EIP-AGRI Focus Group

Agroforestry

Discussion paper - REPORT
November 2016

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Content:

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Introduction:

This discussion paper aims to start discussions at the first meeting of the EIP Focus Group (FG) on Agroforestry. The FG - consisting of experts from different Member States - will together share their knowledge and experiences and "*look into how innovative agroforestry designs and practices can unlock the productivity potential of combinations of trees / woody vegetation with crops/animals at the farm level – maximising the overall ecological performance of agro-ecosystems, while considering the development of new market solutions and diversified value chains*". The stated question for this collaboration is: ***How to develop agroforestry as a sustainable farming system which can boost agricultural productivity and profitability?*** While working on this question the FG will mainly focus on the socio-economic aspects of establishing viable agroforestry systems.

To answer this question, the FG will address the following tasks:

- Provide and compare relevant examples of the integration of woody vegetation with crop and livestock farming systems on the basis of traditional and/or innovative designs of agroforestry systems in Europe.
- Identify and analyse the opportunities for the integration of woody vegetation into specialised farming systems and assess the potential economic benefits linked to additional sources of income (e.g. product diversification, green marketing, public incentives such as payments for biodiversity and landscape scenery...)
- Identify and describe limiting factors generated by the combination of agricultural and forestry practices (e.g. farm size, labour and management, knowledge, legislation, equipment, market outlets, land tenure ...) that can hinder the adoption of agroforestry at farm level.
- Provide practical indications for the further development and introduction of agroforestry, identify innovative approaches, combining scientific and practical knowledge with new business models, modern technologies and practices. Consider the role played by advisory systems and the existence of relevant value chains.
- Provide recommendations in terms of further research needs and ideas for Operational Groups and other innovative projects.

The content of this paper is based on literature, the outcomes of former EIP FGs, current agroforestry projects as well as experiences of participants. During the meetings the FG will further develop the answers to the stated questions and tasks. The first meeting will focus on the first three tasks and use the experiences of the FG members to discuss what is needed to develop innovative agroforestry practices, but also go deeper into selected aspects of interest to facilitate the *integration of woody crops in specialised crop and livestock systems*.

1 What is Agroforestry?

Definitions

There have been several definitions of agroforestry over the years. In 1982 the International Centre for Research in Agroforestry (ICRAF) defined Agroforestry to be:
"A collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components" (Lundgren and Raintree 1982).
They added that this implies that: agroforestry normally involves two or more species of plants (or plants and animals); at least one of which is a woody perennial; an agroforestry system always has two or more outputs; the cycle of an agroforestry system is always more than one year; and, even the simplest agroforestry system is more complex, ecologically (structurally and functionally) and economically, than a mono-cropping system.

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In 2009 agroforestry was defined as "...the practice of deliberately integrating woody vegetation with crop and/or animal production systems to benefit from the resulting ecological and economic interactions" (Mosquera -Losada et al.) As, Nair (1993) points out agroforestry systems are more complex than monoculture systems when it comes to structure, function and economy.

For the purpose of this FG agroforestry is defined as:
"The practice of integrating woody vegetation with crops and/or livestock systems to optimise the benefits from their ecological and economic interactions."

It may be noticed that the definitions use words as "deliberately", "management" and "practice" and include the intentions, decisions and activities of the people working within the systems. Agroforestry can therefore be defined to be human activity systems where the socio-economic factors are important for the sustainability and functions of the systems. At the same time, the FG definition also uses the words "optimise the benefits from" giving a starting point where society shall benefit from the interactions taking place in agroforestry systems.

Classifications and principles

There have been many attempts of classifying agroforestry. The AGFORWARD project (www.agforward.se) has done this by starting out from: the components (crops, trees, shrubs, pasture, animals, aquaculture etc.); the dominant land use (agriculture or forestry); how it is designed in space (on boundaries, in strips, densely mixed, sparsely mixed); by its agroecological environment (tropical, boreal, humid, high land etc.); its socio-economical management level (amounts of inputs and degree of commercialisation) and function (provisioning, biodiversity, regulation, cultural values) (den Herder et al. 2016). From such characteristics there have been many different attempts of classifying agroforestry systems into groups: Forest grazing and wood pastures, High Natural and Cultural Value Agroforestry Integration of high value trees, Agroforestry for High Value Tree Systems, Silvopasture systems, Silvoarable systems, Forest farming, Forest gardens etc.

In socio-economic terms agroforestry has also been classified as being of subsidy, intermediate or, commercial focus (Nair 1993) where commercial agroforestry is meant to produce cash crops. This classification however does not work well in an EU setting where the Common Agricultural Policy (CAP) payments and other types of support may bring in substantial income. For management and landscape reasons there is also a difference in systems where all woody crop plants are harvested for wood or timber or replaced at the same time, and systems where they are replaced on a continuous basis as for wood in a permanent silvopastoral system.

However, this FG is not looking for special classifications but for possibilities to enhance innovative designs and practices. The focus of the work is on those aspects of "***integration of woody plants in specialised crop and livestock systems***" in Europe that can "***be turned into concrete economic benefits at farm level***".

Another way of defining agroforestry systems is to see it as a system that emerge in a place and context when systems including woody plants are developed based on principles as:
functional design, plurality, multifunctionality, appropriate scale, ecosystem services, circulation and effective use of nutrients.

Clearly there are many possible varieties! Even more than there are farms!

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2 Why Agroforestry? Possible gains

In the call for this FG it is stated that: "*Agroforestry systems can increase resource efficiency, enhance productivity, and improve the overall resilience of agro-ecosystems*".

In this work we start out from, and state as facts that, agroforestry practices *can greatly contribute to increasing the sustainability of specialised production systems such as arable, horticulture and livestock farming. It also contributes to diversifying production (e.g. fruits, woody biomass, fibres) making farms more resilient to market changes and more profitable*.

So why is agroforestry said to be such a catalyst for an agriculture to be sustainable socially, economically and ecologically?

Well planned agroforestry design is based on knowledge of how ecosystems work. The designs use perennialism, biodiversity and symbiosis to create systems: that circulate and use nutrients efficiently; where plants and animals play multifunctional roles; where the biodiversity is part of the natural regulation of pests; photosynthesis is enhanced; where beneficial microclimates emerge, etc. When well managed this reduces the need of inputs, improves soils, increases the binding of carbon, gives more habitats for wild biodiversity and so on. Torralba et al. (2016) show through a meta-study that European agroforestry generally enhances the provision of biodiversity and ecosystem services compared to conventional agriculture.

Internationally these systems are also shown to improve self-sustainability and local business. The systems give a diversified output with at least two products instead of one. Even though the production per ha of each single crop can be lower than in monocultures, the total productivity of the agroforestry system has been shown to be potentially larger in several studies. Potential less need of inputs also enhances the profitability as well as if subsidies and payments are available. When customers give added value to products from more sustainable systems such as agroforestry, there is also the possibility of higher prices.

Agroforestry systems are also often pleasing to the eye, have large cultural values and attract tourists. In educational situations, they work well as good pedagogic examples to facilitate discussions of ecosystems, problems with agriculture, potentials of agriculture, needs of transitions for sustainable societies etc.

In short, agroforestry shows promising potentials to sustain the agricultural productive capacity while increasing production in a sustainable way, diversify incomes and perpetuate knowledge as well as social and cultural values.

3 Agroforestry as farm practice in Europe

According to the Agforward project there is 15.4 million ha of agroforestry in Europe. Even though this figure is presented as probably containing some errors the size of almost 9% of the EU agricultural area shows the importance of agroforestry in the EU countries. Of these 15.1 million hectares are different forms of livestock agroforestry and 358 000 ha are arable agroforestry. 1.1 million ha are so called High value trees systems that includes parts of both the other two presented categories (Herder et al 2016 2nd edition).

There are different and plentiful examples of agroforestry used in the different countries. From the reindeer grazing of forest in the north to the agroforestry with carob around the Mediterranean and the intricacy of edible forest gardens. There are wood pastures, hedgerows, windbreaks, riparian buffer strips, intercropped and grazed orchards, grazed forests, forest farming, alley cropping, woodland chickens, food forestry and so on. All take advantage of the interactive benefits from combining trees and shrubs with crop and/or livestock integrated and sustainable land-use system (Lundgren and Raintree 1982, Leakey 1996). Possible products for sale are as diverse: nuts, olives, fruits, berries, seeds, tubers, leaves, edible flowers, biomass, fire wood, wood chips, timber, meats, eggs, milk, honey, etc. Actually almost any kind of possible farm product can be included.

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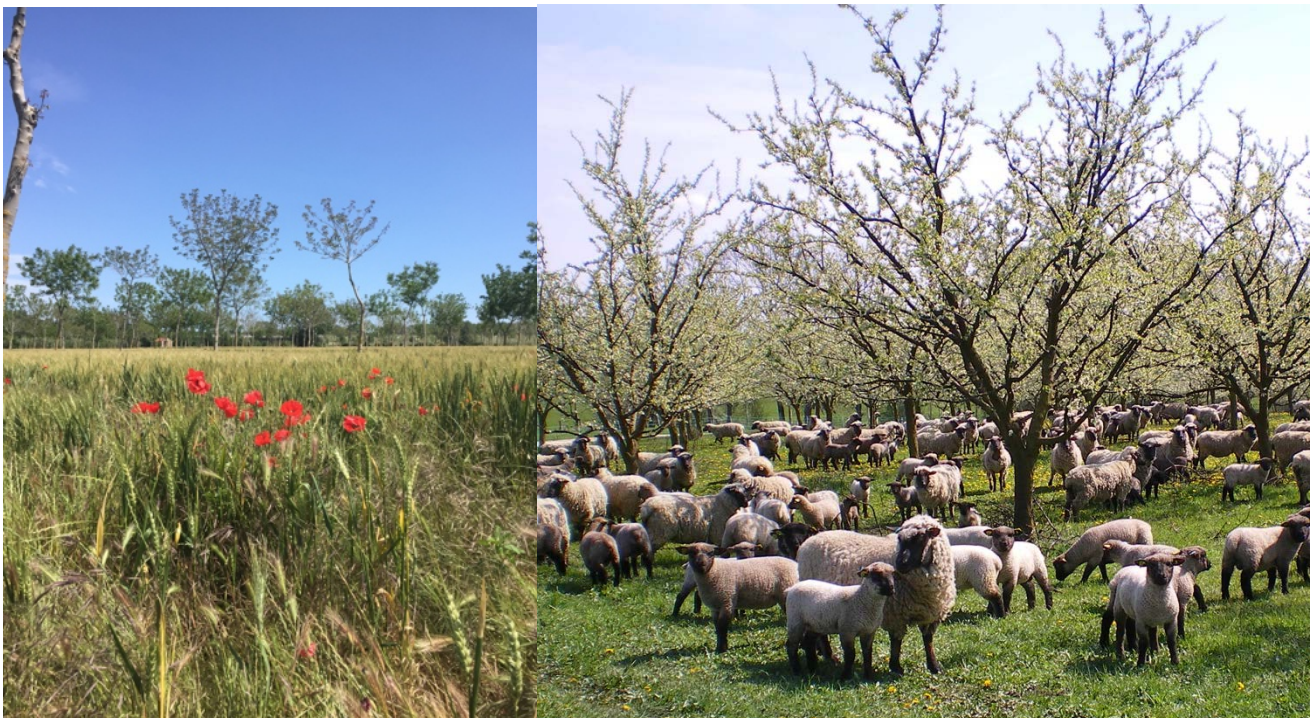
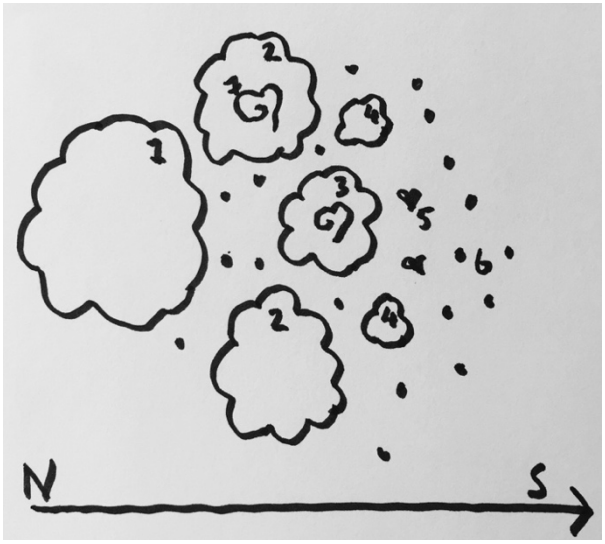
The most common agroforestry examples are on “plot level” with a comparably simple level of complexity. Below are pictures of alley cropping (fig. 1) of walnut trees for timber production and cereal in Montpellier, France, and (fig. 2) of arbo-pastoralism in North East France, Shropshire sheep grazing in a Mirabelle orchard.

Figure 1 and 2. Agroforestry in specialised crop and livestock production



Yet other agroforestry cases are more intricate and really complex on the “plot level” as when multi-strata design of increasing complexity are used for edible forest gardens, riparian buffers, alleys, hedges, field edges etc. Figure 3 illustrates in a very schematic way types of crops and their spacing for shade tolerance. All crops are chosen to produce both products for harvest and other symbiotic services for the system.

Figure 3. Example of complex multi-strata design including 7 “layers” of different type of crops



1 High trees

2 Lower trees

3 Higher bushes

4 Lower bushes

5 Tubers

6 Ground cover

7 Climbers

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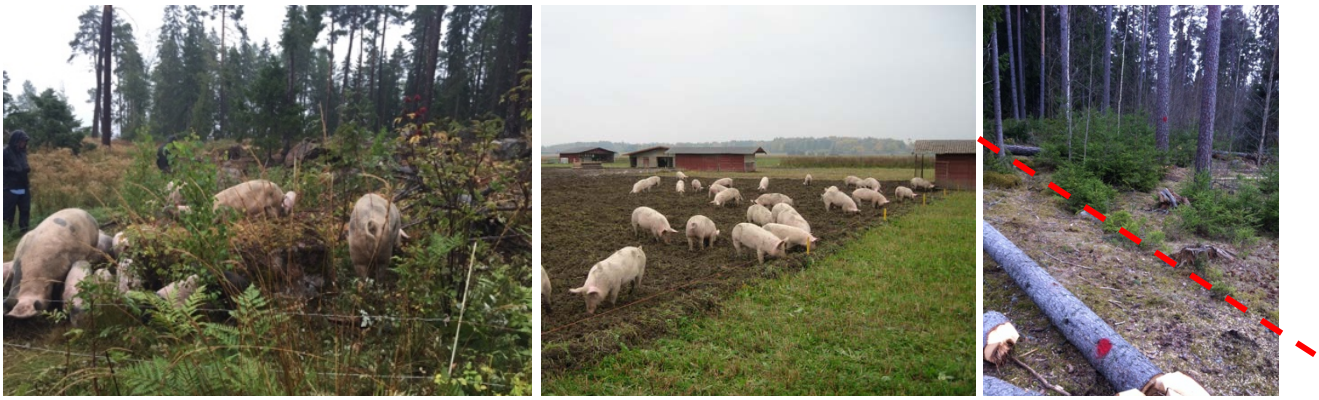
In other cases, farmers have worked to implement the principles of agroforestry in their full farm system where the agroforestry practice may not be bound to one plot. Below is one integrated sub-production of such a farm in Vattholma Sweden. Sows, are kept in movable houses in the fields over the winter. After littering in the spring they graze forest clearings with the piglets to - among other things - give the seeds from the trees that were left, a good start (fig. 4a). In the fall they are moved to another field and prepare the soil as part of the "crop rotation" (fig 4b). The fattening pigs are then slaughtered for traditional Christmas meats. Figure 4c shows where the fence in the forest was and the importance of the pigs work for the seeds to grow.

Figure 4a-c. Pigs in forest clearing, as part of the "crop" rotation in the fields, and the impact of their work on seedling amount



These types of agroforestry practices are more complex at the level of the whole farm system.

4 Challenges and needed changes for enhancing transitions

Going from monoculture crop production or simple pastoral systems, to introducing one or more woody crops definitely makes things more complex! This is not just connecting two pieces in a puzzle. Even if the benefits are clear in the long run, the short term transition of specialised crop and livestock systems to economic profitable agroforestry systems may meet its challenges. In this chapter we focus on factors that have bearing on the socio-economic aspects.

Design and management

Planting trees or shrubs is the easy part. The planning before and the practice after is what can raise new challenges. Even in less complex agroforestry systems - such as growing timber trees in an agricultural field – it becomes necessary to know the effects of wind on trees, of shadow on crops, how roots develop, competition for water and nutrients and so forth. All of this requires advance planning. Any type of agroforestry system needs work of careful design, especially the perennial elements that cannot be easily changed.

There are many questions to look into. Will the spacing of the woody crops work with the width of the existing machinery on the farm? How about tomorrow's machinery? Do the woody crops need special machinery? If there are fruit or berry producing woody crops, will they ripen in a period when the other crop is not there, or, the livestock will not eat it? Is there a risk of fruit falling into manure? Does the introduction of woody crops require fencing? Around the whole field to protect it from wildlife? Or around each plant to protect it from the domestic animals? How are pests that cannot be eradicated by removing the plant avoided? Is a single woody crop species too exposed? Would it be better with a multiple woody crop system? How would those crops interact in the best way?

There are many more questions to plan for, more will arise along the way and an open mind to changes and continued development will be needed. Even though farmers are experts on managing very complex systems

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as farms enterprises, the need of design, diversified knowledge and understanding of more intricate interactions may be a challenge[1].

Productivity, profitability and development of value chains

As mentioned earlier, even though each crop in an agroforestry field or pasture may produce less than if grown as monoculture, there are several reports e.g.(Palma et al. 2009) highlighting that agroforestry gives more total produce per area. This is calculated as the land equivalent ratio. In other words; to get the equal amount of e.g. timber and cereal when grown as monocultures, takes a total larger area than if produced in the same plot. Other possibilities for gaining profitability are reduced needs of inputs, payments for added value by customers and possible payments by society for ecosystem services provided[2]. Another long term effect adding value that needs to be included is the improved ecological sustainability of the farm. So far the possibilities of productivity and profitability look good.

Other issues are more challenging. As the establishment phase for fruit-bearing trees and bushes, as well as the time to mature for harvest of timber or trees for fuel wood, is longer, or a lot longer than any other crop, a new time dimension will have to be integrated by the farmers. It will take time until there is an income from the woody components of their system. It is important to consider that meanwhile the area, or the level of production, for annual production of crops or pasture, may be reduced. Finding ways to level out costs and income over time is key in these cases.

Having access to markets through the development of well-functioning value chains for the new products is important for profitability. The question is: will products from woody agroforestry crops - be it timber, fuel wood or fruit - be in large enough quantities to fit the existing chains for mono-culture production? Or are alternative value chains needed? Selling at local markets, on farm shops, through subscriptions of farm products, having community support agriculture (CSA) etc. takes a whole other approach to selling with close contact with the consumer. This takes time to learn, more skills and time to do. Considering smaller amounts of the products the cost of handling them will also increase per unit of product.
Another major challenge may also be to process the harvest to commercialise products. This will add value, improve the saleability and diversify the products[3]. Income can increase but so does the working hours. There may also be costs for special machinery and new types of storage. Acquiring new knowledge through courses, studies, extension etc. also costs money and time. Yet, when selling through alternative value chains, processed products can prolong the season and are often a prerequisite.

In the EU context, the profitability of agroforestry systems is also closely connected to public support, namely through the second pillar of the CAP. In some countries/regions support to the establishment of agroforestry is envisaged by the rural development programme (RDP). On the other hand, in other contexts, in order to benefit from payments under the same policy (CAP first pillar) trees are cut in traditional silvopastures. Introducing alley cropping can also engender the loss of subsidies, as well as making the actual filling in of the application for the remaining crop part of the fields really difficult.

So, the possible benefits (higher productivity per area, the value of long term sustainability, better pricing through added values and payments for ecosystem service from society) need to be higher than the costs (for establishment, more work, education and extension, new machinery and premises, new value chains and related marketing costs etc.) for agroforestry to be a lucrative choice.

[1] The issue of "managing complex systems" has also been addressed by the work of the FG on "Mixed Farming Systems" (the Final report will be published soon on the EIP website: http://ec.europa.eu/eip/agriculture/en/content/mixed-farming-systems-livestockcash-crops).
[2] See also the work of the FG on optimising profitability of crop production through ecological focus areas: http://ec.europa.eu/eip/agriculture/en/content/optimising-profitability-crop-production-through-ecological-focus-areas

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Farmers often ask for the contribution margin of a crop or livestock to be able to compare profitability of different types of production. Such information does not even exist for monocultural production of special agroforestry crops in all climates, and figures of financial net outcome of the mixed production of interest may be as hard to find. Farmers who start agroforestry productions under such conditions have other strong motivations than only the financial aspects for doing so.

Competence: knowledge and skills

From the earlier sections it is clear that agroforestry is competence-demanding. The more complex a system gets, the more knowledge as well as skills are needed to develop and manage it. The higher the number of interactions, subjects and tasks involved, the larger the challenge. Managing every system takes continuous learning as it develops over time. As these systems are particularly dependent on place there are no true solutions to “copy and paste” between places.

General knowledge (e.g. normal root length of a specific tree) and applied knowledge (e.g. possible root length of the specific tree in different types of soil) are both needed. But so is "systemic" knowledge of complex interactions such as whether the roots' width needs to be reduced and how that will affect the mycorrhiza, which is effected by the nutrients given, which in turn depends on the crops within the alleys ... and so on. As seen earlier there are plenty of questions on different system levels. As new knowledge is needed on different system levels, in different disciplines and subjects, collaboration between different research and development approaches is also needed. Mycorrhizae infection may be best studied in a lab with traditional science methods, understanding the connections in a system will take a more systemic approach and understanding the socio-economic factors may take yet other ways of investigation and research. Improving a complex situation takes a wider competence than fixing a problem.

Traditional transfer of knowledge approaches may work for specific issues but not for others. Such complex systems call for collaboration with people of different backgrounds to come to terms with the actual challenges for practising agroforestry and making a profit. The importance of farmer knowledge is essential. Farmers are usually good at knowing what impacts their farm systems will have on the specific parts, and how specific problems will affect the whole system. They are great at managing the full system, juggling all the different aspects. This is not always knowledge easy to put into words, or write down. They know the landscape features, the wind directions, the water flows, the field specifics, needed interactions with the rest of the farm, what they as the workforce are capable of, the financial needs, they have the basic farm skills, etc. They have a systemic understanding of the farm practice that no outsider can have. In each place their competence needs to be understood to be the base to build on.

To make agroforestry into a practice that will be sustainable, productive and profitable takes new skills and knowledge of all involved actors. It takes specific knowledge as well as systemic, it takes knowledge on agricultural production and value chains, on different research and extension approaches and collaboration. This is why traditional research and extension methods needs to be complimented with methods focused on collaboration across professions and subjects. But, it is as much as important that the interactions with partners such as public authorities, sales channels, and practice works. Enhancing agroforestry therefore requires partly new competence from all actors.

Rules, policy and society

Farming today is a business that faces rapid changes all the time. There are changes in regulations, quality standards, animal welfare issues, policies, climate, requests from consumers etc. (Darnhofer et al. 2010). Adapting to new situations and to have flexible systems, are key to ensure future existence of farm businesses. At the same time, developing new ideas and introducing innovations takes creativity, security and often collaboration. The possibility of planning ahead and knowing that the prerequisites for the planned production will remain are important as agroforestry has an unusual long establishment phase. Even though all systems develop and change over time, an agroforestry system may not be as easy to adapt to new rules as an ordinary crop or livestock system.

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Also, when regulations and rules focus on management practices (correct number of trees per area, the right crops, the right height grass etc.) rather than results, this leaves less room for development of collaborative competence, local adaptations and eventually the development of new innovative systems.

Other local rules may also have great impact. For example, in Sweden permission by the county administrative boards is needed in order to change the use of the land as when planting trees in open fields. Neighbours may also disagree with the new landscape and peer pressure on what it is to be a good farmer has been shown to play a role when introducing agroforestry (Sereke, Graves, and Herzog 2016).

Even though the CAP gives possibilities for national and regional authorities to include agroforestry support in their RDP many countries have not done so. Rather, the CAP is shown to have been part of supporting transitions into dramatic increase in scale and more specialised forms of farming (Bartolini and Viaggi 2013, McMichael 2011). To enhance possibilities of agroforestry, rules at different levels need to comply and be consistent. When for example, CAP rules deciding the expected grazing pressure in a silvopasture do not comply with the animal health rules of the country (Eksvärd and Marquardt 2016), or when trees are taken down or residues burnt in existing silvopastoral systems with high nature values in order to benefit from environmental payments (Eksvärd et al. 2016), agroforestry gets difficult. To enhance agroforestry within the EU calls for adaptation of EU, national and regional laws and rules to fit the development of local best practices.

Conclusion

Agroforestry is a promising approach for all aspects of agricultural sustainability. But, the scaling up (increase in size) and scaling out (increase in number of sites) has it challenges. It is clearly a complex arena that takes new innovations as well as use of old knowledge. It is not a “business as usual” situation. Based on practical examples, during the first FG meeting, there will be discussions on both opportunities and obstacles of how to develop agroforestry by introducing woody crops in specialised crop and livestock systems for those systems to be sustainable and boost agricultural productivity and profitability. The focus will be on issues raised in chapter 4 of this paper, the socio-economic aspects of enhancing agroforestry in the EU.

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funded by European Commission