous plants as main and intermediate crops. Introducing grass and clover leys as feedstuff for ruminants into the rotation and diversifying the crop sequences, as well as reducing ploughing depth and frequency, also augment soil fertility. All these techniques increase carbon sequestration rates on organic fields. The only references for quantifying this effect are long-running field experiments in different parts of the world (Lee et al. 2008). A scientific meta-analysis of the raw data of 74 long-term field trials (most of them in temperate zones) reveal significant carbon gains in organically-managed plots, whereas, in the conventional or integrated[4] plots, soil organic matter is either stable or exposed to losses by mineralization (Gattinger et al. 2012). In this meta-analysis, which gathered the data from all existing long-term field trials, the average difference in the annual sequestration rate between organic and conventional management was 450 kg atmospheric carbon per hectare per year. The mean difference of the carbon stocks of soils was 3.5 metric tons per hectare per year, and the average duration of these long-running field trials was 16 years. A further increase of carbon capture in organically managed fields can be measured by reducing the frequency of soil tillage. In an experiment in Switzerland, the sequestration rate increased to 870 kg of Carbon per hectare per year by not turning the soil upside down with a plough, but by preparing the seedbed by loosening the soil with a chisel plough instead (Gadermaier et al. 2012). In conclusion, the combination of organic agriculture and reduced soil tillage is likely to be among the best strategies for increasing carbon sequestration in arable crops. Unfortunately, this technique is not yet widely adopted by organic farmers as weeds become more difficult to manage.

4.2.6 Good nitrogen use efficiency

Crop productivity has increased substantially through the use of heavy inputs of soluble fertilizers - mainly nitrogen - and synthetic pesticides. However, according to a meta-analysis in the United States (Erisman et al. 2008), only 17 percent of the 100 metric tons of industrial nitrogen annually applied on conventional farms is taken up by crops; the remainder is lost to the environment.

In a long-term field trial in Switzerland (since 1978), the total nitrogen input into an organic arable crop rotation was 64 percent of the integrated/conventional rotation; the total organic yields over the same period were 83 percent of the conventional ones. Therefore, organic farms are likely to use nitrogen in a more efficient and less polluting way (Mäder et al. 2002).

As a result of the limited availability of nitrogen in organic systems, a careful and efficient management of fertilizers is required (Kramer et al. 2006). On the other hand, high levels of reactive nitrogen (ammonium NH_4, nitrate NO_3) in soils may contribute to the emission of nitrous oxides, which are a major source of agricultural emissions. In a scientific meta-analysis based on 12 studies that cover annual measurements, it appeared with a high significance that area-scaled nitrous oxide emissions from organically-managed soils were 492 ± 160 kg carbon dioxide CO_2 equivalence per hectare per year lower than that of non-organically managed soils (Skinner et al. 2014). However, yield-scaled nitrous oxide emissions were higher by 41 ± 34 kg CO_2 equivalence t^{-1} DM under organic management (arable land use). To equalize this mean difference in yield-scaled nitrous oxide emissions between both farming systems, the yield gap has to be less than 17 percent. This underlines the importance of addressing yield stability and productivity in organic agriculture especially in the context of greenhouse gas (GHG) emissions where the negative externalities are global and closely linked to total food production (Rahmann et al. 2008).

The overall performance of organic farming for the reduction of GHG emissions had been evaluated in Germany with a case study of 40 conventional and 40 organic farms (Hülsbergen & Rahmann et al. 2013) for 5 years (2009 to 2013). The comparison resulted in a higher nutrient and energy efficiency and lower greenhouse gas (GHG) emission CO_2 equivalence per product units (milk and wheat). Nevertheless, the variability was higher in organic than conventional farming (Hülsbergen & Rahmann 2013).

[4] Integrated production as an improved conventional farming approach encompasses pesticides sprays according to economic thresholds, fertilizing according to nutrient budgeting and some minimum crop rotation requirement.

4.2.7 Adaptation to climate change

As a result of climate change, agricultural production is expected to face less predictable weather conditions than those experienced during the last century. South Asia and Southern Africa, in particular, are expected to be the worst affected by negative impacts on important crops, with possibly severe humanitarian, environmental, and security implications (Lobell et al. 2008).

Thus, the adaptive capacity of farmers, farms, and production methods will become relevant to cope with climate change. As unpredictability in weather events increases, robust and resilient farm production will become more competitive, and farmers' local experiences will be invaluable for permanent adaptation. Organic agriculture stresses the need to use farmer and farmer-community knowledge, particularly about aspects such as farm organization, crop design, manipulation of natural and semi-natural habitats on the farm, use - or even selection - of locally appropriate seeds and breeds, on-farm preparation of fertilizers, natural plant strengtheners and traditional drugs, and health care techniques for livestock, as well as innovative and low-budget techniques. Such knowledge was described by Tengo and Belfrages (Tengo & Belfrages 2004) as a 'reservoir of adaptations.'

Techniques for enhancing soil fertility help to maintain crop productivity in case of drought, irregular rainfall events with floods, and rising temperature. Soils under organic management retain significantly more rainwater due to the 'sponge properties' of organic matter. Water infiltration capacity was 20 to 40 percent higher in organically-managed loess soils in the temperate climate of Switzerland when compared to conventional farming (Mäder et al. 2002). Pimentel et al. (2005) estimated the amount of water held in the upper 15 cm of soil in the organic plots of the Rodale experiment in Pennsylvania/USA at 816,000 liters per hectare. This water reservoir was most likely the reason for higher yields of corn and soybean during dry years. The water capture in the organic plots was approximately 100 percent higher than in the conventional ones during torrential rains (Lotter et al. 2003).In addition, higher proportion of permanent and temporary grassland respectively grass-clover leys on organic farms and higher earthworm populations (Pfiffner et al.2003) reduce run-off and improve infiltration. These effects significantly reduce the risk of floods, an effect that could be relevant if organic agriculture were practiced over much larger areas. Improved physical properties of soils and therefore a better drought tolerance of crops were also observed in on-farm experiments in Ethiopia, India, and the Netherlands (Pulleman et al. 2003; Eyhorn et al. 2007; Edwards 2007).

The diversification of farm activities, as is typical for organic farms, greatly reduces weather-induced risks, as well. Landscapes rich in natural elements and habitats effectively buffer climate instability. New pests, weeds, and diseases – the results of global warming – are likely to be less invasive in natural, semi-natural, and agricultural habitats that contain a higher number of species and a greater abundance of individuals (Zehnder et al. 2007; Altieri et al. 2005; Pfiffner et al. 2003).

4.3 Weaknesses of organic agriculture

4.3.1 Yield gap

The fast-growing human population gives rise to the crucial question as to whether organic farming could feed the world. The indisputable advantages of organic farming in delivering public goods and services shrink if too much land is needed to produce food (Rahmann et al. 2009). Therefore, the lower yields of organic agriculture are often the main reason that critics question the sustainability of this farming approach. The productivity question has been taken seriously by the organic stakeholders with the strategy of ecological or eco-functional intensification. One has also to be aware of, that most environmental goods and services are absolute ones and cannot be relativized by the per ton approach. This is especially true for the leaching and run-off of nutrients into ground and surface water (nitrogen, phosphorous), the eutrophication of natural and semi-natural habits, for the losses of biodiversity in arable and permanent crops and grassland, soil erosion and soil compaction or microorganism and animal diversity and activity in agricultural soils. One of the few negative externalities of agriculture where a per ton approach really makes sense are the nitrous oxide emissions. Their impacts are global and strongly related to the amount of food produced.

Two recently published scientific meta-analyses shed light on this important aspect: the overall yields of organic crops are estimated to be 25 percent (Seufert et al. 2012) lower than conventional ones, based on 316 comparisons, and 20 percent lower, based on 362 comparisons (De Ponti et al. 2012).The yield difference is an average for all crops analyzed. The categorical meta-analysis showed that organic crop rotations are likely to be nitrogen limited, that phosphorous limits yields in strongly alkaline and acidic soils and that only best management practices can result in yields comparable to those of conventional farms. Out of 362 studies, 316 define best practice as sufficient control of weeds, diseases, and pests.

Another meta-analysis that mainly gathered data from a case study in Africa (Hine et al. 2008) indicated that organic farms are more resilient on water-restricted and drought-affected sites and therefore, likely to be more productive than conventional farms (number of farms in the study > 1 million, yield of the organic farms was 116 percent higher than on conventional one) (Hine et al. 2008). Major factors that influenced the productivity of organic farms in a positive way were soil fertility building and improved on-farm and in-field biodiversity (better use of natural capital). In addition, there were also many socioeconomic factors responsible for the result (improved human and social capital).

The majority of scientists agree that organic farming does not maximize the yield potentials of favorable soils and site climates but has a good total factor productivity (TFP)[5] also under intensive farming in temperate zones (Mäder et al. 2002). For less favorable zones and in regions with predominantly subsistence farming, organic agriculture is an important first step towards an intensification of food production mainly driven by farm internal intensification, sustainable practices and improved farmer knowledge.

4.3.2 Social, animal welfare and quality gaps

Organic production in developing and emerging countries is driven by the demand of the fast growing markets in Europe, United States and Asia. Therefore, exports prevail and domestic markets and self-supply are neglected. The global trade with organic commodities and foods is dominated by companies and traders from Europe and America. Therefore, the organic standards of Europe and the United States override local regulations and inspection and certification bodies are based in Europe and the United States. It is important that the domestic markets as well as local and adapted standards and certification procedures will be developed.

Fair payments and good living conditions (FAO and WHO human well-being criteria) are an important principle of organic farming (the principle of fairness). Indeed, many consumers expect from organic foods fair prices for farmers and correct labor conditions for farm workers and staff working in processing and trade. Nonetheless, the fair trade idea is far from being implemented in the standards and regulations and is not an inherent part of the certification.

Less critical but also an issue are the animal health and welfare standards. Consumers often purchase organic meat, eggs and dairy products because they reject the practices of industrial livestock production. The quality of animal welfare practiced on organic farms around the world varies considerably (Rahmann 2010). In Europe e.g. animal welfare is only consequently practiced in countries, where particular programs are subsidized by the government like in Switzerland. But even there, the reality often differs from the ideals. The removal of horns from beef cattle is still broadly practiced. Hybrid poultry - bred for cage and intensive keeping - kept on organic farms often show severe difficulties in behavior and health. Feather picking and cannibalism are still unsolved problems. Male chicks from laying hen populations are still killed instead of fattened. There are no races of poultry or double purpose breeds used because they

[5] TFP is the ration that relates the aggregation of all inputs to the aggregation of all inputs (Latruffe 2010)

do not fulfill the performance and production requirements of the farmers. Poultry is still kept in large flocks with several thousand animals in one barn.

Feeding of livestock is one of the most difficult problems. As a consequence of the BSE[6] crisis, omnivore animals like pigs and poultry have been turned into pure 'vegans' while maintaining high daily weight gains and accordingly essential amino acid requirements. Synthetically produced essential amino acids, as in conventional animal husbandry, are not allowed in organic agriculture. The protein gap resulting thereof has not yet been closed with plant based organic feeds for fast growing young animals (piglets, chicks) and high yielding animals (sows, laying hens). In addition to the according economic losses this is also problematic from an animal welfare perspective. As of 2012, 100 percent organic feeding should have been required by law. This deadline was postponed several times, now until 2021.

Some gaps also occur in the quality of organic foods. A recent comparison meta-study (Baranski et al. 2014) has highlighted that organic plant products are have a higher density of nutritionally desirable ingredients especially secondary plant metabolites, antioxidants and a few vitamins. In addition, the meta-study based on 342 scientific papers showed significantly lower contaminants like cadmium, nitrate and nitrite and due to the non-application pesticide residues. The latter has already been documented by regular market surveys like the one done by the food monitoring agency of Baden-Württemberg in Germany since 2001[7]. Nonetheless, contamination can also occur on organic farms such as higher dioxin loads in eggs and meat due to the fact that some free-range areas are exposed to the general air pollution and fall-out of industrial plants. A further expectation of the consumers that often is not satisfied is the organoleptic (sensory) quality of fruits and vegetables and processing problems of other organic commodities. Best practices in many countries show that these problems are to be solved but they require not only training but also much more research.

4.3.3 Research gaps

Globally, US$49 billion is annually spent for food and farming research (Beintema et al. 2012). The research spending for knowledge, techniques, and tools that are highly specific to, and in compliance with, organic standards is probably far less than one percent of private and public Research & Development (R&D) budgets (Rahmann et al. 2013; Titonell 2013; Niggli 2008). Innovation on organic farms is, therefore, still more strongly driven by farmers' own initiative and less by scientists and farm advisors. This lack of basic and applied research on organic farming systems is a crucial deficit of organic farming and limits development considerably.

However, the concept of organic agriculture offers ample scope to increase the productivity of farms, on the basis of both eco-functional intensification and the smart and selective use of modern techniques and technologies. The idea of the TIPI vision and research agenda is therefore to highlight these potential advances and to exemplify how research could contribute. As research activities are still far from reaching critical mass fast progress can be expected and the input-output ratio of research funding is expected to be excellent.

4.4 Opportunities of organic agriculture

Addressing the future challenges of agriculture, especially the fast changing ecological, social and economic context of food security, one can identify several main challenges which are very favorable for organic agriculture in the future:

- **Reducing trade-offs between productivity and sustainability:** There is consensus in the most recent scientific and political debates that the long-term productivity in agriculture can only be based on reducing dramatically the trade-offs between food, feed, fuel and fiber production on the one hand and all the other ecosystems services on the other hand (Millennium Ecosystem Assessment reports published in 2005; the TEEB

[6] BSE is the abbreviation of Bovine spongiform encephalopathy.

[7] www.bvl.bund.de

report published in 2010). Rockström et al. (2009) urge for a substantial reduction of inputs, emissions and impacts of agriculture as they destabilize the planet to a substantial extent. The International Assessment of Agricultural Science and Technology for Development (IAASTD) report published in 2009 and the most recent UNCTAD Trade and Environment report, published in 2013 ask policy makers for radical changes of national and international agricultural policies, the framework for international trade and the support provided to farmers with research and training.

- **Sufficiency in times of limited resources:** The report of the 3rd SCAR (EU- SCAR 2011) foresight exercise of the European Commission highlighted that resource scarcities are expected to define future food security, and the report identified two competing narratives. In the past, productivity of farms was often and wrongly reduced to yields or partial productivity of labor. In contrast, the sufficiency narrative recognizes planetary boundaries and the need for behavioral change. According to the definition of the Wuppertal Institute, sufficiency is an inherent aspect of sustainability (Schneidewind et al. 2014).
- **Improved multi-actor cooperation** is crucial to accelerate innovation in agriculture and food systems. The roots of organic farming were characterized by three types of cooperation: (1) 'farmer-to-farmer' cooperation which helped to maintain and exchange individual and site specific knowledge; (2) 'farmer-to-scientist' cooperation which helped to conceptualize organic farming and to increase its agronomic and economic performance; (3) the 'farmer-consumer cooperation' which helped to develop a variety of food chains and to link sustainable production with sustainable consumption.
- **Active participation of farmers in co-innovation needed:** First concepts of this kind of mutual interactions between science and farm practice were called prototyping (Vereijken 1997). The prototyping strategy addressed the ecological deficits of conventional farms and the redesign pointed at integrated and organic farming systems. The concept of prototyping has been criticized for being dominated by scientists, insufficiently integrating farmers and not regarding the diversity of farms in their respective context (Leeuwis 1999). Therefore, most recent concepts emphasize co-innovation where farmers, farm advisors and scientists are involved (Dogliotti et al 2014). As significant and complex changes of farms is not the result of 'take it or leave it' of validated packages of solutions or technology fixes as the authors point out, farmers have to become involved in all stages of the innovation process in order to ensure relevance, applicability and adoption. Even more so as farmers are often the source of innovation.

4.5 Threats for organic agriculture

Organic agriculture is still a niche production with globally only 0.9 percent of farm land under a certification system. However, many more farmers are organic by default and the agro-ecological farming movement, especially in Latin America and also in Europe with High Nature Value (HNV) farms, is much bigger. However, the organic sector is currently challenged to break out of its niche status. Already since 2009, the global area under organic certification has stagnated at 37 million hectares and constant growth rates have been noted only in Europe (Willer & Lernoud 2014). Currently, the markets for organic foods grow mainly in Europe and in the United States, and to a lesser extend also in the fast growing privileged classes of emerging and developing countries.

The readiness to invest public money into research on organic farming systems depends on the combination of areal growth and positive environmental and social impacts. Without public support schemes such as are mainly active in Europe, one could even expect a decline in the number of organic farms.

Innovation on organic farms is defined as a social and a technical process. It is true that productivity and profitability of farms can be raised by cooperation among farmers and by new models of value sharing along the food chain. Farmer-to-farmer cooperation indeed increases the knowledge and improves the production technique considerably. Nonetheless, this kind of innovation can be seen as an improved management of already existing knowledge. Organic regulations also facilitate science-driven innovation like bio-control and botanical agents, managing antagonists of pests and diseases, marker-assisted breeding techniques and many kind of precision farming techniques, robots and the full use of information and communication technology (ICT). Other farming systems use all or part of the permanent scientific progress beyond what is accepted by organic standards, especially certain innovations in molecular sciences, nanotechnology and breeding (e.g. cytoplasmic male sterility (CMS) breeding).These general bans are based on the IFOAM Principle of Care which requires precaution in cases where potential risks for human health, environment and society cannot be excluded (IFOAM n.d.). As the scientific progress in all relevant disciplines is very fast, it is not predictable whether other farming systems will someday minimize trade-offs between productivity and sustainability more effectively than organic farming. This is one of the reasons why the number of voluntary sustainability standards has increased in recent years and organic markets are increasingly in competition with other different sustainability labels (Potts et al. 2014).

5. State-of-the-art of organic farming research

Research in organic farming has increased considerably in recent years. Up to now, activity has been greatest in Europe, but recently organic research has increased in other parts of the world, and more players are appearing on the scene. Research is mostly carried out in a national context, but international coordination and cooperative efforts are increasing.

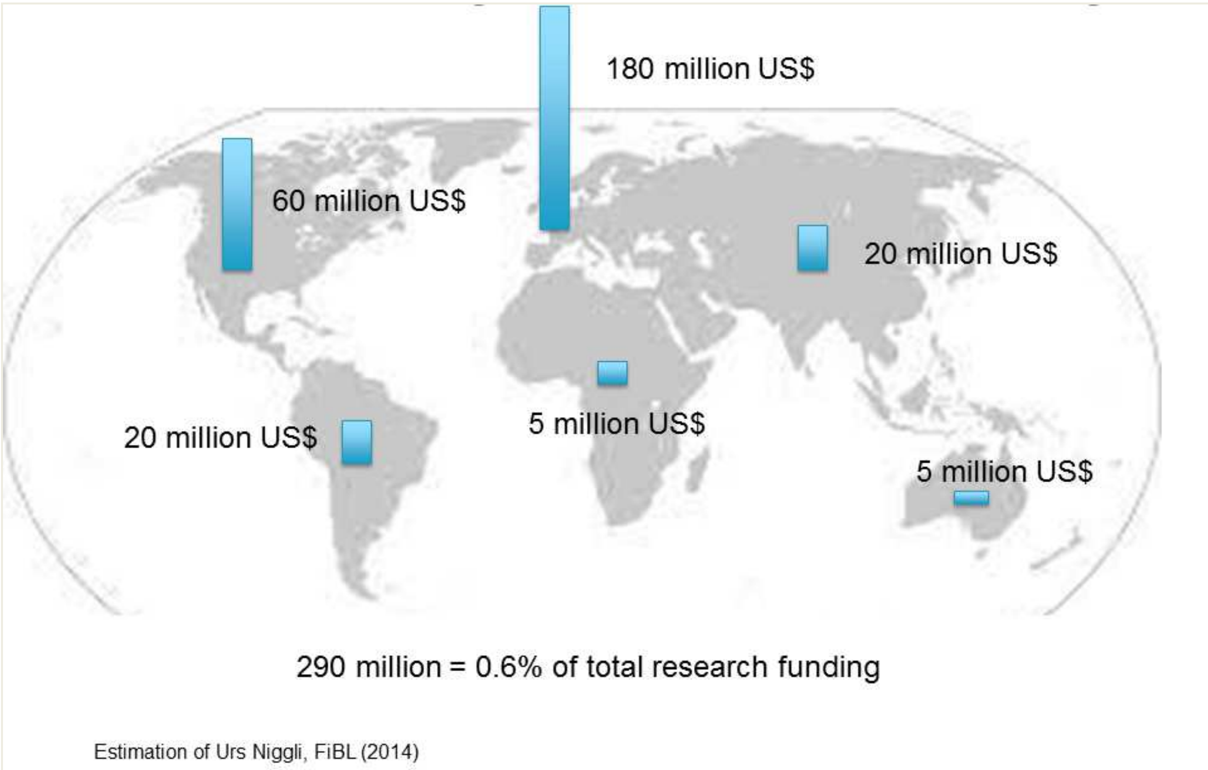

Figure 1: Annual spending on organic food and farming system research. The figures are highly speculative estimations as it is difficult to differentiate between organic, agro-ecological, biodiversity, environmental and animal welfare research.

5.1 World

5.1.1 Organic farming development

Other than in the African Union, the Association of Southeast Asian Nations ASEAN countries or the European Union, there is no global strategy for the development of the organic sector. However, a number of international organizations have relevant activities. An important activity was, for instance, the FAO conference on Food security and Organic Farming in 2007, and in 2009, the Chair of the 36th FAO Conference called for an elevated role of organic agriculture within FAO's work. FAO runs a website on organic agriculture[8] and has funded in the last 20 years several research reports which are highly relevant for organic farming (e.g. Low Input Farming: Merits and Limits (1993), Biological Farming Research in Europe (1997), L'agricultura orgánica (1999), Research Methodologies in Organic Farming (1999), Research Methodologies in Organic Farming: On-Farm Participatory Research (2000), Organic agriculture, environment and food security (2002), Proceedings of the first World Conference on Organic Seed - Challenges and Opportunities for the Organic Agriculture and the Seed Industry (2004), Reports of the International Conference on Organic Agriculture and Food Security (2007), Report on the Africa Conference on Ecological Agriculture (2008), Organic Agriculture and Climate Change Mitigation A Report of the Round Table on Organic Agriculture and Climate Change (2011). Some of these reports were published together with other UN organizations like the United Nations Conference on Trade and Development (UNCTAD), the United Nation Environmental

[8] www.fao.org/organicag/oa-home/en

Program and the United Nations Industrial Development Organization (UNIDO). UNCTAD and UNEP published in 2008 the report 'Organic Agriculture and Food Security in Africa' (UNEP-UNCTAD 2008).

ITC, the International Trade Center joint agency of the World Trade Organization and the United Nations., is involved in the publication of the global statistical data on organic agriculture (Willer & Lernoud 2014). In order to facilitate the access of producers to organic markets, UNCTAD and FAO jointly with IFOAM cooperate on the project Global Organic Market Access (GOMA).

Apart from these selected activities, organic agriculture is not of high priority for the United Nations. The same applies to organic farming research. It has not been a topic of the program of the 15 international research centers Consultative Group on International Agricultural Research (CGIAR) on 'Science for a food secure future'. Nor has it been on the agenda of the process of redefining research priorities in the Global Forum on Agricultural Research (GFAR) of the recent years.

In developing countries, the concept of organic farming has been tested, further advanced and institutionalized by projects co-operations funded by EU and national AID organizations such as Dutch humanist Institute for cooperation (HIVOS), Swedish International Development Cooperation (SIDA), Swiss Agency for Development and Cooperation (SDC), Norwegian Agency for Development Cooperation (NORAD), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and many others. Some of these also encompass applied research, learning methodologies and training. These north-south co-operations are described in the respective chapters of the continents.

5.1.2 International coordination and cooperation efforts

Conferences

The first international conferences on organic farming research were the international scientific conferences of the International Federation of Organic Agriculture Movements (IFOAM). The first one took place in Sissach, Switzerland in 1977, back then called the 'International IFOAM Scientific Conference'. Since 2005, this conference (now named Organic World Congress OWC) has been held in cooperation with the International Society of Organic Agriculture Research (ISOFAR), which shares the responsibility of organizing the scientific part of the congress. The scientific conference proceedings give a unique overview of ongoing organic farming research worldwide and of the key players. ISOFAR as the society of organic scientists has been partner of a growing number of national and regional scientific conferences[9].

[9] www.isofar.org

Table 1: IFOAM/ISOFAR Scientific conferences and congresses since 1973

Year	Venue	Theme	Proceedings
2014	Istanbul (Turkey)	Building organic Bridges	18th IFOAM Organic World Congress (21th General Assembly) 4th ISOFAR Scientific Conference at the 18th OWC)
2011	Gyeonggi Paldang (South Korea)	Organic is Life	17th IFOAM Organic World Congress (20th General Assembly) 3rd ISOFAR Scientific Conference at the 17th OWC (proceedings available on www.isofar.org)
2008	Modena (Italy)	Cultivating the Future	Books of Abstracts. 16th IFOAM Organic World Congress (19th General Assembly). Available at https://www.fibl.org/en/shop-en/article/c/international-en/p/1506-cultivating-future-vol1-2.html 514 pages. ISBN 978-3-940946-03-4 2ndISOFAR Scientific Conference at the 16th OWC . Available at https://www.fibl.org/en/shop-en/article/c/international-en/p/1506-cultivating-future-vol1-2.html
2005	Adelaide (Australia)	Shaping Sustainable Systems	15th IFOAM Organic World Congress (18th General Assembly) 1st ISOFAR Scientific Conference at the 15th OWC (proceedings available at http://orgprints.org/view/projects/int-conf-isofar-2005.html)
2002	Victoria (Canada)	Cultivating Communities	14th IFOAM International Scientific Conference (15th General Assembly)
2000	Basel (Switzerland)	The World Grows Organic	13th IFOAM International Scientific Conference (16th General Assembly) 761 pages ISBN 3-7281-2754-X. (Photocopies available at FiBL)
1998	Mar del Plata (Argentina)	Organic Agriculture: the Credible Solution for the 21st Century	Organic Agriculture: The Credible Solution for the 21st Century 12th IFOAM International Scientific Conference (15th General Assembly) (available at IFOAM)
1996	Copenhagen (Denmark)	Down to Earth- and further Afield	11th IFOAM International Scientific Conference (14th General Assembly) (Photocopies available at FiBL)
1994	Christchurch (New Zealand)	People-Ecology-Agriculture	10th IFOAM International Scientific Conference (13th General Assembly)
1992	Sao Paulo (Brazil)	A Key to a sound Development and a sustainable environment	9th IFOAM International Scientific Conference (12th General Assembly)
1990	Budapest (Hungary)	Socio-Economics of organic Agriculture	8th IFOAM International Scientific Conference (11th General Assembly)
1989	Ouagadougou (Burkina Faso)	Agriculture Alternatives and Nutritional Self Sufficiency	7th IFOAM International Scientific Conference (10th General Assembly)
1986	Santa Cruz (USA)	Global Perspectives on Agroecology and Sustainable Agriculture Systems	6th IFOAM International Scientific Conference (9th General Assembly)

1984	Kassel-Witzenhausen (Germany)	The Importance of Biological Agriculture in a World of Diminishing Resources	5th IFOAM International Scientific Conference (8th General Assembly)
1982	Boston (USA)	Global Perspectives on Agroecology and Sustainable Agriculture Systems	4th IFOAM International Scientific Conference (7th General Assembly)
1980	Brussels (Belgium)	The Maintenance of Soil Fertility	3rd IFOAM International Scientific Conference (6th General Assembly)
1978	Montreal (Canada)	Basic Techniques in Ecological Farming	2nd IFOAM International Scientific Conference (5th General Assembly)
1977	Sissach (Switzerland)	Towards a sustainable agriculture	1st IFOAM International Scientific Conference (4th General Assembly) Towards a sustainable agriculture, 243 page. ISBN 3-85983-017-1, (Photocopies available at FiBL)

Networks

In2003, the International Society of Organic Agriculture Research (ISOFAR) was founded by the German Institute of Organic Agriculture (IOL) in Germany and the Research Institute of Organic Agriculture (FiBL). The goals of ISOFAR are to promote research in organic agriculture by facilitating global cooperation in research and education and knowledge exchange. The individual scientist members of ISOFAR are from all parts of the globe, although the majority resides in Europe where ISOFAR is based.

In 2013, TIPI - the Technology Innovation Platform of IFOAM - was founded to engage and involve all stakeholders that benefit from organic agriculture research. The main objectives of TIPI are to develop and make visible an organic research agenda addressing global challenges, to foster international collaboration in organic agriculture research and to facilitate exchange of scientific knowledge of organic food and farming systems.

Journals, websites and newsletters

Journals, websites and newsletters are important communication tools for researchers. Increasingly, researchers are also publishing in general peer-reviewed journals and this has helped increase the scientific credibility of organic farming research. ISOFAR has launched the scientific journal 'Organic Agriculture' in association with Springer Science[10]. The ISOFAR newsletter reports regularly about global trends in organic farming research[11].

The open access Organic E-prints Archive has more than 15,000 entries now; most of these are from Europe[12]. The archive gives a very good overview of ongoing research in Europe, and it would be good if more research institutions would use this archive. A disadvantage is that many peer-reviewed scientific papers are subject to the copyright of the publishers and cannot, therefore, be archived publicly. News, events and background on organic farming research worldwide is provided at www.organic-research.net.

[10] www.springer.com/life+sciences/agriculture/journal/13165
[11] www.isofar.org
[12] http://orgprints.org

5.2 Africa

Box 2: Key figures on organic agriculture in Africa (Willer & Lernoud 2014)

- Current status (area, producers, markets)
- 1’000’000 hectares of certified organic agricultural land (2012)
- 557’000 producers.
- Uganda: largest organic area (> 231’000 hectares)
- Island State Sao Tome and Principe Country: highest share of organic agricultural land (7 percent)
- Majority of certified organic produce for export markets.
- Key crops: coffee, olives, cocoa, oilseeds, cotton.

5.2.1 Policy environment

Over the years some policy makers and donors have started to recognize the potential of export oriented organic agriculture as a means of generating foreign exchange and increasing incomes, but the broader benefits of organic farming and agroecology (in terms of enhancing food security, environmental sustainability and social inclusion and reducing exposure to toxic pesticides) often go unrecognized or are simply ignored. In 2011, the African Union (AU) coined the term ‘Ecological Organic Agriculture’ (EOA), which integrates two previously distinct concepts, organic and ecologic, with the aim of bringing together the synergies from both concepts and their practices for the benefit of the African continent as documented in a Decision of the African Union (2011). The conference Alternative for Africa, that took place in November 2011 at the UNEP Headquarters in Nairobi, Kenya helped build the alliances required to capitalize on the African Union's Resolution on Organic Farming and implement the ‘African Ecological Organic Agriculture Action Plan’. Since then, an EOA Initiative has been developed aiming to mainstream the practices into national policies by 2025 in order to improve agricultural productivity, food security, access to markets and sustainable development in Africa. This will help to position ecological organic agriculture as a key tool in addressing the pressing problems of food security and climate change in Africa and thus position ecological organic agriculture higher on the agenda of African governments, policy makers and the international donor community.

As part of the EOA, the International Federation of Organic Agriculture Movements (IFOAM) launched the IFOAM Organic Alternative for Africa[13] (TOFA) campaign, bringing a uniting continental approach to advocate organic agriculture and its multiple benefits to be included at national development policy. The campaign empowers Africans especially smallholder family farmers, pastoralists, women and youth in both rural and urban communities to understand the potential of the organic alternative. It strengthens the African organic movement and creates new opportunities for organic development in the region.

5.2.2 Current research situation in Africa

To date, research to track the extent to which organic agriculture approaches are being employed on the ground, or their effectiveness, vis-à-vis other conventional approaches, in meeting economic, social and environmental objectives, is very limited. Yet, there is growing evidence that their appeal is increasing and often proving highly successful in meeting these aims. During the conference on Mainstreaming Organic Agriculture in the African Development Agenda, held in Lusaka, Zambia, from 2 to 4 May 2012, participants shared research results confirming that organic agricultural practices ‘increase yields, improve livelihoods and food security, conserve indigenous knowledge, plant varieties and animal breeds, as well as socio-cultural development, and provide much greater resilience in times of climate extremes, such as drought and heavy rains’. Participants thus adopted the six pillars of the African Organic Action

[13] www.ifoam.org/en/core-advocacy-campaigns/organic-alternative-africa

Plan whose 1st pillar is research, training and extension - to conduct participatory, interdisciplinary, multi-cultural research that informs stakeholder training and offers appropriate knowledge and skills and innovative solutions to the community.

The other five pillars of the African Organic Action Plan as decided in Lusaka are ii) information and communication, iii) value chain and market development, iv) networking and partnership, v) supportive policies and programs and vi) institutional capacity development.

Examples of important scientific institutions involved in organic farming research and training include the Universities of Ibadan and of Abeokuta in Nigeria, the Nelson Mandela University in George in South Africa and the Uganda Martyrs University, Nkozi in Uganda.

In 2008, the national organic agriculture movements (NOAMs) in Eastern and Southern Africa met in Nairobi where the idea for an African Organic Agriculture Network emerged and a resolution to work towards its being a reality was passed. This resolution was shared with other like-minded actors in West Africa during the Nigerian Organic Summit 2008 and it was approved at the 1st African Organic Conference in Kampala in 2009 and at the UNEP/IFOAM conference `Alternative for Africa` in Nairobi in 2011.The African Organic Network (AfroNet[14]) was thus formed as an umbrella organization uniting and representing African ecological/organic stakeholders. The AfroNet is complemented by the Network for Organic Agriculture Research in Africa (NOARA) established during the Organic World Congress in June 2008 in Modena, Italy. For the Mediterranean countries, the Mediterranean Organic Agriculture Network (MOAN), coordinated by the Mediterranean Agronomic Institute in Bari, is very important. It has a distinctive focus on research cooperation.

Box 3: Network for organic agriculture research in Africa (NOARA)

Objectives of NOARA

- Develop research portfolios, policies and system strategies in agriculture.
- Support research program design and management to enhance development of necessary and appropriate technologies, practices and institutions for efficiency along the agricultural value chain.
- Manage scientific information.
- Promote public awareness of the importance of science, technology and indigenous knowledge.
- Foster a scientific community within Africa with national, regional and international research partners.
- Cooperate with credible research agencies for research initiatives.

[14] http://africanorganicnetwork.org/ct-menu-item-3

Table 2: Transcontinental research projects related to organic agricultural research

Project	Funded by	Running from – to	Countries involved	Coordinator
Productivity and Profitability of Organic and Conventional Farming Systems (ProEcoOrganicAfrica): A Comparative Analysis in Sub-Saharan Africa[15]	Dutch Humanist Institute for Cooperation (Hivos), Swiss Development Cooperation (SDC)	2013-2016	Ghana Kenya Switzerland	Research Institute of Organic Agriculture (FiBL) and International Federation of Organic Agriculture Movements (IFOAM)
Amélioration des revenus et de la sécurité alimentaire des producteurs à travers des Systèmes de Production Biologique diversifiés (SYPROBIO)[16]	EuropeAid	2010-2015	Benin Burkina Faso Mali Switzerland	Research Institute of Organic Agriculture (FiBL)
Sustainability of organic farming in a global food chain perspective	Danish Government	2007-2010	Global	International Center for Research in Organic Food Systems (ICROFS)
Development of Organic Agriculture, Certification and Trade in Africa[17]	United States Department of Agriculture (USDA)	2010	Ghana USA	Washington State University
Farming Systems Comparison in the Tropics[18]	Swiss Agency for Development and Cooperation, Liechtenstein Development Service, Coop Sustainability Fund, Biovision Foundation	Since 2007	Kenya India Bolivia	FiBL
Productivity and Growth in Organic Value-chains (ProGrOV)[19]	Danish Ministry of Foreign Affairs	2011-2016	Uganda, Kenya, Tanzania, Denmark	ICROFS

5.2.3 Future challenges for organic farming research in Africa

Organic agriculture faces particularly daunting challenges and constraints on the continent of Africa. The organic sector developed strongly during the last decades despite these challenges. With increased awareness of the benefits of organic foods and farming, greater local and regional market demand is expected. The affiliated environmental services that will generate opportunities and potential gains in socio-economic and environmental wealth are a matter of debate. The positive role that organic agriculture can play in development and its potential to help the agricultural sector mitigate and adapt to climate change may play a pivotal role in African national, regional and international context.

African organic agricultural research and development currently has limited funding support. Organic agriculture has a productivity and profitability gap when compared to conventional systems that is not compensated by lower external input costs. In addition many African governments subsidize fertilizer and even in some cases pesticides, making organic agriculture even less competitive with conventional.

Additional costs for African organic producers, such as for certification, limit market access and development opportunities for the sector. Efforts to address these conditions in a creative and

15 www.proecoafrica.net
16 www.syprobio.net
17 http://organicafrica.wsu.edu
18 www.systems-comparison.fibl.org/en/scp-home.html
19 www.icrofs.org/Pages/Research/progrov.html

regionalized manner, such as with collective (smallholder group) certification, are being tried. Among other things, regionalized organic standards are expected to increase access to domestic organic market.

Limited access to certain inputs - such as organic seeds, appropriate scale equipment for smallholder farms, locally produced bio-control organisms and botanicals for pest and disease control - as well as to information reduces the competitiveness of African organic agriculture with other global regions. African small scale producers depend on an adequate embedded condition to transition to and practice organic farming. Transition is hampered by contamination, lengthening transition periods.

Organic farming systems have strong regional differences because of the diversity of Africa's climates and soils, as well as its economic, social and cultural conditions. In its present form, organic farming originated as a production technique practiced on mixed farms in temperate zones, with an abundant supply of animal manure and organic matter. Adapting organic practices to complex agroforestry systems in tropical and subtropical zones, particularly in arid and semi-arid regions faces great challenges. Major problems include the insufficient supply of organic matter, the low phosphorous availability for plants in highly acidic and highly alkaline soils, cycling nitrogen without livestock, the prevention and biological management of pests and diseases of a vast range of horticultural and arable crops, breeding of varieties and landraces suitable for organic conditions, and the management of tropical livestock diseases. Organic agriculture not only needs to be adapted but completely reinvented from its basic principles of health, ecology, fairness and care (IFOAM n.d.)[20].

With its great number of small holder farmer and rich knowledge of diversified agriculture, organic agriculture is particularly attractive. It enables the co-evolution of new technologies for system-oriented practice with traditional and indigenous knowledge. Organic agriculture demands innovative and knowledge intensive information exchange to generate a dynamic and fruitful cooperation among all involved. In order to create employment opportunities, improve the ecological and social sustainability in African nations and keep farm families on the land, technological and social innovations are needed. Organic farming responds to the global trends in markets, policies, and social structures to overcome societal and environmental challenges.

To address all these challenges and opportunities, the organic community in Africa has focused on regionalizing global organic knowledge. The African network NOARA identified key thematic areas for organic agricultural research strongly based on the system approach that includes productivity and sustainability in crops and livestock systems as well as biodiversity and climate change. The global community of organic agriculture researcher is pursuing an objective assessment and quantification of the benefits and impacts of organic farming. The African organic sector wants to see this in the regionalized or even local context. This will guarantee the credibility of organic farming and of the research itself.

Successful field experimentation and implementation needs to be supported by demand-oriented extension services, technology transfer and knowledge dissemination. To profit from holistic organic farming systems, NOARA emphasizes the relevance of organic marketing and consumer issues embedded in the contextual socio-economics, policies and distinct perceptions and criticisms of organic and sustainable farming.

Box 4: Brief resume of the challenges for research in Africa

The four principles of organic agriculture - health, ecology, fairness and care - are universally valid and applicable. However, the major standards were developed mainly in temperate zones with mixed farms. The challenges, Africa faces to do valid research in organic agriculture are regional adaptation and redesign of organic farming systems suitable for local agronomic conditions, policies, distribution channels and markets (IFOAM n.d.)

[20] www.ifoam.org/en/organic-landmarks/principles-organic-agriculture

5.3 Asia and Middle East

Box 5: Key figures on organic agriculture in Asia (Willer & Lernoud 2014)

- Total organic agricultural area: 3.2 million hectares (2012)
- 700'000 producers (most of these were in India)
- The leading countries by area: China (1.9 million hectares) and India (0.5 million hectares)
- Highest proportion of organic agricultural land: Timor-Leste (7 percent)
- Asian markets for organic products growing; data on the domestic market not complete.

5.3.1 Policy environment

Most Asian countries are classified as low to middle income countries by the World Bank WB. The region also includes some of the wealthiest countries in the world on a per capita basis. Asia is the largest continent in terms of population and area. Food security issues are very challenging in countries with large populations. Most governments in these countries promote policies to increase agricultural production of foods with less consideration of the quality and safety of foods. Environmental impacts are less considered. Organic agriculture needs to demonstrate sufficient productivity, high quality and safety of the foods, and quantify environmental services and public goods provided. Data published in Europe and North America need to be validated under Asian agronomic and socioeconomic conditions in order to support whether organic is a suitable farming approach for these countries. Documented evidence would help convince Asian policymakers and scientists to fund, support and become involved in organic agricultural research.

South Asia (India, Nepal, Pakistan and Bangladesh) and Southeast Asia (Cambodia, Laos and Myanmar) may have significant volumes of organic food production not accounted for in the statistics. Foods on domestic markets and consumed locally are grown in ways that have been sustainable for centuries and are organic in practice. Based on this knowledge and production practice, more sophisticated organic farming techniques could significantly further enhance soil fertility and make these traditional farming practices more productive. Local institutions need to be made aware of this potential, particularly in rural areas where population growth remains high. Beyond the supply of traditional organic food in rural Asia, the establishment of distinct high value added markets for organic food would motivate organic production. At present, organic regulations have been implemented in 23 countries in Asia (Huber & Schmid 2014), which represents a major step towards prosperous organic markets.

In Saudi Arabia, the legal and institutional framework is supervised by the Department of Organic Agriculture of the Ministry of Agriculture, which ensures conditions favor organic-sector development. The national control system for organic agriculture serves as the basis for the sector's functional development. It is rooted in the National Regulation & Standards for Organic Agriculture, modeled on the European Organic Regulation. Subsequent to the approval of the National Organic Regulation, the Saudi Organic Law was drafted to provide a legal basis to enforce organic standards. The Saudi Organic Law was developed by a technical committee of the Ministry of Agriculture and is being revised by higher authorities (Hartmann et al. 2012).

5.3.2 Research situation: Key actors/funding & programs/key research themes in Asia

In recent years, several international organizations such as Food and Agriculture Organization (FAO), International Fund for Agricultural Development (IFAD), United Nations Conference on Trade and Development (UNCTAD), and the Asian Development Bank (ADB) have promoted applied research in organic agriculture in Asian countries. IFOAM has implemented several projects in Asia with international organizations. Though there are not big multi-country projects on organic research in Asia, several projects and activities in individual countries have been noticed.

National research

China

Since the early 2000s, most research conducted in organic agriculture in China has been funded by international organizations such as the International Fund for Agricultural Development (IFAD), the German Technical Cooperation (GTZ, nowadays GIZ), the AMBER Foundation, Greenpeace, Asian Development Bank Institute[21], the International Center of Research in Organic Food Systems ICROFS (Denmark[22]), Asialink, and the Asia-Pacific Economic Cooperation among others.

With the expansion of organic agriculture in China, national and international cooperative research programs have been carried out gradually, focused on a wide range of research issues including:

- Organic development, poverty alleviation and capability building;
- Organic technology research;
- Assessment of organic agriculture;
- Rules, certification and recognition;
- Research and promotion of organic education.

Beginning in 2005, following the development of organic production and domestic organic market in China, related national authorities also funded projects for organic research including Ministry of Science and Technology (MOST), Ministry of Environment Protection (MEP), Ministry of Agriculture (MOA). Projects included organic food development and biodiversity conservation in a natural conservation area, ecological benefits evaluation of organic farming, and the technology of organic products certifications. The total grants will be up toUS$7 million. The research will cover on the whole organic food chain instead of focusing on single techniques. Local authorities, research institutes and enterprises are paying more attention to organic techniques research and development. More than half of the projects focus on high value and complex crops, such as organic tea, vegetable and fruit production. These projects show the state is willing to support further development of Chinese organic agriculture (Feng et al. 2005).

During the early 1990s, Nanjing Environmental Research Institute under China State Environmental Protection Agency (SEPA) began organic research programs 'Comparative Study on Energy, Material & Economic Flows of Organic & Conventional Production System in Pan-Pacific Area' and 'Comparative Study on the Production of Organic & Conventional Wheat, Rice & Vegetable', in cooperation with the University of California, Santa Cruz with support from Rockefeller Foundation. In 1994, the SEPA Organic Food Development Center of Nanjing became first organization engaging in organic agriculture research, certification, training and promotion.

The Agroecology Research Institute and Organic Agriculture Technology Center under China Agricultural University and the Institute of Organic Agriculture under Nanjing Agricultural University, South China Agricultural University and Tea Research Institute of Chinese Academy of Agricultural Sciences established several organic research, consulting and certification facilities. The China Certification and Accreditation Institute under CNCA also play roles of organic research for certification and accreditation and policy making.

Although the national and local government began support of organic research since 2008, it is still a small part of the whole agriculture research fund. The organic agricultural research and consulting system in China is in its early stages of development, with many steps needed to develop a mature research and consulting system.

[21] www.adbi.org

[22] www.icrofs.org

Korea

The Korean Organic Farmers Association (KOFA) has established program of education, training and research. The Korean government provides research, education, training, and other support services to the organic sector through the National Agricultural Cooperative Federation (NACF), the Rural Development Office (RDO) and universities. In the Cheonan Province, the Research Institute of Organic Agriculture of Dan Kook University developed eco-villages for three years with funds from Korean Agricultural Cooperative Agency (KACA). This Institute was established to advance joint industry-academia research for the promotion of organic agriculture with emphasis on scientific technology, promotion of organic agriculture as well as on improved harmonization and global competitiveness of Korean organic agriculture. The Journal of the Korean Society of Organic Agriculture is regarded as a high quality organic academic journal.

Thailand

In 2008, the Thai government started a five year National Organic Development and Action Plan (NODP). One of the four core development strategies was on knowledge and innovation.

Philippines

The Philippine Rice Research Institute (PhilRice), the country's leading institute, is strengthening its researches on organic rice farming to help sustain the country's rice production in the coming years[23].

India

In India, the National Project on Organic Farming (NPOF) was implemented in 2004 by the National Center of Organic Farming, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India.[24] The Indian government has supported program to develop model organic farms and villages, particularly in the mountainous North Eastern states.

As with most of the rest of the world, most agricultural teaching, training, research and extension is concentrated on conventional practices, with a small fraction of the research budget spent on organic agriculture research, training and extension. India's current five year plan (2012-2017) has increased financial support to organic agriculture projects. The Project Directorate of Farming Systems Research—an institution under Indian Council of Agricultural Research (ICAR)—operated from 2002 to 2007. With a budget of US$ 10million, the project involved nine agricultural universities and four ICAR institutes.

Specifically the Natural Resources Management Division of ICAR undertook this initiative in 2004-2005 during Tenth Five-Year Plan (2002-2007) in the form of a Network Project on Organic Farming. This project has following objectives:

- To study productivity, profitability, sustainability, produce quality and input-use efficiencies of different crops and cropping systems under organic farming in different agro-ecological regions.
- To develop efficient crop and soil management options for organic farming.
- To develop need-based cost-effective new techniques for farm-waste recycling.

To achieve the objectives of the project, the following sub-projects were taken up at each of the cooperating centers during 2004-2007, with site-specific changes in respect of crops, crop varieties, cropping systems, inputs (nutrient sources, bio-pesticides) and cultural practices.

- Evaluation of important crops and cropping systems under organic farming;
- Nutrient management in organic farming;

[23] www.philrice.gov.ph/?page=resources&page2=news&id=248
[24] http://ncof.dacnet.nic.in

- Pest and disease management in organic farming;
- Soil organic matter in rice-wheat systems under resource conservation technologies;
- Weed management in organic farming; and
- On-farm research in organic farming.

ICAR institutes and State Agricultural Universities in India are developing research projects in different areas of organic agriculture. For example, the Indian Agricultural Research Institute (IARI) has taken up a project on the development of organic farming modules for sustainable production and quality in high value crops. The project aims to meet nutrient requirements from efficient sources and to develop protocols for inputs use in organic farming.

Other countries in Eastern Asia

Other Asian countries - such as Sri Lanka, Nepal, Malaysia, Indonesia, Vietnam and Bangladesh - have organic research programs conducted by public and private organizations.

Saudi Arabia

The Saudi Organic Farming Association (SOFA) and the Department of Organic Agriculture (DOA) are the most relevant and influential actors of the organic sector in the Kingdom of Saudi Arabia (KSA). Standards are based on the organic regulation of the European Union, with some specific local conditions to address the arid environment. The Saudi organic sector is closely related to the Organic Farming Project managed by GIZ International Service (GIZ IS). The fast-growing sector is supervised by the Department of Organic Agriculture, Ministry of Agriculture, which ensures that framework conditions favor organic-sector development. In 2011, the Ministry of Agriculture delegated the development of the Organic Agricultural Policy to GIZ IS, as a key activity of its Organic Farming Project (OFP). The OFP finalized a comprehensive organic support policy concept in mid-2012, incorporating input from numerous Saudi stakeholders and drawing on international expertise in this field. The organic agricultural policy is linking market orientation with a resource oriented strategy and is focusing on the following four major objectives: 1) Increase in productivity and in the number of organic farms, 2) Production of healthy foods, 3) Conservation of natural resources, and 4) Preservation of water/sustainable water use. Policy priority measures have been suggested by the OFP that are aimed at achieving these objectives. The Organic Agriculture Research & Development Center (ORC) was designated by the Saudi Ministry of Agriculture in June 2009 to conduct organic agriculture research in the Saudi Arabia. Located in Qassim region, ORC is a research institution that trains farmers in organic production methods and delivers farm-based consultancy on special topics. As Saudi Arabia's first organic research center, its main research areas are soil science, horticultural science, plant protection, and biodiversity. The ORC is improving its capacities for playing the lead role in the coordination and implementation of research and extension services related to organic agriculture. Despite a clear public focus on developing organic farming research, at present the center may still be considered to be in its infancy. The ORC is understood to be a 'learning center' for public and private stakeholders, and has conducted a variety of activities and events to promote organic farming. One strategy is to shift ORC's research activities closer to farmers' fields to provide better hands-on solutions to technical challenges and to build a stronger link between research and extension activities. The center is dedicated to the delivery of practical solutions to meet organic producers' needs throughout the Kingdom (Hartmann 2013).

Iran

In Iran, organic agriculture began within the universities, and has been taught in specific courses and lectures for 25 years. Research programs on organic agriculture production, processing and marketing were started recently and are carried out in graduate programs by several institutions, including the Environmental Sciences Research Institute of Shahid Beheshti University in Tehran, Ferdowsi University of Mashhad and Islamic Azad University, Karaj Branch. A postgraduate course on agro-ecology commenced in 2007, which is offered at the University of Ferdowsi (Mashad), ShahidBeheshti (Tehran), Birjand, Shahrekord, Gorgan, Shahrood and Islamic Azad University. The Iranian Scientific Society of Agroecology (ISSA) conducted regular meetings on sustainable agriculture since 2008.

Key institutions

Box 6: Selected examples of organic research stakeholders in Asia

Central Asia

Kazakhstan:

- Organic Center Kazakhstan[25]

Eastern Asia

China:

- Nanjing Global Organic Food Research and Consulting Center OFRC
- Organic Food Development Center (OFDC) of the Nanjing Environmental Research Institute under the State Environmental Protection Administration (SEPA),
- The Agroecology Research Institute, the Organic Agriculture Technology Center Agricultural University
- Institute of Organic Agriculture and Organic Food, Nanjing Agricultural University
- Tea Research Institute, Chinese Academy of Agricultural Sciences
- China Certification and Accreditation Institute under CNCA.

South Korea:

- Korea Organic Farmers Association (KOFA);
- National Agricultural Cooperative Federation (NACF);
- Rural Development Office (RDO)
- Research Institute of Organic Agriculture of Dan Kook University
- Korean Agricultural Cooperative Agency (KACA)
- Korea Society of Organic Agriculture Association KSOA

Japan:

- Japan Organic Agriculture Association (JOAA)

Southern Asia

India:

- Project Directorate for Farming Systems Research, Modipuram (UP)
- Indian Agricultural Research Institute, New Delhi
- Institute of Organic Farming, University of Agricultural Sciences, Dharwad, Karnataka
- Department of Organic Agriculture, CSK, HPKV, Palampur (Himachal Pradesh)
- Central Arid Zone Research Institute26, Jodhpur (Rajasthan)
- Kerala Agricultural University
- Indian Veterinary Research Institute, Izatnagar

South-Eastern Asia

Philippines:

- Philippine Rice Research Institute[27] (PhilRice)

Thailand:

- Organic Agriculture Development Center (OADC), SukhothaiOpen University (STOU),

Vietnam:

- CASRAD Center for Agrarian Systems Research and Development

Western Asia& Middle East

Azerbaijan:

- Azerbaijan State Agricultural University (ADAU)
- Scientific Research Institute of Vegetable growing (ETTI)

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[25] www.organiccenter.kz

[26] www.cazri.res.in/org_farm.php

[27] www.philrice.gov.ph/?page=resources&page2=news&id=248

- Scientific Research Institute of Plant Protection (AzETBMI)
- Scientific Research Institute of Mechanization of Agriculture (KTMI)
- Lenkoran State University (LDU)

Iran:

- Environmental Sciences Research Institute of ShahidBeheshti University in Tehran;
- Ferdowsi University of Mashhad;
- Islamic Azad University, Karaj Branch;

Iranian scientific society of agroecology (ISSA).

Saudi Arabia:

- Organic Agriculture Research & Development Center

Important Asian Conferences

For the first time in Asia, the IFOAM Organic World Congress was held in Korea in 201, and it created immense interest to the organic movement in this region.

IFOAM and FAO hosted the Asia-Pacific Regional Symposium 'Entrepreneurship and Innovation in Organic Farming'- Bangkok, from December 2- 4. 2013.

The Royal Government of Bhutan, in collaboration with IFOAM, Navdanya and the Millennium Institute organized an 'International Conference on Organic and Ecological Agriculture in Mountain Ecosystems' in Thimphu, Bhutan from March 5-8, 2014.

The Asian Network for Sustainable Organic Farming Technology (ANSOFT) held a workshop on August 20-23, 2013 in Dhaka, Bangladesh, which representatives of all eleven countries attended.

International organic conferences were organized by or in partnership with the BioFach organic trade fair (Nürnberg, Germany) and other organic expo events in China, Korea and India in recent years. The Asian Rice Conferences are also regularly held in Korea and China.

Networks

The Asian Network for Sustainable Organic Farming Technology (ANSOFT) consists of eleven member countries: Bangladesh, Cambodia, Indonesia, Korea, Laos, Mongolia, Nepal, Philippines, Sri Lanka, Thailand and Vietnam.

The Asian Research Network of Organic Agriculture (ARNOA) is a network of individual researchers.

The Network for Knowledge Transfer on Sustainable Agricultural Technologies and Improved Market Linkages in South and Southeast Asia (SATNET) is working with institutions that share knowledge on sustainable agricultural technologies and improved market linkages in the region. SATNET facilitates knowledge transfer through the development of a portfolio of best practices on sustainable agriculture, trade facilitation and innovative knowledge sharing. The three-year project funded by the European Union and implemented by the Center for Alleviation of Poverty through Sustainable Agriculture (CAPSA) aims to support innovation by strengthening South–South dialogue and intraregional learning on sustainable agriculture technologies and trade facilitation.

'Towards Organic Asia' was inspired by Bhutan's 100 percent Organic Country policy and global movement of Gross National Happiness. The School for Wellbeing Studies and Research started the Towards Organic Asia (TOA) Program in 2011 in collaboration with Terre Solidaire (CCFD), Thailand Green Market Network and SuanNguenMee Ma social enterprise. Towards Organic Asia is a partner-driven network, managed by the coordinating team based at School for Wellbeing Secretariat Office in Bangkok, Thailand. Their goal is to strengthen and advance the agroecology movements in Asia

After the successful conclusion of the 17th IFOAM Organic World Congress in 2011- the first-ever to be held in Asia – many Asian organic stakeholders wanted to build an organic alliance in the region. 'IFOAM Asia' was officially approved by the IFOAM World Board on November 24th, 2012 and now has more than 100 members.

The Saudi Organic Farming Association (SOFA) and the Department of Organic Agriculture (DOA), Ministry of Agriculture are the most relevant and influential actors in Saudi Arabia. SOFA's main services, in addition to the overall promotion of organic agriculture, are focused on the support of its members through the provision of relevant information about all different aspects of organic agriculture – such as requirements and procedures for certification, marketing opportunities and contacts, innovative farming methods, and legal guidelines. The DOA represents the Ministry of Agriculture in all matters relating to organic agriculture and acts as a driving force for the establishment of all relevant public services and legal guidelines in favor of the organic sector. Its core task is the monitoring and surveillance of all organic sector activities. The DOA also defines, develops, and fine-tunes the necessary legal guidelines to ensure optimal sector development.

In 2012, an 'IFOAM MENA[28]' interim board has been elected in Dubai to promote organic sector development throughout the region. Activities have been temporarily suspended in 2014 and may be taken up again from 2015 with a focus on Middle East countries rather than the entire MENA region.

5.3.3 Challenges for organic farming research/specific comments

The challenges for organic farming research are very diverse and generalizations are difficult to make. Many of the problems faced by farmers are very site-specific. The social, political and economic context is also important, making it difficult to formulate regional policies that will work everywhere.

Public research institutes in most of Asia have limited research programs on long-term organic research, particularly in mid and low income countries. Advocacy and demonstration pilot projects need to persuade policymakers to make organic agriculture research a higher priority. Policy dialogues, awareness building programs, social media and stakeholder involvement all can play roles in such a campaign.

Smallholder farmers are the fundamental pillar of the society in Asia and innovative technology has to increase their production and market development

In most of Asia, research programs on organic agriculture remain scarce. Authorities underestimate research on organic production technologies and institutions that conduct such research have insufficient resources. Organic agriculture as an industry requires pre-, mid- and post-production services. Cultivation, husbandry, preserving, packing, transportation and marketing all have challenges that demand solutions. Although researchers have accomplished some preliminary results, their research has not fully addressed the needs of the rapidly developing organic sector.

The Asian organic industry is in its infancy, but is growing rapidly due to market influences. To sustain adequate levels of production, organic agriculture needs to be science-based and market-oriented. Production costs for organic producers are higher than for conventional production, and the premium paid for organic does not always make up the difference. In many places, extension services are not provided by the government and farmers cannot afford to hire private consultants.

Current research priorities are organic production practices, appropriate technologies, marketing, and policy analysis. Chinese organic production was spurred by global trade; organic enterprises are export driven. Combining traditional agriculture and new techniques is not well developed, understood or implemented; the farmers who cannot find practical techniques face

[28] MENA: Middle East and North Africa

crop failures. Research in technologies to reduce production risk integrates modern techniques with the traditional organic farming systems, integrating of each factor within the whole agri-ecological economy domain. Then building up systematic agricultural production, focusing on the self-replenishment of soil fertility can occur. These techniques can be extended to organic farmers in practice.

Policy research is also needed to identify conflicts between different policies; propose appropriate policies to support the development of organic agriculture, such as subsidies, technology extension, and marketing. The organic market is the driving force for the development of organic industry. Research is needed to study market linkage with organic farmers with competitive, trust-worthy and fair supply chains locally and internationally, from production and processing to market.

The most important challenge of transition to organic agriculture is the management of plant nutrition and protection against pests, diseases and weeds during first years of conversion to prevent any yield reduction.

Rice is the most important crop in Asia; most rice research in the world is conducted in Asian countries. The International Rice Research Institute (IRRI) located in Manila, Philippines, would be an important collaborator for organic rice research. Central and Western Asia, as well as Northern China and Siberia are more wheat-based systems. In all regions, there is a diversity of cropping systems. Animal agriculture faces different needs throughout the continent. Much of the continent is extremely arid, particularly the Arabian Peninsula and Central Asia. Organic farming research is needed to develop appropriate technologies on-farm to further improve farming systems under such dry conditions.

More affluent countries like Saudi Arabia are faced with a growing consumer interest for healthy and environmentally friendly products. Organic operators are called upon to increase organic production to meet growing demand. Aside from research, investments in an organic agriculture extension system, technology transfer and knowledge dissemination will be crucial to meet future organic productivity goals.

5.4 Europe

Box 7: Key facts and figures on organic farming in Europe (Willer & Lernoud 2014)

- 11.2 million hectares of agricultural land managed organically
- More than 320’000 farms.
- 2.3 percent of the agricultural area is organic (European Union: 5.6 percent).
- Thirty percent of the world's organic land is in Europe.
- Countries with the largest organic agricultural area: Spain (1.6 million hectares), Italy (1.2 million hectares), and Germany (1 million hectares).
- Seven countries have more than ten percent organic agricultural land: Liechtenstein (29.6 percent), Austria (19.7), Sweden (15.6), Estonia (15.3), and Switzerland (12.9).
- Sales of organic products: 22.8 billion Euros (European Union: 20.9 billion Euros), strong annual growth.
- Largest markets for organic products: Germany (retails sales of 7 billion Euros), France (4 billion) and the UK (1.95 billion).
- Consumption of organic food: more than five percent in several markets.

5.4.1 Policy environment

In recent years, European Union policymakers have come to recognize the dual role of organic farming.

On the one hand, organic agriculture strives to meet the consumers’ demand for high quality products; on the other, it fulfils an important role in securing certain public goods including protection and improvement of water and soil quality as a result of organic land management practices (European Commission 2004). This understanding began to emerge in the early 1990s, when organic farming was legally defined under EU Regulation (EEC) No2092/91, and when organic farming support payments for conversion and maintenance were introduced under the Common Agricultural Policy (CAP).

Over time, recognition of organic farming has also extended into other EU policy areas such as research and innovation.

Currently the European organic farming sector benefits under the Common Agricultural Policy (CAP), both for direct payments (Pillar 1) and rural development (Pillar 2). Of particular interest in terms of mainstreaming organic farming in rural development is the acknowledgment by EU leaders of the need for agroecological innovation to redirect European agriculture onto a more sustainable path. Innovation is a priority of the next programming period, and will be promoted through the newly established European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI). This is an EU policy instrument supported jointly under the European Union's research framework program Horizon 2020 and rural development policy until 2020.

The main objective of the EIP-AGRI is to bridge the gap between research and farming practice by encouraging stakeholders from different areas of the agri-food system – farmers, businesses, researchers and advisers – to share ideas and experiences, develop innovative solutions to current problems and challenges, and to put the results of research projects into practice.

In addition to support under the CAP, EU legislation on organic food and farming has continued to develop since EU Council Regulation (EEC) No 2092/91 was established. This development process also included a full revision of the regulation, culminating in the adoption of European Organic Regulations (EC) No 834/2007.

Since its adoption, rules on its implementation have been agreed, detailing the organic production, as have specific rules on organic wine, organic yeast and organic aquaculture. EU organic regulations seek to develop a harmonized approach to consumer protection, preventing unfair competition and ensuring common standards for organic production, labeling and marketing in the EU.

On 24 March 2014 the European Commission published a new legislative proposal for organic regulation complemented by annexes, the impact assessment report and a new European Organic Action Plan (European Commission 2014).

5.4.2 Research situation: Key actors/funding & programs/key research themes

Today, organic farming research is substantially funded under national research programs or national organic action plans, as well as through European projects.[29] Even though no figures for all European countries are available, it is known that the funds of the eleven countries that are part of the ERA-Net[30] project CORE Organic amounted to more than 60 million Euros in 2006 (Lange et al. 2006). Newer data are not available. Taking into account that organic research is often difficult to differentiate from agroecological, environmental and animal welfare research; other specialists estimate the research spending in Europe up to 140 million Euros. This figure might be more relevant as a relevant amount of research is also done by in-kind projects of state research centers, which is part of their overall funding.

National research activities

Applied research output with a high relevance for organic farm practice has been produced by national research schemes. Between the different European Union and other European countries, the size of research funding varies greatly. Among the bigger players of organic farming research rank Germany, Denmark, Switzerland, Austria, Sweden, Italy, France, Norway,

[29] EC funded organic research projects: www.organic-research.org/european-projects.html

[30] The objective of the ERA-NET scheme is to step up the cooperation and coordination of research activities carried out at the national or regional levels in the Member States and Associated States.

the Netherlands, Finland, UK and Poland. New EU member states on the other hand have often scarce funding for organic research although their farmers export organic food and feed products to the older member states. Since the Concerted Action 'Channel'[31] was terminated in 2004, sharing research results activities 'East-West' is a major shortcoming in Europe.

National key actors

The most important universities involved in organic farming research in Europe are the University of Kassel in Germany with an entire Faculty of Organic Agricultural Sciences (by far the biggest), the University of Newcastle (UK), the University and Research Center Wageningen (the Netherlands), the University of Aarhus, the Swedish University of Agricultural Sciences (Sweden), University of Hohenheim (Germany), the Technical University of Munich (Germany),the Politechnic University of the Marche in Ancona (Italy), the University of Bonn (Germany), the University of Abersythwyth (UK), the University of Barcelona (Spain), the University of Tartu (Estonia), the Corvinus University Budapest (Hungary), ISARA Lyon (France), the University of Vienna (Austria), the University of Applied Sciences Eberswalde (Germany), the University of Applied Sciences Zurich/Wädenswil (Switzerland).

The most important state research centers involved in organic farming are the Thünen Institute (Germany), the Agroscope research station (Switzerland), ICROFS as coordination unit of organic farming research at Arhus University (Denmark), EPOK as coordination unit of organic farming research at the Swedish University of Agricultural Sciences (Sweden), INRA (France), the LFZ Raumberg-Gumpenstein (Austria), the Bayrische Landesanstalt für Landwirtschaft Consiglio per la Ricerca e la sperimentazione in Agricoltura (Italy), the BioforskØkologi (Norway) and the Finnish Organic Research Institute (Finland).

The most important private research institutes involved in organic farming are the Research Institute of Organic Agriculture (FiBL) in Switzerland, Germany and Austria, the Organic Research Center Elm Farm (UK), the Louis Bolk Institute (Netherlands), the Research Institute of Organic Agriculture ÖMKI (Hungary), the Bioforschung Austria in Vienna, the Research Institute for Organic Agriculture IBLA (Luxemburg) and the Institute for Sustainable Development ISD (Slovenia).

European research framework program

Organic agriculture has been increasingly targeted with research, as its complexity is interesting for the understanding of interactions, interventions and responses in agroecology. The interest has also been the result of a growing economic relevance of the sector. Alone in the 7th and the 6th EU Framework Programmes, five consortia worked on crop rotations (including weed control), six on soil fertility building (legumes, cover crops, mulching, organic fertilizers, soil tillage) and twelve on crop protection issues. Another six consortia worked on crop breeding with relevant aspects for organic farms (Lutzeyer & Kova 2012; complemented by Niggli 2014)[32]. Many aspects limiting productivity of organic farms have also been addressed in the Integrated Project QualityLowInputFood[33]and in the transnational research cooperation CORE Organic and CORE Organic II (ERANet scheme).

Many organic farming research projects have been funded under the framework programs of the European Union (EU) since the mid-1990s. Furthermore, there are several EU projects that do not have organic farming as their focus but carry out research related to organic farming. In the Seventh Framework Programmes for Research and Technological Development, launched in 2008, ten projects focused on organic farming.

CORE Organic - 'Coordination of European Transnational Research in Organic Food and Farming Systems' intends to increase cooperation between national research activities. CORE Organic

[31] http://cordis.europa.eu/search/index.cfm?fuseaction=acro.document&AC_LANG=EN&AC_RCN=6860608&q=C6E2A65DD7A60D627666975C2DEAF38C&type=sim

[32] www.organic-research.net/european-projects.html?&L=eeknldejqsnizq

[33] www.qlif.org

Plus, the third CORE Organic project that started in 2014, has 24 partners from 21 countries/regions. The overall objective of CORE Organic is to enhance quality, relevance and utilization of resources in European research in organic food and farming and to establish a joint pool for financing transnational research in organic food and farming.

The European Technology Platform for Organic Food and Farming Research (TP Organics), which was founded in 2008, joins the efforts of industry and civil society in defining organic research priorities and defending them vis-à-vis policy-makers. The TP Organic vision paper, published in December 2008, reveals the huge potential of organic food production to mitigate major global problems, from climate change and food security, to the whole range of socio-economic challenges in the rural areas (Niggli et al. 2008). In February 2010, the Strategic Research Agenda, the second major document of the Technology Platform TP Organics[34] was finalized, underlining research priorities and a number of suggestions for research projects (Schmid et al. 2009). The Implementation Action Plan explains how the research priorities and research topics, identified in the Strategic Research Agenda, can be implemented. A focus is laid on funding instruments, research methods, and communication of results (Padel et al. 2010). Many of the topics covered in these documents were taken into consideration in recent European calls.

In July 2013, TP Organics was granted official 'technology platform' status by the European Commission; this status is reserved for outstanding European technology platforms (TPs).[35] TPs are explicitly mentioned as stakeholders to be consulted on EU research priorities in the context of the European Innovation Partnerships and play a considerable role in setting priorities for Horizon 2020, the current EU framework program for research running from 2014 to 2020.

In its second action plan for organic food and farming, the European Commission is addressing organic farming research (European Commission 2014). Two actions are suggested:

Action 6: The Commission will organize a conference in 2015 to identify research and innovation priorities for producers in relation to the challenges that may result from the future organic production rules.

Action 7: The Commission will take into account in the relevant Horizon 2020 formats: a) the need to strengthen research, exchange and uptake of research results through specific measures such as research and innovation actions, thematic networks and other types of "Cooperation and Support Actions" that address synergies between, on one hand, research outputs of other production sectors and, on the other hand, conventional and organic research; and b) to support ERA-Net or other types of instruments to improve coordination of research among research funding bodies in the EU, in view of presenting joint research calls

5.4.3 Challenges for organic farming research/specific comments

The European stakeholders of organic food and farming focus their future research priorities on a further increase of the productivity with means of ecosystem functions ('eco-functional intensification') like soil fertility, nitrogen fixating leguminous (inter)crops, functional biodiversity, botanicals and bio-control agents or genetic robustness of crops and livestock. In addition to make better use of the nature capital for farm productivity, this research priority also look at the integration of precision farming, robot technology, ICT and sensor technologies in farm management. Research projects target bottlenecks of organic farming in temperate zones and in all crops grown, annual and perennial ones.

A second set of priorities look at the role organic agriculture can play in order to keep rural areas economically, ecologically and socially attractive ('empowerment of rural areas'). Many of the research projects needed for these second priorities target the power of social innovation for improved farming systems and food chains. Some key words are farmer-to-farmer learning,

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[34] www.tporganics.eu

[35] www.ifoam-eu.org/en/news/2013/07/17/organic-research-and-innovation-platform-tp-organics-officially-recognized-europea

farmer-to-consumer partnerships or joint innovation of farmers, farm advisors and scientists. Ethical and political questions of agriculture such as profit sharing along the food chain, fair trade models, the true cost accounting approach in agriculture to better internalize external costs and animal welfare are also part of this second research priority.

A third set of the future European research priorities revolves around the quality of food ('healthy food for well-being'). These classical themes for organic research deal with the farm gate quality of foods depending on the organic management practices, the food processing technologies and package materials used in organic farming ('gentle food processing technologies'), the interactions between food quality, food eating patterns and human well-being as well as the changing perceptions of food qualities in the society.

All these priorities have been identified nationally by intensive stakeholder dialogues in many countries, especially in Austria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Norway, UK, Sweden, Switzerland, The Netherlands and others. The 25 partners of the transnational research cooperation CORE Organic Plus have also regularly organized mapping of research priorities in the different regions of Europe. The Mediterranean Agronomic Institute of Bari, which coordinates the Mediterranean Organic Agriculture Network synthesizes regularly the research needs of the organic producers and food companies in South Europe, Turkey, the Near East and North Africa (Bteich et al. 2010). A new network for the Balkan countries called Balkan Organic Network BON delivers research challenges from this region of Europe.

5.5 Latin America

5.5.1 Current status

In Latin America, slightly more than 300'000 producers managed 6.8 million hectares of agricultural land organically in 2012. This constitutes 18 percent of the world's organic land and 1.1 percent of the region's agricultural land. The leading countries are Argentina (3.6 million hectares), Uruguay (0.9 million hectares, 2006) and Brazil (0.7 million hectares). The highest shares of organic agricultural land are in the Falkland Islands/Malvinas (35.3 percent), French Guiana (10.6 percent), and the Dominican Republic (8.9 percent). Notable growth is occurring in Mexico and Peru. Domestic organic markets are being developed in every country, and the most popular farmers' fairs are being consolidated in many places. Participatory Guarantee Systems are legally accepted in several countries and commonly used in local markets. However the export market is still the main driving force for organic growth. It has been ten years since Costa Rica attained 'third-country' status with the European Union (2002); the first country that was granted this status was Argentina, in 1992. A new scenario, with equivalence agreements among the US, Canada, and EU, is bringing new possibilities for the facilitation of organic product trade in the region.

5.5.2 Research situation: Policy environment, key actors/funding&programs/ research themes

Investment in agricultural research (conventional and organic) in the region varies widely. On the one hand we have the three largest countries (Argentina, Brazil and Mexico) investing around 2 billion US $ per year (70 percent of the total Latin American investment on agricultural research). At the same time, countries in Central America, such as El Salvador or Guatemala, have an investment of 5 million US $ that decreases year after year (4 to 5 percent decrease over the last decade based on Agricultural Science and Technology Indicators (ASTI) and International Food Policy Research Institute (IFPRI) data). In most countries, funding for research comes from the government, with the exception of some countries where international donors' funds are still the main source of founding (Nicaragua and Honduras for example). Nevertheless, a mix of the two sources is the general situation in the region. Most of the research is oriented to crops (fruit, coffee, bananas, etc.), and only few cases (Uruguay, Argentina), there are more funds for research in livestock. In most countries, state agriculture research funds finance the National Institutes for Agricultural Research (INTA in Spanish). Few INTA's such as Argentina and Chile (Chillan), have developed Agro ecological Research Programs. In Argentina INTA has done research in organic in the organic food systems and value chain, in their multiple research stations.

Research in organic farming with government funds is a relatively recent activity in the region, and it represents a small proportion of the total research investment in agriculture. Research in organic production is usually not a direct policy area, but rather the effort of individual researchers committed to this field. However, it is common to find a ('sustainable agriculture') research theme with topics such as biological control, composting, agroforestry, etc. What is frequently absent is the integration of those topics to define an organic production system.

In academia, there are several universities working on organic farming or agroecology, more at the graduate level than undergraduate. However, there is an undergraduate program B.Sc. in Agroecology in the National University in León Nicaragua and the University of Chapingo (Table 3). In the most Andean, Brazilian and Mexican universities, topics a such as agro-biodiversity are an important research topic, although not called organic research

Key actors in organic research in the region were also NGOs such as the Centro Latino Americano de Desarrollo Sustentable (CLADES) in Chile, Construyendo la empresa social agroecological (CEDECO) in Costa Rica, Brazilian Association of Agroecology (ABA) in Brazil. In addition, more recently private companies are doing important research for the development of biological or natural inputs for organic farming.

However, the farmers themselves were the pioneers and did most of the research in organic agriculture for the last 30 years. Since there were few alternatives for them in the market and there was little institutional research happening, they became researchers. Many of the technical resources used in the region for organic farming, such as Mountain Microorganism or Bocashi, were adapted through local farmers' research. This situation has caused that many University researchers seek the collaboration with organic farmers, since most of the knowledge is in their experience.

Table 3: Examples of research and training programs in agroecology and organic farming in Latin American Universities

Country	University	Department or Section dedicated to organic farming
Argentina	La Plata University	Agroecology Program
Brazil	EMBRAPA	EMBRAPA Agrobiología
Colombia	Antioquia University National University (Medellin) and SOCLA	PhD Program in Agroecology[36] Support of the University of California, Berkeley
Costa Rica	Costa Rica University (UCR)	Program in Organic Agriculture: researchers working together to promote organic research
Costa Rica	National University (UNA)	Master in ecological agriculture
Mexico	El Colegio de la Frontera Sur[37] (ECOSUR)	
México	Chapingo University- CIAO	Centro de Investigación en AgriculturaOrgánica-
Nicaragua	National University León	BS in Agroecology
Nicaragua	National University of Nicaragua, SOCLA	PhD Program in Agroecology[38] Support of the University of California, Berkeley
Peru	Agrarian University La Molina	El Huerto: line of research in organic agriculture[39]

36 http://agrarias.udea.edu.co; www.medellin.unal.edu.co/cienciasagrarias/index.php/programas/posgrado/doctorado/agroecologia

37 www.ecosur.mx/

38 www.una.edu.ni/

39 www.lamolina.edu.pe/hortalizas/agriculturaorg.html

Networks

There is a diversity of networks in the region to promote collaboration among organic production and agroecology researchers. The main regional network is the Latin America Society for Agroecology (SOCLA) led by Clara Nichols (University of California, Berkeley and Universidad de Antioquia, Colombia), Miguel Altieri (University of California, Berkeley), and Fernando Funes (Cuba). SOCLA is a member organization created to promote research and communication in agroecology throughout Latin America. The SOCLA network works at different levels. SOCLA is represented by country chapters (e.g. in Peru, Chile) or through alliances with national universities such as Universidad de Antioquia in Colombia or the National University in Nicaragua. In addition, there are close links with the Spanish Society for Ecological Agriculture (SEAE) with whom SOCLA developed the Iberoamerican Agroecology Network for the development of climate change resilient agricultural systems (REDAGRES[40]), financed by the Ibero-American Program for Science, Technology and Development (CYTED).

A second network is the Encuentro Latinoamericano de Agricultura Orgánica (ELAO), which organizes conferences to promote farmers research in organic production. In general, ELAO's speakers are 70 percent farmers sharing their research results, and 30 percent are academic researchers and technicians. The first ELAO took place in Costa Rica in 2003, where the concept was developed and presented as a strategy for Mesoamerica (Central America, Mexico and Colombia) and the Caribbean. After five conferences in the region (Costa Rica, Cuba, Mexico, Nicaragua, and El Salvador), it was decided to make it a Latin-American platform. Since then, there are conferences in Peru, Bolivia and Colombia. Encuentro Latinoamericano de Agricultura Orgánica (ELAO) conferences had always the support of FiBL, Switzerland.

There are also very active national networks like Mexican Society in Sustainable Agriculture (SOMAS[41]), with 175 researchers. They have organized 12 national conferences, and keep a record of publications. Also networks of NGOs are actively engaged in research in organic farming, such as Brazilian Association of Agroecology (ABA[42]).

Publications

There are several journals and magazines in Agroecology in the region. The University of Murcia, Spain, in collaboration with the Latin America Society for Agroecology (SOCLA), Spanish Society for Ecological Agriculture (SEAE) and Brazilian Association of Agroecology (ABA) publish the Agroecology Journal on line[43]. The Agriculture Network publishes the LEISA magazine in Peru. The Tropical Agriculture Research and Higher Education (CATIE[44]) established a journal on integrated pest management, but then transformed the journal adding the agroecological component; Manejo Integrado de Plagas y agroecologia (MIPA).

Communication of research results to producers has been a major role for NGOs and universities. The NGO Information Service for Mesoamerica for Sustainable Agriculture (SIMAS) has played a major role since 1992 in Nicaragua[45], as have the Centro de Educación y Tecnología (CET[46]) and Centro Latino Americano de Desarrollo Sustentable (CLADES) in Chile.

5.5.3 Challenges for organic farming research/specific comments

Some of the challenges are:

- To strengthen the collaboration between academic researchers and producers, in a two-way communication strategy.

[40] www.redagres.org

[41] www.somas.org.mx/

[42] ht tp://aba-agroecologia.org.br/

[43] http://revistas.um.es/agroecologia

[44] www.catie.ac.cr

[45] www.simas.org.ni/

[46] www.corporacioncet.cl/

- To develop a more interdisciplinary research strategy, to design organic integrated farming systems within a market fair value chain.
- To promote more nutrient efficient agroforestry systems with the use of soil amendments (i.e. biochar), crop rotations, intercropping, etc.
- Weed management with a better understanding of the ecology and potential use of weeds.
- To promote the development of appropriate equipment for small farmers and farms, in hilly areas.
- To promote research in some topics such as livestock production, seed production, fruit production, waste management, postharvest and processing, nutrition and marketing.
- To define appropriate social, ecological and economic indicators for integrated agroecological food systems.
- To promote alternative fair market strategies, including more inclusive alternative guarantee systems and short channels of production and consumption.
- To articulate more research process with small-scale farmers, to improve not only production but also consumption of organic products in the family farming systems.
- To consolidate networks among research institutes to cover different bioclimatic regions for the construction of better adapted resilient agroecological systems

5.6 North America

Box 8: Key figures on organic agriculture in North America (Willer & Lernoud 2014)

- Total organic agricultural land area: >3 million hectares (2012).
- Of these, 2.2 million in the United States (2011 data), 0.83 million in Canada.
- Represents 0.7 percent of the total agricultural area in the region and 8 percent of the world's organic agricultural land.
- US market: Organic food sales rose 10.2 percent to reach 29.023 billion US dollars (4.3 percent of total food sales).
- Canadian market: 3 billion Canadian dollars; exports worth approximately 458 million Canadian dollars.

5.6.1 Policy environment

Organic agriculture research in North America has a long and uneven history. Scientific examination of organic farming methods began over 100 years ago, with the scholarly work of Frank King, who examined the permanent agricultural systems of China, Korea and Japan (King, 1911). North American awareness of Asian, Latin American and European developments in organic agriculture research were soon picked up and integrated into existing research programs in the US and Canada. North American farmer innovations in organic farming and post-harvest technologies predate the existence of a separate market for organic food, despite the negative image historically held of organic practices by agricultural experts (Lockeretz & Anderson1993).

In 1980, United States Department of Agriculture (USDA) published its Report and Recommendations on Organic Farming, which for the first time officially viewed organic agriculture as a legitimate alternative to conventional farming in the US. The report made numerous recommendations about how research and education in organic agriculture could address numerous issues in the American food system, mainly related to water pollution, biodiversity and exposure to pesticides. However, this official approval was short-lived with the appointment of Secretary of Agriculture John Block in 1981. Block called organic farming a 'dead-end' and methodically marginalized organic agriculture within the USDA with an explicit agenda to negate any support for organic farmers (Youngberg & DeMuth 2013).

Organic agriculture withstood the USDA's assault, and by the end of the 1980s had recovered and was growing again. With a lack of support from public institutions, a research infrastructure developed in the private sector, led by the Rodale Institute, with programs from New England to California. While not all programs were strictly organic by later standards, these institutions conducted research and working demonstrations of ecological farming systems. The New Alchemy Institute in Massachusetts, Meadowcreek Project in Arkansas, Michael Fields Institute in Wisconsin, Land Institute in Kansas, Farallones Institute in California, and the Aprovecho Institute in Oregon. The Organic Farming Research Foundation (OFRF) was started in 1990 to conduct original organic farming, starting with a series of on-farm projects. By the end of the 1980s, various state governments also supported ecological, renewable, sustainable and organic farming systems research, including the University of California and its campuses at Santa Cruz, Berkeley, and Davis; the University of Maine; and Iowa State University.

With the passage of the Organic Foods Production Act (OFPA) as part of the 1990 Farm Bill, the Federal embargo on organic agriculture research effectively ended, but official support was still years away. The 1990 Farm Bill also authorized the Sustainable Agriculture Research and Education (SARE) program. While SARE funded a number of projects relevant to organic farmers, the mandate was not limited to organic farming systems and it was not practical to conduct large-scale or long-term projects within the constraints of SARE. With support from the USDA's Initiative for Future Agriculture and Food Systems, a coalition of Iowa State University, North Carolina State University, The Ohio State University, Tufts University and the Organic Farming Research Foundation (ORF) formed the Scientific Congress for Organic Agriculture Research or SCOAR. Towards that end, SCOAR held two assemblies and three workshops in 2001 and 2002 to listen to organic farmers' research priorities. OFRF conducted a series of surveys of organic farmers to determine their research needs. Results of the most recent survey was published in 2004 (Walz 2004). Conclusions and recommendations based on SCOAR and the organic farmers' survey were published in the National Organic Research Agenda (NORA) in 2007 (Sooby et al. 2007). That was followed by organized efforts to promote a research agenda to serve the organic farming sector and led to the creation and authorization of the Organic Research and Education Initiative (OREI) in the 2008 Farm Bill [PL 110-234].

Organic agriculture in Canada developed in parallel to the US and Europe, drawing from both the US and UK experiences (Hill & MacRae 1992). The Organic Agriculture Center of Canada (OACC) was created in 2001 to serve Canada's organic sector through science and education. OACC conducted a survey of Canadian organic farmers to determine their research priorities (Organic Agriculture Center of Canada 2008). Results were compiled by region and sector, and priorities of producers varied significantly depending on their farming systems' needs. However, one message was clear: producers wanted research that was either conducted on working farms or done in a way to reflect actual farming conditions.

5.6.2 Research situation: Key actors/funding programs/key research themes

State research programs on organic agriculture (USA)

The Organic Research and Education Initiative (OREI) was funded at a level of 16 million US$ in 2009 and 2010. In 2011, the funding level was increased to 20 million US$ and 19 million US$ was awarded in 2012. Goals and priorities were set legislatively. Priority was given to integrated systems approach projects, with several such projects funded in the 1 to 3 million US$ range. Several planning grants were given to regions and research areas that are considered underserved to build capacity. Grants were also given for regional or topical conferences.

Table 4 provides a list of recently awarded OREI projects.

Table 4: Projects funded by the USDA Organic Research and Education Initiative, 2011-2012

Project Name	Principal Investigator & Institution	Funding
Improving the safety and post-harvest quality of field grown organic leafy greens: assessment of good agricultural/production practices along the farm to fork continuum	Ravishankar, S. University of Arizona, Tucson, AZ	$1,072,766
Improving soybean and dry bean varieties and rhizobia for organic systems	Orf, J. H. University of Minnesota, St Paul, MN	$1,069,999
Strategies to improve profitability of organic dairy herds in the upper Midwest	Heins, B. J. University of Minnesota, St Paul, MN	$1,924,693
Targeted grazing to reduce tillage: environmental, ecological, and economic assessment of reintegrating animal and crop production	Menalled, F. Montana State University, Bozeman, MT	$1,499,815
Whole-farm organic management of brown marmorated stink bug and endemic pentatomids through behaviorally-based habitat manipulation	Nielsen, A. Rutgers University New Brunswick, NJ	$2,672,327
Addressing critical pest management challenges in organic cucurbit production	Mazourek, M. Cornell University, Ithaca, NY	$1,962,562
Creating an organic plant breeding center	Reberg-Horton, S. North Carolina State University, Raleigh, NC	$1,262,855
Mental models and participatory research to redesign extension programming for organic weed management.	Doohan, D. J. Ohio State University, Wooster, OH	$420,636
Northern Organic Vegetable Improvement Cooperative (NOVIC)	Myers, J. Oregon State University, Corvallis, OR	$539,344
Alternative post-harvest washing solutions to enhance the microbial safety and quality of organic fresh produce	Zhong, Q. University Of Tennessee, Knoxville, TN	$1,990,879
Developing adapted varieties and optimal management practices for quinoa in diverse environments	Murphy, K. M. Washington State University, Pullman, WA	$1,603,653
Forage-based parasite control in sheep and goats in the Northeast US	Kotcon, J. West Virginia University, Morgantown, WV	$1,850,360
Development and participatory implementation of integrated organic pest management strategies for crucifer vegetable production in the south	Fadamiro, H. Auburn University, Auburn, AL	$881,829
Organic farming planning proposal for research and extension in Alabama	Kpomblekou-A, K. Tuskegee University, Tuskegee, AL	$49,886
A collaborative research and extension network for sustainable organic production systems in coastal California	Shennan, C. University Of California Santa Cruz, Santa Cruz, CA	$2,608,205
Carrot improvement for organic agriculture with added grower and consumer value	Simon, P. W., USDA Agricultural Research Service, Peoria, IL	$2,097,770
Co-creating research and extension objectives for organic management of the brown marmorated stink bug	Grieshop, M., Michigan State University, East Lansing, MI	$45,695
Assisting organic dairy producers to meet the demands of new and emerging milk markets	Brito, A. F., University Of New Hampshire, Durham, NH	$2,863,915
Planning for enhanced economic sustainability of organic peanut farming in the Southwest	Idowu, O. J., New Mexico State University, Las Cruces, NM	$36,102
Value-added grains for local and regional food systems	Sorrells, M. E., Cornell University, Ithaca, NY	$2,356,999
Northeast organic farming research symposium	Mendenhall, K. Northeast Organic Farming Association Of New York, Inc. Rochester, NY	$49,663
A whole farm approach incorporating pasture raised organic poultry and a novel cereal grain (naked oats) into an organic rotation	Lilburn, M. S., Ohio State University, Wooster, OH	$896,092
Development of non-antibiotic programs for fire blight control in organic apple and pear	Johnson, K. B. Oregon State University, Corvallis, OR	$475,835
Western region functional agricultural biodiversity planning grant	Ellen, G. Oregon State University Extension Service, Corvallis, OR	$46,580
Finding the right mix: multifunctional cover crop cocktails for organic systems	Kaye, J., Pennsylvania State University, University Park, PA	$2,296,803
International organic fruit symposium	Granatstein, D., Washington State University Extension, Pullman, WA	$45,239
Conference for dry land organic agriculture in the pacific northwest: addressing constraints to production, economics & sustainability	Carpenter-Boggs, L., Washington State University Extension, Pullman, WA	$28,891

Because of the budget impasse, sequester government shutdown and failure to reach agreement on a Farm Bill in 2013, no OREI funds were granted that year. The Farm Bill was signed on February 7, 2014, with an authorization of 20 million US$ per year over five years. However, OREI's funding for 2013 was not carried forward, and several long-term projects were interrupted or stopped as a result. Also, Congress inserted more restrictive language that may limit the effectiveness of the program. The USDA issued a Request for Applications on March 14, 2014 (USDA National Institute for Food and Agriculture 2014).

Private research organizations in the USA

The five principle private sector organizations responsible for organic agriculture research in the US are the Rodale Institute, the Organic Farming Research Foundation (OFRF), the Organic Materials Review Institute (OMRI), The Organic Center (TOC), and the Michael Fields Agricultural Institute (MFAI). All saw significant drops in funding from 2008 (revenues of all 5 private research centers: 7.8 million US $) to 2010 (less than 7 million). While 2011 saw a slight improvement, most organizations were level or declined in 2012. Funding has not recovered to pre-2008 levels. Even with the recent slow-down in organic food sales, the organic sector has continued to grow. Funding in organic agriculture research has not kept pace with the growth in the organic market and corresponding demand.

Research activities in Canada

Canada's Organic Science Cluster (OSC) is a collaborative effort led jointly by the (OACC) and the Organic Federation of Canada (OFC). The OSC's goals are 'to facilitate a national strategic approach to organic science in Canada, link scientists across the country and disseminate the knowledge generated to organic stakeholders'. The Organic Science Cluster identified 10 sub-projects including 30 research activities to be conducted by over 50 researchers plus 30 collaborators in approximately 45 research institutions (Organic Agriculture Center of Canada). The OSC received 8.8 million CAN$ over four years from 2009-2013. Another OSC is under development by OACC and OFC.

5.6.3 Important networks

There have been noticeable improvements in many states and a handful of states with strong institutionalized programs have continuity. However, institutional continuity is needed on a national basis to maintain programs and build support in the US. These farmer-researcher networks need to be established on an ongoing basis. Some regional efforts are underway (CERES Trust 2013).

A strategic planning session to identify research priorities for the second Organic Science Cluster was held during the February 2012 Canadian Organic Science Conference in Winnipeg, Manitoba (Organic Agriculture Center of Canada 2012). Participants identified research opportunities and objectives for field crops, livestock, horticulture and mixed farming systems.

5.6.4 Challenges for organic farming research/specific comments

North American organic agriculture is some of the most advanced in the world, with the technological capacity for high production on a large scale. Despite the recent global economic crisis, the organic sector continues to grow and do its research needs. Despite some progress made over the past twenty years, researchers in both the US and Canada face limited capacity and an uncertain funding climate going forward. However, there is no question that capacity to conduct organic agriculture research has increased in the US compared with ten years ago. Whether it will continue to grow, has hit a plateau, or fall as a result of the combined fiscal and economic crises remains to be seen. Continued growth in organic farming research capacity, as well as technology transfer is needed to ensure that the growing needs of the organic sector are met in the future.

5.7 Oceania

Box 9: Key figures on organic agriculture in Oceania (Willer & Lernoud 2014)

- Total organic agricultural land area: 12.2 million hectares.
- Represents 32 percent of the world's organic land.
- 14'600 producers.
- Australia: 12 million hectares (figures from 2009), 97 percent of which is extensive grazing land
- New Zealand: 106'000 hectares
- Samoa: 33'500 hectares.
- Highest share of all agricultural land are in Samoa (11.8 percent), followed by French Polynesia (5.5 percent), Australia (2.9 percent, 2009) and Vanuatu (2.2 percent)
- Growth in the organic industry in Australia, New Zealand, and the Pacific Islands: Strongly influenced by rapidly growing overseas demand
- In Australia, the domestic market was valued at 1.2 billion Australian dollars[47] and in New Zealand at 130 million New Zealand dollars.

5.7.1 Policy environment

Australia

In Australia, the Government and its Department of Agriculture positions itself to organic and biodynamic food industry. The department's Agricultural Productivity Division is the contact for issues concerning domestic organic policy matters. The department is responsible for organic industry export policy matters, including maintaining the National Standard for Organic and Biodynamic Produce and certifying exports of organic food against that standard. Domestically marketed organic products are commonly certified by one of Australia's seven private certifiers who base their certification standards on the National Standard for Organic and Biodynamic Produce Edition 3.4 July 2009 (the export standard which is also referred to as the National Standard) used by the department for export certification. The voluntary Australian Standard 6000-2009 Organic and biodynamic products was released on 9 October 2009. Standards Australia developed this standard through a representative technical committee comprising organic stakeholders, including certifiers, retailers, manufacturers, consumer groups and government agencies.

All foods produced or imported for sale in Australia and New Zealand, including organic food, must be labeled in accordance with the Food Standards Code developed by Food Standards Australia New Zealand (FSANZ). FSANZ protects the health and safety of the people in Australia and New Zealand by maintaining a safe food supply. It is a bi-national independent statutory authority which develops food standards for composition, labeling and contaminants, including microbiological limits. These standards apply to all foods produced or imported for sale in Australia and New Zealand.

Pacific Islands

In the Pacific Islands, the Secretariat of the Pacific Community (SPC) developed a policy brief in 2009. The policy brief aims to assist governments and others in the region to develop relevant policy focuses on how organic agriculture can assist in meeting regional challenges and outlined seven initial policy recommendations. There has been gradual but steady progress since that time with organic agriculture increasingly gaining mention and recognition in national policy and planning documents, such as the recent 'Over-arching sector plan for productive industries' in Vanuatu and the Solomon Islands Organic Policy. In most cases this has not evolved into legislation however both French Polynesia and New Caledonia have enacted organic regulations

[47] 1 euro = 1.2407 Australian dollars(average exchange rate 2012); Source: European Central Bank at http://sdw.ecb.europa.eu/browse.do?node=2018794

that recognize the Pacific Organic Standard as their national reference standard and also recognizes Participatory Guarantee Systems for organic certification. There are resource constraints at national levels in moving this agenda forward, but the 2012 endorsements by the Heads of Agriculture and Forestry Services and Ministers of Agriculture and Forestry to mainstream organics into regional and national strategies and programs may provide further impetus for this development, Government and international support. The Secretariat of the Pacific Community (SPC), as a regional intergovernmental organization, continues to provide support for coordination and now houses the secretariat of the Pacific Organic and Ethical Trade Community (POETCom), but the need for developing a longer term financing strategy to support the movement is critical. In 2013, POETCom received development assistance from the European Union, the International Fund for Agricultural Development (IFAD) for program costs and the French Pacific Fund and the United Nations Development Programme, which was predominantly for training and capacity building activities at country level. POETCom national affiliates continue to receive assistance from partners such as OXFAM New Zealand, Canada Fund, UNDP small grants programs, and bilateral donor assistance from Australia and New Zealand. In a few cases, national governments also provide financial support (Mapusua 2014).

5.7.2 Key stakeholders

Australia

In the context of very limited government support for organic farming, Organic Trust Australia - Research and Education (OTARE), an independent, non-profit organization formed in 2009 by the Organic Federation of Australia, continues to develop opportunities for co-funding of projects through sponsorships, donations and support for grant applications. A Travel Grant scheme was established in 2013 to provide support for postgraduate students to attend a conference to present their research (Mitchell & Kristiansen 2014).

The Australian Rural Industries Research and Development Corporation (RIRDC) initiated the Organic Produce Research Programme in 1996. Based on the R&D Advisory Committees recommendations five program priorities have been agreed and R&D support is allocated based on the priorities[48].

Horticulture Australian Limited (HAL) works in partnership with individual horticultural industries on strategic planning and developing and managing programs that address the needs of the industry. They conduct various research projects related to organic horticulture. HAL also brings the expertise and experience it has gained in working across all industry programs to benefit individual industries. Capturing the synergies between industry programs delivers time and cost savings and aids in the application of best practice. Through HAL, horticultural industries are able to access matching Australian Government funding for all R & D activities[49]. The Biodynamic Education Center offers a range of courses for Biodynamic farming, gardening and agriculture from the one-day workshop to a full certificate program. The courses and workshops conducted by the Biodynamic Education Center have attracted a wide range of participants from a diverse range of backgrounds such as broad acre cropping, pasture and stock management, dairying, ginseng growing, herb growing, small mixed farms, market gardening and home gardeners, as well as teachers involved in Biodynamic gardening curriculum development[50] (FAO 2005).

Pacific Islands

The Pacific Organic and Ethical Trade Community (POETCom) is the peak body of the organic and fair trade movement in the Pacific region, it has been housed in the Secretariat of the Pacific Community since 2012. POETCom is a membership organization with over 30 members in 13 Pacific Island Countries. POETCom is active in coordination, information sharing, networking,

[48] www.rirdc.gov.au/programs/org.html#newprojs

[49] www.horticulture.com.au/

[50] www.biodynamiceducation.com.au/

and capacity building programs as well as establishing a regional certification scheme to support market access and trade. A key role of POETCom is management of the Pacific Organic Guarantee System which includes 3rd party and PGS certification and the Pacific Organic Standard. The Pacific High Level Organics Group (PHLOG), an informal grouping of Pacific Island leaders chaired by the Prime Minister of Samoa provides valuable advocacy support for organics in the region and endorsement of POETCom's aims and objectives (Mapusua 2014).

5.7.3 Research, publications and conferences

Pacific region

There is no formal research agenda for organics in the Pacific region and currently occurs in an ad-hoc manner without consultation with the organic industry about priorities. Research is required for crops and products with market potential but also to ensure food security under the pressures of climate change. Pest and disease management and soil fertility are key areas of concern and low lying atolls have particular needs with regard to soil fertility and building soil. The Pacific Organic Standard has a section pertaining to Climate Change and research is also required on cost effective green technologies for value adding of organic products.

The Australian Center for International Agricultural Research (ACIAR) is a statutory authority that operates as part of the Australian Aid Program. The Center encourages Australia's agricultural scientists to use their skills for the benefit of developing countries and Australia. ACIAR funds research projects that are developed within a framework reflecting the priorities of Australia's aid program and national research strengths, together with the agricultural research and development priorities of partner countries. Although not a stated priority for ACIAR they have undertaken some research work in organic agriculture in the Pacific region and have the potential to become an important stakeholder. ACIAR also work closely with the National Agricultural Institute of Papua New Guinea (NARI), the University of the South Pacific and the Secretariat of the Pacific Community (SPC), who also undertake some research activities in the area of organics.

POETCom hosts an annual technical exchange bringing together organic practitioners from the region to share learning and experience, on farm trials and research. This is a farmer to farmer exchange and it is expected that over time as more formal research takes place in the region that more scientific papers will also be presented.

Journal of Organic Systems

The Journal of Organic Systems[51] began its eighth year of publication as a peer-reviewed scholarly journal in which researchers could publish their findings on 'Organic Systems' across a wide range of discipline areas. While the original aim was to focus on the Australasian and Pacific Regions, in recent years the journal has broadened its scope, publishing papers from Africa, the Middle East, South Asia and Europe. It is operating in an increasingly competitive niche within academic publishing as new journals emerge with a focus on organic systems, such as Organic Agriculture (Springer) and Organic Farming (Librello).

[51] www.organic-systems.org

6. How will organic farming look like by 2030? A visionary forecast

6.1 Future challenges for agriculture in general

Since the World Food Summit of the FAO in 2009, the dominant future challenge for agriculture, food chains and human nutrition has been to considerably reduce negative trade-offs between productivity and sustainability. This new paradigm is labeled as 'sustainable intensification' by the UN organizations, as 'ecological intensification' by the European Commission and as 'eco-functional intensification' by the European Union Group the International Federation of Organic Agriculture Movements (IFOAM EU Group). For related the literature, see Buckwell et al. 2014, Garnett & Godfray 2012, and Elliot et al. 2013. This chapter is a brief summary of global developments and conflicts that society and the economy will face in the coming decades. More detailed information is available in the Millennium Ecosystems Report (2005), in the Report of the International Assessment of Agriculture Science and Technology for Development (IAASTAD 2008) and in the UNCTAD Trade and Environment Review (2014).

Foresight studies from different continents emphasizes unanimously that several **resources** which are indispensable for agricultural productivity may become scarcer and markedly more expensive. **Fossil energy** will become too expensive to be used for the production of nitrogen. Forecasts about peak oil vary between 2010 and 2030 (Chapman 2014). Therefore, nitrogen will become the first resource impacting conventional productivity negatively. **Water** has always influenced agriculture and led to adaptation and migration on a local scale. With the anthropogenic acceleration of climate change, water scarcity has become a global problem. The adaptation of agricultural production, farming systems, and individual farms to both general water scarcity and temporal floods is still inadequate (Lobell et al. 2008). These accelerated adaptation measures have to be taken for both rain-fed and irrigated production systems. **Phosphorous** which is essential for plant growth as it is for all forms of life is finite when mined. Estimates for how long it will take until depletion rank between 100 and 300 years. Optimistic scenarios are based on the assumption that new sites for mining are discovered continuously and that current prognoses are likely to be wrong (Heckenmüller et al. 2014; Scholz & Wellmer 2013). The most recent models see no indication for a 'phosphorous peak' situation any soon. Nonetheless all experts urge for the better recycling of phosphorous and for improved uptake of phosphorous from the organic and mineral pools in soils as these kinds of local pools are huge but rather inert (Cornish 2010; Schachtman et al. 1998).

Ecosystem services will continue to be threatened by agricultural production. Locally, biodiversity, soil fertility and water quality will suffer and reduce agricultural productivity. Globally, impacts on huge natural ecosystems like rainforests, coastlines or permafrost systems will add to the instability of the planet (Rockström et al. 2009). Some of these negative externalities can be even quantified. Food production has globally degraded 60 percent of the ecosystem services, mainly supporting, regulating and cultural services (MEA 2005). The growing costs of biodiversity loss and ecosystem degradation for both society (macro-economic costs) and the business (micro-economic costs) are already partly known, and are horrendous (TEEB 2010). The most recent global debate on bee death in the context of biodiversity loss, insecticide sprays and habitat-poor landscapes is only one of the many problems the society, politics, businesses, and farmers will face in the future. The degradation of ecosystem services will limit future productivity gains and is not likely to be compensated by technological progress. In addition, intensive soil tillage and the spatial separation of crop and livestock production will increase carbon losses from soils and nitrous oxide emissions. Soil erosion will continue to be a problem as it is strongly linked to industrialized forms of agriculture in combination with the impacts of climate change. The pace of soil degradation and soil erosion has not been halted although it is a problem recognized early and being high on the national and international political agendas. The current loss rates of fertile soils suited for agricultural production (both arable land and grazing areas) is 10 million hectares per year (Pimentel et al. 2005) and likely to be higher than per area yield gains by breeding progress.

Migration of people from the land to the urban and per-urban centers will continue to happen. More than 50 percent of the human population already lives in cities. On all continents, farmland is abandoned and no longer productive for food. Partly, this development is mitigated by professional companies buying or renting land from farmers and producing in a broad-acre manner for the global markets ('land grabbing'). Productive, knowledge-intensive and site-specific agriculture based on a careful and sustainable exploitation of local, natural resources is not possible with this kind of industrialized agriculture. It threatens ecological, economic and social sustainability and further accelerates migration from the land.

All these developments clash with the **growing demand for food**. In an ideal world where access to food would be equally fair for everybody, current agriculture could feed more than 10 billion people. As a result of the predominant economic and political frameworks, one out of 7 billion people undernourished come upon one billion obese people. Concurrently, one third of the produced food is lost after harvest or wasted by processing, trade and consumption. On top of that, a growing part of the arable land is used for energy production, heavily subsidized by public money of developed and emerging countries.

In order to respond to these significant changes urged by the Millennium Ecosystem Assessment (MEA 2005, see Box 11), new approaches are also needed in research, knowledge creation and learning (IAASTD 2008). The IAASTD's Johannesburg recommendations emphasized that ecosystem research was the only approach to successfully cope with food security, interdisciplinary research was indispensable, the indigenous/tacit knowledge of farmers should be included, and women play an important role not only in farming, but also in researching, teaching, and advising. The IAASTD report also urged for a critically restrictive development of technologies in a case-by-case assessment but did not support general technology bans.

Box 10: Extract from the conclusions of the Millennium Ecosystem Assessment (2005)

The challenge of reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met under some scenarios that the Millennium Assessment has considered, but these involve significant changes in policies, institutions, and practices that are not currently under way. Many options exist to conserve or enhance specific ecosystem services in ways that reduce negative trade-offs or that provide positive synergies with other ecosystem services.

To summarize, the future challenges of agriculture centered around the minimization of negative trade-offs between further productivity gains and long-term sustainability. As a consequence, the European Commission has already established the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) and published in 2013 a Strategic Implementation Plan (SIP) for a relevant part of the common research budget for the years to come

6.2 Is organic agriculture part of the solutions and does it respond to the global challenges?

Globally organic agriculture is a tiny niche and the question of whether organic agriculture can contribute to solving the global challenges might be obsolete. In the few countries where organic agriculture represents 10 to 20 percent of the agricultural land, the question becomes more relevant. In some marginal or ecologically sensitive areas such as the Austrian and Swiss alpine grassland area, organic farms cover more than 50 percent of the agricultural land. For watershed and water catchment management, organic farming is the predominant land use method in many parts of the world; even more so in buffer zones between agriculture and nature conservation areas. There is a lot of evidence showing that organic farm management halts loss of species diversity on agricultural land and in the semi-natural buffer zones between wilderness and natural habitats and vegetation. Similarly, the evidence is strong that soil erosion is significantly lower than in other forms of productive agriculture. In many cases, soil fertility and soil structured can be rebuilt by organic farming.

As a consequence, farmers and scientists involved in organic agriculture often claim organic to be a viable dual strategy for 'high quality foods' and 'mainstreaming as the best sustainability farm practice'. The term 'quality' expresses different characteristics, such as organoleptic quality, nutrient density, social quality (e.g. fair income and salaries), values in agriculture and food processing (e.g. increased responsibility for animal welfare), preference for naturalness of processes and inputs or preventive and precautionary management and decision making.

This chapter aims to position the future development of organic agriculture in these cross-purposes of a lifestyle and health niche and mainstreaming organic agriculture as a relevant sustainability pathway.

6.2.1 Organic agriculture has not been a mainstream strategy in the past

Organic agriculture is a niche production with 37.5 million hectares of certified land. It represents 0.9 percent of global agricultural land. After a fast growth between 1990 and 2009, it has stagnated, in recent years. Organic farmers have become relevant only in European countries so far, especially in Austria with 20 percent of the farmland, Sweden with 16 percent, in Estonia with 15 percent, in Switzerland and the Czech Republic with 12 percent. In the global South, only the Malvinas/Falkland Islands, French Guiana and Samoa have high proportions of 10 percent or more.

The main focus of organic foods is the high-quality markets in the North. The European and the USA markets represent more than 90 percent of all organic sales. Globally the sales of organic food are likely to be less than 1 percent of all retail sales. The profile of organic foods is its superior quality of raw material, its special requirements for processing aimed at qualities like authentic, natural, gentle, non-evasive techniques, its higher safety and better traceability. It also implies ethical values like animal welfare, fair payment for farmers and farm workers as well as a strong emphasis of the precautionary principle. The wealthiest consumers in most developed countries raise organic food sales up to 8 percent of all foods in Denmark and in Switzerland and around 4 percent in Germany and ant the United States. Some products however, reach far higher shares. In Switzerland, more than 20 percent of the eggs sold are organic.

Therefore, although organic agriculture is a productive system with a high output of public goods and less negative impacts on the environment, it is not likely to become mainstreamed in the form of the current code of conduct or regulations applied world-wide by different states, farmer associations, and the business actors. In contrast, agroecological farming approaches without certification systems, fewer restrictions for the use of technologies and more oriented towards qualifiable or quantifiable positive impacts on the sustainability are gaining attention (Altieri & Nicholls 2006). In addition, the number of voluntary sustainability standards is increasing (Potts et al. 2014). These programs and labels suddenly compete with organic to be listed and displayed at the point of sale of supermarkets (POS), discounters and even high quality retailers.

The economic competitiveness of organic farming and organic foods is likely to improve with more research. Most factors which influence productivity and profitability are linked to unsolved agronomic problems and higher labor input. An important reason for the weaker economic competiveness of organic agriculture is the fact that negative environmental and social externalities of agricultural production are not fully internalized as is required in other parts of the economy. True cost accounting is likely to increase the economic performance of organic agriculture in a substantial way. Unfortunately, in the past, introducing true cost accounting has failed, not only because of disinterest of the dominant economy and policy, but also because the scientific community was not able to develop manageable solutions. One of the problems is that true cost accounting is a very dynamic concept and is strongly influenced by technology leaps and bounds. In order to exemplify this, the availability of phosphorous for plant fertilization is likely to be much longer than was expected a decade ago, especially in cases when i) good recycling of sewage sludge and human urine is in place, ii) food waste and field losses are considerably reduced, iii) the field application is massively improved by precision farming machinery, and iv) the size of mineable reservoirs is much greater than known today. All these technologies help to reduce the negative impact on the environment as well. A similar example could be given for nitrogen fertilizers, where first, solar energy-driven Haber-Bosch plants will soon be technically and economically feasible and nitrogen applications can be made very precisely. Therefore, true cost accounting can not only make organic agriculture more competitive, but also can help to reduce the negative externalities of conventional farming.

6.2.2 Mainstream or not, organic agriculture is an interesting model for agricultural and food research

Regardless of these introductory remarks, organic agriculture is an interesting model or case-study for how the global challenges might be addressed in a more comprehensive or holistic way. Organic agriculture is a model for:

- Reducing negative trade-offs between productivity and sustainability;
- Making better use of farmer knowledge and farmer-based innovation which is crucial for any sustainable farming system;
- Improving famer-to-farmer as well as farmer-to-consumer communication and cooperation;
- Well-functioning co-innovation of farmers, farm advisors, and scientists;
- Technology development in the context of long-term sustainable farms and landscapes;
- Exploitation of high value food chains and voluntary sustainability standards for progressing societal objectives and producing public goods and services.
- A better focus of agricultural production on ethical values like animal welfare, social concerns like the livelihoods of farmers (fair trade) and cultural ecosystem services like amenity landscape management.

These model functions of organic agriculture are described as follows.

6.2.3 A model for research on how to reduce negative trade-offs

The surpassing provision of public goods of organic agriculture has been documented by several hundred scientific papers since 30 years ago (Niggli 2014). The literature encompasses all climate and socio-economic zones of the world, but has a bias towards Europe. The good ecological and social performance of organic farming is accompanied by a lower productivity, which is in the range of 20 to 25 percent. Nonetheless, the potential for yield increases is high, especially under subsistence farming conditions, marginal regions and drought-affected zones (Hine et al. 2008). These are exactly those parts of the world where hunger occurs temporarily, and malnutrition occurs permanently.

Organic agriculture is therefore an excellent model for how food production can be intensified with respect to the overall and long-term sustainability. The approach to be taken starts differently from that of conventional farming systems. Organic farms are mostly organized as economically, socially, agronomically and ecologically resilient entities, preferably embedded in synergistic interactions with semi-natural landscape habitats. To increase whole farm-related productivity without diminishing the environmental, social, and ecological qualities is an interesting concept for future research activities around organic farming systems.

The meta-analyses on yields showed that organic crop rotations are likely to be N-limited, that phosphorous limits yields in strongly alkaline and acidic soil and that only the best management practices (meaning the best control of weeds, diseases, and pests) can result in yields comparable to those of conventional farms. These limitations already frame future research activities in organic crop production.

In general, it is observed that organic farmers allocate their limited resources, such as labor, land, internal inputs or farm infrastructure, to different activities and try to optimize the performance of the whole farm. They are aiming at a high Total Factor Productivity (TFP), which is a ratio that relates the aggregation of all outputs to the aggregation of all inputs (Latruffe 2010). Therefore, maximizing single crop and/or livestock yields might be subordinate in many cases, and optimizing farm income is likely to be the better strategy to keep rural areas attractive. These kinds of whole farm productivity and profitability strategies are further fields of interesting research

6.2.4 A model for research on how to deal successfully with scarcities?

Organic agriculture at least partly adds the element of sufficiency to productivity. The report of the 3rd SCAR foresight exercise highlighted that resource scarcities were expected to define future food security. It identified two competing narratives to address these scarcities, efficiency and sufficiency (Schneidewind et al*.* 2014). Organic farming systems have an excellent input/output ratio and therefore a high efficiency (Mäder et al*.* 2002). On the European policy level, for example, the regulation on organic production (Council Regulation (EC) 834/2007) reduces or bans the use of high energy nitrogen fertilizers and restricts the use of phosphorous which both depend on finite mining activities. Therefore, organic farming can well respond to both the efficiency and sufficiency narrative.

6.2.5 A model for research on co-innovation

Organic agriculture has its origin and still a strong stake in co-innovation of farmers and scientists as partners. As a contrast, the adaptation of sustainable farming practice in conventional agriculture is often impeded by the insufficient integration of farmers and the diversity of their farms in their respective context (Leeuwis 1999). Research is often too dominated by scientists. Therefore, most recent concepts emphasize co-innovation, where farmers, farm advisers, and scientists are involved on an equal basis (Dogliotti et al. 2014). The authors point out that significant and complex changes of farming practice cannot be the result of a 'take it or leave it' choice of validated packages of solutions or technology fixes. The farmers have to become involved in all stages of the innovation process in order to ensure relevance, applicability and adoption. For many practical problems, farmers are often even the main source of innovation. Active knowledge creation has superseded passive 'technology transfer' (Koutsouris 2012). A farmer-driven approach will be important, but a process that looks only at farmers' immediate and short-run needs without a deeper understanding of the causes of what they identify as research needs will be limited in effectiveness. Experienced organic farmers note that the innovations that they adopt evolve over time, and that as the ecological state of their farm transitions, that old problems go away and new ones emerge. Transitional farms have a different set of needs than those of experienced organic farmers.

For better responses to global environmental change, more open knowledge systems are required. Therefore, the leading European universities have shifted towards knowledge systems which include societal agenda setting, collective problem framing, a plurality of perspectives, a better handling of dissent and controversy and stakeholder participation (Cornell et al. 2013). The multi-actor approach of organic agriculture is well-marked and very effectively used.

To conclude, organic farms, especially farmers, are excellent cases to carry out co-innovative research.

6.2.6 A model for research on innovation pathways

The innovation pathway of organic agriculture is slower and much more challenging for farmers, farm advisors and scientists. Innovation emphasis social processes, traditional knowledge and best farm practices in the first place. Technical innovation is mainly based on combination breeding and different crossing methods, managing antagonists of pests and diseases, developing bio-control and botanical agents for both plant and animal health, precision farming and robot technologies. This kind of more holistic, but slower and less risky, innovation pathway makes organic farming an interesting model. Other farming systems use all or part of the permanent scientific progress beyond what is accepted by the organic standards, especially certain innovations in the field of molecular science, nanotechnology and modern breeding and multiplication techniques. These general bans are based on the IFOAM Principle of Care which requires precaution in cases where potential risks for human health, the environment, and society cannot be excluded. As a consequence, the innovation strategy of organic agriculture needs a much stronger support through basic and applied research in order to maintain economic competitiveness against conventional agriculture.

A crucial question in the innovation debate will be whether organic will persevere in elite and expensive niche markets (currently 0.9 percent of global production and 4.7 percent of the production in the EU) or whether organic farming and food systems will become mainstreamed as a major pathway towards long-term sustainability.

Organic farmers want to produce abundant, high-quality, nutritious and healthy food for a growing population. Farmers who are not organic, but are interested in growing more sustainably, cite a number of obstacles to making the transition. Many of these obstacles are technical in nature that potentially can be addressed through improved technology. A number of studies have explored what organic farmers identify as research priorities. A number of methods have been used. Over the years, researchers and research institutions have conducted a number of surveys to find out the research, innovation, and technology needs of organic farmers (Baker & Smith 1987; Walz 2004; Formas 2006; EPOK 2014; Wivstad 2013). Researchers have also surveyed and interviewed non-organic farmers to identify obstacles that discourage or barriers that prevent the adoption of organic practices (Blobaum 1983; Fisher 1989)

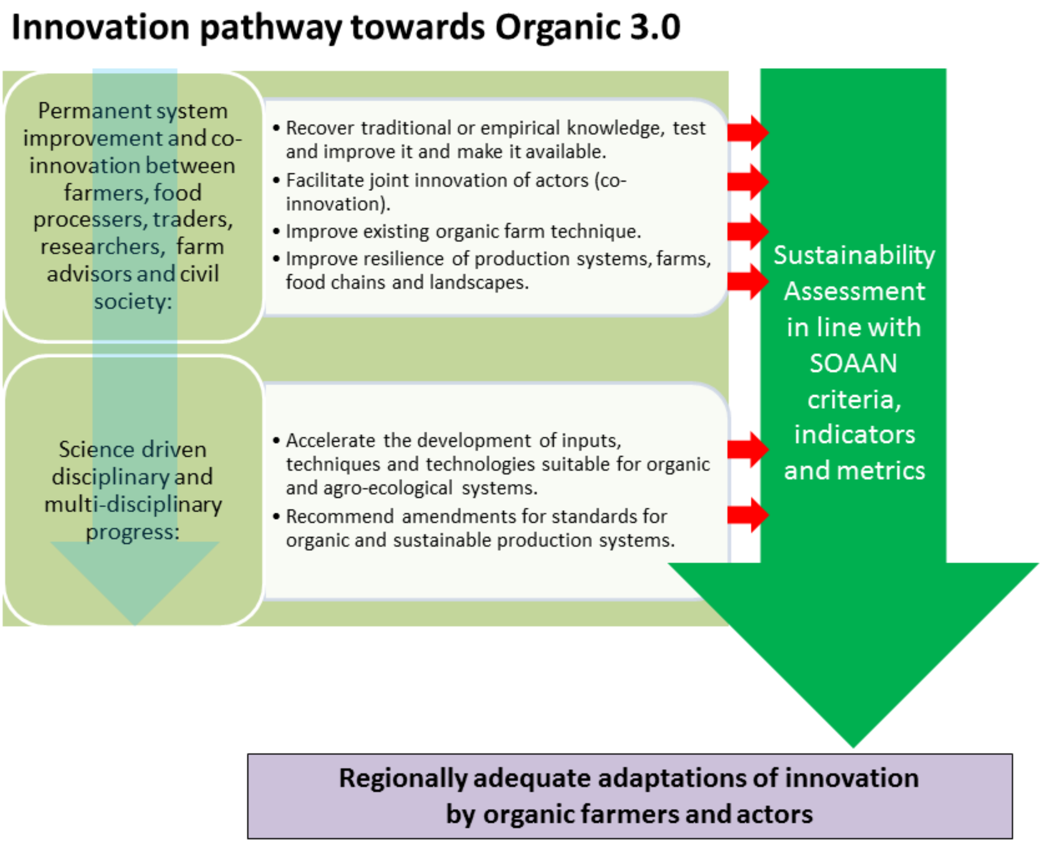

Figure 2: Innovation pathway towards Organic 3.0[52]

[52] For detailed information see (Arbenz 2014)

7. The Vision 2030 for the future development of organic farming between lifestyle and solving global problems

The future development of organic agriculture will follow three main pathways. The first describes the meaning and the function of organic agriculture for the empowerment of rural areas. Organic farms and organic farm families can help to increase the attractiveness and the viability of rural regions especially those being ecologically, economically and socially marginalized (see pathway 1). In many rural regions of the world, organic agriculture even has the potential to become the predominant land use system. The second pathway of the future development of organic agriculture addresses the need for the further intensification food production in both ecologically and climatically optimal areas as well as in marginal sites. Organic agriculture has the potential for a good productivity while recurring ecosystem services (see pathway 2). An finally, a steadily growing number of consumers are interested in healthy foods, high tastes, a high safety and transparency of the food chain and the ethical values around agriculture and food processing (see pathway 3).

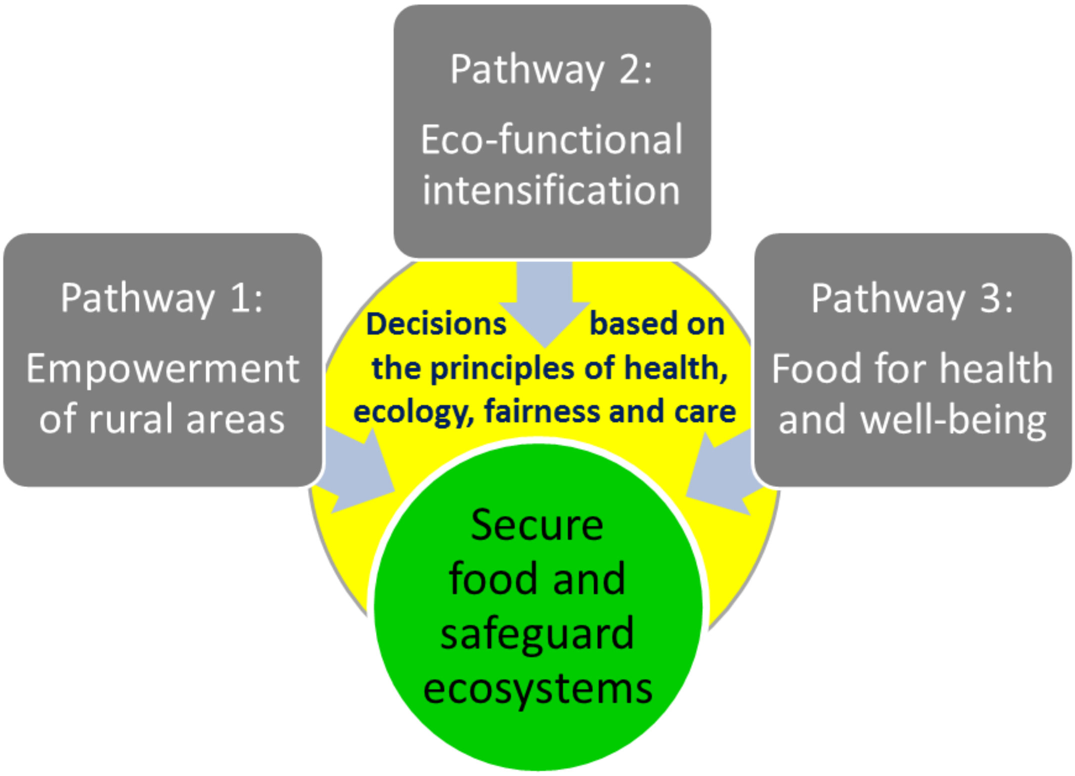

Figure 3: Pathways of future development of organic agriculture

The three pathways of the future development of organic agriculture are driven by the three following visions.

7.1 Pathway 1: Organic farming and food systems crucially empower rural areas across the whole world and help to stop migration from the land

Vision

'Organic agriculture, food processing and eco-tourism will become important drivers of the empowerment of rural economies. In many disadvantaged regions, organic agriculture will be the preferred land use model and become mainstreamed. A diversified local economy will attract people and improve livelihoods and will halt or even reverse migration from rural areas to urban centers. Organic farm practices, animal welfare and organic food will foster a dialogue between urban and rural populations leading to intensified forms of partnership between consumers and producers. Organic farming will motivate and unite actors of sustainable food chains and contribute to the attractiveness and unique quality of the world's landscapes. It will be a powerful intensification strategy on marginal sites and for subsistence farm making best use of nature, as well as human and social capital in agriculture (Hine et al. 2008).'

Examples of research fields and activities which can be deduced from the vision are:

- Create value added food chains in rural economies by sourcing regional, high-quality foods from organic farms, and using local processing, packaging and labeling units. Use and modernize traditional food techniques in order to create regional products and a strong bonding and commitment of consumers to local agriculture. Add value not only with organic agriculture but also in combination with fair-trade, agroecology and agrogenetic heritage farming.
- Improve the economic viability of short food chains – e.g. community supported agriculture (CSA), box schemes, farmer markets in cities, towns and villages by the use of new media and information and communication technologies (ICT).
- Set up farmer-researcher innovation groups in order to boost co-innovation in rural areas.
- Look into transformation costs and macroeconomic efficacy of organic agriculture compared to targeted agri-environmental and social schemes in order to achieve a sustainable development of rural economies. Collect data on the environmental and social costs of organic agriculture in comparison with conventional and other farming approaches and validate them with models.
- Further improve the ecological, social and economic sustainability of (organic) farms. Develop and validate concepts, indicators, metrics and tools for advice, benchmarking, and certification activities towards truly sustainable farms, regions, and food chains.
- Regionalize organic farm practices towards a high resilience and local adaptation under all global pedological, climatic, cultural, social, and economic conditions.
- Improve methods and concepts for Participatory Guarantee Systems PGS and group certification
- Study on consumer preferences in different regions and hurdles for organic consumption
- Apply of indicator-based bench marking and certification schemes preferences in different regions and hurdles for organic consumption

7.2 Pathway 2: Secure food and ecosystems by eco-functional intensification

Vision

'The availability of food and the stability of the food supply will be noticeably increased through eco-functional intensification, and access to food will be considerably improved thanks to revitalized rural areas. Food productivity based on non-renewable resources and off-farm inputs will become partly obsolete. Knowledge among farmers about how to manage ecosystem services in a sustainable way will be much greater, and animal welfare and environmentally sound farming will be state-of-the-art in food production. Organic farms will demonstrate how negative trade-offs between productivity and sustainability can be minimized. It will be the benchmark for the responsible and precautionary use of the scientific progress in food and farming systems. Organic farmers will become models for ecosystem managers, co-researchers, and in- and output optimizers.'

Examples of research fields and activities which can be deduced from the vision are:

- **Improve the resilience and homeostasis of farms** with all the traditional and modern knowledge that is available.
- **Combine system design/habitat management with direct interventions** ('nature & high-technology')**.** Examples are: Functional biodiversity plus inundative and inoculative release of biological control agents; mixed cropping systems ('contour' arable or vegetable farms but also fruit, vine and berry orchards with variety mixtures modeled and designed with epidemiological data) harvesting with precision farming technology (camera- and sensor-geared harvesters) intelligent encapsulation of plant extracts against animal and crop diseases with modern materials.
- **Mixed stands of crops with legumes** in order to reduce nitrogen and protein shortages. Increased investment in the breeding of leguminous crops (yields, robustness). Co-breeding of most adapted crop partners (e.g. maize and beans; lupines and cereals).
- Improve **plant health** in organic crops. Replace old-fashioned organic fungicide and insecticide applications as well as conventional chemical veterinary medications with new bio-control organisms, botanicals, low energy physical equipment and other products.
- Address the main reasons for yield gaps in arable crop rotations such as nitrogen and phosphorous shortages as well as insufficient weed control. The main focus should be put on crop breeding programs for low-input conditions and on ways of improving the recycling of nutrients (e.g. new sewage sludge technologies).
- **Enhance the diversity** of locally made food, medicinal, and non-food products based on the revival and exploitation of lesser used locally available agricultural products, thereby increasing the opportunities for eco-intensification with corresponding economic rewards.
- **Soil fertility building techniques** for soils in tropical and arid zones.
- **Breeding of** crops and livestock which are better adapted to low external input farming systems and enable the best use of local resources.
- **Improve climate smart livestock and mixed farm systems** that favor carbon sequestration and the effective use of resources, are adaptive to unpredictable climate changes and fulfill high animal welfare standards.

7.3 Pathway 3: High quality foods – a basis for healthy diets and a key to improving the quality of life and health.

Vision

'In the future, people will have more healthy and balanced diets. Food and quality preferences will have changed: fresh and whole foods will be the ultimate trend and processing technology will produce foods with only minimal alterations to their intrinsic qualities. Specific tastes and their regional variations will be more appreciated than those that are artificially designed. This trend towards a higher quality of foods, a more conscious and less wasteful consumption of food and the renaissance of authentic traditional foods will be spearheaded by organic farmers and food processors and distributors. Cooperative and participative models of transport, and safe and traceable food systems will prevail, and organic actors will be the most innovative ones.'

Examples of research fields and activities which can be deduced from the vision are:

- Explore experimentally the **interaction between food quality parameters of organic foods with people's health status** (intervention or cohort studies). The major differences among crops are (see Baranski et al. 2014) considerably higher contents of secondary plant compounds (bioactive compounds, antioxidants) and significantly lower nitrate, cadmium and pesticide contents. What is the health relevance of these differences?
- **Reduce and avoid food wastes in organic food chains** on the field, in processing, and in better shelf life (storages, shops, households). New recycling techniques for food wastes and their re-use in organic farming.
- **Resource management** throughout the food chain and effects of different **distribution systems**
- **Explore the value of the genetic diversity** (inter- and in-species) of foods for health and well-being of animals and humans.
- Experimentally develop, improve, and adapt **traditional and modern food processing techniques for natural, authentic and heritage foods**.
- Develop strongly improved concepts - based on HACCP, analytical tools and process documentation - **for inspection and certification** in order to improve the integrity of organic foods and prevent food chains from fraud. These concepts can be extended to other quality foods like animal welfare, regional and heritage foods.
- Improved **methods and concepts for Participatory Guarantee Systems** (PGS) and group certification.
- Eco-friendly packaging of organic foods
- Implement indicator and metric-based certification system on the basis of the Guidelines of the Sustainable Organic Agriculture Action Network (SOAAN 2013).

8. Approaches and methods for globally advancing organic agriculture research and farmer innovation

Questions to be answered in the chapter:

- Should organic research be focused on certified systems or agreed production standards, or should it be based on the wider ideas, principles and goals of organic farming, or should the existing standards/certification paradigm be overhauled to enable a real Organic 3.0[53] evolution?
- Is 'Organic 3.0' a means to developing new perspectives and principles or an opportunity to rediscover the original principles and goals that have perhaps become obscured by the focus on specialist markets and certification?
- Should organic and agro-ecological research be separated, or is there significant common ground, accepting that the term agro-ecology itself is used in many different senses by researchers?
- Can organic be THE solution to every problem or do we need to recognize and find ways of working with its limitations and the trade-offs between multiple goals?
- Is the organic concept more critical of science itself or the technologies resulting from scientific endeavors? The scientific method is fundamental to our work, but could organic research provide a basis for rediscovering a critical but evidence-based approach to technology assessment, which is arguably often lacking in current debates?
- Does organic research need to find global, or more locally adapted solutions?
- Should the emphasis be on systems rather than component perspectives or system (re)design rather than technological inputs?
- What is the role of stakeholders in the process? What does participatory really mean? Are researchers still leading the innovation or, for some research/innovation questions, are farmers leading the research process with researchers playing only a support role (possibly in the context of farmer innovation clubs or field schools)? What about other research questions, aimed at different audiences where participatory approaches may be irrelevant? (see also Lockeretz & Anderson 1991; the book Agricultural Research Alternatives addresses some of these questions).

8.1 Different approaches for addressing the challenges of organic agriculture

The continuously growing demand for organic foods (long-term average annual growth in the last 20 years > 5 percent), and the model character of organic food and farming systems for advancing productivity in a truly sustainable way, justify local, national, and international research on these systems to a much greater extent than in the past. In order to fulfill the promise and deliver the benefits described in the previous chapters, many of the production and distribution challenges associated with organic food and farming systems will need to be addressed. The focus of adequate research programs and the way solutions have to be approached can be characterized as follows:

i. Disciplinary or multidisciplinary innovations are developing novel solutions for agronomic problems of farmers. These solutions target economic (yields, marketable quality, shelf life), ecological (reduction of leaching and run-off of nutrient elements, emission of climate gases, losses of biodiversity) and social weaknesses (hand weeding in vegetables, hand thinning-out in apple orchards, both mainly done by cheap laborers; replacement of nicotine and rotenone insecticides by non-toxic biocontrol organisms). These innovations are often regarded as 'silver bullet' solutions typical for conventional research and therefore criticized. In fact, such research is urgently needed for organic farming as well as the market for organic inputs and non-chemical techniques and implements are still economically not attractive for industrial research.

[53] For detailed information see (Arbenz 2014)

ii. Interdisciplinary research into improving and fine-tuning organic farming systems on different levels such as fields or animals, crop rotations and livestock herds, farm units, farm-landscape interactions and along entire food chains including consumers. It is entirely done in an organic context. It always involves several or ideally all scientific disciplines. Interactions between partial components of systems provide solutions which are sometimes unexpected and fully satisfying without 'silver bullet' interventions. The effects are influenced by varying site conditions, but can be generalized when experiments cover a certain range of environments. As the interactions between the partial components of the system studied are geared by the farmer(s), the effectiveness of the solutions depends greatly on the skills of the farmer(s). As a factor, human beings cause a huge variability in the results and are, therefore, part of the research design. These innovations are often described as being typical or unique for organic research. In fact, research activities comprehensively addressing food and farming systems with best performance as a goal, are critically underfunded and urgently needed.

iii. Describing, assessing and comparing food and farm systems as comprehensively and thoroughly as possible. This kind of research is often seen as very static, not dynamically improving agricultural productivity or ecological and social sustainability. It requires multidisciplinary research as many different indicators are considered. It encompasses long-running field or livestock herd experiments under controlled conditions, a great number of farm comparisons or the modeling of data and the verification of the results with investigations on farms. In many countries, comparative research has marked the beginning of organic research. Famous experiments are the Rodale Farm System Trial in Pennsylvania, the DOK trial in Switzerland, the bio-dynamic field experiment in Darmstadt (Germany) or the System Comparison in India, Kenya and Bolivia. Other comparative investigations focus on entire farms and also cover socio-economic and animal welfare/health research. All these comparisons help to understand the functioning and performance of organic farming compared with integrated, agroecological and conventional farming. In addition, they deliver important data for the public and for policy makers. Finally, they help to develop indicators and metrics for sustainability assessments of food and farming systems.

An approach that looks at farming systems as a whole will require restructuring not only the way research is done, but also how disciplines interact, the fundamental purpose of the work, and how the results are disseminated.

Therefore, capacity-building for organic agriculture research requires a different approach from any taken in the past. The special challenges and tremendous opportunities afforded organic agriculture have not been adequately addressed by research institutions as they are currently constituted. The capacity to address organic agriculture's research needs requires deliberate design to meet those challenges and opportunities.

8.2 Methods for research successfully advancing organic agriculture and organic practice

8.2.1 Controlled experiments and component research

Agricultural research under the dominant paradigm breaks down questions into manageable hypotheses that can be verified or falsified. It cannot be ignored that research with controlled experiments and disciplinary or multidisciplinary approaches are predominant in organic farming research as well, especially in countries with relevant research activities in organic agriculture such as Switzerland, Germany, Denmark, Sweden, Norway, Finland, Canada, USA, the Netherlands, UK, France, Italy, Hungary, the Baltic States, the Czech Republic and many others. Classical or conventional research approaches are used for socioeconomic, agronomic, ethological, veterinarian, food quality, and food nutrition research. An example is the work on the replacement of copper fungicides in vine, fruits, berries, vegetables, potatoes and hops which is still being widely used in temperate zones against different diseases mainly of the *Oomycetes* family. The current research work focuses on breeding of less sensitive or resistant varieties and on copper free alternative fungicides like botanicals, all kinds of plant 'strengtheners' (including homeopathic and biodynamic preparations) stimulating the immune system or different formulations of stone meal powders. This is nothing less than state-of-the-art breeding and phyto-medical research and testing. Potential solutions have to function in the context and environment of low input and organic farming, and this is often different from high input systems where farmers expect a very high efficacy of measures. The more holistic approaches like improving the production system with best soil fertility building, good nutrient management, hygiene measures from pre-planting to harvest, plant density, planting orientation, crop rotations and crop mixtures, have not yet been proven as sufficient to achieve constantly good yields. Several fungal diseases have epidemic potentials. For other diseases, such as *Moniliophtoraperniciosa*, the 'Witches' Broom Disease' in cocoa, the production system is also a powerful solution to reduce the damage. While cocoa orchards with no shade (full sun) have 100 percent infection, low diversity shade agroforestry systems reduce infection to 50 percent, and high diversity shades, as often practiced in organic farming can reduce infection to 20 percent (Jakobi 2013).

8.2.2 Co-innovation of farmers, farm advisors and scientists

The organic standards are very restrictive with the quick fixes of modern agriculture. This is especially true for crop production, and to a lesser extent for animal production and food processing. These restrictions are all related to the ban of chemical and fast release fertilizers, chemical pesticides, herbicides in general, synthetic food processing aids and ingredients and finally, with Genetically Modified Organisms (GMOs) and products thereof. Chemical inputs are still in use for livestock diseases as otherwise, animals would suffer pain. Research on health prevention and natural medications are still underrepresented in general and in organic farming research especially.

What can be described as 'co-innovation' is a powerful approach typically for organic scientists and in many cases born out of the scarce resources available for organic research. Amazingly, it often provides fast progress, improves the profitability of farmers considerably and facilitates market access with a continuous supply of quality organic foods.

There are different ways of co-innovation to be mentioned:

- Sharing, applying and further improving **best organic practices** of farmer groups, mostly grouped along the dominant production branches such as dairy, sheep, pig, poultry, arable crops, vegetables, fruit producers or vine producers. The methods are mostly mutual farm visits, conferences where farmers and scientists talk about the latest results and achievements, and simplified experiments on individual farms with or without scientific backing (ring tests) and peer advisory services. Usually, such activities are volunteering although both the output of ideas, new approaches and techniques can be huge and the learning effect is sustainably big. Farmers bring in a variety of individual and side-specific observation, permanently improve techniques and develop new tools and equipment. As many brains, eyes, ears and hands form a critical mass, the innovation, its local adaptation and the adoption by the participating farmers and other practitioners, are accelerated.
- **Interviews of knowledgeable farmers, veterinarians, and farm advisors** also provide ideas and solutions in abundance. It is not only interesting from an ethnological science perspective; it is also a source of practical techniques still valuable for sustainable farm management. A good example is the first collection of techniques and agents used by the early organic gardeners in German speaking countries by Otto Schmid (FiBL), and published as the first comprehensive book on Biological Plant Protection in Horticulture in the year 1978. In the following 30 years, the number of crop protection techniques and products multiplied tremendously, resulting in farm input lists of the Organic Materials Review Institute (OMRI) and Research Institute of Organic

Farming (FiBL) relevant for organic certification. More recent examples include the interviews of 200 farmers in Switzerland by a team of pharmaceutical and veterinarian scientists which has already delivered a documentation of 1025 homemade remedies and the therapeutic use of 100 plants. The vast information, including: mode of action from scientific literature, application rates and frequencies and experiences from farmers on the efficacy is being made available for other farmers via internet databases (Walkenhorst 2014).

- Classical on-farm research: On-farm research offers many advantages to build capacity to ask questions about organic agriculture, agroecology and farming systems. Farmers already form hypotheses about the different system conditions and conduct experiments to find ways to solve problems. However, farmers often lack the training, time, equipment and money to conduct rigorous experiments that would withstand scrutiny. Therefore, the involvement of scientists in on-farm investigations has become important in organic research. There are all kinds of intensities, interactions and professionalisms in on-farm-research, such as, i) practical application of improved or novel techniques or products by the farmers with parts of the field or windows in the field where the old established procedure or no treatment can be seen in order to have a certain success control, ii) applications or treatments in stripes on the fields with none, one or several replications, iii) professional field trials with randomized block designs mainly conducted by technicians and scientists with regular sampling, measurements, scoring, and statistical interpretation. On-farm research is also an efficient way for livestock research as research facilities with different herd sizes are costly and scarce. With such research designs, alternative and preventive health strategies have been tested over several years with 200 dairy herds in Switzerland where the challenge of replacing antibiotic treatments with a combination of homoeopathy and health prevention had been developed (Klocke et al. 2010).On-farm research has a number of advantages over research conducted off the farm (Lockeretz & Anderson 1993). It is not practical in many cases for experiment stations and research centers to replicate the conditions found on farms. The human element of farm management is often neglected when research is conducted off the farm. Whole farming systems involve numerous interactions that are difficult if not impossible to capture in a controlled experiment.
- **'Mother-daughter' experiments:** Development of a farming systems research program entirely within an experiment station or research center setting would be prohibitively expensive. Instead, it is necessary to complement research center results with verification and—hopefully—validation on the farm. One possible approach is the 'mother-daughter' experiment. Under such a program, the research center or experiment station has the 'mother' experiment, while components of the experiment (the daughters) are replicated on individual farms.
- **Participatory Action Research** is a methodology which was not developed by the organic farming association nor by their scientists. It is an approach to research in communities that emphasizes both the participation and the action. It seeks to understand landscapes, production systems and farms by trying to change them, collaboratively and following reflection. The most important characteristics of Participatory Action Research are that it is not static but very dynamic and the system or part of the system which is looked at is in full evolution. The drivers of the permanent evolvement are the farmers or other actors. As a consequence, more information is provided on how robust progress and evolution are as the reaction of the actors is already part of the research. Additionally, the understanding of reasons for failures and weak adoption of scientific progress can be better understood. Within Participatory Action Research (PAR) 'communities of inquiry and action evolve and address questions and issues that are significant for those who participate as co-researchers' (Reason & Bradbury 2008). This method contrasts with many research methods, which emphasize disinterested (or positively formulated neutrally objective) researchers and reproducibility of findings. PAR practitioners make a concerted effort to integrate three basic aspects of their work: participation (life in society and democracy), action

(engagement with experience and history), and research (soundness in thought and the growth of knowledge) (Chevalier & Buckles 2013).

In agriculture research, participatory research has not been widely used, but is beginning to be utilized partly in response to a growing number of successes with farmers in developing countries and in countries where agricultural production is not supported by government, i.e. Australia (Aagaard-Hansen et al. 2007). This had particular resonance for organic farming as in facilitating ecological knowledge systems, the emphasis of research should shift from developing technologies for farmers to working with farmers e.g. on-station and on-farm research, as well as participatory technology development (Rolling & Jiggens1998).

8.2.3 Component research versus farming system research

There are many other relevant problems in organic farming that could be solved by conventional research institutes and by industry-based R&D work. Experiments on different components can help understand the mechanisms that cause responses to the different stimuli or stresses. A deeper understanding of the causes and effects that result in outcomes will often require greater patience and more trial and error than a farmer is willing to risk. However, to advance understanding, the experiment station or research center can better bear the costs and put land, labor and other resources towards asking these tough questions. So far, the little interest of the scientific community in organic farming research has economic reasons as organic farming is a niche. In addition, the strict framework of the organic standards is a hurdle not easily taken by science striving for novel quick fixes.

Farming systems research is inherently difficult to design when compared with controlled experiments. To begin with, the design is based on the purpose of the farming system, built around the different crops, animals and people who manage them. As such, the human element cannot be excluded from the farming system, which to some inherently introduces human error and bias. . Farming systems are complex, and with complexity comes chaos. Researchers are not able to fully control treatments and variables, increasing the amount of random variability and error. Research in farming systems is interactive, particularly when conducted by collaborative partnerships of farmers and researchers. Finally, because farming systems research is interactive, it is adaptable.

Because the empirical data collected is based on a specific time and place, it is not possible to completely replicate a given farming system in another location and/or time frame. Results become site-specific and depend on the state of the climate, soils, and ecological pressures of a given season. This does not deny the importance of replication—if anything, more replications are needed with farming systems, not fewer. However, whether a given practice will work on a given farm in a given year is no longer black and white. The picture that is developed becomes more realistic than the yields and returns that occur under 'ideal' conditions which do not reflect the circumstances under which farmers manage their farms. More importantly, the idea that there are global 'optimal' practices for all farms becomes questionable.

Organic best practices are not based on maximizing a single parameter. Performance therefore must be measured by criteria other than a single season's yield and profitability. The ecologically relevant metrics are whether a system is stable and resilient and produces a yield that can be sustained. Sustainable economic performance can be measured by the long-term returns to the farmer's work and equity, rather than short-run profits. As a general rule, a common lens of assessment – e.g. the Best Practice Guideline for Agriculture and Value Chains of SOAAN (2013) should be employed.

In order to provide farm scale data over a time horizon sufficient to judge sustainability, a large-scale and long-term commitment of resources is needed. A greater diversity of sites and specific farming systems is required. While long-term experiments can provide meaningful guides to field studies, replication needs to take place in many locations and across similar and dissimilar production models, before any general conclusions can be made about a given practice. Several years of data are needed to test the systems under different annual conditions. The longer a practice is able to succeed, the more likely it is to be sustainable.

The design of experiments related to soil fertility, fertilizer response or efficacy of various pesticides to control pests, pathogens and weeds often ignores the influence that the components outside of the experiment will have on the results. By contrast, farming systems research looks at all of the factors - natural as well as human – to explain the outcomes produced by a given farming system. As a result, farming systems research is inherently interdisciplinary.

Farming systems are designed primarily for the production of food, fiber, medicines and other products that are useful to people. As such, they are human creations that cannot be viewed in isolation from social structures and economic forces. However, humans are far from the only species that influence the stability, resilience and productivity of agricultural systems. Conventional research institutions, in particular the research centers of the CGIAR, recognized the need to understand farming systems in the late 1960s and early 1970s (Simmonds 1986; Collinson 2000). However, the initiatives related to farming systems research by these centers often remained focused on technology packages based on the production of cash crops with purchased inputs, rather than on self-reliance and local food systems (Pretty 1995). Instead, farming systems research based on ecological principles will look at natural regenerative cycles.

To conclude, many synergies exist between component research and system research in a sense, a hybrid of reductionism and holism in needed.

8.3 Farmer and researchers: A renewed partnership

The gap between organic and non-organic food is due, at least in part, to the reduced capacity to carry out the basic research, development and technology transfer for appropriate innovations which can be used in organic farming systems. This gap has long been recognized and there is a general consensus that the expansion of such capacity needs to be based on an agroecological and farming systems approach. However, building the capacity needed to address the research needs of organic farmers and other practitioners is more complex than capacity building under the conventional model. The partnership between farmers and researchers is inherently different within a systems approach than with components. The way that research is conducted is also different, which means changes are necessary in the education of both researchers and farmers. Carrying out long-term research on an ecological scale requires expanded physical capacity. Finally, an integrated farming systems approach has implications for the diffusion of innovations and technologies that flow from it.

The premise that farmers are not just clients, but are also partners in research creates a different working relationship that involves greater responsibilities for farmers. Farmer-led research predated the existence of universities and governmental research centers in agriculture. Under the farmer-first model, the farmer's needs are the highest priority. Farmers are engaged in the setting of priority and designs of the systems so that they ask the right questions and those questions are rigorously examined in a system that reflects the farmers' actual practices.

After the design of the system, and the rigorous experimentation that follows, farmers can test and possibly validate the results by introducing the best practices resulting from the experiments. Such validation can increase farmer confidence when successful. Failure to validate the results of controlled experiments can also yield useful information, such as methodological flaws, or specific conditions that are not able to be controlled.

In many cases, farmers can be trained and instructed as on-farm researchers, taking on the responsibility of the timely work on the field and with the animals, collecting samples and data, and securing part of the project management. To be a farmer-scientist is not only interesting, it also opens access to improved farm income. Many of the farmers involved in on-farm activities become farm advisors later on and help to spread knowledge among their colleagues. Farmers inherently deal with integrated whole systems and still need to be conversant in the different disciplines in order to make management decisions. The use of farmers as research associates, can add much-needed integrative perspective. However, the farmers require training to understand the methodology and know how to collect the data. Because of the opportunity cost of the farmer's time used in designing, managing, collecting data and analyzing, farmers may need to be compensated for that skilled work.

Filling out the capacity will require the enrolment of farm land and equipment that is in organic production. The most important test to a farmer is how well a practice or system performs under actual farming conditions. To enlist the cooperation of organic farmers will require a building of trust, a common understanding, a shared vision and incentives. Farmers will need to be able to participate in the research as equal partners. That is not to say that farmers are sufficiently trained and prepared to be equal partners in all cases. Farmers need to be educated and conversant in the scientific methods used to carry out the experimental work being conducted on the farm.

Farmers also have a role in information dissemination. Other farmers are often the primary source and most reliable source of information on the performance of innovative technologies. The follow-through on research in the form of technology transfer and diffusion is often neglected. Many promising research findings are not applied due to a lack of follow-through.

Researchers' roles, on the other hand, are not diminished by the new partnership. A rigorous examination of different systems is beyond the capacity of most farmers. Even within the context of farmer-first, researchers provide the needed capacity to design, carry out, analyze and publish the results of the research. Conducting on-farm research has several additional factors not present in experiment station research. The sites are often remote and scattered, requiring attention to logistics. Farmers are focused on the management of their operations, in most cases to make a profit. Peak demands for farm labor often conflict with the research schedule.

A scientific revolution requires a new generation of scientists. Institutions of higher education in agriculture will need to develop curricula to create a multi-disciplinary research environment. While specialization will still be needed, specialists are expected to be able to communicate their findings to specialists in other fields. An assembly of multi-disciplinary teams requires that team members are able to share knowledge through a common frame of reference. Developing the human capacity to conduct and disseminate the results of multi-disciplinary research requires a restructuring of the curriculum for training agricultural scientists, a methodology that bridges the different disciplines and draws from their collective strengths, and a system that rewards collaboration, creativity and performance.

Thus, multi-disciplinary team building will require that research institutions, in many cases, change their missions and structures. As the pursuit of science has become more specialized, it has also become more fragmented, with a lack of a common frame of reference, methodology and even language used by the different disciplines. Weak multi-disciplinary research takes place on a number of projects, where the different disciplines work independently, and the results are accumulated separately. A more intensive approach requires that the different disciplines work together from the beginning and throughout the project, with interaction in design, data collection, analysis, and final presentation.

Broadening education in the various agricultural disciplines, when the trend in many fields is towards increased specialization, will undoubtedly face departmental backlash in many universities. Breaking down the walls between—or even within—academic departments will require more than simple restructuring. New methodologies are needed to answer questions and test alternative hypotheses that do not produce simple 'yes/no' results. These methodologies allow researchers to make inferences regarding the quality of ecosystems and go beyond simple quantification of populations or biomass. Social scientists seem to be more willing to embrace broader types of analyses compared to physical scientists – the two kinds of studies need to be integrated more, with bridges built between them. At least initially, holistic and qualitative methods will need to co-exist with quantitative ones. Basic research in systems, genetics, and population dynamics can complement applied research to develop hypotheses and test the sustainability of agro-ecosystems and their ability to respond to different environmental stimuli and stresses, such as climate change. Similarly, questions of animal health and welfare are as often qualitative in nature as they are quantitative (Lund & Algers 2003).

Research institutions will not be restructured unless there is an incentive to do so. The restructuring needs to be understood accepted and broadly supported within the research community in order to be successful. The intrinsic rewards of working on the intellectual challenges of systems research and the recognition by peers, policymakers and practitioners for ground-breaking work can help move the institutions to address the broader issues of sustainability in a more holistic way. Support for a research agenda that benefits the public through open source technologies developed for long-term economic, social and environmental sustainability will need to come from a range of stakeholders. A reallocation of direct funding for relevant research is necessary, but not sufficient for organic agriculture to grow and prosper. Renewed and reformed partnerships are needed—between farmers and researchers, between the public and private sectors, and among all who care about the future of our food systems.

Farmers can influence research institutions to deal with whole systems and addressing their needs. By organizing and making their voices heard as the main clients of these institutions, they can influence key policymakers who set and implement the research agenda.

Policymakers - legislators, administrators, foundation directors and others who set, fund, implement, and evaluate the agricultural research agenda - may be influenced by a number of factors themselves. It is especially important to address directly the questions on whether organic agriculture is practical, feasible, and successful. While the models of success offered are not all exclusively organic, they have a large organic constituency and are consistent with organic principles.

8.4 Models for success of farmer-researcher partnerships

Building successful partnerships between farmers and researchers requires organizational ability and a coordinated effort. Fortunately, some functional networks are in place that can be used as models. These include participatory plant breeding clubs, farmer innovation networks, and farmer-to-farmer exchanges. The existing networks are not all exclusively dedicated to organic, but organic farmers participate in them.

8.4.1 Participatory plant breeding

With the growing concentration of the seed sector, and its control by biotechnology companies that are focused on genetic engineering and the control of the intellectual property of new varieties, increasing numbers of farmers throughout the world are turning to participatory plant breeding as a way to develop varieties that are suitable for their growing conditions. Organic farmers are active participants in organized plant breeding associations throughout the world. The European Consortium for Organic Plant Breeding ECO-PB[54] is an organization based in Europe that promotes participatory plant breeding for organic farms. The EU consortium, SOLIBAM, provides an overall view of such on the ground activities[55]. Their website also shows examples from different parts of the world. The number of participatory breeding activities involving farmers, coached by scientists or practical breeders, has accelerated in the last ten years.

8.4.2 Farmer innovation networks

Throughout the recorded history of agriculture, farmers have been known to share information on innovative technologies. Changes in information technology through the Internet and cell phones have decreased the cost of transferring that knowledge and made it more readily available. This is true even in the poorest developing countries, where mobile phone have become one of the most important tools used by peasants and small-holders. Formal and

[54] www.eco-pb.org

[55] www.solibam.eu/modules/addresses/viewcat.php?cid=1

informal sharing of information on innovative farming techniques, have long been a feature of rural life. Mobile phones and the information and services provided by them are becoming an innovative tool for farmer networks. As an example, the program iCow[56] offers, via text messaging, regular information to farmers on prices, demand and supply, technical advice, etc.

Practical Farmers of Iowa (PFI) was established in the 1980s to deal with the economic crisis in the Corn Belt of the US. PFI is a farmer-led, member-driven non-profit organization, with a mission to advance profitable, ecologically sound and community-enhancing approaches to agriculture through farmer-led investigation and information sharing (Practical Farmers of Iowa 2014). Two more recent grassroots efforts, with very different histories and backgrounds serve as models for decentralized innovation and technology transfer. One is Farm Hack, a project of the National Young Farmers Coalition. In many ways, Farm Hack is an application of the hacker culture epitomized by Steve Jobs and Stewart Brand. Technology is open-sourced and developed in a wiki-like environment, and ideas are swapped by farmers attending workshops.

The other is Syprobio, a EuropeAid funded research and development project to produce farmer-proposed innovations to be jointly tested by farmers and researchers. Syprobio works with farmers in Benin, Burkina Faso, and Mali to identify production challenges and promising solutions for cotton-grain rotation systems. The project's objective is to produce practical and scientifically tested technological innovations and approaches relevant to all West African cotton-cereal farmers through applied research. Farmer groups identified innovations based on their own ideas and experiences in five key areas: soil fertility, plant health, seeds, crop management, and socio-economic (Nicolay & Fließbach 2012). Farmers working cooperatively through associations can invent and implement technologies designed specifically to provide food security and adapt to climate change. Innovations that are invented and tested jointly by farmers and researchers are presumably more likely to be adopted than those invented and tested only by farmers or only by researchers. Such jointly developed technological innovations are expected to result in more robust agricultural and food systems that will improve food security. The services and information are also delivered via text messaging and mobile phones.

8.4.3 Stakeholder engagement

These are not the only innovation networks involving organic farmers. It is also possible to have approaches that are more inclusive of other stakeholders. For example, the Technology Platform for Organic Food and Farming Research (TP Organics) also holds promise to develop innovations that benefit society. As stated in the introduction, all stakeholders need to be engaged in the transformation. The agenda to promote a more sustainable agriculture has grown as the political power of farmers has been diminished. One reason is that stakeholders other than farmers have taken an interest in the research agenda. Non-farmer support is essential for the continued growth of the organic sector. The greatest expression of non-farmer support is through consumer preferences and the demand for organic food.

Organic agriculture continues to receive public support as a more environmentally sound practice. Many of the innovations that emerge from organic agriculture research are public goods that cannot be privatized. These include a range of ecosystems services, reduced external input use and social innovations. While farmers have developed and applied appropriate technologies on their own, a strategic multi-stakeholder approach is more likely required for such innovations to reach their full potential (Schmid et al. 2012).

[56] www.icow.co.ke/

9. The knowledge chain

9.1 State-of-the art

Access to knowledge and the exchange of knowledge are key problems identified by many organic farmers and by the other actors of the organic food chain. Not only is the knowledge about techniques and codes of conduct insufficient, but also, the information on the quantities of organic foods produced, distributed, and sold in different parts of the world. This makes it difficult for a business to develop the markets rapidly and increases insecurity and fraud risks.

A great variation of knowledge and access exists from country to country and region to region. Countries with strong and very active organic farmer associations are for example Switzerland, Denmark, Germany, Austria, Italy, Estonia, the Czech Republic and Sweden. These organic farmer associations are important platforms of knowledge exchange and they actively promote information exchange, learning, and capacity building. Advisory and research services strongly support these farmer-driven activities. Similarly, active learning and information exchange capacities exist in Canada, United States, Australia, and in a few Latin American, African, and Asian countries.

In many parts of the world, acquiring knowledge about organic agriculture is fostered by hundreds of national or regional organic associations, project co-operations between countries, IFOAM activities, regional IFOAM groups, and also by activities of UN organizations. Many of the regional and national farmers groups are on different continents

In Europe, capacity-building in organic farming has been funded in the different Research Framework Programmes; the first project started in 1992. These applied research projects with a strong component in dissemination have had a positive impact on access to knowledge and have accelerated the sector's development.

9.2 Existing important on-line learning and information portals

Information is already available on different websites and databases. Much of the information is written for scientists or farm advisors, rarely for practical farmers.

- The biggest on-line portal is the knowledge and literature archive Organic E-Prints[57] with 15'500 entries, more than 90 percent of which are still for Europeans although the archive is promoted globally. The entries are written in languages such as English, Danish, German, Spanish, French, Italian, Portuguese and some other languages.
- The archive BIOBASE[58] , based in France is also important. It is all in French.
- The SINAB database provides information in Italian[59]. SINAB is the national information system for organic agriculture.
- For German-speaking farmers, the website of the Federal Organic Farming Scheme and Other Forms of Sustainable Agriculture[60] provides information on 850 (research) projects funded by the German government.
- The Organic Agriculture Center of Canada provides information on their website[61] in English and French.
- EXTENSION is America's Research-based Learning Network [62]

[57] www.orgprints.org
[58] www.abiodoc.com
[59] www.sinab.it/
[60] www.oekolandbau.de
[61] www.organicagcenter.ca/
[62] www.extension.org/pages/25242/webinars-by-eorganic#.VB8G-P4cQdU

- One of the biggest on-line shops for technical guieds, brochures, checklists, and other informative materials is the FiBL shop[63]. The material is available in the following languages: German, French, partly Italian and English.
- Films, videos, and discussions about organic agriculture and organic themes can be watched at the FiBL YouTube[64] channel. Many of the films are practical demonstrations of farmer techniques, new equipment and so on.
- For organic farming in Africa, the African Organic Agriculture Training Manual[65] provides comprehensive information in English, and some party are also available in Swahili.
- Swiss organic farmers will find most comprehensive practical information in four languages (German, French, Italian and Romansh) in bioaktuell[66].
- In India, the Organic Farming Association of India [67] makes information available to farmers.

9.3 Bottlenecks

The bottlenecks for the availability of, and access to knowledge on organic farming systems are the same everywhere in the world:

- The size of the research community is correlated with the intensity of the knowledge creation and exchange; the same is true for the size of the markets and the position of organic farming in the national agricultural policy;
- The degree of organization and cooperation among organic farmers is essential for a better knowledge exchange;
- While the international communication between scientists has become easier because of the dominance of English, the exchange of knowledge on farmer level is exacerbated by language barriers. Knowledge can only be spread by national and regional languages;
- The attitude of the scientific community, the administration and the policy towards traditional, tacit or organic knowledge is still dismissive.

Many of the ways in how knowledge creation, access to knowledge and mutual learning among farmers and other actors can be facilitated are described in chapter 8.2. They encompass the different qualities of knowledge and different ways of acquiring and improving them further. The first – and not so expensive – steps are interviewing knowledgeable farmers, farmer groups, and communities as well as planning jointly simple on-farm experiments where the fields, the labor and the farmers' machinery are used.

9.4 Potential activities of TIPI in knowledge exchange

The activities that TIPI could realistically provide are:

- Making good examples of farmer-driven innovations and of international cooperation among farmers more public and known from all climatic regions of the world;
- Providing and permanently updating access to all archives where results from research and farm surveys are accessible (see chapter 4.3);
- Membership-based knowledge exchange: A comprehensive data and information gathered from all members of TIPI permanently up-dated[68] resulting in an inventory of all research programs, institutes, and scientific literature;

[63] www.fibl.org/de/shop/startseite.html
[64] www.youtube.com/user/FiBLFilm/featured
[65] www.organic-africa.net/training-manual.html
[66] www.bioaktuell.ch
[67] www.ofai.org

- The consolidation of all existing data in one archive (e.g. organic E-prints).
- Motivating farmers associations, research institutes and advisory services to co-produce practical leaflets and brochures, as well as teaching material. Examples of such co-productions are the FiBL technical leaflets which are jointly written by all major organic farming associations in Switzerland, Germany, Austria and Luxemburg;
- As a mid-term vision, TIPI could produce thoroughly summarized and written practical state-of-the-art knowledge on different and most important fields and themes in international organic agriculture. Additionally, cutting-edge innovation from research could be reported on in a way that it motivates farmers to learn more about it;
- Also as a mid- or long-term option, TIPI could initiate, critically accompany and revise an international farmer Wikipedia with entries made by farmers all around the world. It would be a compendium of newly gained farmer experience, tacit knowledge traded in farmer communities or families, results from on-farm research, etc.

[68] www.organic-research.net

10. Next Steps: Towards an action plan

10.1 The role of TIPI

The Technology Innovation Platform of IFOAM seeks all stakeholders - farmers and other practitioners, industry, policymakers, and civil society - to engage in a dialog where they can find common ground. The extent to which the agenda for organic agriculture research is farmer-driven will depend on the organizational ability and political will of farmers to articulate their research needs. Farmers will continue to innovate as they always have, and farmer-to-farmer technology transfers are expected to remain the main way that innovation diffusion takes place.

The objectives of TIPI are to intensify multi-actor cooperation, to better communicate the powerful ideas and potential solutions of organic research and organic practice to the decision makers and the public and to better advocate for the positive role research on organic food and farming systems can play in order to meet the global challenges.

TIPI will need to engage farmers where they gather. It is most important to recruit the organic farmers' organizations to participate as equal partners with the research institutions. The two distinct cultures of farmers and researchers will require that a bridge be built. Researchers respond to a different set of incentives than do farmers. Each side needs to understand and respect the other's situation.

Similarly, the needs of other end users need to be addressed. The growing volume of production and trade in organic products needs to be looked at for bottlenecks between the farmers and the consumers as well. Input suppliers and manufacturers are key stakeholders in the innovation process and have a place at the TIPI table.

A key objective of TIPI is that research in organic food and farming systems generate products relevant to a greater number of end-users and that it be useful not only to organic and other farmers, businesses, consumers and stakeholders, but also to civil society and to policymakers.

Through its diverse stakeholders, TIPI is characterized by multiple perspectives and has access to a large pool of expertise. These aspects were brought together in a comprehensive analysis of research and development priorities

10.2 TIPI's action plan

The Implementation Action Plan will define the next steps to be taken by TIPI towards empowering organic farmers through both social and technical innovation.

In order to expand global organic agriculture research, the following actions will be taken:

- Motivate as many local, national and regional organic associations to become party to the Technology Innovation Platform of IFOAM (TIPI);
- Ask and convince scientific institutes and groups – both organic and agroecological - to engage in TIPI as members;
- Ask as many civil society groups, NGOs, public administrations and governmental organizations as possible to become members or supporters of TIPI;
- Further invest in the website platform Organic Research[69], as an attractive, lively and increasingly visited platform for international organic research. Permanently increase visits and downloads from the website;
- Set-up a board of TIPI reuniting the different stakeholders representing the membership;
- Establish a database of the most important bottlenecks of the further development of organic agriculture worldwide (evidence-based and with quantifiable economic, social and ecological benefits);

[69] www.organic-research.net

- Write policy briefs for IFOAM and empower IFOAM to argue on the basis of scientific facts and findings in favor of organic agriculture in international debates, negotiations, and treaties;
- Establish a database on the best experts for all themes of organic agriculture worldwide;
- Enable communication on farmer driven innovation with the help of a Wikipedia solution;
- Publish case-studies on farmer-driven innovation within the organic movement;
- Bring stakeholders to scientific conferences of IFOAM and ISOFAR;
- Raise funding for global discussions on the future pathways of organic agriculture (Organic 3.0);
- Organize workshops and sections at international or regional conferences – both scientific and political nature – on Organic 3.0 and other themes related to innovation and the future development of organic agriculture.
- Set-up an international internship scheme for students working on organic farms and at research groups all over the world

The Action Plan shows the way forward for the Technology Innovation Platform of IFOAM. Although it lists activities for the present time, it will be moulded in an operational work program of the TIPI Council once the entire paper is adopted by the membership. The work program will be regularly discussed with the World Board of IFOAM. The TIPI Council will report back to its membership about the progress of the work program mainly by regular news and articles on the website Organic Research[70].

[70] www.organic-research.org

11. References

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