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Diversity of European Farming Systems and Pathways to Sustainable Intensification

by Rolf Meyer, ITAS

European agriculture is confronted with a number of ongoing and new challenges. At the level of crop production, sustainable intensification is proposed as the way forward. Two different pathways for improvement of crop production are grouped under the umbrella of sustainable intensification: high-tech approaches and agro-ecological approaches. Because of the high heterogeneity of agriculture in the EU, these approaches are not equally appropriate for all European farming systems and are associated with specific opportunities and limitations. Agro-ecological approaches of sustainable intensification demand not only changes at farm level but also include a transition of the currently dominating technological paradigm and development trajectory.

Die Landwirtschaft in Europa muss sich einer Reihe von bereits bestehenden, aber auch neuen Herausforderungen stellen. Im Bereich der landwirtschaftlichen Produktion wird eine „nachhaltige Intensivierung“ als notwendige Weiterentwicklung vorgeschlagen. Unter diesem Begriff werden zwei verschiedene Wege zur Verbesserung der landwirtschaftlichen Produktion diskutiert: hochtechnisierte Ansätze und agrarökologische Ansätze. Aufgrund der hohen Heterogenität der Landwirtschaft in der EU sind diese Ansätze nicht für alle europäischen Landwirtschaftssysteme gleichermaßen geeignet. Sie sind jeweils mit bestimmten Chancen und Einschränkungen verbunden. Agrarökologische Ansätze der nachhaltigen Intensivierung erfordern nicht nur Veränderungen in der Praxis der landwirtschaftlichen Betriebe, sondern auch einen Wandel des gegenwärtig vorherrschenden technologischen Paradigmas und Entwicklungspfads.

1 Introduction

Since the 1950s, the intensification of European agricultural production was driven by farm mechanisation and the strong increase in external (purchased) input, increasing the dependency on

non-renewable resources such as fossil fuels. This was accompanied by a huge simplification of agricultural systems at all levels, from field and farm to landscape and region. Agricultural research and development has led to the availability of larger machines and buildings which are not only more efficient in themselves but strongly encourage the exploitation of economies of scale, i.e. larger fields and farms, resulting in structural changes in agriculture (Davidova et al. 2013, p. 30). Environmental impacts of specialisation and increasing labour productivity through simplification of crop management and greater use of external inputs include water contamination, rising greenhouse gas emissions, soil degradation, and loss of biodiversity. As an alternative, it is proposed that opportunities should be explored to capture ecological interactions among different land use systems to make agricultural production systems more efficient at cycling nutrients, improving soil quality, preserving natural resources and the environment, and enhancing biodiversity (Lemaire et al. 2013).

The trajectory of technological development, coupled with greater market orientation of agriculture over time, is driving a process of structural change towards fewer and larger farms. Despite this ongoing process, a wide variation in farm structures across the EU-27 is maintained. With the accession of the New Member States, farming in Europe is carried out primarily on small-scale farms. Consequently, in recent years small-scale farms have received increased attention in the political debate, recognising the role they play in rural areas and the need to improve their economic and social conditions (EC 2011).

The United Nations declared 2014 the “International Year of Family Farming”. Family farming dominates EU agriculture,¹ with a vast diversity in farm size, labour input and production approaches. The European Commission organised a conference in November 2013 entitled “Family farming: A dialogue towards more sustainable and resilient farming in Europe and the world” with around 500 participants (EC 2013a), followed this year by a number of events in Europe and worldwide. Part of the challenges family farming is confronted with is to increase production with reduced inputs and environmental

impacts. Sustainable intensification is proposed as an answer to this challenge.

2 The Concept of Sustainable Intensification

A prominent starting point in the scientific and policy development of the sustainable intensification concept was the Royal Society (2009) report “Reaping the benefits”.² Therein, sustainable intensification is understood as producing more food from the same area of land while reducing the environmental impacts (Godfray et al. 2010). The concept focuses on crop production, chiefly arable crops (Garnett et al. 2013). The need for sustainable intensification is based on the recognition of the following challenges:

- The global population growing to some 9 billion people by mid-century and the nutrition transition associated with wealth growth will lead to remarkably increased food demand. But the necessary extent of increased future food production is challenged (Grethe et al. 2011; Tomlinson 2013). Nevertheless, an overall increase in production is regarded as essential (Garnett et al. 2013).
- Yields on existing agricultural land should be increased instead of expanding the area of agricultural land to increase gross production because the latter would result in losses of vital ecosystem and biodiversity services (Royal Society 2009, p. 7).
- Agricultural production per unit of non-renewable inputs and impacts upon ecosystem services must be improved. It is recognised that there is a need for agricultural systems that achieve the necessary levels of production with substantially lower reliance on fossil fuels (Royal Society 2009, p. 47). Therefore, sustainable intensification is also about relative efficiencies in food production with respect to environmental resources and impacts (Fish et al. 2014).
- Since the 1990s, growth rates of yields and productivity, especially in industrialised countries, have slowed down (Alston et al. 2009). The 2007/08 food price spike could be the beginning of a period of rising and more volatile food

prices, indicating mismatching between food demand and production (Godfray et al. 2010).

The proposed sustainable intensification is not without controversy. Major critical arguments are that the goals of intensification and sustainability are considered to be incompatible; a marriage of sustainable agriculture and intensive farming could only result in a continuation of industrialised agriculture which is accompanied by environmental harm and reductions in sustainability. Secondly, sustainable intensification would prioritise market-orientation as crucial to improving the situation of small-scale farmers, and nearly all proponents would also heavily promote liberalised trade. Therefore, the vulnerability of poor farmers and poor countries would increase. And thirdly, the openness with regard to technological approaches would open the door to any technology, including those that are specifically adapted to work in large-scale commercial, intensive agriculture, to be defined as “sustainable” (Collin/Chandrasekaran 2012; review by Garnett/Godfray 2012).

In reaction, Garnett et al. (2013) emphasise that sustainable intensification does not mean business-as-usual food production moderated by marginal reductions in environmental impacts. On the contrary, it demands radical rethinking of food production to achieve major improvements in sustainability. They propose a more sophisticated definition, working out the underlying premises. Additionally, important interfaces with other major food-system goals and policy areas are discussed (ibd.). Overall, the concept of sustainable intensification is still evolving, now also taking into account social and economic beneficial conditions.

The statement “No techniques or technologies should be ruled out” (Royal Society 2009, p. ix) leaves open the question of priorities and most preferable technology options. A distinction of different pathways for improving crop production is a first step to understand better the diversity of possible approaches. Overall, improved crop production under changing environmental conditions can be achieved through improving yield potential and safeguarding yields by plant breeding,³ and/or introducing upgraded technologies and management systems of crop production. The latter includes different objectives such as reducing yield gaps, improving input use effi-

ciency, increasing the site-specific yield potential (Meyer et al. 2013, p. 41).

When identifying technologies or crop production systems which can contribute to achieving these objectives, the diversity of European farming systems must be taken into account. This is necessary because the need, the suitability and the impacts of technologies and management systems of crop production depend on the specific configuration of the respective farming system.

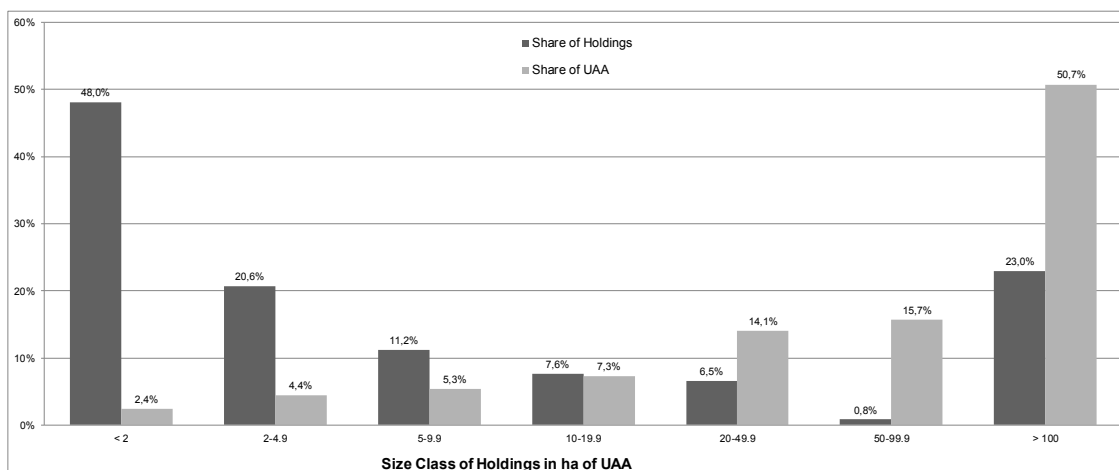
3 Diversity of European Farming Systems

European agriculture is characterised by high heterogeneity in terms of agro-ecological conditions and constrains, economic potential and agrarian structural conditions, production intensity and environmental performance, and social situation and cultural environment. As an example, Figure 1 shows the distribution of farms and their share of total agricultural area by size class of agricultural holdings. The farming system approach identifies groups of individual farms with broadly similar production systems and practices, enterprise patterns, household livelihoods, resource bases, and external conditions. Depending on the objective and scale of analysis, a farming system can encompass a few dozen to many millions of farms (Dixon et al. 2001, p. 9).

Farm size, production intensity, specialisation, and integration in food chains are criteria used to set up a simplified scheme of farming systems in the EU.⁴ As a result, the following farming systems were identified for the EU-27 (Meyer et al. 2013, pp. 11–12):

- *Extensive small-scale, semi-subsistence farming*: Over 40 % of all holdings in the EU-27 produce food for the family and relatives, only surplus goes to the market. This farming system is only of importance in New Member States and Mediterranean countries, with Romania being the most important. Small-scale farms apply extensive production methods, partly without external inputs. Only a third of all semi-subsistence farms operate in less-favoured areas. Semi-subsistence farms have a share of 7.6 % of total utilised agricultural area in the EU-27 (21.6 % in the New Mem-

Fig. 1: Share of agricultural holdings and of total agricultural area by size class of holdings in the European Union (EU-28) in 2010



UAA = Utilised Agricultural Area

Source: EC 2013

- ber States) and 3.9 % of total standard gross margin in the EU-27 (20.1 % in the New Member States) (Davidova 2011).
- *Extensive farming in less favoured areas:* 54 % of all farms in the EU-27 are located in less-favoured areas. Less favoured areas cover over 50 % of the total agricultural area in Austria, Czech Republic, Finland, Greece, Hungary, Ireland, Italy, Malta, Portugal, Slovakia, Slovenia, and Spain. Farming in less favoured areas is characterised by extensive production systems respectively traditional land-use systems, often based on grazing livestock. But cereal production is also important in less favoured areas.
- *Medium intensive, mixed farming systems:* Mixed farming systems combine crop and livestock production in different ways and are characterised by a relatively low specialisation level, in contrast to specialised farming systems such as pure cropping or poor intensive livestock production systems, which have become dominant since World War II (Lemaire et al. 2013). Around 13 % of all farms in the EU-27 are mixed farms. Above-average shares of mixed farming systems (with over 10 % of the total agricultural area) can be found in Belgium, Czech Republic, Denmark, Germany, France, Latvia, Lithuania, Hungary, Poland, Portugal, Romania, Slovenia, and Slovakia.

- *Intensive, larger-scale crop farming:* The regions with concentrated cereal and specialised crop production are at the same time the areas with a high share of larger-scale farms. Larger-scale farming, based on high external inputs, is concentrated in low-land areas with high productivity. High input farm types are predominant in the Netherlands, Belgium, South-Eastern England, Northern France, North-Western Germany, Northern Italy, and Northern Greece.
- *Large-scale corporate farming:* Large-scale corporate farming comprises production cooperatives and various types of farming companies. Overall, they are the result of the transition process in Central and Eastern Europe since 1990. In 2010, corporate farms (where the holder is a legal entity) comprised 2.4 % and group holdings (owned by a group of natural persons) 0.6 % of all farms in the EU-27 (EC 2013b). Corporate farms held over 50 % of the total agricultural area in Bulgaria, Czech Republic, and Slovakia. Large corporate farms tend to specialise in cereals and oil crops.

This typology of EU farming systems is centred on crop production. Further important farming systems in the EU are intensive horticulture and intensive livestock farming systems, which occupy only a small part of the agricultural area but are important in economic terms.

4 Pathways to Sustainable Intensification

A broad spectrum of technologies and management concepts for crop production can be considered for achieving the objectives of sustainable intensification. This chapter assesses overall approaches to crop production systems and their appropriateness for the EU farming systems.

4.1 General Approaches

Improving input use efficiency is currently a major objective in intensive agriculture. The most prominent example is precision agriculture (PA) – the spatially variable management of crop production. The aim is to apply the right treatment in the right place at the right time by taking into account in-field variations of soil and crop. PA applications can be found in all the main stages of the crop production process, such as nutrient application, manure application, weed control, disease management, and water management. The manifold PA approaches are in different stages of development, from research and demonstration to commercial availability, and they use various new or advanced technologies such as satellite-supported positioning systems, yield mapping, remote sensing, sensor technologies, geo-information systems, various rate application techniques, and decision support systems (Meyer et al. 2013).

Information-based crop management (also called “digital agriculture”) implies a transfer of standardised management routines and farmers’ knowledge through to automated data collections and computerised decision support systems. The dependence on support suppliers tends to be increasing. Precision agriculture in most cases only leads to restricted yield increases, in a range up to 5 %, due to its adoption mainly in highly productive areas with intensive crop production. Overall, precision agriculture does not call into question high external inputs and specialisation in crop production, but intends to make these production systems more effective and environmentally friendly (Meyer et al. 2013).

In contrast, various other crop production systems aim to use and *improve the agro-ecological conditions of crop production (site-specific yield potential)*, with maintenance and enhance-

ment of soil fertility being an important issue. Conservation agriculture,⁵ system of rice intensification,⁶ agroforestry,⁷ integrated crop-livestock systems, and organic farming have in common that they formulate fundamental principles and highlight key elements. When it comes to concrete application, the principles have to be translated on a case-by-case basis into production technologies and farmer practices adapted to local conditions (Meyer 2010). This system-based approach tries to address the specific agro-ecological, social and economic complexity of farms at their specific location, including local and indigenous knowledge and participatory approaches. In this context, organic farming has a specific status as a legally defined production method of food with international standards, labelling and separated markets.

High potential for increasing yields is reported for conservation agriculture and for the system of rice intensification in developing countries. There is a mixed picture for organic farming, with high yield increases for low external input systems in developing countries and yield reductions in developed countries. Mixed systems of agroforestry and integrated crop-livestock farming have the potential to be more productive (Meyer et al. 2013).

Agro-ecologically oriented management systems imply deeper changes in the current conventional crop production systems (Meyer et al. 2013). Diversified farming systems at farm and landscape levels aim to include functional biodiversity at multiple spatial and/or temporal scales in order to maintain ecosystem services that provide critical inputs to agriculture, such as soil fertility, pest and disease control, water use efficiency, and pollination (Kremen et al. 2012). In developed countries with already high land productivity, the challenge is to replace the reliance on external inputs by re-establishing ecosystem services generated in the soil and the landscape, while maintaining high, stable productivity levels (Bommarco et al. 2013). Examples for such technologies and practices for sustainable intensification are seed mixtures, intercropping, diversified crop rotations, plant associations, green manure and permanent organic-matter soil cover, biological pest control, integration of crop and livestock production, hedgerows and/or buffer strips. It is important to notice that improvements do not result from single measures but from

locally adapted combinations of elements. Higher input efficiency is here more an impact from pursuing the goal of improving site-specific yield potentials and reducing yield gaps.

4.2 Sustainable Intensification in the EU Farming Systems

The overall approaches to sustainable intensification are associated with different opportunities and limitations, depending on the farming system they are applied to.

The farming system *extensive small-scale semi-subsistence farming* is characterised by low or no use of external inputs and very limited financial resources. This represents a good starting point for agro-ecological approaches but does not fit with expensive high-tech approaches such as precision agriculture. The production of certified organic food is generally not feasible due to the missing integration into food chains, the small surplus amounts and the costs of certification. But elements of organic crop management can well be used for sustainable intensification. Semi-subsistence farms partly use agroforestry systems and are often integrated crop-livestock farms, which offer further potential for sustainable intensification.

Small-scale semi-subsistence farming plays an important role as part of social safety nets and in the provision of ecosystem services but is more or less neglected by agricultural policies. Direct payments are generally not available due to farm and plot size thresholds, and measures addressed to semi-subsistence farming from Pillar II of the Common Agricultural Policy (CAP) are given low priority and do not fit well (Davidova 2011; Csaki/Forgas 2009, p. 20). Development concepts are still oriented towards the changes in the farm structures in the old EU from the 1950s to the 1970s, with the abandonment of small-scale farming (Souchon 2014). But in the face of restricted employment perspectives outside agriculture such a development is unlikely and would be associated with high social costs. Therefore, a reorientation of research, extension and support services is needed to achieve sustainable intensification adapted to this farming system and sustaining the benefits of small-scale farming.

Less favoured areas are characterised by relatively low land productivity, and *extensive farming in less favoured areas* is dominated by extensive production systems. Organic farming in Europe is concentrated on extensive farming systems because the agronomic and economic barriers for conversion are relatively low. When using best organic management practices, the yields are close to conventional yields. Organic yields are often low in the first years after conversion and gradually increase over time due to improvements in soil fertility and management skills (Seufert et al. 2012). Organic farming takes part in the overall yield development, but productivity could be further improved.

Traditional agroforestry systems have survived in a number of less favoured areas so that there are chances for a revival of agroforestry. Besides the important extensive livestock systems based on grazing, integrated crop-livestock farming is also of relevance (Meyer et al. 2013). This provides additional potential for sustainable intensification. The introduction of conservation agriculture in Europe is lagging behind, but conservation agriculture is highly relevant to less favoured areas due to the risk of soil degradation by erosion.

Research and development, on-farm testing and demonstration, extension services, and farmer-to-farmer learning for improving crop management in less favoured areas are still weak in Europe. For extensive farming in less favoured areas, the design of agro-environmental support measures by the Member States within Pillar II is crucial for sustainable intensification with agro-ecological approaches.

Medium intensive, mixed farming systems are by definition integrated crop-livestock farms which are mostly located in intermediate areas (Bonaudo et al. 2013). They range from extensive farms with traditional land-use systems to modern farms with intensified grassland and fodder crop production. There is ongoing economic pressure to specialise, and support measures from Pillar II of the CAP still favour investment in specialisation. This tendency is combined with farm and land abandonment on the other hand. Nonetheless, integrated crop-livestock systems have the potential to improve economic performance (e.g., by reducing sensitivity to fluctua-

tions of input and output prices) and environmental effects (e.g., by reducing chemical inputs, improving nutrient cycling, increasing diversity of farm land use) (Ryschawy et al. 2012).

Overall, the prospects of agro-ecological management systems are good. Mixed farming is a key element of many organic farms so that the conversion potential is in many cases high. Conservation agriculture and agroforestry can be integrated in mixed farming, restricted by the already existing complexity of farm operations. In contrast, the relevance of precision farming is low due to the relatively high investment costs and learning requirements (Meyer et al. 2013).

The farming system *intensive larger-scale crop farming* is located in areas with high land productivity. It has high potential for the application of precision agriculture with the aim to enhance input use efficiency and to reduce production costs. To date, precision agriculture techniques in Europe have mainly been adopted in highly productive areas of Denmark, France, Germany, and United Kingdom (Meyer et al. 2013). Their wider successful application depends on progress in the development of scientifically and economically sound decision support systems to handle the increasing amount of data and complexity of management decisions.

In intensive crop farming systems, the maintenance and enhancement of soil fertility is becoming of increasing importance. Here, a suitable approach is conservation agriculture. For a wider spread of conservation agriculture to be achieved, the following requirements must be met: change of mindset in order to replace long-established conventional soil cultivation by no-tillage, change of weed management, and increased profitability of alternative crops for diversified crop rotations (Meyer et al. 2013).

The competitiveness of organic farming is relatively low, and higher conversion rates can only be expected when new marketing channels with attractive price premiums can be opened up and/or public support schemes are improved. Silvoarable agroforestry has vanished in intensive crop farming due to the impediment of highly mechanised cultivation and unfavourable economic incentives. Barriers to the introduction of modern agroforestry systems are relatively high. Over the last

decades, larger-scale crop farms have abandoned livestock production. The potential for reintegration of crop and livestock production is limited by the absence of operational structure and management skills for livestock in specialised crop farms and large capital requirements for change (Meyer et al. 2013). Overall, agro-ecological approaches to sustainable intensification require major changes in crop management and farm organisation and will only take place in intensive, larger-scale crop farming with substantial incentives.

Large-scale corporate farms specialise in capital-intensive production and in products with low labour monitoring requirements. Therewith, they have a comparative advantage and mostly specialise in cereal and oilseeds production (Ciaian et al. 2009). In transition countries with a high share of large-scale farming companies, labour productivity growth is very strong due to high reductions in agricultural employment (Swinnen/Vranken 2010). In the case of large-scale corporate farming, economics of scale are favourable for the introduction of precision agriculture. Potential barriers to implementation are missing management skills and the associated workload.

The picture is ambiguous for agro-ecological approaches. Conservation agriculture is a relevant approach for maintenance and enhancement of soil fertility. Mindset and lower profitability of diversified crop rotations can be barriers. Large-scale corporate farms have successfully converted to organic farming. But conversion implies major changes in farm organisation and marketing. Hence, adequate transformation capacity is a prerequisite. Agroforestry is at odds with mechanisation and specialisation. Modern forms of agroforestry systems are therefore not easy to introduce. In parts, corporate farms are integrated crop-livestock operations. Integration of livestock production in corporate farms specialised on crop production is limited by high investment costs and missing management skills for livestock (Meyer et al. 2013).

5 Outlook

A recent study of the International Food Policy Research Institute (IFPRI) assesses the effects of a broad range of agricultural technologies for the key staple crops maize, rice and wheat with a glob-

al modelling approach and indicates important contributions to yield increase and food availability. Crop production technology impacts differ substantially by crop, technology, region, and within regions (Rosegrant et al. 2014). Of interest here are the relevant potential contributions to sustainable intensification, not the detailed numbers since they strongly depend on assumptions about baseline growth, future availability of technologies, adoption pathways, and other model specifications.

For these potentials to be realised, more investment in agricultural research and development and extension services are needed – but not sufficient (Rosegrant et al. 2014). The past and current technological paradigm and trajectory of modern industrialised agriculture favours high-tech approaches to intensive crop production, such as precision agriculture. This persistence of a research and technology development trajectory creates path dependence. This process can lead to technological lock-in situations in which the dominant technology cluster excludes or hinders competing technology approaches (Vanlonqueren/Baret 2009).

Agro-ecological approaches to sustainable intensification require not only changes at farm level but also major changes in the whole innovation system. The need for a paradigm change is called into question in the debate: for example, Conner and Mínguez (2012) argue for an evolutionary change of farming systems, while the Standing Committee on Agricultural Research (SCAR) regards a radical change in food consumption and production in Europe as “unavoidable to meet the challenges of scarcities and to make the European agro-food system more resilient in times of increasing instability” (Freibauer et al. 2011, p. 9). Key point in the debate is whether increases in yields and production can be achieved with low-input and organic systems. Different meta-analyses on yield comparisons between organic and conventional agriculture (Badgley et al. 2007; Ponti et al. 2012; Seufert et al. 2012) indicate that organic yields are lower in areas with intensive production in developed countries, that organic and semi-organic yields are higher compared to locally prevalent low-input systems in developing countries, and that yield differences are highly contextual (Meyer et al. 2013, p. 74).

Beyond the controversy on organic yields, approaches are envisioned which develop crop production systems towards low input/high output systems, and which integrate historical knowledge and agro-ecological principles that draw on the capacity of nature (Freibauer et al. 2011, p. 8). However, so far mostly isolated examples of the successful introduction of agro-ecologically based production systems have been reported. It is certainly not a one-size-fits-all situation (Davidova et al. 2013, p. 39). There is no single technology or crop production system that is equally suitable for all farming systems. Addressing the different European farming systems is important because small-scale farmers have been largely overlooked by research and innovation policies so that they can neither benefit from advances in science and technology, nor participate in knowledge creation as co-producers (Freibauer et al. 2011, p. 103). This means that small-scale and semi-subsistence farmers need perspectives beyond commercialisation and growth. Important elements for mainstreaming agro-ecological approaches are:

- Niche innovations: Niches play a crucial role in the stimulation of radical innovations that deviate from path dependence and lock-in, and as laboratories to explore the possibilities for wider changes (Vanlonqueren/Baret 2009). This includes the development of new business models since agro-ecological innovations are not per se saleable products. Therefore, niche innovations need support and an enabling environment.
- Transdisciplinarity: Farmers are needed as co-creators of knowledge and innovation for site-specific agro-ecological approaches. In order to enhance two-way information exchange and strengthen adoption of new technologies, participation of farmers or farmer-managed trials is recommended as part of research programmes. This type of research needs to be funded by the EU and Member States because it does not attract private funding (Freibauer et al. 2011, p. 8). Methods have to be further developed that allow farmers’ knowledge to be combined with integrated or fed into scientific knowledge and innovation (Doré et al. 2011).
- Agricultural extension: The traditional extension service concept was conceived as a link in

the distribution network that moves technologies and crop management schemes from research centres towards peripheral end-users. A new understanding of agricultural extension revolves around tasks of communication and innovation, network building, co-design, and negotiation (Garb/Friedlander 2014). Extension services show high diversity between Member States, with some countries having completely privatised their extension services. For the new tasks, a revitalisation of publicly funded extension services reaching all farming systems is demanded (Meyer et al. 2013, p. 197).

- Common Agricultural Policy (CAP): The transition to agro-ecological approaches will be strengthened or eroded by government policies and the economic structures they promote (Darnhofer 2014). Direct payments to farmers under the CAP are neutral in regard to the applied crop production systems. A more enabling environment for sustainable intensification would require a longer-term transformation of the CAP with a phase out of direct payments, replaced by public payments linked to the provision of societal benefits (Meyer et al. 2013, pp. 17).

Besides the possibilities to directly adapt and transform crop production systems, the resilience of farms and farming systems is of increasing interest. This addresses the capability to handle possible economic and environmental crises in the future: “To achieve resilience requires a creative tension between maintaining the system despite a shock and changing the system, as well as dynamic interplay between incremental and transformational changes.” (Darnhofer 2014, p. 9–10)

Notes

- 1) Sole-holder family farms accounted for 85 % of all EU farms in 2010 (Davidova/Thomson 2014, p. 9).
- 2) The term “sustainable intensification” was originally coined in the 1990s in the context of pro-poor, smallholder-oriented development of African agriculture, where yields are often very low and environmental degradation is a major concern (Garnett/Godfray 2012, p. 8).

- 3) Plant breeding is not discussed in this paper. Breeding goals and approaches also depend on the conditions and problems of farming systems.
- 4) Meyer et al. (2013) developed a similar scheme of farming systems for crop production at the global level.
- 5) Conservation agriculture is based on the three key principles of continuous no- or minimal mechanical soil disturbance, permanent organic-matter soil cover, and diversified crop rotations with the aim to prevent soil degradation and to preserve and/or enhance soil fertility.
- 6) The system of rice intensification is an innovation in rice production systems, which is basically a set of modified practices for managing rice plants, including soil, water and nutrient management. In the meantime, it is also transferred to other crops.
- 7) Agroforestry systems are land use systems that simultaneously combine deliberately interplanted annual crops and trees. Agroforestry consists of a set of reasoning and design principles rather than fixed planting schemes. Countless agroforestry systems have been developed across the globe.

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Food Waste Generation in Europe

Reasons, Scale, Impacts, and Prevention Strategies

by Carmen Priefer, Juliane Jörissen, and Klaus-Rainer Bräutigam, ITAS

The reduction of food waste is seen as an important lever for achieving global food security, freeing up finite resources for other uses, diminishing environmental risks and avoiding financial losses. Although the estimates of global losses along the food chain are based on highly uncertain data, there is no doubt that considerable amounts are at stake. In its roadmap for a resource-efficient Europe, the European Commission has set the target to halve the generation of food waste by 2020. The present paper gives an overview on the scale, reasons, and impacts of food wastage in Europe and addresses prevention measures under discussion. The authors conclude that up to now, mainly soft instruments like awareness campaigns, round tables and information platforms have been implemented, whereas more rigorous approaches like amendments to EU regulations and financial incentives have been circumvented.

Die Reduzierung der Lebensmittelverschwendung gilt als ein wichtiger Hebel zur Sicherstellung der Welternährung, zur Freigabe begrenzter Ressourcen für andere Nutzungen, zur Verringerung von Umweltbelastungen und zur Vermeidung finanzieller Verluste. Auch wenn die Abschätzung der globalen Verluste entlang der Lebensmittelkette auf einer höchst unsicheren Datenbasis beruht, besteht kein Zweifel, dass es um beträchtliche Mengen geht. In ihrer Roadmap für ein ressourceneffizientes Europa hat die Europäische Kommission das Ziel festgelegt, die Lebensmittelabfälle bis zum Jahr 2020 um die Hälfte zu reduzieren. Der vorliegende Artikel gibt einen Überblick über das Aufkommen, die Gründe und Auswirkungen der Lebensmittelverschwendung in Europa und behandelt Vermeidungsmaßnahmen, die in der aktuellen Debatte eine wichtige Rolle spielen. Der Artikel kommt zu dem Ergebnis, dass bislang hauptsächlich „weiche“ Instrumente wie Aufklärungskampagnen,