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Can Agroforestry Grow beyond Its Niche and Contribute to a Transition towards Sustainable Agriculture in Sweden?

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Abstract: Agroforestry is thought to be an approach that could support agriculture in the transition from a system with sustainability problems to one containing regenerative activities contributing to viable ecosystems and, therefore, sustainability solutions. A transdisciplinary and participatory action research (PAR) group that included farmers approached the development of temperate agroforestry systems in the modern agricultural setting of Sweden through practical experience on 12 farms for collective analysis. The objective was to research potential systems such as edible forest gardens, silvopasture and silvoarable systems to discuss their use and effects as well as scaling possibilities. Knowledge and experiences of challenges and solutions related to the development of agroforestry were identified 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 at the expense of a decrease in other ecosystem services that are important for human wellbeing [1]. The use of non-renewable resources such as fossil fuels 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, and climate change) have exceeded "the safe zone boundaries" into uncertain zones [3]. In accordance with Agenda 2030 and the UN Sustainability Goals (SDG), the FAO has addressed the need to transform food and agricultural systems and agroecological initiatives could contribute to this effort [4]. From a global assessment identifying redesign approaches that could contribute to a transition in agriculture and agroforestry practices, "trees in agriculture" are one of the seven listed [5].

1.1. Temperate Agroforestry

One agroecological practice, agroforestry, is defined by the European Agroforestry Federation (EURAF) as "the integration of woody vegetation, crops and/or livestock on the same area of land". Temperate regions have a long tradition of agroforestry system adoption (e.g., animal grazing in natural woodlands, alleycropping, orchard intercropping, and home gardens/edible forest gardens). Some practices have been re-introduced due to the influence of tropical regions, where more research has been conducted than in temperate regions.

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

Compared to conventional agriculture, the integration of trees and other perennials with the landscape increases biodiversity and supports both wildlife (habitats) and domestic animals (health) while extending ecosystem regulation services by reducing fire risks, enhancing carbon sequestration, reducing soil erosion and nutrient leaching and increasing levels of soil organic carbon. Stakeholders in Europe also perceive aesthetic qualities and other cultural benefits that could attract tourists and other visitors [6–8]. The limitations of agroforestry relate to increased labour needs, more complex work (e.g., working with trees and harvests), and management and administrative costs [7,9]. Furthermore, the establishment of woody perennials takes time as well the evaluation of effects of planting certain trees, which may be possible after 20–80 years [6,10]. This could constitute one of the factors behind why research on agroforestry in temperate regions is limited [11,12].

1.2. Agroforestry in Sweden

Depending on what is included on the concept of agroforestry, different account emerge. Land Use and Land Cover Survey (LUCSUS) data show that in Sweden, arable agroforestry, livestock agroforestry and high value tree agroforestry (e.g., fruit and nuts orchards) represent 1.1% of territorial areas, reflecting 15.2% of all utilized arable area [13]. Livestock agroforestry constitutes 99% of the total area designated for agroforestry in Sweden [13]. At the farm level, an assessment of ecosystem services of woody pastures of at least one Swedish farm has been included in a European project [14].

Historical and contemporary examples of agroforestry in Sweden show that extensive forests have traditionally been used for cattle, sheep and goat grazing in silvopastoral systems and by the system of summer farms [15]. In northern parts of Sweden and in Finland and Norway, the Sami people have traditionally maintained and still maintain large herds of semi-domesticated reindeer grazing freely in mountainous and forested areas. In terms of area, Valinger et al. (2018) claim this to represent one of the largest agroforestry systems in Europe (i.e., reindeer husbandry alongside forestry, hunting and tourism) [16]. Field experiments addressing agroforestry with a focus on the intercropping of perennials are under development at the Swedish University of Agricultural Sciences (SLU). One project is developing and testing how edible forest gardens installed at pre-schools could function as pedagogic tools for children [17]. There has also been an emerging interest in different agroecological approaches in sometimes overlapping grassroot movements related to permaculture, urban gardening and Transition town movements [18–20].

1.3. The Need for Transition

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

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

To explore and learn more about agroforestry in temperate regions, a group of researchers and Swedish agricultural producers has conducted a pilot project on agroforestry in Sweden through a participatory action research (PAR) project and has tested and analysed different forms of agroforestry across 12 farms. The joint work and the process of establishment applied at each farm are presented in detail in an online report written in Swedish [28], and outputs of the PAR project are published in Björklund et al. (2018) [29]. In this paper, we will investigate the need for agroforestry to expand beyond its niche and through this transition become an acknowledged facet of Swedish sustainable agriculture.

2. Materials and Methods

This initiative, a case study of a participatory action research (PAR) project conducted from 2012–2016 as a pilot project to investigate the establishment of agroforestry in Sweden, will be described in depth. This agroforestry innovation system, i.e., a collaborative platform created by participants and their practices, is explored as an example of an agricultural transition and in reference to the need to scale transitions [30] depending on practices, prerequisites and contexts.

The PAR project on agroforestry was based on cross-organizational collaboration fostering transformational change towards sustainability through work in "real-world laboratories" as described by Luederitz et al. (2017) [31] in adherence with principles of agroecology [32]. It was carried out through a participatory action research (PAR) group of producers from 12 different areas: 9 were small holders of farms of different sizes (3–200 ha) often with a combination of different forms of food production and other activities (e.g., visitors as tourists or participants in learning events), 2 were community projects inspired by transition town movement, one was a part of an ecovillage, and one managed a demo/learning site involving a large number of volunteers and a formal educational programme where agroforestry practices have been implemented since the start of 2004. Despite their heterogeneity, we refer to them hereafter as 12 *farms*. Two researchers, both with a background in agronomy and one with facilitating skills initiated the project. Through the workshops, which each involved 1 or 2 people from each farm, 18 people participated over 4 years. On several occasions, experts on subjects such as soils, pasture and leaf protein were invited to the workshops. The goal of the work was to develop modern agroforestry systems and to learn about their effects, practices, use and scaling opportunities. Potential farmer participants were identified before the actual research project started through a pre-workshop held by people with agroforestry experience in southern Sweden to explore interest in an investigation of applied agroforestry in Sweden. Anyone with such an interest was invited to participate in the research project. None of the participants used commercial fertilizers or pesticides, and all were interested in reducing the amount of oil used in agriculture. Their management approaches focused on resource effective production with limited external inputs. Agroforestry was seen as a way to achieve less dependence on such inputs.

The group met for 9 workshops over 4.5 years and held 14 telephone meetings. The facilitated workshops were conducted at the different farms. To facilitate learning on new and unexperienced practices, three activities were engaged in: i) collectively determining the scope and intentions of the group; ii) on an iterative basis, "exploring impacts through situation analysis defined through the analysis of questions and by deciding which to explore" [33]; and iii) creating a space for creativity, sharing and feedback.

The farming systems research project was driven by all of the participants, and the facilitating researchers were also practitioners who also took part in the research. The research questions were formulated jointly by the researchers and farmers. All participants were invited during the project to attend national meetings and international agroforestry conferences and were also consulted during the production of public written materials. All farms contributed to the report in Swedish with detailed descriptions of case studies and of methods employed on 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 conditions through our collective learning and vice versa.

To facilitate discussions on scaling and transitions, transition theory and multilevel perspective (MLP) theory [36] adapted to agriculture [37] were used as heuristic tools in group discussions. This approach was adopted to facilitate coverage of societal impacts on systems, including aspects observed at the niche, regime and landscape levels and their complex connections. The niche reflects the micro level from which new innovations or local projects are developed and are regarded as "seeds for change" [38], while the regime or meso level considers areas such as policy, science, market or technology. The landscape level reflects a less dynamic environment (e.g., economic growth or oil prices) [38]. A transition involves societal change as the outcome of interactions between niches, which could also involve places or communities and the regime or landscape levels [38].

3. Results

Here, we provide an overview of the *processes*, *outputs* and *outcomes* of the project. Practical experience and means of scaling possibilities and limitations are presented in reference to each form of agroforestry. When using the term "group" or "PAR group" below, we refer to points raised through group discussions held at several workshops.

3.1. Process Overview

During the first workshop (April 2012), the PAR group decided to use agroecological principles of functional design, biodiversity, multifunctionality, adapted scales, ecosystem services, circulation and plant nutrients as a basis for collective work on the design and development of agroforestry systems to be studied. In this way, quantitative goals were set, and an agreement was made to work in teams. In April 2016 (workshop 9), the group summarized the outputs and outcomes of the project.

Through the PAR project, the group decided to plan for and apply three forms of agroforestry: edible forest gardens at all 12 farms where 3 of the farms also planned for silvopastures and five planned silvoarable systems. The edible forest garden design (compositions of plants and sizes) presented in Björklund et al. 2018 was adopted by the group [29]. Locations, the preparation of land and the addition of plants were individually determined at different farms (see Figure 1 and Table 1). Experiences with introducing and managing these systems were shared through facilitated discussions with the group and were well documented. The materials produced were analysed and re-discussed by the group and conclusions were agreed upon.

Figure 1. Map of Sweden showing the geographic positions of edible forest gardens studied, reprinted from Björklund et al. 2018.

Table 1. Farmers' observations of the establishment phase (2013–2016) of the edible forest gardens. The table pertains to project described here and is published in Björklund et al. 2018.

Farm	Labour Hours, Establishment of Tree and Shrub Layers	Labour Hours, Management and Harvesting	Preparation before Planting Trees and Shrubs	Preparation before Planting Herbal and Ground Cover Layers	Manure	Irrigation, Occasions, yr	Inclusion of Annuals during Establishment	Main Harvested Plants	General Observations
1	25	10	Tilling	Tilling	None	4–6	No	*Amelanchier anifolia, Malus domestica, Hippophae rhamnoides, Chenopodium bonus henricus*	Satisfactory growth of trees and shrubs, promising *Chenopodium bonus henricus* growth
2	22	22	None, sward planting	Plastic weave	None	None	Yes	*Fragaria x ananassa, Amelanchier anifolia, Hippophae rhamnoides, Rubus lacinatus*	Slow growth when planting in swards, invasive *Rubus lacinatus*, *Malus domestica* disfavoured due to high levels of groundwater
3	26	5	Tilling	Cardboard, litter	Well composted sheep manure	Few	No	*Amelanchier anifolia, Malus domestica, Rubus lacinatus*	Tree and shrub growth is retarded due to competition with the herbaceous layer
4	28	n.a.	None, sward planting	Cardboard, litter, cultivation of annuals	Grass cuttings, composted manure	Yes	Yes	*Fragaria vesca, Amelanchier anifolia, Malus domestica, Hippophae rhamnoides, Agastache foeniculum, Hablitzia tamnoides*	Symphytum upplandica is invasive to *Malus domestica*, less work and more harvesting, leaves and flowers for salads are produced each year
5	24	18	None, sward planting	Cardboard, newspaper and litter	Fresh sheep manure	Few	No	*Amelanchier anifolia, Hippophae rhamnoides, Rubus lacinatus, Chenopodium bonus henricus, Agastache foeniculum, Hablitzia tamnoides, Mentha* spp., *Origanum vulgare*	*Vinis vinifera* and *Malus domesticus* suffer from low pH *Mentha* spp., *Alliaria petiolata* and invasive *Chenopodium bonus henricus*
6	24	6	Cultivation by pigs	Cardboard	Grass cuttings, composted horse and sheep manure	Few	Yes	*Fragaria vesca, Agastache foeniculum, Chenopodium bonus henricus*	*Symphytum upplandicum* is invasive, fences for roe deer are needed, greater contributions to households each year
7	28	n.a.	Cultivation by pigs	Newspaper, litter	None	None	Yes	*Hippophae rhamnoides, Rubus lacinatus*	Tree and shrub growth is retarded due to competition with the herbaceous layer

3.2. Outputs

As outputs of this project, 12 edible gardens and one silvoarable system were established as well as reference data for future research, extensive nutritional data on two unmapped crops, additional nut gardens created on 12 farms, demonstration plots with nearly 140 varieties, a conference article and poster, and a report describing the 12 cases and group outcomes published online in Swedish [28,29].

3.3. Edible Forest Garden Experiences

All of the farms established edible forest gardens of the same size (60 m^2) and with the same woody plants across 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 human needs for vitamins and minerals. Establishment was performed by hand, and production took 3 years to initiate. These first years were time intensive, but the need for attention declined as planting continued. Identifying the right plant species and good quality varieties is critical to not prolonging establishment, but this is difficult to achieve. Good plant material is quite expensive. Weeds must be extensively tended to during establishment, and good mulching materials must be used. The household edible gardens were perceived as conferring multifunctional benefits in producing new products for *human consumption* and in offering aesthetic qualities from an enhanced richness of species such as flowers, butterflies, bees and birds.

Factors identified for the establishment of edible forest gardens in terms of scaling out (increasing quantities) and scaling up (increasing the size) were numerous. In practical terms, the improved availability of plants, seeds and seedlings and plant schools providing information on edibility were greatly appreciated, especially in reference to different types of nuts capable of producing in the northern climate. Knowledge of ways to determine which plants grow together (intercropping) and of the nutritional value of different plants was also desired.

As such gardens are still not well understood in Sweden, more well-functioning prototypes used in different growing zones were called for, especially for application in official contexts such as parks and campuses. For farming purposes, edible forest gardens were discussed as suitable for field boundaries, islets and corridors and as means to develop multi-strata alleys. To enhance the self-sufficiency of gardens under current circumstances, a shift in norms and values, a reduction in wage labor hours and cultural acceptability are likely needed. The report by Eksvärd et al. 2016 is accessible online and provides detailed information in Swedish on different modes of establishment applied in different farms and households with or without animals and based on different climatic zones [28].

3.4. Agroforestry with Animals: Silvopasture Experiences

In the group, five farmers were especially interested in silvopasture. Prior to the PAR project, all of the participants had started small-scale animal productions (less than 15 livestock units on a yearly basis) based on natural and field-based pastures. Natural pastures that had developed over time served as multifunctional systems producing apples, berries, fodder, timber and firewood. Modern forms of animal keeping were also integrated with crop rotation and forest re-establishment by pigs. Such multifunctional pasture systems were identified suited to their local contexts.

Pasture profitability in Sweden is very financially dependent on the Rural Development Program (RDP) [40] and is therefore bound by different production rules. As an approach to multifunctional production is not outlined under the Swedish RDP, developing such systems is financially difficult in practice. For those attempting this task, the group concluded that the regeneration of trees presents as a problem to solve: how do you plant new trees in an area where animals graze without many resources and with high labour costs? Additionally, when fruit trees are grown in a natural pasture with uneven ground, they are difficult to arrange in rows. Preventing fallen fruit from becoming contaminated on the ground was also discussed, as were harvesting techniques. All production steps were concluded to take more time than when applied to plain grazing areas, though sites may generate more production.

The farmers claimed that for silvopasture to be encouraged, a re-evaluation of 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, while garnering the interest of different authorities and adjusting RDP support systems is another. More research on the contributions of multifunctional pasture systems and on ways to tend them was requested. The need for financially re-valuing products such as cider apples and wood were discussed. Again, the norms and values of our society and market system were concluded to not assign adequate economic value to farm products and ecosystem services such as carbon binding.

3.5. Agroforestry in the Field, Silvoarable Experience

As three farmers planned for and one had initiated agroforestry systems with fruit bearing trees and bushes in agricultural fields, discussions of this issue were at times intense. Among the participating small-scale farmers of woody landscapes, adding trees to their most small crop fields surrounded by forests was not of interest. Fields that have been cleared in such landscapes by earlier generations with much toil quickly return to forest when not tended to, and acreage is needed for fodder products. However, farmers with more acreage and marginal land that today is not productive enough for cereals were interested in the combined production of cereals or pasture with fruit and berries.

For the couple of farmers with comparably large-scale farms with flat fields, a focus on crop production and a desire to expand and improve farm ecosystem services and field agroforestry was noted. The farmers had planted demonstration patches of 140 different varieties of perennials in windy locations. This was done to determine how such varieties perform in the environment, their potential yields and potential financial outcomes as well as to determine which crops must be bred to survive in the Swedish environment. Plots were arranged and labelled for other agricultural actors to study with fellow farmers in mind. In addition, 1 ha of alley crops with rows of fruit, nut and berry crops was introduced, which was financed and set up by Organic Farmers Countering Climate Change [41]. To plant woody crops in their fields, the farmers needed to seek permission from their neighbours and county administrative boards. Support from the RDP was limited and the application process proved very complicated. Additionally, questions surrounding harvesting remained a challenge for the farmers.

Other questions that emerged from the group discussions focused on ways to secure as many services from a multi-strata design as possible in adopting edible forest gardens in the field. How much of the 7-layer structure of symbiosis can be maintained? Should one plant in alleys or islets, and how should boundaries be designed? How do different approaches to agroforestry correspond with landscapes, soils, points of the compass, farm machinery, labour capacities, etc.?

For agroforestry to proliferate, the group concluded that more trials and demonstrations are needed to further knowledge and management experience with different approaches and crop varieties. The use and development of technologies for harvesting and the use of labour spurred varied discussions. Another issue raised concerned the capacity to sell smaller amounts of diversified products. Questions regarding the value chain from storage approaches to selling products with added value on a market were also discussed.

To conclude, the group argued that the development of agroforestry as an agricultural approach in Sweden will be shaped by the availability of new crop varieties; changes in production systems, tools and methods; changes in consumption patterns and diets; access to markets; cultural expectations of landscapes; knowledge regarding design, symbiosis and other effects; and nutrient analysis. Additionally, further research, demonstration plots, monitoring and evaluation, more understanding from authorities, and adjusted rules and subsidies were called for.

3.6. Outcomes of the Agroforestry Project

In addition to establishing plantations as learning sites and supporting the PAR project as a learning platform, the group contributed to the arrangement of the first national conferences on agroforestry held in Sweden (Stjärnsund in 2014, Gothenburg in 2015, and Alnarp in 2017) as well as contributing to the establishment of the Swedish Agroforestry Association. Networking activities involving other research and development projects have been extensive. The group's work was covered in at least 8 magazine articles and in a scientific programme broadcast on public radio. The sites were visited by well over 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 also participated in higher education courses and lectures. One of the participants decided to start a Ph.D. project on agroforestry. One high school paper, two Bachelor's theses and one Master's thesis related to the group's work were also written [39,42–44]. Some participants helped established the European Agroforestry Federation (EURAF) and participated in its conferences in Montpeiller, France in 2016 and in Nijmegen, the Netherlands in 2018. Two research articles were also drafted.

4. Discussion

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

4.1. Farm-Level Management

In the PAR group, agroforestry was seen as a way to ensure less dependence on external inputs. This can be accomplished by adopting nitrogen fixating crops, crops with deep roots, well-established mycorrhiza and self-regulative processes. Agroforestry systems and multi-strata in particular are more complex systems requiring different management approaches such as harvesting from different layers. Such management necessitates new forms of competence that, according to García de Jalón et al. (2017), together with added administrative burdens, are perceived as principal constraints by European farmers when asked about their views regarding the adoption of agroforestry.

4.2. Financial Situations and Contexts

Whether the agroforestry systems studied were designed for subsistence or commercial purposes, they needed to generate a net profit of some kind. This was found to depend on many aspects and took the discussions to "higher than farm" levels of institutional change, as described in [45].

As a financial strength of an established and well-functioning agroforestry system, it can produce more harvests per acreage than mono-cultural systems [9,46]. However, as today's agricultural policies and food prices force farmers to rely on sources of income other than production amounts and their pricing, this aspect cannot ensure agroforestry production profitability. Additionally, for perennial woody crops, symbiotic interactions take time to establish, and productivity levels are low during the establishment phase. This raised questions regarding ways to increase productivity throughout the transition. How can production in, for example, a field be established to generate as much produce as possible during a transition? What crops can be grown in the meantime? As ways to generate income to cover extra costs and a lack of income, the farmers discussed two possibilities: increasing prices for added value, which would involve branding and developing value chains, and adapting support systems that would give credit to agroforestry systems.

Other questions posed on the importance of financial concerns were as follows. Is there a need to invest in machinery and to develop new machinery? Should high-tech solutions be adopted? Alternatively, can less resource-intensive low-tech solutions be adopted by hiring more labour? Hiring personnel at set Swedish salaries is expensive and is often unfeasible for smaller farmers. The farmers studied already use cheap labour through organized volunteering or internships. In a society where labour time is an expensive asset, access to appropriate technology is critical.

While voluntary labour that lowers monetary income and increases one's own labour load may be an option when seeking self-subsistence, for most farmers, this is not an option. Creating opportunities to enhance farm labour is closely connected to solutions at the regime level.

4.3. Competence Building

As agroforestry is very complex, support from research and extension services must offer advice that combine agriculture, horticulture and forestry in a systemic setting. This calls for collaboration and the development of competence in all actors.

Through our PAR project, the transition, however small, was not initiated with a research- or regime-level "push"; rather multiple actors "pulled" the process forward as described by [47]. An openness to connect with "multi-actor colleagues" proved essential in supporting creativity and processing inputs. Sharing from different actors, the co-creation of practical farm work (where the change actually happens), and research (where facts get analysed, validated and put into print) helped clarify the required inputs from different professions. The importance of such transdisciplinary approaches for sustainable development is illustrated by [32,48,49] among many others.

The experiences of the studied group point to a need for "knowledge and innovation brokering" [47] rather than for traditional extension and education according to the transfer of knowledge. As systems must be developed according to specific contexts at the local level, one cannot "copy and paste" systems or management approaches. Therefore, extension and education or brokering must promote creativity and innovation for transitions to occur. As an example, "hybrid forums" serve as spaces between the niche and regime levels where niche innovators can scale innovations up and out, as described by López-Garcia et al. 2018 in reference to a training programme provided at a Spanish university [50].

4.4. Bridges and Barriers

When defining biodiversity as a "necessary ecological structure to support agricultural production" [26] that varies in each location as observed through this PAR study, this definition clashes with EU policies on biodiversity. The identification of well-suited local systems does not adhere well to prefabricated, generalized and quantified indicators of control as today's formal systems postulate. When rules are top-down, as under the RDP, they may work as lock-in systems hindering creativity, biodiversity and development [40]. For agroforestry to become a more widespread approach, changes must also be made to forms of authority, as claimed by [37], and policies [51]. Several barriers to the spread of agroforestry were identified. The need to convince farmers emerged as an underlying theme. We argue that interest in agroforestry in Sweden has occurred the other way around in parallel with and in synergetic relationship with an agroecological movement that has emerged over the same period.

While there are problems to solve at the niche level, barriers to agroforestry have also been identified at the regime level. The management of multiple service systems must be supported through policy and institutional innovation for public education to offer the required incentives to support a reduction in agriculture's environmental footprint [52,53].

Potters et al. (2014) [30] showed that the scaling of a novel approach to agriculture may involve an increase in transactions at the local level, the emergence of technical and organizational changes and the involvement of different actors. Their study as well as ours revealed the importance of contextual factors of scaling. Rather than determining how a novel practice can be scaled, the question concerns how a society can provide room for novelty.

Thus, the notion of principles is brought into context. Midgley (2016) provides a condensed description of principles and methodological processes required for the co-creation of knowledge to be fruitful. These include taking account of multiple possibilities and allowing new and emerging properties be generated to enhance systemic awareness and create a generative context [54].

For society to contribute to agroforestry systems, new knowledge and skills must be acquired. Nicholls, Altieri, and Vazquez (2016) [23] describe such a systemic change that can re-design the needs of farming systems by applying agroecological principles.

5. Conclusions

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

A viable and strong agroecological movement with an interest in agroforestry in Sweden continues to grow. However, to increase acreage and develop agroforestry into an agricultural approach rather than an interest of enthusiasts, there is plenty yet to do. As shown in our discussion, education and extension services must be developed, profitability and legislative issues must be addressed, and practical production issues must also be addressed. In theory, agroforestry offers great benefits in regard to productivity, ecosystem services, regenerative processes, etc. In practice, while such benefits remain, a wide range of challenges were identified by the PAR group in terms of finding plant materials and adequate extension services and ensuring (sufficient) profitability.

To facilitate an agricultural transition that is not only sustainable but also regenerative, societal actors must learn to work with agricultural systems based on open system goals: improvements to each farm and principles (e.g., agroecological principles) and equality (e.g., PAR) at a regime level as shown in this article. The scaling of agroforestry to improve food self-sovereignty and to offer ecosystem services involves acknowledging local knowledge, multifunctionality in systems, flexible payment systems, and the interconnectedness of scales, creating opportunities for these systems to become profitable enough to live off of and easy enough to manage from the field and office.

Our PAR project based on 12 farms involved a unique collaboration of farmers and researchers in Sweden focused on agroforestry and may support more long-term studies on temperate regions, as the establishment of agroforestry systems takes time [10,12].

High temperatures experienced in the summer of 2018 that affected access to fodder for grazing animals in Sweden drew attention to farmer issues and to potential vulnerabilities to climate change. It may thus be necessary to monitor and evaluate existing practices to identify ways of improving agroforestry techniques and ways that authorities can adapt regulations to not further delay the ongoing process. Regime-level actors can work based on principles of equality, shared goals and transdisciplinarity to facilitate transitions within agriculture not only to ensure sustainability but also to allow for re-generative solutions such as agroforestry systems.

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