Can agroforestry grow beyond its niche and contribute to a transition towards sustainable agriculture in Sweden?

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Abstract: Agroforestry is claimed to be an approach that could support agriculture in the transition from contributing to sustainability problems to being a regenerative activity contributing to viable ecosystems and therefore part of sustainability solutions. A transdisciplinary and participatory action research (PAR) group including farmers approached the development of temperate agroforestry systems in the modern agricultural setting of Sweden through practical experience on 12 farms and collective analysis. The objective was to research possible practices, such as edible forest gardens, silvopasture and silvoarable systems, to discuss their use and effects, as well as scaling possibilities. Knowledge and experience of challenges and solutions for the development of agroforestry where found at both niche and regime levels.

Keywords: agroforestry; temperate; agroecology; participatory action research; transition; niche innovation

1. Introduction

Modern agriculture has contributed to an increase in yields on the expense of a decrease in other ecosystem services important for human wellbeing [1]. The use of non-renewable resources such as fossil fuel and phosphorus is extensive. Almost all of the ten planetary boundaries are related to food production [2], and four of them; biodiversity, biogeochemical flows, land use change, climate change have exceeded “the safe zone boundaries” into uncertain zones [3]. In accordance with the Agenda 2030 and the UN Sustainability Goals (SDG) FAO address the need of transforming the food and agricultural systems and that agroecological initiatives could contribute to this [4]. In a global assessment identifying redesign types that could contribute to the transition of agriculture, agroforestry practices; “trees in agriculture” is one out of the seven listed [5].

Temperate agroforestry

One agroecological practice, agroforestry, is defined by the European Agroforestry Federation (EURAF) “the integration of woody vegetation, crops and/or livestock on the same area of land”. Temperate regions have a long tradition of agroforestry systems such as animal grazing in natural woodlands, alleycropping, orchard intercropping, home gardens/edible forest gardens. Some of them are re-introduced with influences from tropical regions, where more research have been conducted compared to temperate regions.

In the research project AGFORWARD, 40 stakeholder groups involving about 820 stakeholders across 13 European countries, agroforestry innovations was field tested and developed by participatory research in order to understand how agroforestry can support European agriculture...
and rural development [6]. Agroforestry, which constitutes 9% of the agricultural land in EU, is encouraged by working with farmers and at a farm or landscape level, rather than per hectare squares [6].

Compared with conventional agriculture the benefits from integration of trees and other perennials to the landscape is the increase of biodiversity and the improvements for both wild life (habitats) and for domestic animals (health), and the increase of the regulation ecosystem services such as reduction of fire risks, increase carbon sequestration, reduction of soil erosion and nutrient leaching and the increase of soil organic carbon. Stakeholders in Europe perceived aesthetic qualities and other cultural benefits which could attract tourists and other visitors [6,7,8]. The limitations of agroforestry are increased labor, more complex work (such as working with trees, harvest), management costs and administrative cost [9,7]. Also establishment of woody perennials takes time, and so do the evaluation of the effects from certain tree plantation, which might be possible after 20-80 years [10,6]. This could be one of the factors behind that research on agroforestry in temperate regions is limited [11,12].

Agroforestry in Sweden

Depending on what to include in the concept agroforestry different pictures occur. Data from Land Use and Land Cover survey (LUCSUS) shows that in Sweden arable agroforestry, livestock agroforestry and high value tree agroforestry (ex fruits, nuts orchards) is 1.1% of total territorial area, which is 15, 2 % of total utilized arable area [13]. Livestock agroforestry constitutes 99% of the area of the total agroforestry in Sweden [13]. On the farm level, an assessment of ecosystem services of such system; woody pasture, from at least one Swedish farm have been included in an European project [14].

Historical and contemporary examples of agroforestry in Sweden shows that traditionally the extensive forest has been used for grazing of cattle, sheep and goats in silvopastoral systems and also by the system of summer farms [15]. In northern parts of Sweden, plus Finland and Norway, the Sami people traditionally kept, and still keep large herds of semi-domesticated reindeer grazing freely in mountainous and forested areas. In terms of area Valinger et al. (2018) claims this is one of the largest agroforestry systems in Europe; reindeer husbandry alongside forestry, hunting and tourism [16]. Research that address agroforestry explicitly are field experiment is under development on intercropping of perennials at the Swedish University of Agricultural Sciences (SLU). One project is developing and testing how edible forest gardens at pre schools could function as pedagogic tool for children [17]. There is an emergent interest in different agroecological approaches in sometimes overlapping grassroot movements such as permaculture, urban gardening and the transition town movements [18,19,20].

The need of transition

The need of a change to a modern agriculture that contributes to a sustainable planet takes not only an adjustment or change within the maintained production system but a transition [21,22]. New methods of agricultural performance based on agroecological principles could allow transitions, as shown by Nicholls, Altieri, and Vazquez (2016) [23]. Such agricultural production approaches considered to be not only sustainable but also regenerative are different agroforestry systems [24,25].

To address global food security, Tittonell et al. (2016) [26] point to the need of local agricultural innovations worldwide. Their suggestions include perennial crops and functional diversity at plant, field and regional scales. They also show that in the global North, reducing agricultural impact on the environment requires the greatly reduced use of external inputs. Additionally, in Sweden, the increased production of fruit, berries and greens could reduce the use of inputs abroad, as the dependency on imported vitamins and minerals through fruit and vegetables is high [27].

In order to explore and learn more about agroforestry in temperate regions a group of researchers and Swedish agricultural producers have conducted a pilot project on agroforestry in Sweden in a participatory action research (PAR) project, and have tested and analyzed different types of agroforestry on 12 farms. The joint work and the process of establishment at each farm have been
presented in details in a on line-report, in Swedish [28] and the outputs of the PAR-project is published in Björklund et al. (2018) [29]. In this study we will investigate the needs for agroforestry to expand beyond its niche and in this transition also become an acknowledged part of Swedish sustainable agriculture.

2. Materials and Methods

This initiative, a case study on a participatory action research (PAR) project conducted 2012-16 as pilot project in order to investigate the establishment of agroforestry in Sweden as project will be presented in depth. This agroforestry innovation system, i.e., the collaborative platform created by the participants and their practices, as an example of an agricultural transition process, and describe the needs for scaling transitions [30], depending on practice, prerequisites and context.

The PAR-project on agroforestry is based on a type of cross-organizational collaboration fostering transformational change towards sustainability through working in “real-world laboratories” as described by Luederitz et al. (2017) [31] and is an approach fitting agroecology well [32]. It was carried out by a participatory action research (PAR) group consisting of producers from 12 different places; 9 of them small holders of different sizes from 3 ha-200 ha, often with a combination of different types of food production and other activities including visitors as tourists or participants in learning events, 2 of them are community project inspired by transition town movement, one is located in an ecovillage, one is demo/learning site involving both a large number of volunteers and a formal educational program, where agroforestry practices have been a part since the start 2004. Although its heterogeneity, we from here on refer to them as 12 farms. Two researchers, both with a background in agronomy and one with facilitating skills initiated the project. In the workshops participated 1 or 2 people from each farm; 18 people over the 4 years. On several occasions, experts on subjects such as soil, pasture and leaf protein, were invited to the group’s workshops. The aim of the work was to develop modern agroforestry systems and to learn about their effects, practices, use and scaling possibilities. The group of potential participating farmers were identified before the actual research project started in a pre-workshop held by people with experience from agroforestry in the South in order to explore the interest to investigate applied agroforestry in Sweden. Everyone with such an interest were invited to participate in the research project. None of the participants used commercial fertilizers or pesticides to begin with, and all were interested in reducing the amounts of oil used in agriculture. Their management approaches were focused on resource effective production with low external inputs. Agroforestry was seen as a way to have less dependency on such inputs.

The group met for 9 workshops during a period of 4.5 years and held 14 telephone meetings. The facilitated workshops were conducted at the different farms. To facilitate learning on such new and unexperienced practices, three types of activities were used: i) collectively deciding on the scope and intentions of the group; ii) on an iterative basis, “exploring impacts through situation analysis, defining from the analysis the question domains and deciding which to explore” [33]; and iii) creating a space for creativity, sharing and feedback.

The farming systems research project was driven by all participants, where the facilitating researchers were also practitioners and the practitioners also took part in the research. The research questions were formulated jointly by researchers and farmers. All participants were invited during the project to go to national meetings, internationally agroforestry conferences and were also included in the writing process of popular materials [KE2]. All farms contributed to the report in Swedish with detailed descriptions of case studies and the process of the 12 farms. The approach used in this study builds on experiential [34] and social learning [35] for all participants to gain competence. The process was designed to enable learning about individual farm situations through our collective learning and vice versa.

To support the facilitation of the discussions on scaling and transitions, transition theory and the multilevel perspective (MLP) theory [36] adapted to agriculture [37] was used as a heuristic tool in group discussions. This was to facilitate coverage of societal impacts on the systems, including aspects at the niche, regime and landscape levels and their complex connections. The niche is the
micro level in which new innovations, or local projects are developed and are regarded as “the seeds for change” [38] the regime level or the meso level consider areas such as policy, science, market or technology. The landscape level is the low dynamic environment, and examples are economic growth or oil prices [38]. A transition is the societal change which is the outcome of the interactions between niches; which also could be places or communities, and the regime and landscape levels [38].

Results

Here an overview of the process, outputs and outcomes of this project is presented. Practical experience and ideas for scaling possibilities and limitations is presented for each agroforestry type. When using the term “the group” or “the PAR group” below we refer to results or point that origins from group discussions at several workshops.

Process overview

During the first workshop (April 2012), the PAR group decided to use agroecological principles of functional design, biodiversity, multifunctionality, adapted scale, ecosystem services, circulation and effective use of plant nutrients as the basis for the collective work on the design and development of the agroforestry systems to be tried. In this way the open, quantitative goals where set and an agreement was made to work in equal teamwork. In April 2016 (workshop 9), the group summed up the outputs and outcomes of the project.

In the PAR project the group decided to plan for and try three versions of agroforestry: edible forest gardens at all 12 farms, where 3 of the farms also planned for silvopastures and 5 of them for silvoarable systems. The design (composition of plants and size) of the edible forest gardens, presented in Björklund et al 2018 was developed by the group [29]. The location, preparations of land and inclusion of more plants were individually chosen at different farms, see Figure 1 and Table 1. The experiences of introducing and managing these systems have been shared through facilitated discussions with the full group and well documented. The materials produced were both analyzed and re-discussed by the group and conclusions were agreed upon.

Figure 1 Map of Sweden showing geographical positions of the edible forest gardens in the study.
Table 1: Farmer observations of the establishment phase 2013-16 of the edible forest gardens (Björklund et al. 2018)

<table>
<thead>
<tr>
<th>Farm</th>
<th>Labour hours, establishment of tree and shrub layers</th>
<th>Labour hours, management and harvest</th>
<th>Preparation before planting trees and shrubs</th>
<th>Preparation before planting herbal and ground cover layer</th>
<th>Manure</th>
<th>Irrigation, occasions, yr⁻¹</th>
<th>Inclusion of annuals during establishment phase</th>
<th>Main harvested plants</th>
<th>General observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>10</td>
<td>Tilling</td>
<td>Tilling</td>
<td>None</td>
<td>4-6</td>
<td>No</td>
<td>Amelanchier anifolia, Malus domestica, Hippophae rhamnoides, Chenopodium bonus henicricus</td>
<td>Satisfactory growth of trees and shrubs, Chenopodium bonus henicricus promising</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>22</td>
<td>None, planting in the sward</td>
<td>Plastic weave</td>
<td>None</td>
<td>None</td>
<td>Yes</td>
<td>Fragaria x ananassa, Amelanchier anifolia, Hippophae rhamnoides, Rubus lacinatus</td>
<td>Slow growth when planting in sward, Rubus Lacinatus invasive, Malus domestica disfavoured due to high ground water</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
<td>5</td>
<td>Tilling</td>
<td>Card board, litter</td>
<td>Well composted manure sheep</td>
<td>Few</td>
<td>No</td>
<td>Amelanchier anifolia, Malus domestica, Rubus lacinatus</td>
<td>Tree and shrubs growth retarded due to competition with herbaceous layer</td>
</tr>
<tr>
<td>4</td>
<td>28</td>
<td>n.a.</td>
<td>None, planting in the sward</td>
<td>Card board, litter, cultivation of annuals</td>
<td>Grass cut, composted manure</td>
<td>Yes</td>
<td>Yes</td>
<td>Fragaria vesca, Amelanchier anifolia, Malus domestica, Hippophae rhamnoides, Agastache foeniculum, Hablistia tanninodes, Amelanchier anifolia, Hippophae rhamnoides, Rubus lacinatus, Chenopodium bonus henicricus, Agastache foeniculum, Hablistia tanninodes, Mentha spp., Origanum vulgare</td>
<td>Symphytum upplandica to invasive to Malus donev-tica, less work and more harvest, leaf and flower for salads, each year</td>
</tr>
<tr>
<td>5</td>
<td>24</td>
<td>18</td>
<td>None, planting in the sward</td>
<td>Card board, newspaper and litter</td>
<td>Fresh manure sheep</td>
<td>Few</td>
<td>No</td>
<td>Agastache foeniculum, Hablistia tanninodes, Mentha spp., Alliaria petiolata and Chenopodium bonus henicricus</td>
<td>Vinis vinifera and Malus domestica suffer from low pH</td>
</tr>
<tr>
<td>6</td>
<td>24</td>
<td>6</td>
<td>Cultivation by pigs</td>
<td>Card board</td>
<td>Grass cut, composted manure horses and sheep</td>
<td>Few</td>
<td>Yes</td>
<td>Fragaria vesca, Agastache foeniculum, Chenopodium bonus henicricus</td>
<td>Symphytum upplandicum invasive, fences for roe deer needed, larger contribution to the household each year</td>
</tr>
<tr>
<td>7</td>
<td>28</td>
<td>n.a.</td>
<td>Cultivation by pigs</td>
<td>Newspaper, litter</td>
<td>None</td>
<td>None</td>
<td>Yes</td>
<td>Hippophae rhamnoides, Rubus lacinatus</td>
<td>Tree and shrubs growth retarded due to competition with herbaceous layer</td>
</tr>
</tbody>
</table>
Outputs

The outputs from this project were 12 developing edible gardens, and one silvoarable system were established, including reference data for future research, extensive nutritional facts on two unmapped crops, an additional nut garden at 12 farms, demonstration plots approaching 140 varieties, a conference article and poster, and a report describing the 12 cases and the group learning and published online in Swedish [28,29].

Edible forest gardens experiences

All farms an edible forest gardens of the same size (60 m²) and with the same woody plants were established at different farms in southern Sweden [28,29]. As shown by Bodö (2013) [39], these gardens work well as a production unit on a household scale and are able to adequately support the human need for vitamins and minerals. Establishment was done by hand, and the time until production started took 3 years. These first years were time demanding, but the need for attention decreased as the planting was completed. Finding the right plant species and varieties of good quality are important for not prolonging the establishment, but are difficult. Good plant material is quite expensive. Weeds need to be extensively tended to during the establishment and good mulching materials were needed. The household edible gardens were perceived as provisioning multifunctional benefits such as new products for food on the plate, serenity and aesthetic qualities from its increased richness of species such as flowers, butterflies, bees and birds.

Factors identified for the establishment of edible forest gardens, both scaling out (increasing the numbers) and scaling up (increasing the size) were numerous. On the practical side, the improved availability of plants, seeds and seedlings and for plant schools to provide information on the edibility were greatly asked for, especially different types of nuts capable of production in the northern climate. Knowledge on how to design what plants go together or do not (intercropping) and nutritional values were also factors requested.

Since such gardens are still not well known in Sweden, more well-functioning prototypes in different growing zones were asked for, especially in official contexts such as parks and campuses. For farming, edible forest gardens where discussed as an approach suitable for field boundaries, islets and corridors and as an inspiration to develop multi-strata alleys. In order to increase self-sufficiency from gardens under today’s circumstances, a change in norms and values, readiness to reduce wage labor hours and cultural acceptability is probably needed. The report by Eksvärd et al. 2016 is accessible online and provides detailed information in Swedish on each farm on the different ways of establishment used in different contexts such as for households or farms, with or without animals and differences in climatic zones.

Agroforestry with animals: silvopasture experiences

In the group, 5 farmers were especially interested in silvopasture. All of these participants had before the PAR project started small scale animal productions (less than 15 livestock units on a yearly basis) based on natural and field based pastures. The natural pastures that had developed through history were already multifunctional systems producing extensive apples, berries, fodder, timber and firewood. There were also modern versions of animal keeping integrated into the crop rotation and forest re-establishment by pigs. These multifunctional pasture systems where all very fitted within their local context.

Pasture profitability in Sweden is very financially dependent on the Rural Development Program (RDP) [40] and is therefore bound by the different rule sets for these productions. As an approach of multifunctional production is not included in the Swedish RDP, developing these systems becomes financially difficult in practice. For those trying, the group concludes that regeneration of trees is a problem to solve: how do you plant new trees in an area where animals...
graze without too high resource and labor costs? Additionally, if fruit trees are grown in a natural pasture with un-even ground, they are difficult to place in time effective lines. Keeping fallen fruit away from on ground contamination was also discussed, as were harvesting techniques. All the production steps were concluded to take more time than when performed in plain grazing areas, though the site might generate greater total production.

The farmers claimed that for silvopasture to increase, re-evaluation of the trees already existing in pastures is needed. For farmers to better appreciate and see the potential in what they already have and are doing is one thing, to gain interest by the different authorities and adjust the RDP support system is another. More research on the contributions of multifunctional pasture systems and how to tend them was requested. The need for financially re-valuing products such as cider apples and wood was discussed. Again, the norms and values of our society and market system was concluded to not give adequate economic value to farm products and services such as the binding of carbon.

Agroforestry in the field, silvoarable experience

As three farmers planned for, and one started, agroforestry with fruit bearing trees and bushes in the agricultural fields, discussions on the topic were at times intense. Among the participating small-scale farmers in woody landscapes, adding trees in their usually small crop fields surrounded by forest were not of interest. Fields that have been cleared in such landscapes by earlier generations under much toil quickly return to forest when not tended, and the acreage was needed for fodder products. However, the farmers with larger acreages and marginal lands that today are not productive enough for cereals were interested in combined productions of cereals or pasture with fruit and berries.

For the couple with a comparably large-scale farm with flat land fields, a focus on crop production and wanting to increase and improve the ecosystem services of their farm, field agroforestry was of great interest. They planted demonstration patches of 140 different varieties of perennials in their windy location. This was to determine how they work in the environment, the potential yields and therefore possible financial income but also to learn what crops need breeding to work in the Swedish environment. The plots were arranged and labelled for other agricultural actors to study with fellow farmers in mind. They also started 1 ha alley cropping with rows of fruit, nuts and berries, which was financed and set up by Organic Farmers Countering Climate Change (www.solmacc.eu). To plant woody crops in their fields, they needed permission from the neighbors and the county administrative board. The subsistence and support from the RDP was reduced and the filling in of the application became very complicated. Additionally, the question of how to harvest was an unsolved challenge at the farm.

Other questions that emerged from the group discussions have been on how to secure as much of the services of a multi-strata design as possible that an edible forest garden provides when moving into the fields. How much of the 7-layer structure of symbioses can be kept? Should the design be in lines as alleys or as islets, and how should they be designed around boundaries? How do these different approaches to agroforestry fit with the landscape, soil, point of the compass, machinery on the farm, labor capacity, etc.?

For agroforestry in the field to spread, the group concluded that more trials and demonstrations are needed for improving the knowledge and management experiences of different types of designs and fit crop varieties. The use and development of technology fit for harvest vs use of labor provided discussions with many aspects. Another issue raised is the capability of selling smaller amounts of diversified products. Questions on the value chain, from storage possibilities to selling products with added values on a market, were discussed.

To conclude, the group argue that for agroforestry to develop as an agricultural approach in Sweden takes the availability of new crop varieties; changes in productions systems, tools and methods; changes in consumption patterns and diets; access to markets; cultural expectations on landscape views; knowledge on design, symbiosis and other effects; and nutrient analysis. Additionally, research, demonstration plots and cases for monitoring and evaluation, better
knowledge and understanding from authorities, as well as adjusting rules and subsidies were requested.

Outcomes of the agroforestry project

In addition to the actual establishments of plantations as learning sites and the PAR group as a learning platform, the group had also contributed to the arrangement of the first national conferences on agroforestry in Sweden in Stjärnsund 2014, the following one in Gothenburg 2015, and one in Alnarp 2017, as well as contributed to the establishment of the Swedish Agroforestry Association. Networking activities with other research and development projects had been extensive. The group’s work was covered by at least 8 magazine articles and a scientific program in the public radio. The sites were visited by well above 2000 people from transition groups, local growers’ organizations, students, the Federation of Swedish Farmers, universities, the Swedish Society for Nature Conservation, and others. The researchers participated in courses and lectures in higher education.

One of the participants decided to start a PhD project on agroforestry. One “high school”, two bachelor’s and one master’s thesis connected to the groups work were performed and written [39,42,43,44]. Some participated in the establishment of the European Agroforestry Federation (EURAF), and their conferences in Montpeiller, France 2016 and in Nijmegen, The Netherlands 2018. Two research articles were drafted.

Discussion

What is needed to establish agroforestry as an acknowledged part of Swedish agriculture and national food self-sovereignty and, for this transition of agriculture to proceed, what does it take for agroforestry in Sweden to expand beyond its niche, and what does it take for such a transition process to expand?

Farm level management

In the PAR group agroforestry was seen as a way to have less dependency on external inputs. Instead this was accomplished through using nitrogen fixing crops, crops with deep roots, well established mycorrhiza and self-regulative processes. The agroforestry systems, the multi-strata in particular, is a more complex system and needed a different management approach such as harvesting from all the different layers. This management takes new competence that, according to [7], together with the added administrative burden, are perceived as principal constraints by European farmers when asked about their views on adopting agroforestry.

Financial situations and context

Whether the agroforestry systems in this study were aimed for self-support or sales, they needed to give a net profit of some kind. This has turned out to depend on many aspects and took the discussion to “higher than farm” levels of institutional change, as described in [45].

The financial strength of an established well-functioning agroforestry system is the potential of producing more total harvest per acreage than mono-cultural production [46,9]. However, as today’s agricultural policies and pricing on food makes the farmers rely on sources of income other than the production amounts and their pricing; this aspect is not enough to ensure profitability in agroforestry productions. Additionally, as both perennial woody crops, and the symbiotic interactions take time to establish, the productivity was low during the establishment phase. This raised questions on how to increase productivity during the whole transition process: How is the production in, for example, a field established to give as much total produce as possible during the transition process? What crops can be grown meanwhile? To gain income to cover the extra costs and lack of income, the farmers discussed two possibilities: increasing prices for the added values, which would take branding and work on developing value chains, and adapting support systems that would give credit to agroforestry systems.
Other questions of importance to the financial situations were as follows: Is there a need to invest in machinery and develop new machinery? Should they be high tech solutions? Alternatively, is the way to go more low-tech solutions and less resource consumption by hiring more hands? Hiring people at the set levels of Swedish salaries is expensive and is often out of reach for smaller farmers. The farmers in the study already use cheap labor through organized volunteering or internships. In a society where labor time is an expensive asset, access to appropriate technology is important.

The voluntary choice for households of lowering monetary income and increasing one’s own labor may be an option when increasing self-subsistence, but for most farmers, this is not a possible choice. Creating possibilities for an increase in farm labor is closely connected to solutions on regime level.

**Competence building**

Since agroforestry is very complex support from research and extension services need to provide a combination of advice on agriculture, horticulture and forestry in a systemic setting. This calls for collaboration and approaches for the competence development of all actors.

In this PAR project the transition process that started, however small, was not initiated from a research or regime level “push”, rather multi-actors were attracted, or “pulled” the process forward, as phrased by [47]. The openness to connect with “multi-actor colleagues” was important for creativity and inputs to the process. The sharing by and listening to different actors and the co-creation between practical farm work, where the change actually happens, and research, where facts get analyzed, validated and put into print, was a process of clarifying the needed inputs from different professions. The importance of such transdisciplinary approaches for sustainable development has been shown by [32,48,49] among many others.

The experiences of the group point to the need of “knowledge and innovation brokering” [47] rather than traditional extension and education according to the transfer of knowledge approach. As the systems need to be developed according to the specific context at the local level, there is no possibility to “copy and paste” systems or management approaches. Therefore, extension and education, or brokering, need to promote creativity and innovation for transitions to happen. An example is “hybrid forums”, a space between the niche and the regime level, where niche innovators could scale up and out innovations, here a training program at a Spanish University described by López-Garcia et al 2018 [50].

**Bridges and barriers**

When seeing biodiversity as a “necessary ecological structure to support agricultural production” [26], which will be different at each location as with all the cases in this PAR study, it clashes in abiding with EU policy on maintaining biodiversity. The process of finding well suited local systems does not fit well with prefabricated, generalized and quantified indicators for control as the formal systems of today postulate. When the rules are set top-down, as in the RDP, they may work as lock-ins hindering creativity, biodiversity and development [40]. For agroforestry to become a more widespread approach, changes also need to occur in the settings of authorities, as claimed by [37], and policies [51]. In several barriers to the spread of agroforestry are discussed. The need to convince farmers is an underlying theme. We argue that the Swedish process of increased interest in agroforestry happened the other way around; in parallel with and in an synergetic relationship with the emergent agroecological movement during the same period of time.

There are problems to solve on the niche level, but real challenges for agroforestry are also identified on a regime level. Management of multiple service systems needs support from policy and institutional innovations and for public education to make the needed incentives that could create a reduction in agricultures’ environmental footprint possible [52,53].

Potters et al. (2014) [30] showed that the scaling of a novel practice in agriculture may take an increase in transactions on the local level, the emergence of technical and organizational changes and involvement of different actors. Their study, as well as ours, showed the importance of contextual
factors in scaling. Instead of asking how a novel practice can be scaled, the question is how the contextual society can provide room for the novelty to grow.

Thus the notion of principles is brought into context. Midgley (2016) gives a condensed description of the principles and methodological processes for co-creation of knowledge to be fruitful. These include taking account of multiple possibilities and letting new emergent properties be generated to enhance systemic awareness and create a generative context.

The capability of society to include contributing agroforestry systems takes new knowledge and new skills. Nicholls, Altieri, and Vazquez (2016) [23] describe this systemic change that re-designed the needs of farming systems through applying agroecological principles.

Conclusion

We can conclude that the systemic and symbiotic thinking and actions used by the PAR group have been foundations for the work of exploring the introduction of modern agroforestry systems in Sweden. This basis gave not only the outputs presented in [29], but also the outcomes provided here.

The viable and strong agroecological movement with an interest in agroforestry in Sweden keeps growing. However, to increase acreage and have agroforestry turn into an agricultural approach rather than an interest of enthusiasts, there is plenty to do. As shown in the discussion, there are the needs of education and extension services, profitability and legislative issues to be solved, as well as all the practical production issues. In theory, agroforestry has great benefits in regard to total productivity, ecosystems services, regenerative processes, etc. In practice, all those benefits remain, but there are also a wide range of challenges such as experienced by the PAR group in finding plant material, adequate extension service, being profitable (enough).

To facilitate a transition of agriculture to become not only sustainable but also regenerative, actors in society needs to learn to work with agriculture based on open system goals: improvements from the situation at each farm, and principles (such as agroecological) and equality (such as in PAR) on a regime level, as shown in this article. The scaling of agroforestry to improve food self-sovereignty, as well as providing ecosystem services, requires acknowledging local knowledge, multifunctionality in systems and flexibility of payment systems, as well as the interconnectedness of scales. This is to give possibilities for these systems to become profitable enough to live off and easy enough to manage both in the field and office.

The 12 farm PAR-project is a unique collaboration in Sweden between farmers-farmers and farmers-researchers in Sweden on agroforestry, which also could make long term studies in temperate region possible, since establishment of agroforestry systems takes time [10,12]. The research project and establishment of edible forest gardens at kindergartens has the potential of becoming another type of long term relationship cross sectors; a collaboration between Jönköping University, a housing company (Riksbyggen) and kindergartens in the public sector as a learning platform [17].

Now, in the light of the high temperatures of the summer 2018 that affected the access of fodder for grazing animals in Sweden this caused attention to farmers situation, and to potential vulnerabilities to climate change, could be the time for the monitoring and evaluation of existing practices to suggest improvements for future agroforestry, and for authorities to adapt the regulations so as to not smother or delay the ongoing process. A conclusion is for regime level actors to work more based on principles, equality, open goals and transdisciplinarity to give room for transitions within agriculture to foremost become not only sustainable but open up for re-generative solutions as agroforestry.

References


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