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The development of agroforestry systems in Flanders.

A farming systems research approach to social, institutional and economic inquiry.

Thesis submitted by Lieve BORREMANS
in fulfillment of the requirements of the PhD Degree in Agronomy and Bioengineering (ULB - “Docteur en Sciences agronomiques et Ingénerie biologique”)
Academic year 2018-2019

Supervisors: Professor Marjolein VISSER
(Université libre de Bruxelles)
Unit of Landscape Ecology and Plant Production Systems
and Dr. Erwin WAUTERS (ILVO)
Social Sciences Unit

Thesis jury:

Charles DE CANNIÈRE (Université libre de Bruxelles, Chair)
Nicolas VEREECKEN (Université libre de Bruxelles, Secretary)
Fleur MARCHAND (ILVO)
Eduardo DE LA PENA (UGent)
Euridice LEYEQUIEN ABARCA (Van Hall Larenstein University)

ILVO
Flanders research institute for agriculture, fisheries and food

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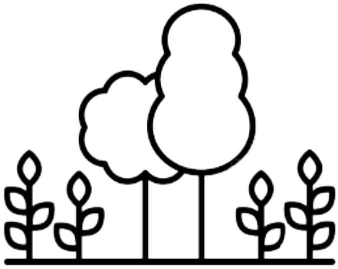
List of abbreviations

A	Attitude
AF	Agroforestry
AFINET	Agroforestry innovation networks
AF s.l.	Agroforestry sensu largo
AF s.s.	Agroforestry sensu stricto
AKIS	Agricultural Knowledge and Information Systems
AIS	Agricultural Innovation System
BWK	Biologische waarderingskaart
CA	Conservation agriculture
CAP	Common Agricultural Policy
CH	Chapter
CSA	Community-supported agriculture
DFS	Diversified farming systems
D&D	Diagnos and design
EFA	Ecological focus area
ERS	Efficiency, subsitution and redesign model
EU	European Union
E&O	Educational and organizational pathway
FAO	Food and Agriculture Organization
FSR	Farming Systems Research
GN	Group norm
GPS	Global positioning system
I	Intention
ICLS	Integrated crop livestock systems
IGP	Intergroup perceptions
IPES	International panel of experts on sustainable food systems
RDP	Rural Development program
LER	Land Equivalency Ratio
MN	Moral norm
M&F	Market and financial pathway
NEM	Narrow Ecological Modernization discourse
PBC	Perceived behavioral control
PC	Political correctness discourse
PES	Payment for environmental services

P&I	Policy and institutional pathway
RE	Response efficacy
RA	Radical agroecology discourse
RDP	Rural Development Programs
RSPCA	Royal society for the prevention of cruelty to animals
SAF	Suitability, acceptability and feasibility model
SALV	Strategic advisory board for agriculture and fishery
SDG	Sustainable Development Goals
SI	Social identiy
SN	Subjective norm
SQ	Discourse maintaining the status quo
S&T	Science and technological pathway
S&B	Social and behavioral pathway
TPB	Theory of planned behavior
TV	Transformational viewpoint discourse
UAf	Uncertainty about agroforestry
UAg	Uncertainty about agriculture
UN	United Nations
WP	Work package

Chapter 1

Introduction



In this chapter we introduce AF as a traditional farming system that has been reinvented. We elaborate on how AF systems contribute to addressing challenges in modern agriculture, how AF can be interpreted as a transformative solution, and how AF systems in Europe are currently supported through the Common Agricultural Policy. Afterwards we zoom in on AF adoption and development in Flanders, which is the case study this thesis focuses on. We conclude with the general objective of this thesis, which is to gain a better understanding of the current implementation gap with respect to AF by investigating AF adoption and development making use of a farming systems research approach. This overall objective is translated into four research questions, which are answered in the course of this thesis.

1.1 Agroforestry, a traditional farming system that has been reinvented

Trees, scattered or planted in groups or rows, are central elements of many agricultural landscapes worldwide (Plieninger et al., 2015). This was also true in Flanders and other parts of Europe, where trees were considered as valuable and productive elements. They were grown by farmers, mainly for the production of fruits, fodder and wood, but also taking advantage of other benefits delivered by trees, such as provision of shade and shelter for livestock and the prevention of soil erosion. However, from the 1960's on trees slowly disappeared from the agricultural landscape in Flanders, just like in other temperate regions. Scaling and intensification lie at the heart of this evolution, but also economic and policy factors may have been at play, with the market conditions and subsidy regime in the European Union being until recently unfavorable towards silvoarable practices (Eichhorn et al., 2006; Herzog, 1998).

Because of the multiple values and services trees deliver to society, in recent years a renewed interest for trees in a farming context emerged, especially among researchers, policy makers and civil society actors. These farming systems, traditional or modern, in which trees are deliberately combined with the cultivation of crops and/or livestock production are now called agroforestry (AF) systems. They are defined within the European Union as "land use systems in which trees are grown in combination with agriculture on the same land". Within Agforward, a European research project on AF, four different groups of AF systems are differentiated (Rosati et al., 2018): (1) existing AF systems of high nature and cultural value, such as the Dehesa and Montado systems in Spain and Portugal, and wood pastures and parkland in Germany and the UK; (2) the integration of grazing or intercropping in high value tree systems, including olive trees, fruit trees, and walnut and cherry trees grown for high value timber; (3) silvoarable systems, i.e. the integration of trees into arable systems; and (4) silvopastoral systems, i.e. the integration of trees in livestock systems.

In a time where the agricultural sector is confronted with a lot of environmental and societal challenges, AF systems are gaining prominence because of the different regulating and cultural ecosystem services they deliver to society. However, AF can also bring about benefits for the farmers for example through diversification in production, protection against soil erosion, climate change adaptation (i.e. creation of a micro-climate) etc., at least on the condition that suitable trees are selected and appropriate tree management is applied (Nerlich et al., 2012). Nevertheless, the majority of the farmers remain skeptical about its' opportunities in the context of Europe, which restrains its current adoption rates. Taking into account the gap between the conceptual opportunities and the actual implementation of AF, we focus in this thesis on AF adoption by farmers, and this specifically for Flanders, the northern region of Belgium, located in Northwestern Europe. But before elaborating on the case study and the objective of this thesis, we shed light on the opportunities of AF, its position within the spectrum of agricultural models, and the tools the Common Agricultural Policy (CAP) provides to incentivize AF adoption by farmers.

1.2 Agroforestry systems to address challenges in modern agriculture

1.2.1 Agroforestry and the Sustainable Development Goals

Between 1960 and 2015 agricultural production has more than tripled, owing in part to productivity-enhancing Green Revolution technologies and a significant expansion in the use of land, water and other natural resources for agricultural purposes (FAO, 2017). However, the expansion and intensification of food production have often come at a heavy cost to biodiversity, ecosystem functioning and climate, as well as product quality, animal welfare and human health (Martin et al., 2013). These problems are acknowledged by the FAO (2017) and are represented in ten challenges that the FAO formulated for the future of food and agriculture:

1. Sustainably improving agricultural productivity to meet increasing demand
2. Ensuring a sustainable resource base
3. Addressing climate change and intensification of natural hazards
4. Eradicating extreme poverty and reducing inequality
5. Ending hunger and all forms of malnutrition
6. Making food systems more efficient, inclusive and resilient
7. Improving income earning opportunities in rural areas and addressing the root causes of migration
8. Building resilience to protracted crises, disasters and conflicts
9. Preventing transboundary and emerging agriculture and food system threats
10. Addressing the need for coherent and effective national governance

To address these challenges, calls are made by the FAO for a transformative process towards holistic approaches that protect and enhance the natural resource base. This could imply technological improvements such as climate-smart agriculture, but also agroecological farming systems that build on traditional knowledge. Within the pool of agroecological solutions, AF is considered as an interesting farming system because it delivers both food and wood products, as well as environmental and socioeconomic benefits at the same time. The role that AF could play in addressing challenges in agriculture, is especially analyzed in relation to the Sustainable Development Goals (SDG) of the United Nations (UN). In this respect, Mbow et al. (2014) reviewed to what extent AF concepts and practices can form an effective, efficient and fair pathway towards the Sustainable Development Goals (SDG) in Africa. They found that AF combines traditional and more recent research-based knowledge and evidence related to optimizing the interactions of trees, crops, livestock, water, soil and social and economic systems in order to respond sustainably to challenges of development and sustainability. Waldron et al. (2017) on the other hand, illustrate how AF systems can increase yield while also advancing multiple SDG. The figure was especially made taking into account the small developing-world agriculturalists central to the SDG framework, but acknowledges that AF also entails benefits for more intensive farmers in temperate regions and for society in general. The figure shows some general global trends for AF systems, although the exact direction and the magnitude of the impact of AF always have to be determined taking into account the local context.

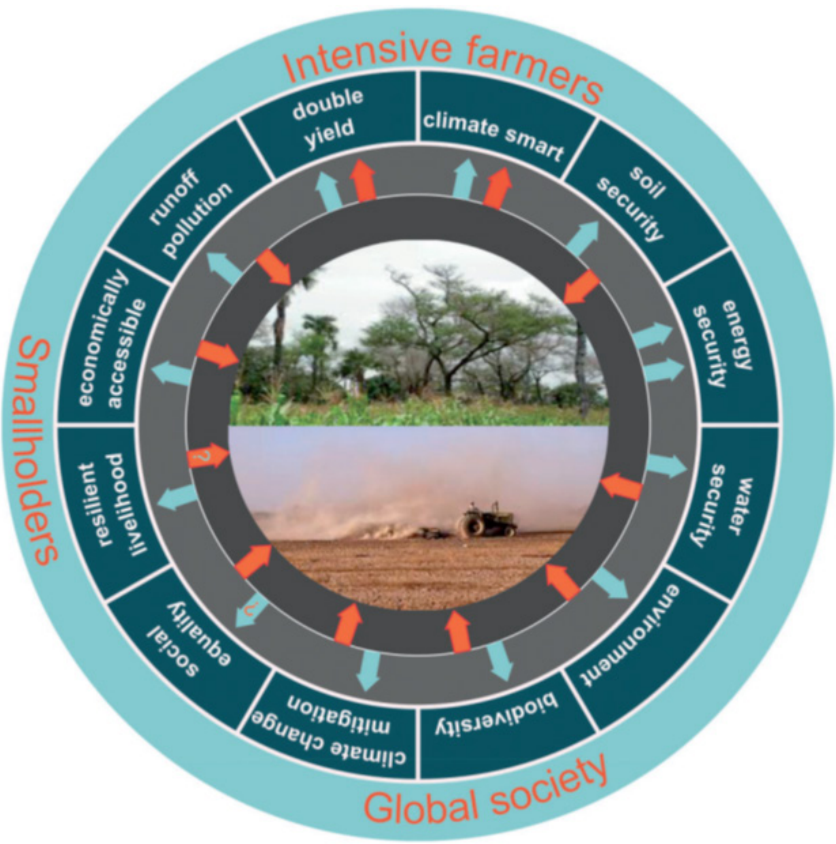


Figure 1 - 1: Agroforestry (top photo), conventional agriculture (bottom photo), and the achievement of multiple goals. Twelve goals are shown, all related to food security (especially for developing-world agriculturalists) and to other sustainable development goals connected with agriculture. Arrows compare how agroforestry (lighter blue) and conventional intensification (darker red) affect each goal: Arrows pointing away from the circle centre indicate a likely positive impact on the goal, vice versa for arrows toward the centre. To reflect uncertainties, arrow heights are arbitrarily equal. Alternative theories exist for some goals, for example, social equality and livelihood resilience. Some goals are also important to global society (e.g. climate change and biodiversity) and larger farmers using conventional intensification (e.g. yield and climate-smart crops). (Waldron et al., 2017)

1.2.2 Evaluating agroforestry against the Ecosystem Services Framework

Although the reviews of Mbow et al. (2014) and Waldron et al. (2017) are especially focused on the role AF can play in developing countries, AF systems are also considered valuable in temperate regions and developed nations. Moreover, AF systems have proved to avoid the trade-off between provisioning and several other ecosystem services that occur today in many modern intensive farming systems (Smith et al., 2012). Indeed, evaluating AF systems against the Ecosystems Services Framework as outlined by the Millennium Ecosystem Services Assessment (MEA, 2003), results in AF ticking of many boxes. In this respect, Fagerholm et al. (2016b) provided the first systematic synthesis of ecosystem services research in relation to European AF. They found the research on ecosystem services of European AF to be focused on some regulating (habitat diversity, climate regulation) and provisioning services (food, fiber and fuel), whereas the assessment of cultural services was limited to aesthetic values. In the majority of the cases, the research approach was biophysical or monetary, including often quantitative methods and biophysical field measurements of only one or two services. Fagerholm et al. (2016) conclude that European AF research should diverse towards a wider variety of approaches, especially socio-cultural approaches that involve different kinds of stakeholders. An overview of ecosystem services that have been studied is given below.

- **Provisioning ecosystem services:** refer to the biotic renewable resources produced by the ecosystem (Grunewald and Bastian, 2015). The tangible products produced in AF systems may be diverse and manifold because AF is inherently an integrated farming system, combining the cultivation of trees and crops and/or livestock farming. In addition, the productivity of AF systems may be very high in AF systems. This has to do with the fact that AF systems are based on the ecological theory of niche differentiation, i.e. crops and trees use partially different resources of the environment, resulting in a higher total productivity than in mono-cropping systems (Dupraz and Newman, 1997). In this respect, the Land Equivalent Ratio (LER), calculated as the ratio of the area under sole cropping to the area under intercropping needed to give equal amount of yields at the same management level (Mead and Willey, 1980), is used to compare the productivity of agroforestry and monocropping systems. Although in theory AF systems have LER's higher than one, Kay et al. (2017) and Torralba et al. (2016) found through systematic reviews a negative effect of European AF on biomass production. This suggests that despite the niche differentiation competition effects are at play. The relevant provisioning ecosystem services for AF in Flanders are (Smith et al., 2012):

- *Food products:* AF systems can be managed to produce arable crops, vegetables, animal products (meats, eggs, dairy), fruits and nuts, etc. In Flanders, Pardon et al. (2018b) found the effects of AF on crop yield to be limited near young tree rows, but substantial yield reductions were observed near mature trees, especially for maize and potato.
- *Fodder and forage products:* livestock in AF systems can browse on tree leaves and forage grasses and legumes, or fodder and hay or silage can be cut, transported, stored and fed to livestock later on.
- *Timber:* AF systems can be managed to generate high value timber that can be used for furniture, construction, veneers, etc.
- *Fuelwood*: AF systems can be managed to generate fuel wood as its primary woody product or as a by-product of management for other products (e.g. pruning of side branches).

- **Regulating (and supporting) ecosystem services:** refer to processes that regulate the ecosystem, and allow human life to exist (Grunewald and Bastian, 2015). In the context of AF, they are interpreted as the environmental benefits for farmer and society. Moreover, AF offers proven strategies as an environmentally benign and ecologically sustainable land management practice. Within European AF research there is lately a strong focus on the assessment and quantification of regulating and supporting ecosystem services in an attempt to secure provision of these services by rewarding the suppliers (Fagerholm et al., 2016b). In this context, Tsonkova (2014) is working on an easy to use method accessible to stakeholders with varying backgrounds, to facilitate comparison of the delivery of regulating and supporting ecosystem services for landscapes with various tree proportions. The regulating and supporting ecosystem services relevant for AF in Flanders, are:
  - *Soil conservation:* refers to erosion control and the maintenance of soil fertility

  - *Erosion control:* Riparian buffers and other AF systems can reduce run-off and increase infiltration. In the Midwest USA a multispecies buffer that included woody perennials increased infiltration rates to five times that of cultivated and grazed fields (Bharati et al., 2002).
  - *Soil fertility:* Pardon et al. (2017) measured the soil organic carbon level and nutrient status of the plough layer on a set of 17 arable AF fields in Flanders. They found significantly higher soil organic carbon and nutrient concentrations of N, P, K, Mg and Na in the vicinity of trees, most likely resulting from the input of tree litter and nutrient-enriched through fall water.
- *Climate regulation:* AF system can regulate the climate at the local scale through modification of the micro-climate and at the global scale through reductions in atmospheric carbon (Smith et al., 2012).
  - *Micro-climatic effects:* Trees modify micro-climatic conditions, including temperature, humidity and wind speed, which can have beneficial effects on crop growth and animal welfare.
  - *Global effects (carbon sequestration):* AF reduces the atmospheric carbon by increasing afforestation of agricultural lands. Aertsens et al. (2013) identified AF as the agri-environment measure with the highest net sequestration potential (compared to hedges, reduced tillage and cover crops), which would be between 1.5 and 4 tons of carbon per ha per year.
- *Habitat richness and biodiversity:* The meta-analysis of Torralba et al. (2016) of ecosystem services provided by European AF systems, shows a strong positive effect on biodiversity, which is linked to the capacity of AF systems to provide food, shelter, habitat and other resources for multiple species. In Flanders, Pardon et al. (2018a) assessed the abundance of soil-dwelling arthropods and predatory arthropods in AF systems, and found an increased abundance and diversity of woodlice and millipedes in the tree rows. Increased biodiversity can also have benefits for farmers, for example:
  - *Pollination:* Bennett and Isaacs (2014) found bee abundance, and thus pollination, to be positively correlated with the proportion of forest patches in the USA.
  - *Pest and disease regulation:* Higher natural enemy abundance and lower abundances of pest species have been recorded in several AF systems (Smith et al., 2012). On the other hand, some pest groups

have been observed in higher numbers in AF systems. In Flanders Pardon et al. (2018a) found no consistent beneficial effect of tree presence on predatory arthropods, although a limited increase in carabid diversity occurred in the arable zone near the tree rows.

- **Cultural ecosystem services:** refer to the opportunities that ecosystems provide for enjoyment, inspiration, intellectual enrichment, aesthetic delight and recreation (Grunewald and Bastian, 2015). They are often intangible and intuitive in nature, and therefore they are often not easy to value in monetary terms (Milcu et al., 2013). Overall one can say that people prefer mosaic landscapes (Van Zanten et al., 2014), although the values people attach to landscapes depend on land tenure and public access (Fagerholm et al., 2016a). Although farmers rarely plant AF systems solely because of the cultural ecosystem services delivered, they are often taken into account when comparing costs and benefits. The relevant cultural ecosystem services for AF in Flanders are:
    - *Aesthetic and amenity values:* landscapes with AF systems are more highly appreciated by respondents than landscapes without trees (Baeyens, 2014; Franco et al., 2003). Baeyens (2014) found the differences in appreciation to be related to criteria such as ‘variety’, ‘attractiveness of vegetation’ and ‘ecological value’.
    - *Recreation and ecotourism:* farmers can increase the touristic potential by ‘decorating’ their farm with trees (Gao, 2012). In this respect, AF is considered a marketing instrument, which strengthens short supply chain initiatives such as farm shops (implying many customers stopping over at the farm).
    - *Information and cultural heritage values:* traditional AF systems have to be interpreted as relicts of the past, showing forgotten and vanished farm practices. The fact that traditional farming practices already exist for a long time, shows that they are ecologically sound, which provides a lot of learning opportunities (Antrop, 1997).

This systematic review shows that temperate AF systems excell in the provision of a diverse range ecosystem services, which benefit in theory the interests of both farmers and society. In practice however we see that AF systems do not meet the expectations of farmers. Although it is possible to achieve higher biomass yields through AF systems, for farmers only the loss in crop yield matters, as the time frame that is necessary to produce woody biomass and gain an income of the tree component is far too long. Regulating and cultural services might deliver several benefits to farmers (protection against soil erosion, better soil fertility, climate change adaptation, opportunities for farm tourism, etc.) but they are not directly economically quantifiable and therefore do not convince many farmers. The more important role of these regulating and cultural services for society on the other hand is logically not taken into account by farmers, given that these services are not valued and payed for in the current market and policy context. When we thus talk about the values and benefits of AF systems in this thesis, then we refer especially to the many societal values that AF systems imply and to the ecological benefits for farmers in the long term by contributing to the creation of a healthy and robust farm ecosystem. This explains also why many of the cost-benefit analyses comparing direct economic costs and benefits of AF systems with those of monocropping systems, often indicate monocropping as the preferred solution when no compensation for the ecosystem services produced are foreseen (Faasch and Patenaude, 2012; Van Vooren et al., 2016; Yates et al., 2006). The question remains thus how to change this unilateral perspective of farmers and a whole range of other actors to a more balanced perspective taking into account both short-term and long-term, and direct and indirect costs and benefits.

1.3 Interpreting agroforestry as a transformative solution

1.3.1 A diversity of agricultural models

According to Therond et al. (2017) farming systems can be positioned in a 2-dimensional spectrum, of which the axes represent respectively their biotechnical functioning and their socio-economic context (Figure 1 - 2). First, Therond et al. (2017) distinguish three types of farming systems depending on their biotechnical functioning, i.e. based on the amount of external inputs that are used and the amount of ecosystem services produced:

1. **Chemical input-based farming systems**, which are focused on improving input use efficiency, and are often associated with the concept of “sustainable intensification”;
2. **Biological input-based farming systems**, which aim to decrease impacts on biodiversity and human health by replacing some or all chemical inputs by biological inputs, but limiting itself to incremental adaptations; and
3. **Biodiversity-based farming systems**, which are focused on the development and management of biodiversity to increase ecosystem services and decrease external inputs, often requiring a redesign of the farming system, and often being associated with “(agro)ecological intensification”.

These different types of farming systems, which have to be interpreted as a continuum, coincide to a large extent with other opposing farming approaches described in literature. Duru et al.

(2015) for example explain that the negative impacts of productivist agriculture have led to the emergence of two forms of ecological modernization of agriculture. The first, *efficiency-substitution agriculture*, aims to improve input use efficiency and to minimize environmental impacts of modern farming systems. The second, *biodiversity-based agriculture*, aims to develop ecosystem services provided by biological diversity. Kremen et al. (2012) interpret the latter as *diversified farming systems*, i.e. farming practices that intentionally include functional biodiversity at multiple spatial and/or temporal scales in order to provide critical inputs to agriculture. In a similar way, Tittonell (2014) opposes the discourses of *sustainable intensification*, which intends to reduce negative externalities while improving yields, and the discourse of *ecological intensification*, defined as the means to make intensive and smart use of the natural functionalities of the systems to produce food, fiber, energy and ecological services in a sustainable way.

Second, based on the dependence on global market prices and the level of territorial embeddedness, Therond et al. (2017) distinguished the following four socio-economic contexts in which farming systems can be embedded:

1. **Globalized commodity-based food systems**, which are focused on improving productivity and efficiency via industrial processes and standardized techniques. They result in in generic and standardized commodities, traded in global markets;
2. **Circular economy systems**, which are developed to limit resource scarcity, waste and pollution, i.e. to close loops of material and energy as much as possible
3. **Alternative food systems**, which are developed to address issues of human health, environment conservation, animal welfare, taste and freshness, local producers and development. Attention is also given to the development of supply chains based on trust, collaboration, transparency and equitable relationships;
4. **Integrated landscape systems**, implies collective governance of multiple land managers to design the spatial distribution of land use and semi-natural habitats to increase the targeted ecosystem services, supporting diversified farming systems and landscape conservation.

Also the extremes of this continuum of socio-economic contexts of farming systems, are already presented in literature under different forms and names. Hörlings and Marsden (2011) for example speak about the *bio-economy paradigm*, which works at a global scale through the activation of a range of innovative economic and technological processes, and the *eco-economy paradigm*, which is an alternative and more diverse arena for the development of new production and consumption chains and networks. Van der Ploeg (2017) on the other hand distinguishes *entrepreneurship*, which is grounded on a far-reaching commoditization of the main resources, and *peasantry*, which implies producing commodities for the downstream markets, but grounded on low levels of commoditization of the main resources.

Third, by combining the three types of farming systems with different possible socio-economic contexts in which they can be embedded, Therond et al. (2017) characterized six different agricultural models addressing sustainability issues in different ways (Figure 1 - 2). They represent both the main socio-technological regime and the different niches. However, they have to be considered as "archetypes", that help render the diversity of models tractable. Figure 1 - 2 shows that most of the models are situated on or close to the diagonal extending from the third to the first quadrant, which indicates that there is often a positive relation between, on the one hand the amount of ecosystem services produced in a system and the level of territorial embeddedness, and on the other hand amount of external inputs used and the dependence on global market prices. This is why many discourses that were mentioned above include elements of both dimensions.

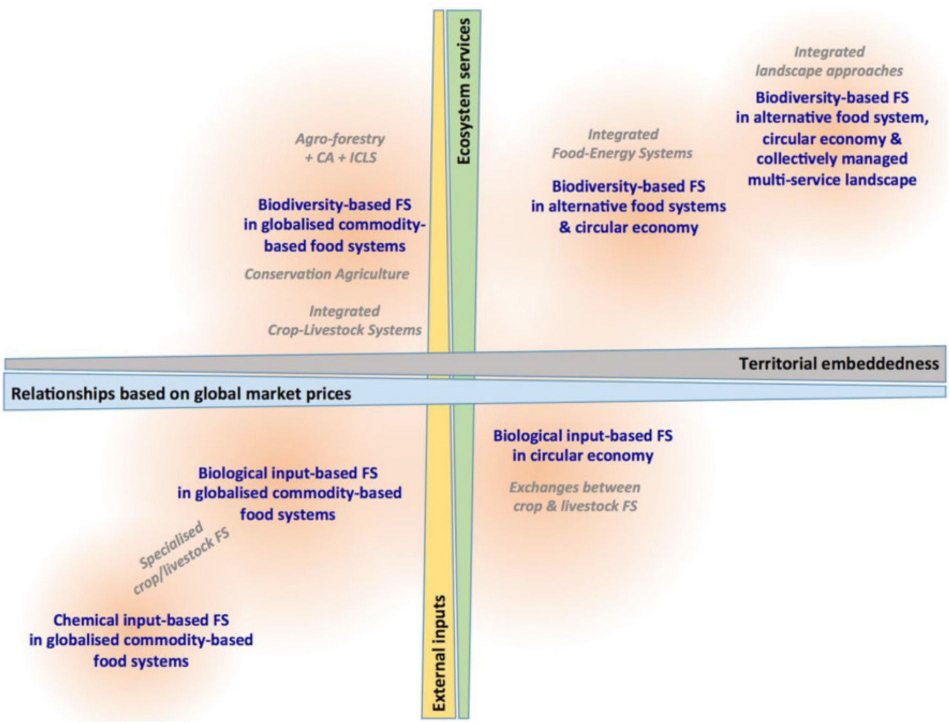


Figure 1 - 2: Six key models of agriculture according to the degree to which biotechnical functioning of farming systems is based on ecosystem services versus external inputs (vertical axis) and the degree to which their relationships with socio-economic contexts are based on global market prices versus territorial embeddedness (horizontal axis).

Examples are presented in grey. CA = conservation agriculture, ICLS = Integrated Crop Livestock System. (Therond et al., 2017)

1.3.2 Positioning agroforestry within the spectrum of agricultural models

Therond et al. (2017) also give prominent examples of different kinds of farm models, and allocated AF systems to the "biodiversity-based farming systems in globalized commodity-based food systems". These models are positioned in the upper left quadrant of Figure 1 - 2 and are explained as biodiversity-based farming systems developed in socio-technical niches, i.e. farmers sell commodities produced in biodiversity-based farming systems through globalized commodity-based food supply chains, mainly because no other solutions exist or because prices are not attractive. This may be especially true for alley cropping systems, in which uniform crops are produced and marketed in the same way as before the plantation of the trees. However in Flanders, there are many farmers starting with AF in the context of a transition towards an alternative farm business model, or coupling it with alternative marketing techniques. In these cases, AF is rather embedded in the circular economy and alternative food systems, or even in integrated landscape systems if multiple stakeholders are involved. Depending on the socio-economic context, AF systems can thus be placed left or right side of Figure 1 - 2. Also the positioning of AF on the vertical axis of Figure 1 - 2 is not predetermined: crops and trees can be combined on the field in many different ways, on which different management regimes can be applied. These factors will all have an influence on the amount of ecosystem services that will be produced, and on the amount of external inputs that need to be applied. The position of AF in Figure 1 - 2 thus has to be determined context- and case-specifically.

1.3.3 Agroforestry as an example of an agroecological innovation

Increasingly, AF is used in research as an example of an agroecological innovation (e.g. Louah et al., 2017; Prabhu et al., 2014; Vanloqueren and Baret, 2009). This is because AF is relatively tangible compared to agroecology, which is used and interpreted in different ways (Box 1 - 1). On the other hand, the development of AF is affected, in the same way as agroecology, by different aspects (practical, social, economic, etc.) and by different groups of stakeholders (farmers, researchers, policy makers, etc.). AF research should thus just as much as agroecology tap into different dimensions. Therefore, AF is often framed within or envisaged with regard to the discourse of agroecology.

Box 1 - 1: Agroecology as a science, a movement and a practice

The FAO defines agroecology as “applying ecological concepts and principles to optimize interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system” (FAO, 2018). However, the term agroecology has different uses, and is described as a science, a set of practices and a social movement (Bernard and Lux, 2016; Silici, 2014; Wezel et al., 2009). Moreover, it is:

1. A scientific discipline involving the holistic study of agro-ecosystems, including human and environmental elements
2. A set of principles and practices to enhance the resilience and ecological , socio-economic and cultural sustainability of farming systems
3. A movement seeking a new way of considering agriculture and its relationships with society

Agroecology is often perceived as complex, with the way people use the term being affected by a variety of factors related to geography, scientific and contextual backgrounds (Wezel et al., 2009). Therefore the term agroecology and its interpretation is increasingly contested (Giraldo and Rosset, 2017; Levidow, 2015; Pimbert, 2016; Stassart et al., 2018). In response, Gliessman (2016) conceptualized the transition to agroecology and sustainable food systems in a five-level framework (Miles et al., 2017):

1. **Efficiency:** Improving system efficiency to reduce the use of conventional agro-chemical inputs and their ecological and social risks
2. **Input substitution:** Substituting more sustainable inputs and practices into farming systems
3. **Farm-scale agroecology:** Redesigning farming systems based on ecological knowledge to maximize ecosystem services
4. **Transformative agroecology:** Reestablishing connections between producers and consumers to support a socioecological transformation of the food system
5. **Global transformation to a sustainable society:** supporting a fundamental shift in global society where ethics, knowledge, culture and economy are rethought and directed toward ecological restoration, social justice and equity in the food systems and within all forms of human activity

The different conceptualizations as defined by Gliessman (2016) (Box 1 - 1) can be positioned within the two-dimensional spectrum defined by Therond et al., which is illustrated in Figure 1 - 3. The extent to which the first three levels of Gliessman's framework are covered, define the position on the vertical axis, whereas the extent to which fourth and the fifth level are taken into account define the position on the horizontal axis. Overall, farm models in which agroecology is interpreted it in broadest form, situate themselves in the first quadrant of Figure 1 - 3, whereas more reductionist interpretations of agroecology situate themselves in the third quadrant. Taking this into account, an agroecological transition of a farm can be interpreted as a shift from the original position towards the upper-right corner of the spectrum, with the length and exact direction of the shift depending on the extent and character of the transition. Although there is no sacred level of ecosystem services or territorial embeddedness that should be achieved for a farming system to qualify as agroecological, opinions on what a agroecological transition should minimally imply differ to a large extent. In this respect some stakeholders consider that efficiency and input substitution are as important as the other levels defined by Gliessman, whereas others are of the opinion that at least farm-scale agroecology has to be achieved before one can talk of real agroecological systems (Stassart et al., 2018). This discussion is equally relevant for AF systems, which are interpreted by the former as agroecological farming systems per definition, whereas the latter only interpret them as an agroecological innovations if they contribute at least to a transition towards farm-scale agroecology, and if possible have broader social and economic transformative potential.

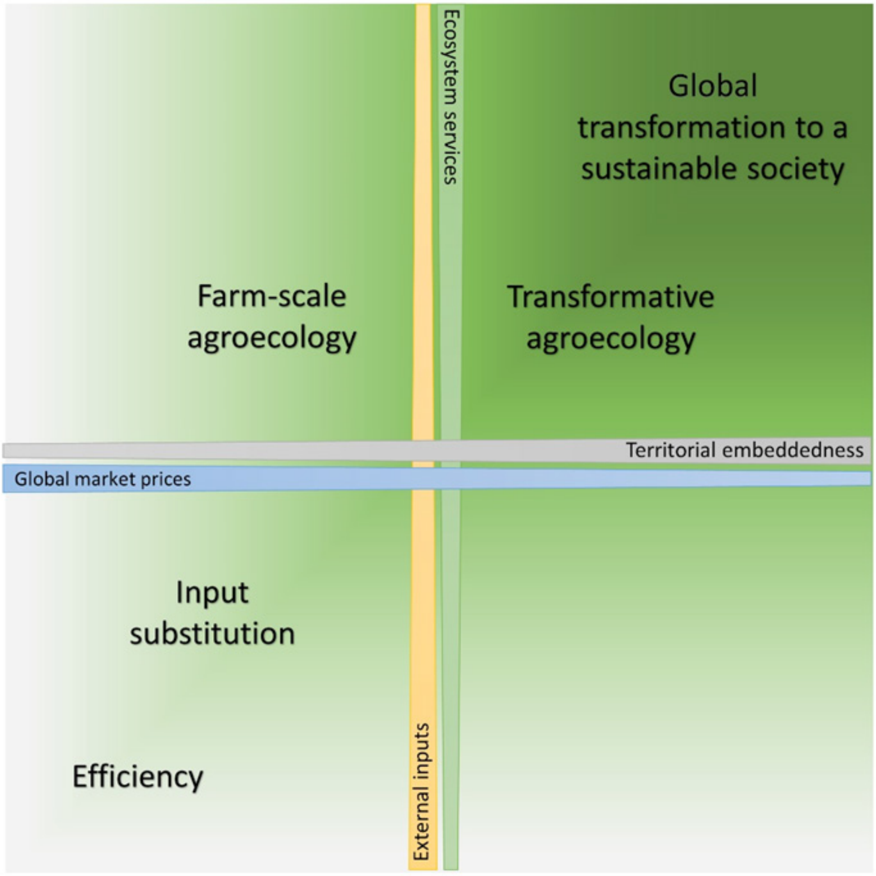


Figure 1 - 3: The different conceptualizations of agroecology of Gliessman (2016) can be positioned within the two-dimensional framework of Therond et al. (2017). They are positioned closely to the vertical axis extending form the third quadrant to the first quadrant, since the level of ecosystem services produced and the level of territorial embeddedness of the farm are often (but not always) associated.

1.4 Policy support for agroforestry systems in the EU

There are three different channels through which the EU supports AF development throughout Europe. First, Europe promotes AF development through the funding of international research projects focused on AF. The main example is AGFORWARD (AGroFORestry that Will Advance Rural Development), a four-year research project funded by the European Union's Seventh Framework for Research and Technological Development, which ran from January 2014 until December 2017. The project, of which the European Agroforestry Federation was partner, built on existing AF experiments, on-farm trials and previous research projects such as “Silvoarable Agroforestry For Europe (SAFE)”. It is followed up by AFINET (AgroForestry Innovation NETworks), which is technically not a research but a networking project, aimed at fostering the exchange and the knowledge transfer between scientists and practitioners in AF. The AFINET project runs from January 2017 until December 2019.

Second, AF is promoted through both pillars of the Common Agricultural Policy (CAP), of which Mosquera-Losada et al. (2016) give an extensive overview, both for the CAP periods 2007-2013 and 2014-2020. In the first pillar, AF is especially promoted through the “greening payment”, which makes up 30 % of the single payment and depends on the implementation of agricultural practices beneficial for climate and the environment (Lamaison, 2014). This includes moreover the maintenance of the level of permanent pasture, crop diversification and the establishment of 5 % of ecological focus areas (EFA) for holdings with more 15 ha of arable land (EU, 2013a). In this respect, Europe selected a list of land uses and farming practices eligible as EFA, among which AF systems, and this based on their direct and indirect effect on biodiversity. Whereas Pillar 1 in this way may incentivize farmers to plant trees, Mosquera-Losada et al. (2016) criticize at the same time the fact that the first pillar of the CAP still encourages farmers to remove woody vegetation from farmland trough maximizing the density of trees on farmland to 100 trees/ha to be eligible for the single payment scheme.

Depending on the country though, the second pillar of the CAP may be more important. This second pillar exists of Rural Development Programs (RDP), and includes payments for farmers who subscribe on a voluntary basis to environmental commitments related to the preservation of the environment and maintaining the countryside (EU, 2013b). Mosquera-Losada et al. (2016) mention that the RDP included a variety of measures that can support AF development. In the CAP 2007-2013 the most popular measure to promote AF was measure 214 (Agri-environmental payments), which has continued in the CAP 2014-2020 as measure 10.1 (Agro-environment climate commitment). At European scale this measure was more wide-scale adopted and therefore more important for AF development than measure 222 in the CAP 2007-2013, which specifically focuses on AF and finances the first establishment of AF systems on agricultural land (Figure 1 - 4). The measure continued as measure 8.2 in the CAP 2014-2020, during which it had more success due to the recognition of woody vegetation and the compensation of five years of maintenance for newly established AF plots.

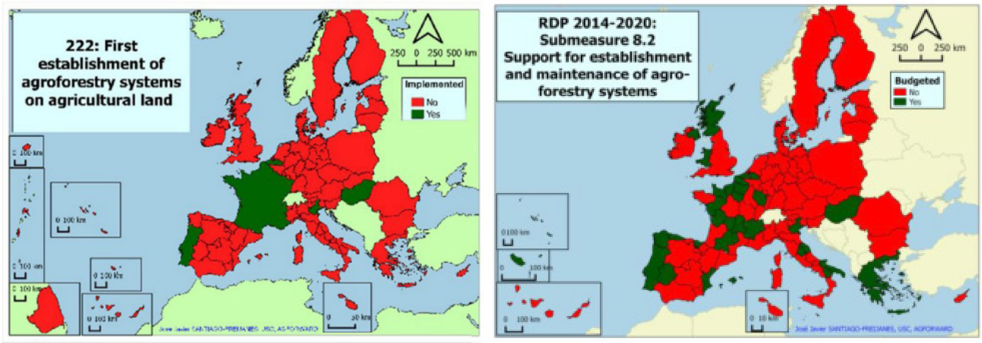


Figure 1 - 4: The implementation of measure 222 in the CAP 2007-2013, supporting the first establishment of AF systems on agricultural land, was limited to Portugal, France, Hungary, Veneto (Italy), and Flanders (Belgium). It continued in the CAP 2014-2020 as measure 8.2, which supports both the establishment and the maintenance of AF systems. In addition to the regions and countries already implementing measure 222 in the CAP 2007-2013, measure 8.2 in the CAP 2014-2020 was adopted by Greece and (extra) regions of the UK, Spain and Italy (Santiago-Freijanes et al., 2018).

Overall, considering both pillars of the CAP, Mosquera-Losada et al. (2018) evaluate the European policy support for AF as fragmented. Therefore they advocate a better recognition of AF in the CAP, through collating the measures in one place. This is a very topical issue, as in June 2018 the European Commission presented its legislative proposals on the future of the CAP for the period after 2020. To what extent and in which ways AF will be supported in the new CAP remains to be seen.

1.5 Flanders as a case study

Flanders is one of the few regions in Europe which supports AF systems through both pillars of the CAP. First, as part of the first pillar, AF systems were qualified as EFA. Second, as part of the second pillar, Flanders included AF in the list of agri-environment measures and management agreements eligible for subsidies. This resulted in 2011 in the set-up of an initial subsidy program for the installation of AF plots, which was renewed in 2014. However, the Flemish subsidy program only finances 'AF *sensu stricto*', following the rather narrow definition of AF as defined in the Flemish regulation and meeting a list of requirements relating to (Departement Landbouw en Visserij, 2017):

- the ownership of the plot: the applicant has to be the owner of the plot, or the tenant with written permission of the owner
- the surface area: has to be minimum 0.5ha

- the tree density: has to be between 30 and 100 trees per ha, or between 30 and 200 fruit-bearing trees per ha
- the tree species planted: non-standard fruit trees, coniferous trees, (invasive) and exotic species such as Black cherry (*Prunus serotina* Ehrh.), Northern red oak (*Quercus rubra* L.) and Black locust (*Robinia pseudoacacia* L.) are excluded
- the distribution of the trees: has to be uniform
- the agricultural component: at least one crop has to cultivated in between the trees, which has to be registered each year in the single application
- the time span that trees have to be maintained: at least ten years

AF *sensu stricto* thus excludes windbreaks, shelterbelts, dispersed trees in grassland and rows of trees at the border of agricultural fields. However, the latter do comply with the AF definition provided by Herder et al. (2015) in the context of the AGFORWARD project, i.e. “land use systems in which trees are grown in combination with agriculture on the same land”. These systems might be equally valuable and important as those complying with the definition of the Flemish government and therefore are referred to in this thesis as ‘AF *sensu lato*’.

Despite the local implementation of various European support measures for AF, the adoption of AF systems in Flanders did not meet the initial expectations: although the original objective of the Flemish government was to establish 250 ha of AF sensu stricto through the new subsidy program by the end of 2013, Figure 1 - 5 shows that the initial response was low with only 6, 5 and 5 plantations established in respectively 2012, 2013, and 2014. These plantations added together merely 32.2 ha to the AF acreage in Flanders. The objective of the new program period (2014–2020) is to establish 300 ha. With respectively 7, 8, 10 and 11 accepted applications from 2015 until 2018 resulting in an extra surface area of 94.4 ha of AF, reaching the target surface area of 300 ha in 2020 seems to be difficult. Nevertheless, the amount of farmers applicating for the subsidy program and planting AF seems to be increasing, with a record of 20 farmers applying for the subsidy program in 2018 (for plantation in 2019).

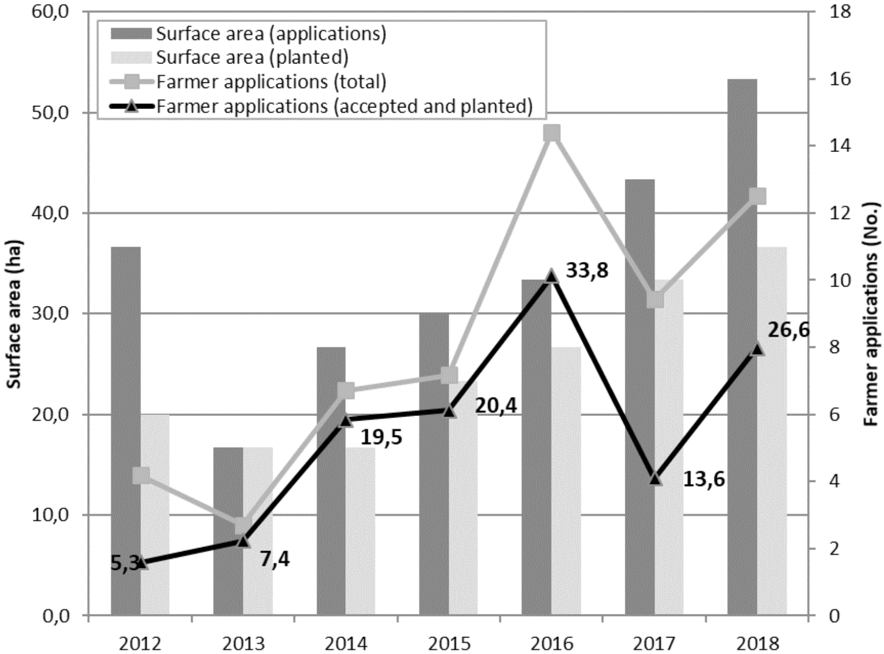


Figure 1 - 5: From 2011 until 2017 52 plots were planted with the subsidy program, which resulted in 126.6 ha of AF

Taking into account the current policy support for AF systems in Flanders and the conceptual opportunities of AF as a farming system as presented in section 1.2, Figure 1 - 5 indicates that AF adoption in Flanders is lagging behind. Moreover, there seems to be a gap between the conceptual opportunities and actual implementation of AF systems in Flanders. A first and introductory assessment of this implementation gap in Flanders, presented in CH 3, shows that it is a result of barriers which are entangled in complex ways. Other studies digging into farmers' perceptions and uptake of AF practices in Europe tell a similar story (Anil et al., 2017; Camilli et al., 2017; Rois-Díaz et al., 2017; Tsonkova et al., 2018). Therefore, in this thesis, we use Flanders as a case study to gain understanding of the unfavorable environment for AF adoption and development, and to formulate recommendations for the elimination of barriers. Although the results are not directly transferable to other regions, they may create insights in how these implementation gaps are formed and sustained. In this way the results of this thesis may help in formulating locally adapted action plans, with the aim of eliminating adoption barriers and closing the AF implementation gap throughout Europe.

1.6 A systemic, interdisciplinary and participatory research project

This thesis forms part of a larger research project, i.e. 'Agroforestry in Flanders, an economically profitable answer to the demand for agroecological production methods'. An overview of the structure of the project is given in Figure 1 - 6, showing the three main clusters of the project, i.e. a cluster focused on scientific research, a cluster focused on participatory change processes and a cluster focused on knowledge dissemination and demonstration. The research project is financed by VLAIO, initiated in September 2014 and will last until August 2019. It is carried out by a diverse group of organizations, including the Research Institute for Agriculture, Fisheries and Food (ILVO), the University of Ghent (UGent), the Belgian Pedological Services (Bodemkundige Dienst van België), Inagro and Agrobeheercentrum Eco[2]. The overall objective of the project is to create a breakthrough of feasible, profitable and effective AF systems in Flanders, and this in the relatively short term (Projectconsortium Agroforestry in Vlaanderen, 2018). The project partners tries to tackle this challenge through a farming systems research approach, which implies (1) systems-thinking, by taking different scales of analysis ranging from plot- over farm- to landscape level; (2) interdisciplinarity, by looking from different disciplinary background at AF as a farming system; and (3) a participatory approach by co-development, consultation of stakeholders, transdisciplinary guidance of practitioners, and the capturing of grassroots ideas.

The project has been important for this thesis in three main aspects. First, the project has set some boundaries for the thesis, as well as for the other thesis conducted in the context of the AF project. Moreover, they had to cover specific objectives of the project, which are respectively (1) to obtain an increased understanding of intention, attitude, norms, perceptions and the social identity of the stakeholders involved, in order to overcome social and psychological barriers; and (2) to increase the knowledge about ecological interactions, ecosystem services, technical impact and economic opportunities for the Flemish agricultural context. Both theses were supposed to give a broad overview of the situation with respect to AF in Flanders, which limited the opportunities for more integrative and action-oriented research at farm level. Second, we adopted the general FSR approach of the project as a central thread in this thesis. We let ourselves inspire by FSR to select appropriate methodologies, theories and concepts, and combine them in analytical approaches relevant for the research questions at stake. On the basis of these analytical approaches our research chapters were further shaped and developed. Third, insights about AF adoption and development were not only gained throughout the different analytical analyses which are part of this thesis, but also through project meetings and activities organized in the context of other work packages, e.g.

WP 7 about participatory change processes and WP 8 about knowledge dissemination and demonstration.

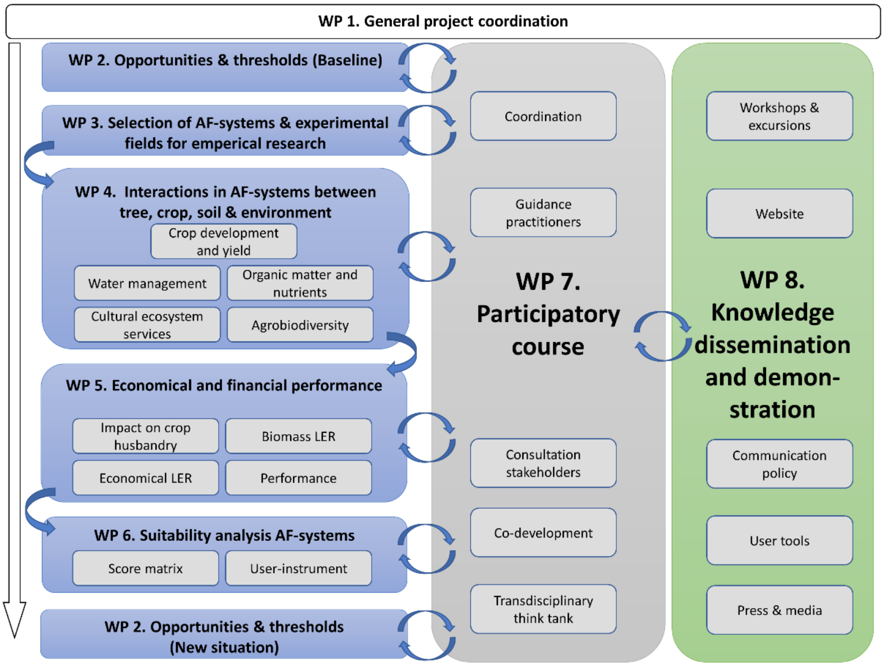


Figure 1 - 6: Scheme of the participatory and interdisciplinary research project 'Agroforestry in Flanders: an economically profitable answer to the demand for agroecological production methods' (Projectconsortium Agroforestry in Vlaanderen, 2014)

1.7 Objectives, research questions and outline

As is mentioned in the sections above, AF is increasingly recognized as a farming system that has the potential to address current challenges in modern agriculture. Moreover, it is interpreted as an agroecological innovation that may improve the total amount of ecosystem services delivered to farmer and society, and the local embeddedness of the farm. In this way, AF systems may form part of the solution to a better and fairer food system. However, despite its opportunities and the subsidy program that was established to minimize plantation costs, adoption of AF systems by farmers in Flanders remains limited. Therefore, the overall research objective of this thesis is to ***gain a better understanding of the unfavorable environment for AF adoption and development making use of a farming systems research approach (FSR).***

The overall research is translated into four research questions, which are addressed in the consecutive chapters of this thesis. After formulating each research question, a short overview is given of the chapter(s) addressing that research question. Figure 1 - 7 presents the research outline graphically.

RQ 1 – APPROACH: ***How can we study AF adoption and development making use of a farming systems research approach?***

Chapter 2 is a methodological chapter, which presents FSR as central research approach. This chapter explains (1) what the crucial components of FSR are, and which different methodologies, theories and concepts are often used in FSR; (2) how the research project stimulated us to take up a farming systems research approach; and (3) how we practically implement FSR in this study, i.e. how we look at AF adoption and development from a diversity of angles to provide a broader and deeper perspective.

RQ 2 – DIAGNOSIS: ***Why do AF systems, despite their societal values, currently not break through in Flanders?***

RQ 2.1: *What is the current state of AF adoption and development in Flanders?*

RQ 2.2: *Who are the stakeholders, and what role do they play with respect to the development of AF in Flanders?*

RQ 2.3: *What are the different barriers that hold back AF development?*

RQ 2.4 *Which perspectives exist on AF, and to what extent are they embedded in general agricultural discourses?*

After the methodological chapter, **chapter 3** sets the scene by reporting about the current state of AF adoption and development in Flanders. To answer RQ 2.1, chapter 3 includes an analysis of farmers' perceptions of AF and intentions to adopt AF practices, and also gives an overview of the current surface area and the characteristics of the AF plots in Flanders.

Chapter 4 addresses RQ 2.1 and RQ 2.2. In this chapter the Agricultural Innovation Systems (AIS) concept is used to analyze the development of AF in Flanders in an integrative and holistic way. It includes (1) a structural-functional analysis, in which the different stakeholders and their roles with respect to AF development are determined, and (2) a structural-transformational analysis, in which the barriers and catalysts (i.e. failures and merits) with respect to AF development are identified.

Chapter 5 answers RQ 2.3 by digging into the different perspectives that exist on AF systems among the stakeholders that were identified. Making use of Q-methodology three different perspectives on the scope and appropriateness of AF in Flanders were differentiated, which are linked with general discourses on agriculture.

RQ 3 – DESIGN: ***Which specific organized or market-based governance models can foster AF implementation by using the benefits of AF to create value for society?***

Chapter 6 addresses RQ 3 by presenting a wide range of institutional and economic instruments, which can give incentives to farmers to adopt AF. The chapter also provides more depth by analyzing four cases in detail with respect to suitability, acceptability and feasibility, showing that different incentive mechanisms can co-exist and reinforce each other.

RQ 4 – PATHWAYS: ***Which pathways have to be followed to give incentives for the breakthrough of AF systems in Flanders?***

Chapter 7 is the discussion chapter, which bundles the insights gained throughout the previous chapters by formulating recommendations to further stimulate AF development in Flanders. This is done in the form of 'pathways', which address different sets of challenges, and imply the active collaboration of different kind of stakeholders. Chapter 7 thus addresses RQ 4, but also reflects on the research approach, the implications for agroecology and the contributions of this thesis to temperate AF literature.

Chapter 8 concludes by reflecting on the main research questions, by giving some suggestions for further research.

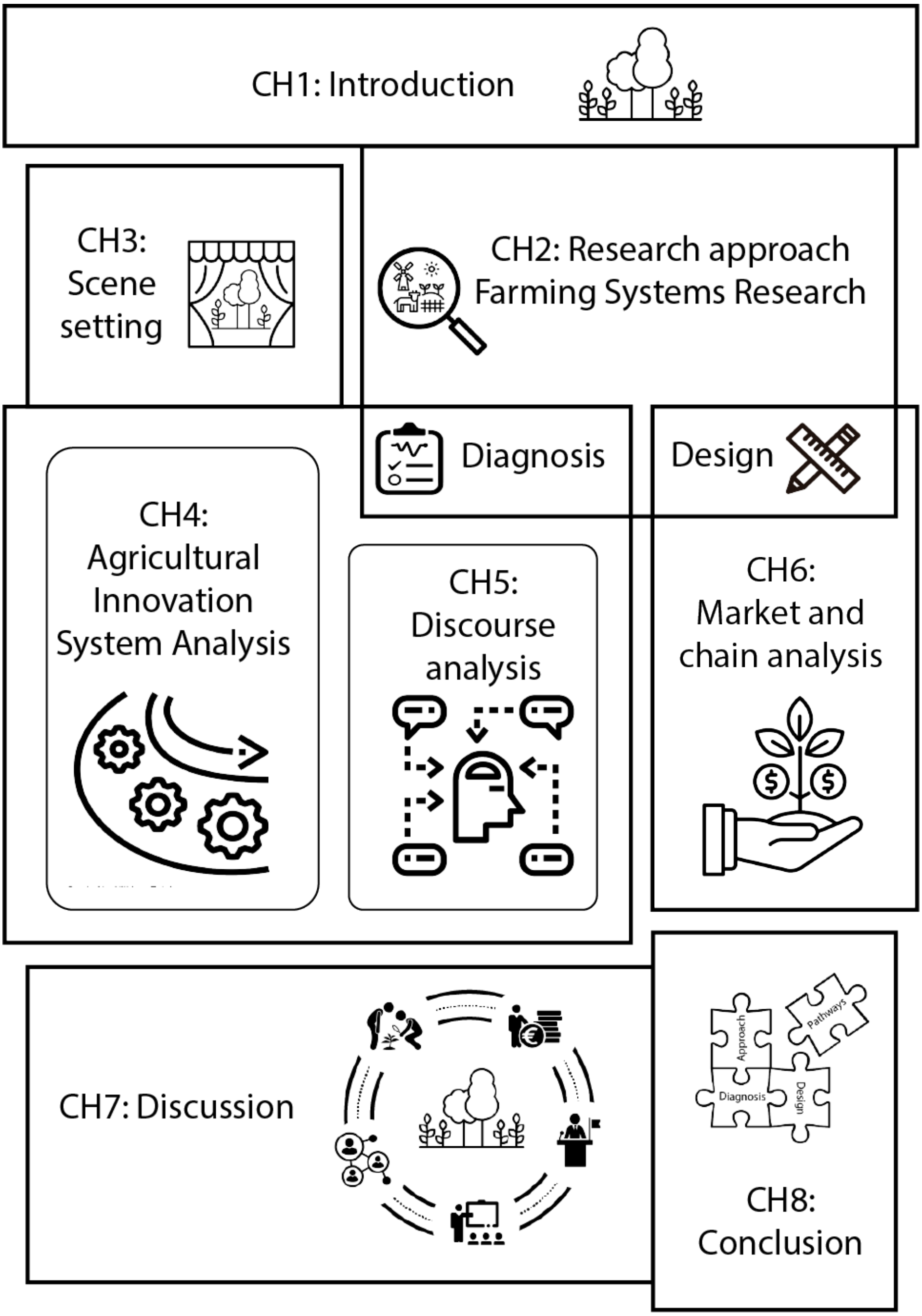


Figure 1 - 7: Research outline

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Chapter 2

Research approach

In this chapter we present Farming Systems Research (FSR) as our general research approach. First, we give a comprehensive overview of FSR and how it guides our understanding of agricultural innovations. Afterwards, we elaborate on how we practically implemented FSR in this thesis, i.e. how we use the Diagnosis and Design approach (D&D) and the framework of Renting for multifunctional agriculture to select complementary research approaches for the holistic study of AF adoption and development.

2.1 A comprehensive overview of FSR

Farming systems research (FSR) is an approach towards the study and analysis of a broad range of issues linked to agricultural production. With the emergence of FSR, in the 1970's and 1980's, the logical starting point of analysis was the farm. However soon, it was recognized that also the interactions between farms and their biological, economic, social, and political environments needed to be taken into account to understand farm operation and decision-making. Taking this into account, the appropriate scale of analysis in FSR thus can broaden from plot-level (e.g. the analysis of the interaction of crops and trees), over farm-level (e.g. a cost-benefit analysis of an AF project), towards landscape level (e.g. the study of the effect of trees on cultural landscapes) (Figure 2 - 1). However, independent of the scale of analysis, three characteristics need to be considered for a research to qualify as FSR (Darnhofer et al., 2012):

- **Systems thinking:** thinking about the interconnections between a system's elements, its dynamics, and its relations with the environment, keeping always the bigger picture in mind, even when a study focuses on a specific aspect or subsystem.
- **Interdisciplinarity:** collaboration between agronomic sciences (crop production and animal husbandry), social sciences (sociology, economics, political sciences), and in the case of AF research also forest sciences.
- **A participatory approach:** integrating the knowledge of farmers and other stakeholders by involving a broad range of societal actors (farmers, policy makers, forestry experts, local inhabitants, representatives of civil society groups, etc.).

Implementing all three characteristics in a single research project may be a challenge, and may often not be feasible or effective. In this respect, FSR has to be considered as an approach to research rather than a fixed set of methods which can be applied recipe-like. Taking this into account, FSR also requires a core quality of the researcher, which is reflexivity in designing, implementing and evaluating research (Darnhofer et al., 2012). More specifically, reflexivity is defined as drawing attention to the complex relationship between processes of knowledge production and the knowledge producer, not taking for granted assumptions and blind spots which may stem from disciplinary background, research community or personal preferences.

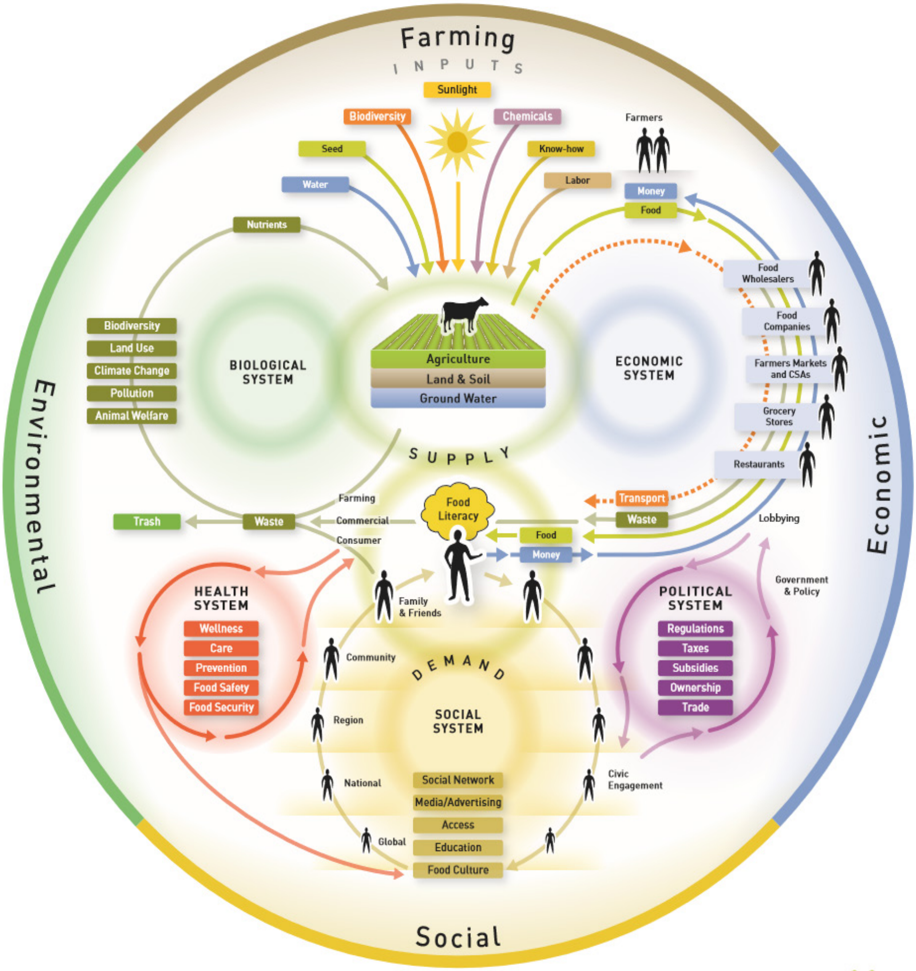

Figure 2 - 1: FSR finds itself at the interface of farming systems and biological, economic, social, political and health systems, and the scale of analysis may broaden from plot-level, over farm-level towards landscape-level (WorldLink, 2014).

2.2 A FSR approach to agricultural innovation.

As mentioned in the introduction modern AF can be considered as an agricultural innovation. This is a topic to which special attention has been given by agricultural researchers since the 1960's. However, under influence of the emergence of FSR, a clear shift in theoretical perspectives on the topic occurred throughout time (Table 2 - 1) (Klerkx et al., 2012):

- In the 1960's the first theories on agricultural innovation adoption and diffusion were developed. These were linear adoption models, in which researchers were supposed to put together technology packages and distribute them to farmers. Differences in the adoption behavior of farmers were related to differences in social systems, i.e. networks of close friends, relatives and neighbors and the influence of mass media. The institutional and the policy context on the other hand were seen as external factors, which develop themselves independently of science and technology.

- In response to the limitations of linear adoption models, an increasing attention emerged in the 1970's and 1980's for the key characteristics of FSR. This resulted in calls for the development of partnerships between farmers and technical and social scientists, and for the involvement of farmers in the design of innovative farming systems. Later on, also other stakeholders, such as extension agents and policy makers were expected to participate in de design process. This process required the agro-ecological and farm-economic context to be assessed in an integrated way. At the same time also the research scope broadened from productivity and input-output efficiency gains towards sustainable livelihoods, i.e. improved productivity integrated with social equity and protection of natural resources.
- Building on the insights of the early FSR, the concept of Agricultural Knowledge and Information Systems (AKIS) was developed with the purpose of aiding in agricultural extension. It was initially defined by Röling (1990) as "a set of agricultural organizations and/or persons, and the links and interactions between them, engaged in processes as the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilization of knowledge and information, with the purpose of working synergistically to support decision making, problem solving and innovation in a given country's agriculture or domain thereof." This definition refers to innovation systems with clear boundaries, often at the national or sectoral level. Later on also a 'soft systems approach' towards AKIS was developed, which focuses more on the coordination among actors with different perspectives, who are part of 'human activity systems' with arbitrary boundaries. Independent of hard or soft boundaries, the novelty of AKIS in comparison with the early farming systems research, is that science and technology are understood to be embedded within a historically defined social, political, economic and agroecological context, and thus have to developed taking into account the local context.
- Agricultural Innovation Systems (AIS) were developed in parallel with AKIS, but from a research perspective rather than an extension's perspective. It was defined by Hall et al. (2006) as "a network of organizations, enterprises, and individuals focused on bringing new products, new processes and new forms of organization into economic use, together with the institutions and policies that affect the way different agents interact, share, access, exchange and use knowledge." Relative to AKIS, AIS stands

out because of its greater and explicit focus on the influence of institutions (seen as organizations like companies, public research institutes and governmental entities) and infrastructures on learning and innovation, and its aim to involve all relevant organizations beyond agricultural research and extension systems in the innovation process (Hall et al., 2006). Therefore, topics that are frequently studied from an AIS' perspective are value chains and institutional change, the latter which is considered a 'sine-qua-non' for innovation.

Table 2 - 1: Shifts in theoretical perspectives on agricultural innovation (Klerkx et al., 2012)

Characteristics of the perspective	***Diffusion of innovations/ transfer of technology***	***Early Farming Systems Research***	***Agricultural knowledge and information systems***	***Agricultural innovation systems***
Era	Central since 1960's	Starting in 1970's and 1980's	From 1990's	2000's
Mental model and activities	Supply technologies through pipeline	Learn farmers' constraints through surveys	Collaborate in research (participatory research) and extension	Co-develop innovation involving multi-actor processes and partnerships
Knowledge and disciplines	Single discipline driven (breeding)	Multidisciplinary (agronomy plus agricultural economics)	Interdisciplinary (plus sociology and farmer experts)	Transdisciplinary, holistic systems perspective
Scope	Productivity increase	Efficiency gains (input-output relationships)	Farm-based livelihoods	Value chains, institutional change
Core elements	Technology packages	Modified packages to overcome constraints	Joint production of knowledge and technologies	Shared learning and change, politics of demand, social network of innovators
Drivers	Supply-push from research	Diagnose farmers' constraints and needs	Demand-pull from farmers	Responsiveness to changing contexts, patterns of interaction
Relation with policy and institutional environment	Science and technology are relatively independent of political and other social partners. Institutional factors as external conditioners of the adoption process	Science and technology are relatively independent of political and other social partners. Institutional factors as external conditioners of the adoption process. Agroecological and farm-economic context is considered in integrated way	Science and technology develop and are embedded within a historically defined social, political, economic and agroecological context	Science and technology develop and are embedded in a historically defined social, political, economic and agroclimatic context. Institutional change is considered a 'sine-qua-non' for innovation
Innovators	Scientists	Scientists and extension agents	Farmers, scientists and extension agents together	Multiple actors, innovation platforms
Role of farmers	Adopters or laggards	Sources of information	Experimenters	Partners, entrepreneurs, innovators exerting demands

Role of scientists	Innovators	Experts	Collaborators	Partners, one of many responding to demands
Key changes sought	Farmer’s behavior change	Removing farmers’ constraints	Empowering farmers	Institutional change, innovation capacity
Intended outcomes	Technology adoption and uptake	Farming system fit	Co-evolved technologies better fit to livelihood systems	Capacity to innovate, learn and change

2.3 Practical implementation of FSR in this thesis

2.3.1 General overview

As FSR is an approach to research rather than a fixed set of methods, it gives a lot of freedom to the researcher. Researchers thus still have to look out for appropriate methodologies, theories and concepts to combine into an analytical approach, which should be relevant for the research questions at stake. How we went from our general research questions to different research approaches is schematically represented in Figure 2 - 2. First, we looked for different methodologies, theories and concepts in literature, that endorse the three main FSR characteristics. This resulted in a long list of potential FSR building blocks to can be used for answering the research questions. After this literature review, for each of the research questions, one central methodology, theory or concept had to be chosen from the list. We did this selection ensuring that the different research approaches look at AF adoption and development from different perspectives. This resulted in different research objectives (diagnosis versus design), different levels of analysis (farm versus territorial) and a focus on different governance mechanisms (public versus market regulation), which should create better and deeper understanding. In this way, we try to meet the call for reflexivity in designing, implementing and evaluating research, which should be the core quality of the researcher in FSR.

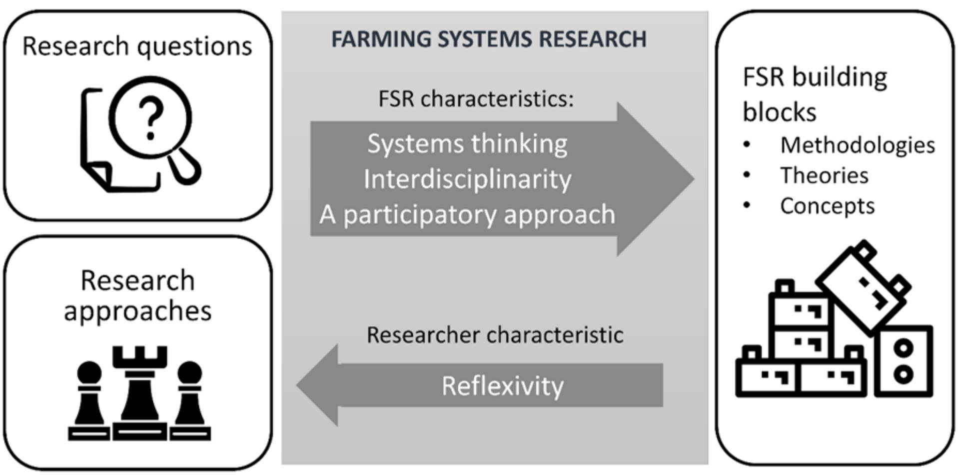

Figure 2 - 2: The practical implementation of FSR in this thesis

2.3.2 FSR building blocks

The methodologies, theories and concepts used by FSR researchers are usually found within the own research community, which has led to the emergence of different trends within FSR with their own focus and accents. At the same time there are methodologies, theories and concepts which are not specifically developed with the FSR approach in mind, but which endorse to a smaller or greater extent the same characteristics and values, and may be used by farming system researchers. A non-exhaustive overview of the methodologies, theories and concepts used in this thesis, serving as building blocks for the development of our research chapters, is given below.

- Methodologies:
  - Q-methodology is a methodology developed by William Stephenson in the 1930's to assist in the examination of human subjectivity (Brown, 1980). Q-methodology possesses both quantitative and qualitative dimensions bringing along its respective advantages, i.e. its qualitative component makes the method more holistic than traditional surveys, while its quantitative component provides the researcher better structure, replicability and a more rigorous analytical framework (Cross, 2005; Louah et al., 2017). This combination makes it an increasingly popular method to identify different groups and their shared perspectives (Hermans et al., 2012). The method involves a rank-ordering exercise (i.e. Q-sort) that is performed by a group of stakeholders (i.e. the Q-sorters), which is followed by correlation and factor analysis and interpretation of the factor scores.
- Theories:
  - **Diffusion of Innovations' theory** explains how, over time, an idea or product gains momentum and diffuses through a specific population or subsystem. Rogers (1962) found the characteristics of people to play a role in this, which should be studied to help in the dissemination of an innovation. He facilitates this by defining five adopter categories, i.e. (1) *innovators*, a small group of people exploring new ideas and technologies; (2) *early adopters*, considered to be opinion leaders who may share positive testimonials; (3) *early majority*, a group of followers, who will take the testimonials of early adopters at heart; (4) *late majority*, sceptics who are not keen on change; and (5) *laggards*, who will only adopt if there are no other alternatives. But not only the characteristics of the farmer, also characteristics of the innovation determine the adoption process (Ajzen, 1991).

- **The Theory of Planned Behavior,** is a theory developed by Ajzen (1991), which dictates that intentions are guided by three considerations: (1) attitude, which is the degree to which execution of the behavior is evaluated positively or negatively; (2) subjective norm, which is the perceived social pressure from significant others to engage or not to engage in the behavior; and (3) the behavioral control, the perceived own capability to successfully perform the behavior. Given sufficient actual behavioral control, which is the availability of prerequisites in terms of capital, knowledge, skills and opportunities, people will carry out their intentions (Fishbein and Ajzen, 1975).
- **The Efficiency, Substitution and Redesign (ESR) model** describes and assesses progressive strategies to support the transition from conventional to sustainable agriculture (Hill and MacRae, 1996). It features (1) efficiency, which focuses on making best use of resources within existing system configurations; (2) substitution, focusing on the use of new technologies and practices to replace existing ones that may be less effective on both productivity and sustainability grounds; and (3) redesign, which centers on the design of agro-ecosystems to deliver the optimum amount of ecosystem services to produce food and improve natural capital. Although redesign requires more time to implement and demands greater changes in the use of human and physical resources, it is acknowledged as a game changer which is proactive and can generate permanent solutions to problems (Hill and MacRae, 1996).
- **The Suitability, Acceptability and Feasibility (SAF) model,** developed by Johnson and Scholes (2007), is often used in the context of business management, and features suitability, acceptability and feasibility as three criteria to determine the optimal strategic choice for a company to reach a certain goal. The criteria are concerned with, respectively, (1) whether a strategy addresses the key issues relating to the strategic position of the organization; (2) the expected performance outcomes of a strategy and the extent to which they meet the expectations; and (3) whether a strategy could work in practice.

- Concepts:
  - **Agricultural Innovation Systems (AIS),** referring to a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance (Hall et al., 2006).

- **Agroecology,** as explained in Box 1 - 1, can be understood as (1) a set of agronomic practices, (2) an academic discipline, as well as (3) a social movement focused on reforming the food system (Foran et al., 2014). These different interpretations make researchers and agronomists think about agroecosystems as systems at different levels, which is why agroecology is included as a conceptual framework in this list.
- **Diversified Farming Systems (DFS)** refer to farming systems that are ecologically diversified and generate ecosystem services that may supply critical inputs to agriculture (Kremen et al., 2012). The DFS concept builds thus on agroecological principles.
- **Multifunctional agriculture** refers to the fact that agricultural activity may have several functions beyond its role of producing food and fiber, such as renewable natural resource management, landscape and biodiversity conservation and contribution to the socio-economic viability of rural areas (Renting et al., 2009).

2.3.3 Triangulation

In this thesis, we try to gain a better and deeper understanding of AF adoption and development by looking at it from different perspectives. This can be interpreted as triangulation, a method to check and establish validity in studies by analyzing a research question from multiple perspectives (Guion et al., 2002).

However, the different perspectives we want to capture in this study cannot be grasped solely by the different types of triangulation put forward by Guion et al (2002). Therefore the triangulation process was guided by two more relevant frameworks for the topic under study, i.e. the D&D methodology that was developed for the study of AF systems (Avila and Minae, 1992; Raintree, 1987) and the framework of Renting (2009) for the study of multifunctional agriculture. These frameworks categorize different research approaches according to different dimensions, such as the research objective (diagnosis versus design), the level of analysis (farm versus territorial) and the governance mechanism (public versus market regulation). In this way, they encompass especially **data, theory and methodological triangulation**. In the next paragraphs, we first explain these two frameworks. Afterwards we use them to illustrate the different perspectives we used to study AF adoption and development in Flanders in this thesis, and how these analytical approaches complement other studies that were done in the context of the research project.

Box 2 - 1: Triangulation in qualitative research

Validity in qualitative research refers to whether the findings of a study are true and certain, - "true" in the sense that research finding accurately reflect the situation, and "certain" in the sense that research findings are supported by the evidence. Triangulation is a method used by researchers to check and establish validity in their studies by analyzing a research questions from multiple perspectives. Five different types of triangulation exist, which are:

- **Data triangulation**, involving different sources of information;
- **Investigator triangulation**, using different investigators in the analysis process;
- **Theory triangulation**, using multiples perspectives to interpret a single set of data;
- **Methodological triangulation**, using both multiple qualitative and/or quantitative methods to analyze a subject;
- **Environmental triangulation**, using different locations, settings and other key factors related to the environment in which the study took place.

Diagnosis and Design

Diagnosis and Design (D&D) is a systematic methodology developed by ICRAF to initiate, monitor and evaluate AF programs especially in the context of developing countries (Avila and Minae, 1992). It is based on the philosophy that knowledge of the existing situation (diagnosis) is essential to plan and implement (design) meaningful and effective AF programs. In this respect, D&D should be interpreted as an iterative process, in which the diagnostic and design procedures used to initiate the project, are repeated over time in order to monitor and evaluate the project as it develops over time (Raintree, 1987). Besides at different moments in time, D&D also should be done at different levels: Macro D&D is a large scale analysis of an eco-zone within a country or a group of countries, and is important for deciding on the national AF research and extension agenda, whereas micro D&D focuses on one specific land use system, and involves a detailed analysis of households and their production systems. According to Raintree (1987), D&D corresponds to a large extent to the FSR approach, with the difference that it does attempt to develop a special focus on AF-related constraints and opportunities within existing land use systems and to highlight AF potentials that might be overlooked by other approaches.

Framework of Renting for exploring multifunctional agriculture

Renting et al. (2009) classified different strands of literature on multifunctional agriculture, both from natural and social sciences, according to their focus on specific governance mechanisms and levels of analysis into four main categories of research approaches:

- A first category are the **market regulation approaches**, which give particular attention to economic aspects and to governance mechanisms structuring markets for 'non-commodity' outputs of agriculture for which markets do not exist or function inadequately. These include (1) studies of an theoretical economic nature, about concepts like public goods and externalities; (2) economic valuation techniques to allow the calculation of social and private costs and benefits in monetary units; and (3) studies on the basis of (neo-)institutional economics, which aim to determine optimal governance structures for providing public goods and services.
- A second category comprises **land use approaches**, which give central attention to spatial issues related to the multifunctionality of agriculture and rural areas. These include (1) descriptive/analytical approaches, aimed at describing and explaining current or historical land-use patterns through combining biophysical with socio-economic information; (2) predictive approaches, which provide insights in developments that are likely to happen given certain assumptions; (3) explorative approaches focus on developments which are feasible, based on possible land management strategies and limits set by natural resource use efficiencies; and (4) design-oriented approaches, geared to elaborating a small number of options and the selection of the most desirable one to be implemented.
- **Actor-oriented approaches** give central attention to multifunctional agriculture at the farm level and in particular to decision-making processes of actors in the social construction of multifunctional agricultural practices. These include (1) studies focusing on the analysis of different farm household strategies according to the motivation, patterns of activities, and the wider social and market networks of farmers; (2) studies addressing the societal impacts of different farm development trajectories, and their economic viability at farm level and economic impact at aggregate levels; and (3) studies focusing on the evolving motivations and identities of actors as driving force for multifunctional agriculture.
- **Public regulation approaches** give central attention to institutional and policy aspects of multifunctional agriculture. It focuses on ways to operationalize the role of public institutions in facilitating and monitoring multifunctional agriculture, and its social, economic and environmental impacts. These include (1) studies about the degree of recognition of the multifunctionality of agriculture by government institutions; (2)

studies about the role of institutional structures in the development of multifunctional agriculture; and (3) ex-post evaluations of multifunctional agricultural policies.

2.3.4 Research approaches

Figure 3 - 3 shows where the research approaches situate themselves along the two main dimensions given by the D&D methodology. Figure 3 - 4 structures the three research approaches according to the different categories given by the framework of Renting (2009) for multifunctional agriculture. The research approaches were further developed into research chapters, i.e. CH 3, 4, 5 and 6.

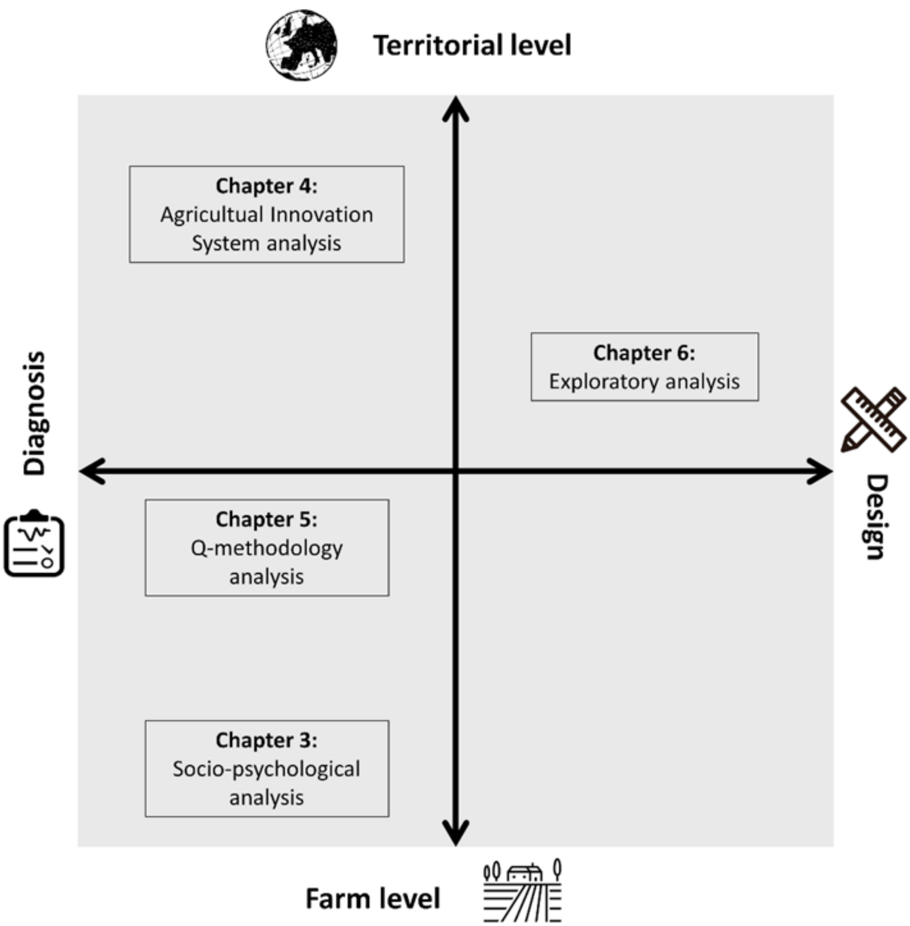

Figure 2 - 3: Using the D&D methodology and its different dimensions, i.e. research objective (horizontal axis) and scale of analysis (vertical axis) to select a diversity of research approaches.

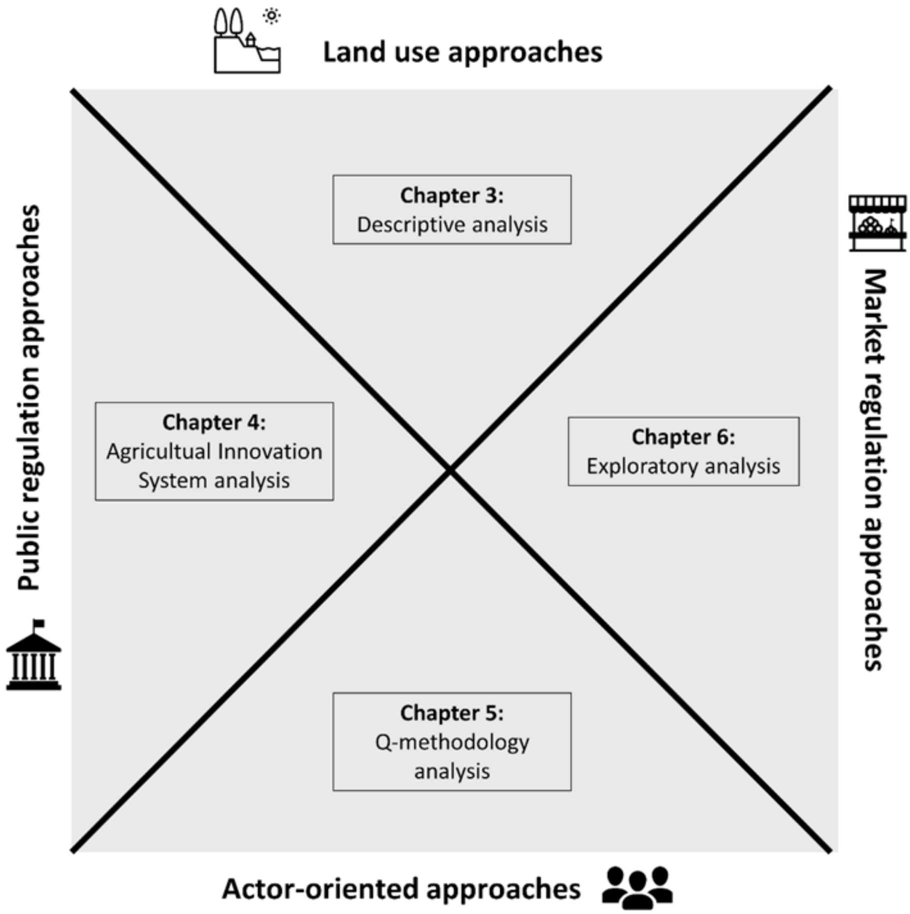

Figure 2 - 4: Using the framework of Renting (2009) for exploring multifunctional agriculture to select a diversity of research approaches.

Chapter 3: Socio-psychological analysis and descriptive analysis

Box 2 - 2: Overview CH 3

- Research questions addressed:
    - What is the current state of AF adoption and development in Flanders?
        - Socio-psychological analysis: What is the current intention of farmers in Flanders to adopt AF systems?
        - Descriptive analysis: What is the current surface area and what are the different types of AF currently implemented in Flanders?
- FSR building blocks:
    - Socio-psychological analysis: TPB as central framework
    - Descriptive analysis: GIS and descriptive statistics as methodology
- Data collection technique:
    - Socio-psychological analysis: quantitative by means of questionnaire
    - Descriptive analysis: quantitative by means of GIS and survey
- Research approach
    - Socio-psychological analysis: diagnosis at farm level
    - Descriptive analysis: land use approach

CH 3 is an introductory scene setting, which gives an overview of the current state of AF adoption in Flanders. The data for CH 3 were already collected and analyzed for the start of the project, and its methodology and framework were thus not chosen in function of the general FSR. Nevertheless, the chapter can be split-up in a socio-psychological analysis and a descriptive analysis, which can also be positioned respectively on Figure 2 - 3 and Figure 2 - 4. The socio-psychological analysis diagnoses farmers' intentions, and thus is positioned in the lower left-hand side of Figure 2 - 3. They were not primarily collected by the PhD student, in contrast to the other data collected in the context of the thesis. This can be considered as **investigator triangulation**, which helps to pursue a broader vision on AF adoption. The descriptive analysis on the other hand gives information on the extent and the characteristics of AF in Flanders, and is a good example of a land use approach. Both the socio-psychological and the descriptive analysis are based on quantitative data, which balances the more qualitative approach throughout the rest of the thesis. In this respect, CH 3 contributes also to **methodological triangulation.**

CHAPTER 4: AGRICULTURAL INNOVATION SYSTEM ANALYSIS

Box 2 - 3: Overview CH 4

- Research questions addressed:
  - RQ 2.1: Who are the stakeholders, and what role do they play with respect to the development of AF systems in Flanders?
  - RQ 2.2: What are the different barriers that hold back AF development?
- FSR building blocks:
  - AIS concept used as central framework
  - Agroecology and diversified farming systems used as relevant concepts
- Data collection technique: qualitative through interviews, focus groups and literature review
- Research approach:
  - D&D: diagnosis at territorial level
  - Renting: public regulation approach

In CH 4, the AIS concept was chosen as a central framework, because it helps to obtain a holistic, all-encompassing view on the different direct and indirect factors contributing to the unfavorable environment for AF develop. In this respect, the AIS concept is used to “diagnose” the slow adoption rate of AF in Flanders, i.e. at a territorial level, and this using different data sources **(data triangulation)**. Therefore CH 4 situates itself in upper left quadrant of Figure 3 - 3. Although the AIS concept also pays attention to the development of appropriate value chains and to the inclusion of multi-stakeholder processes and partnerships, the focus is even more on institutional change, which is considered a ‘sine-qua-non’ for innovation. In this respect, CH 4 belongs to the public regulation approaches (Figure 3 - 4), more specifically to the subcategory of the studies about the role of institutional structures in the development of multifunctional agriculture. Overall, the AIS concept and associated framework play a pivotal role in the chapter, to a much larger extent than the theories used in other chapters (e.g. the TPB in CH 3 and the SAF model in CH 6), therefore this chapter contributes especially to **theory triangulation**.

Chapter 5: Q-methodology analysis

Box 2 - 4: Overview CH 5

- Research question addressed: RQ 2.3: Which perspectives exist on AF, and to what extent are they embedded in general agricultural discourses?
- FSR building blocks:
  - Discourse analysis as main approach
  - The efficiency, substitution and redesign model as relevant theory
- Data collection technique: qualitative/quantitative by means of Q-methodology
- Research approach:
  - D&D: diagnosis at farm level
  - Renting: actor-oriented approach

In CH 5, we opted for a discourse analysis as an actor-oriented approach (Figure 2 - 4), focusing specifically on the evolving motivations and identities of actors as driving force (or barrier) for AF adoption. In contrast to CH 4, which aims to give a holistic perspective on AF development in Flanders, CH 5 provides more depth by zooming in on the farmers and stakeholders, and diagnosing the prevailing perspectives. This was done making use of Q-methodology, a methodology which has both qualitative as quantitative elements and contributes in this regard to **methodological triangulation**. Q-methodology allowed us to delineate and elucidate the different perspectives on AF in Flanders, and to learn about the embeddedness of these AF perspectives in general discourses about agriculture. This is why CH 5 is located in the lower left quadrant of Figure 3 - 3, relatively on the upper side because of the link that is made between AF discourses and general discourses on agriculture. Q-methodology was also chosen, as it offers better structure and replicability than purely qualitative discourse analyses, and therefore may provide better guidance for researchers who are less experienced in qualitative data collection. The outcome of the Q-methodology (i.e. the factor scores) can also be more easily interpreted by and discussed between different researchers than in the case of a purely qualitative discourse analysis. In this respect, the Q-methodology contributes also to a certain extent to **investigator triangulation**.

CHAPTER 6: EXPLORATORY ANALYSIS

Box 2 - 5: Overview CH 6

- Research question addressed: RQ 3: What specific organized or market-based governance models can foster AF implementation by using the benefits of AF to create value for society?
- FSR building blocks:
  - The suitability, acceptability and feasibility model as central framework
  - Agroecology and multifunctional agriculture as relevant concepts
- Data collection technique: qualitative by means of interviews and focus groups
- Research approach:
  - D&D: design at territorial level
  - Renting: market regulation approach

In CH 6, the third research chapter, the goal was to explore from an economic and institutional perspective the potential of different instruments to convert the values of AF into direct economic incentives for farmers. Data were collected through brainstorm sessions and case studies **(data triangulation)**. Based on this information, AF instruments were "designed" and evaluated for Flanders according to the three criteria given by the SAF model. CH 6 thus situates itself at upper right quadrant of Figure 3 - 3. However, vertically the chapter was located closer to the horizontal axis, as one of the cases is a bottom-up approach, developed at the local level. Although there is attention in this chapter for institutional and policy aspects, the overall focus is to a greater extent on economic aspects and to governance mechanisms structuring markets for 'non-commodity' outputs of agriculture. This chapter thus belongs to the market regulation approaches, more specifically the subcategory of the (neo-)institutional economic studies. Whereas in this thesis the focus in on Flanders as central case study, we expand our view in this chapter to promising instruments implemented in other European countries, which is a good example of **environmental triangulation**.

Other studies and activities conducted in the context of the agroforestry project

This thesis cannot be viewed in isolation from the other studies and activities that are done in the context of the AF project, which complement our research chapters in many ways and thus strengthen our triangulation approach towards reflexivity. Van Vooren et al. (2016) for example developed an economic model and investigated profitability changes of two greening options with permanent woody elements, i.e. hedgerows and alley cropping. According to the framework of Renting (2009) the study belongs to category of the land-use approaches, relating both to the subcategory of the descriptive/analytical approaches as to the predictive approaches. The studies of Pardon et al. (2018, 2017) zoom in on the effect of AF systems on carbon and nutrient availability, and on the abundance and diversity of ground dwelling arthropods for Flanders. These two studies belong in a more clear-cut way to the descriptive/analytical approaches which is part of the same category, i.e. the land use approaches, of the framework of Renting (2009). On the other hand, Meus (2017) used participatory modeling at the farm level to study and learn about AF systems in the free range of chickens. Because of its focus on design at the farm level, the study can be situated in the lower right quadrant of Figure 3 - 3. Also relevant in this respect, are the activities that are done as part of the 'participatory change' cluster of the AF project, including the coaching of interested farmers by extension agents in the design of their AF plot. This guidance includes some field visits and conversations about the status of the plot and the goals of the farmer, to arrive to an adequate planting design, custom-made for the farmer. These kind of activities, although they are not scientific in nature, also fit perfectly in the lower right corner of Figure 3 - 3. Although we do not refer to all of these studies and activities in the rest of this thesis, they all helped to gain a broad view on AF adoption and development, and therefore contributed to the general insights created in this thesis.

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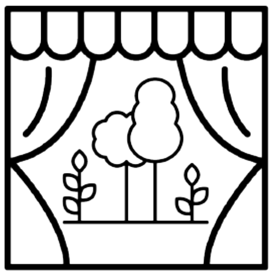
Chapter 3

A socio-psychological analysis of AF adoption in Flanders: Understanding the discrepancy between conceptual opportunities and actual implementation



While the opportunities of modern AF systems are increasingly recognized by policy makers, consultants, researchers, and educators, the response of farmers to the recent subsidy program for alley cropping systems in Flanders is relatively low. Therefore, in this study, a mixed method technique, including a survey (n = 86), interviews (n = 33), and a GIS analysis, is used to better understand the reasons behind this implementation gap. The study showed that 55% of the Flemish farmers are not familiar with AF and that the intention to engage in AF is very low. As a result, alley cropping in Flanders remains sparse with only around 30 farmers known to be consciously engaged in the practice. In the last couple of years, these pioneers have installed one or more AF plots (average surface area of 2.3 ha) that often combine a variety of trees with grassland. Whereas negative perceptions of Flemish farmers are mainly related to compatibility and profitability of such a farming system, pioneers consider legal issues, such as land tenure, the most pertaining drawback. Therefore, future research and policy and extension efforts should target these aspects in order to enhance further diffusion.

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3.1 Introduction

From a historical point of view, various AF systems existed in Flanders as in the rest of Europe. AF is considered here as a collective noun for all land use systems in which tree cultivation is combined with agricultural crop production and/or animal husbandry. Besides alley cropping systems, i.e. land use systems in which crops are grown in alleys formed by rows of trees or shrubs inside the field, also windbreaks or shelterbelts, standard fruit trees with grazing livestock and rows of pollard willows or poplar at the borders of agricultural parcels are considered here as AF sensu lato (s.l.) (Herzog, 1998). Despite the fact that these systems were previously very common, trees in the agricultural landscape have increasingly disappeared with intensification of agricultural production (Nerlich et al. 2012). In Flanders the former orchards with standard fruit trees and grazing livestock have been replaced by more intensive orchard systems with dwarf or half-standard fruit trees without livestock. Only some historic relics of traditional AF systems can be found, while modern AF in the form of alley cropping rarely exists.

In recent years a renewed interest in AF emerged because of its potential to deliver both food and non-food (mainly wood) products as well as environmental services and socio-economic benefits at the same time, therefore avoiding the trade-off between provisioning and several other ecosystem services that occur today in many modern intensive farming systems (Smith et al. 2012a). Because AF systems are based on the ecological theory of niche differentiation, partially using different resources of the environment, their total system (biomass) productivity is often higher than in mono-cropping systems, where trees and crops are cultivated on different plots (Dupraz and Newman, 1997). Economic studies have shown that this higher biomass yield in combination with increased output diversity can lead to financial benefits with higher long-term returns (Benjamin et al. 2000; Brownlow et al. 2005; Yates et al. 2006; Rigueiro-Rodríguez et al. 2009), although the economic performance of AF is highly variable depending on the interaction of many factors influencing the output (Palma et al. 2007). Also the potential environmental benefits of AF systems are manifold with the regulation and enhancement of nutrient cycles, air quality, carbon sequestration, water quality, erosion control and biodiversity as most important examples (Rigueiro-Rodríguez et al. 2009; Smith et al. 2012a). From a social perspective AF systems could allow higher landscape amenities and a restoration of traditional landscapes. This could positively influence rural tourism leading to a broadening of farm activities and income, and a differentiation from other farm enterprises (Rigueiro-Rodríguez et al. 2009).

Since AF is increasingly recognized as a sustainable agricultural innovation which could at least partially address current social, ecological and biodiversity problems in European agriculture, it is supported in Flanders through the regional implementation of both pillars of the new European Common Agricultural Policy (CAP 2020). In the first pillar 30% of the basic payment is 'greening payment' and depends on the implementation of agricultural practices beneficial for climate and the environment (Lamaison, 2014). Besides permanent pastures and crop diversification also the establishment of Ecological Focus Areas (EFA) is listed as a greening requirement (Smith et al. 2012b; EC 2014). As such, conventional holdings with more than 15 ha of arable land need to dedicate 5% to EFA from 2014 onwards and possibly 7% from 2017 onwards (EU, 2013a). The inclusion of AF as one of the types of areas qualified by the EU as potential EFA, is thus a strong support for AF development in Flanders and the rest of Europe. The second pillar of the CAP is focused on rural development and is funded for 50% by the European Agricultural Fund for Rural Development. It includes agri-environment measures and management agreements, i.e. payments to farmers who subscribe on a voluntary basis to environmental commitments related to the preservation of the environment and maintaining the countryside (EU, 2013b). They are implemented through regional Rural Development Programmes (RDP), translating the European into regional regulation. Examples of agro-environmental measures and management agreements concluded in the Flemish RDP for the period 2014-2020 are the cultivation of papilionaceous flowers, mechanical weed control, preservation of local cattle breeds, botanic management, erosion control, organic production, etc. (Van Liefferinge, 2015). To further support AF, the Flemish government included AF in this list of agri-environment measures and management agreements eligible for subsidies. An initial subsidy program for the installment of AF parcels was set up in 2011 and renewed in 2014. Though the original objective of the Flemish government was to establish 250 hectares of modern AF through the new subsidy program by the end of 2013, the initial response was low with 11, 5 and 7 accepted applications in 2011, 2012 and 2013 respectively, all together resulting in the establishment of merely 36 hectares of AF. In 2014 and 2015 respectively 8 and 9 applications were accepted, good for an extra 60 ha of AF. The objective of the new program period (2014-2020) is to establish 300 ha.

According to Rogers' Diffusion of Innovation theory (1962), alley cropping in Flanders is a typical example of an agricultural innovation that is in its pioneer and early stage of diffusion. According to this theory, Flemish AF adopters belong to the two first of five different innovation adopter categories (innovators, early adopters, early majority, late majority and laggards). Furthermore Rogers' theory says that people who adopt an innovation early in time have in general different characteristics than people who adopt an innovation later in time, although exceptions exist (Parra-Lopez et al., 2007).

The limited success of AF in Flanders as contrasted to the conceptual opportunities of such systems, reveals the need for more research about farmers' willingness to implement AF.

According to Montambault et al. (2005) and Pattanayak et al. (2003) AF research expanded in the late 90's from tropical into temperate regions, and with this expansion came also the need for more research on social, economic and adoption aspects of AF. By reviewing 32 studies about AF adoption in primarily tropical regions Pattanayak et al. (2003) found that most adoption behavior is significantly influenced by risk, biophysical and resource factors. Those factors are classified by Meijer et al. (2014) as extrinsic characteristics of adoption. Researches that focus on intrinsic characteristics, which are more emotional and dependent on individual perceptions, are less common although they are, according to Meijer et al. (2014), at the centre of the decision making process. The largest research with respect to farmers' perceptions towards AF in Europe was performed in 2003-2004, during which 264 farmers across seven European countries were interviewed about their views on silvoarable systems (Graves et al. 2009). The study showed that many farmers in Europe are open to the possibility of integrating trees and crops, although large differences existed between regions with willingness to implement AF ranging from 19 to as much as 90%.

The overall aim of this study is to shed light on and better understand the reasons behind the implementation gap between conceptual opportunities and actual implementation. By doing this, we want to offer perspectives for the future of AF development, related to policies, governance, research, markets and extension. We achieve our overall aim by tackling three objectives, which are (1) to learn about the perceptions and attitudes of a small but representative sample of Flemish farmers towards this new innovation, (2) to give an overview of the current occurrence of land use systems in Flanders that combine trees with crops or husbandry (AF s.l.) and (3) to learn about the experiences of a subgroup of farmers who already practice alley cropping and to give an overview of the characteristics of their alley cropping systems. To answer these different research questions a mixed method technique is used. As such it can be determined what is needed, in terms of knowledge, policy or logistics to tackle the current status quo.

3.2 Materials and methods

3.2.1 Study area

The research took place in Flanders, the northern region of Belgium which is administratively divided in five provinces. Furthermore six different agricultural zones can be distinguished in the study area (Figure 3 - 1) which are determined in a historical perspective by soil conditions and topography and described in detail by Peeters (2010). These agricultural zones determine the local agricultural value, production type and system, and therefore also the relationship with and characteristics of 'trees on farms'.

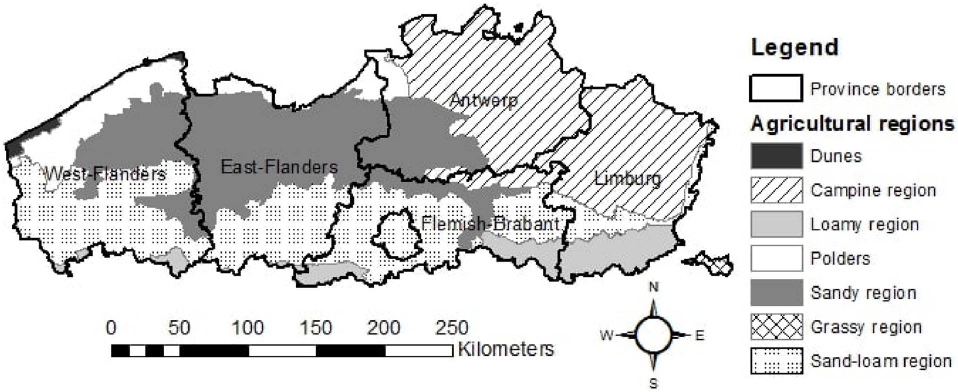

Figure 3 - 1: Provinces and agricultural regions in Flanders

In 2014 about 46% (616.301 ha) of the total land area in Flanders was under agricultural use, of which 56% served for the production of fodder crops, 35% for the production of arable crops (grains, potatoes and sugar beets) and the remaining 8% for horticulture (vegetables and fruits). The number of farm units in 2014 amounted up to 24.252, which is a decrease of 32% in comparison with 2004. At the same time average farm size increased with 42% over the last ten years to 25.4 ha, which proves the current scaling up practice in Flemish agriculture (Departement Landbouw en Visserij, 2016; Platteau et al., 2014). This scaling up practice is related to the land consolidation processes that found place from the 1950's onwards with the original goal to improve food productivity. This implied a clustering of the fragmented parcels into large units with an optimal rectangle shape and located adjacent to the farm, resulting in the disappearance of traditional hedges and 'bocage'-elements separating different parcels (Pauwels, 2014). Furthermore Flemish farms are characterized by a strong specialization (84%) in either livestock, arable farming or horticulture and a strong majority (64%) of leased agricultural land (Departement Landbouw en Visserij, 2016; Platteau et al., 2014).

To promote AF the Flemish government set up a subsidy program, which is supported by the second pillar of the CAP and of which 50% is financed by the European Agricultural Fund for Rural Development. This subsidy is entirely directed to the farmer and not to the landowner in case of leased land, although the tenancy law prescribes that the landowner always has to give permission to the renter to plant trees, which means that the landowner thus plays an important role. Since 2014 the subsidy covers up to 80% of the plantation costs, at least if some requirements are fulfilled: the surface area of the parcel is minimum 0.5 ha, conifers, short rotation coppice and some exotic woody species are excluded from the subsidy, tree density should be between 30 and 200 trees per hectare, the way in which the trees are spread over the parcel should enable a true interaction between tree and crop, the trees have to be maintained for at least 10 years and an agricultural crop production (or animal husbandry) has to be maintained on the parcel.

3.2.2 Theoretical framework

Figure 3 - 2 shows a holistic conceptual framework for the study of AF adoption. It is slightly adapted from Meijer et al. (2014) with inclusion of the Theory of Planned Behavior as proposed by Ajzen (1991). According to Meijer et al. (2014) knowledge, perceptions and attitudes are at the center of the analytical framework, which are shaped by a large number of extrinsic variables. Those can be divided in three categories of which the first category is named 'characteristics of the farmer' (A) and includes personal characteristics (gender, age, marital status, etc.), socio-economic characteristics (income, assets, education, etc.), personality characteristics (self-confidence, independence, etc.), position in social networks (network size, connectedness, frequency of interaction, etc.), status characteristics (control over political power or economic resources) and familiarity with technology. The second category 'characteristics of the external environment' (B) includes geographical settings (ecology, topology, soil conditions, climate, demography, proximity to forests, etc.), societal culture (language, religion, ideologies, norms, values, etc.) and political conditions (land tenure and access rights, national and regional policies, the structure of the government, political freedom and laws, etc.). Finally the third category shaping knowledge, perceptions and attitudes of farmers (C) includes the benefits (contribution to household income, food security, soil fertility improvement, delivery of firewood and building materials, etc.) and the costs of the new practice (installment of AF parcel, equipment, extra labor, etc.). This category corresponds largely with the attributes of innovations (relative advantage, compatibility, complexity, trialability and observability) as explained by Rogers (1962) in his diffusion of innovations' theory. Meijer et al. (2014) furthermore emphasize the role of communication and extension services in the development of knowledge, perceptions and attitudes about agricultural innovations. With respect to communication and extension a deviation was made from the model of Meijer et al. (2014) by adding the RESET-model influencing extrinsic rather than intrinsic characteristics as proposed by Meijer et al. (2014). This model sums up possible strategies (regulation, education, social pressure, economic incentives and tools) to induce a desired behavioral change by acting upon farmers' extrinsic characteristics.

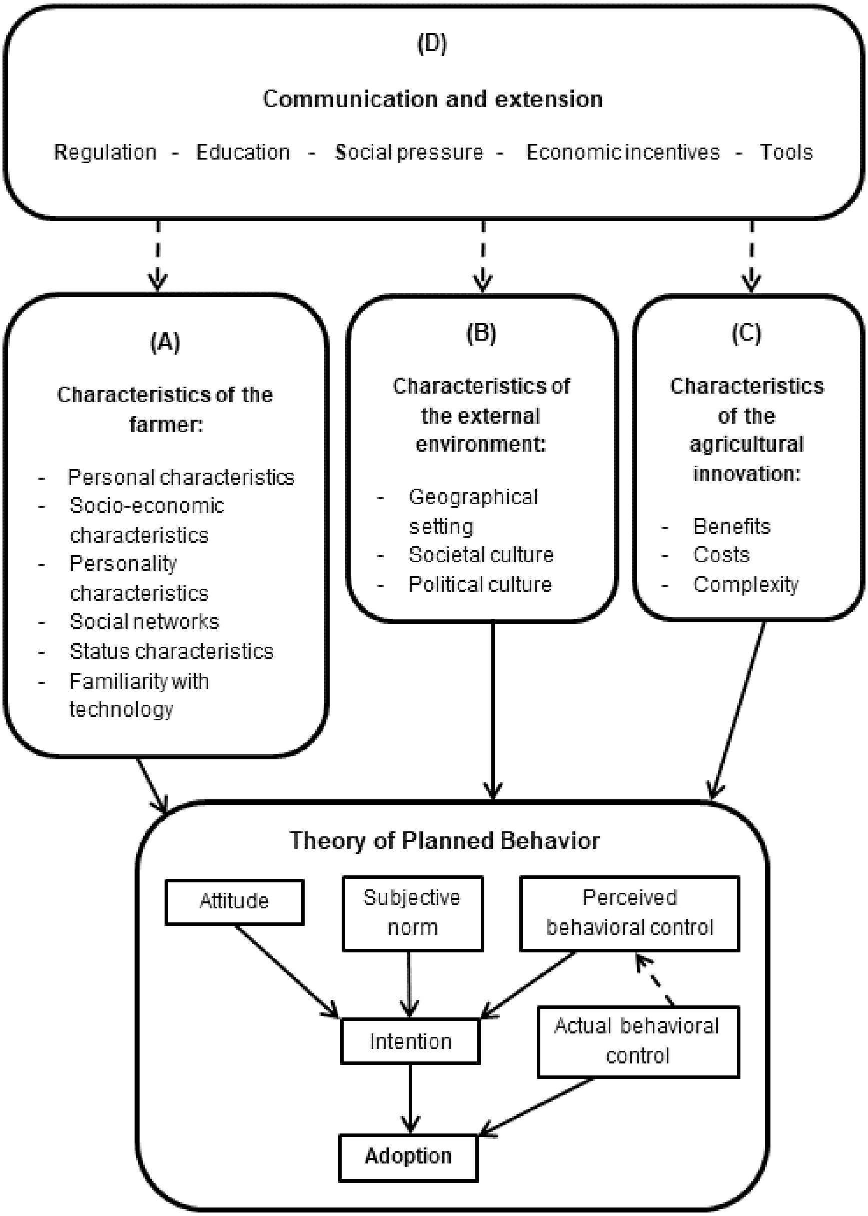

Figure 3 - 2: Conceptual framework showing the linkages between extrinsic variables (A, B, C) and intrinsic variables (TPB) and the influence of communication and extension services (D) in the decision-making process of adoption of agricultural innovations. Adapted from Meijer et al. (2014), with inclusion of the TPB model (Ajzen 1991) and the RESET model (Van Woerkum, Aarts, and Van Der Poel 1999; Leeuwis and Van den Ban 2004).

The core of the decision making process consists of knowledge, perceptions and opinions, which are in this study analyzed by means of the Theory of Planned Behavior (TPB). This socio-psychological theory dictates that intentions are guided by three considerations: (1) attitude, which is the degree to which execution of the behavior is evaluated positively or negatively, (2) subjective norm, which is the perceived social pressure from significant others (referents) to engage or not to engage in the behavior and (3) the behavioral control (the perceived own capability to successfully perform the behavior) (Ajzen, 1991). Given sufficient actual behavioral control, which is the availability of prerequisites in terms of capital, knowledge, skills and opportunities, people will carry out their intentions (Fishbein and Ajzen, 1975). Although the TPB has already been used multiple times to interpret environmentally friendly behavior, such as reducing energy use (Harland et al. 1999), recycling (Nigbur et al. 2010), sustainable farming techniques (Fielding et al. 2005) and agri-environmental measures (Home et al. 2014), the current applications of the TPB to AF systems are, to our knowledge, limited to Switzerland and Pakistan (Hussain et al., 2012; Sereke et al., 2015; Zubair and Garforth, 2006)

An important aspect of the TPB is that it goes beyond identifying the direct determinants of intention and behavior, but that it also theorizes about the underlying foundations of the psychological constructs (attitude, subjective norm and perceived behavioral control) and this according to the expectancy value theory. As such attitude is based on beliefs that the behavior will be associated with outcomes (behavioral beliefs), which are weighted by an evaluation of the outcomes (outcome evaluations). Subjective norms on the other hand are thought to be a function of how much a person perceives that other referents think he should perform the behavior (normative beliefs), weighted by our motivation to comply with the referents (motivation to comply). Finally perceptions of behavioral control are based on the beliefs about the factors that facilitate or act as barriers to perform the behavior (control beliefs) weighted by the expected impact that these factors would have if they were to be present (perceived power) (Fishbein and Ajzen, 1975).

Although the TPB has a large support base, it is acknowledged that for some contexts and behaviors inclusion of other variables may increase the predictive utility of the model (Conner and Armitage 1998; Cook et al. 2002). Especially the inclusion of core concepts from the social identity theory seems useful as the subjective norm is often the weakest predictor of intention of all variables in the TPB model (Fielding et al. 2008). For this reason, in this research 7 extra variables were added to the TPB model. Applied to this study these variables are (1) social identity, which refers to the extent to which a farmer feels a member of the agricultural community; (2) group norm which refers to the explicit or implicit prescriptions regarding a farmer's appropriate attitudes and behaviors as a member of the agricultural community; (3) intergroup perceptions, which are the farmer's perceptions about relations between famers and agricultural policy makers; (4) moral norm, which refers to the degree to which a farmer thinks he should apply a certain practice; (5) response efficacy, which is the degree to which a farmer believes that a recommended practice results in a certain positive effect; and finally (6) uncertainty about agriculture and (7) uncertainty about AF.

3.2.3 Procedure and data collection

The procedure applied in this research is a mixed method, which means that qualitative data collection and research techniques were combined with more traditional quantitative techniques and this in different stages.

In a first step a series of semi-structured interviews were executed in the summer of 2011, and this with eight Flemish AF pioneers and early adopters and two timber buyers. The semi-structured interviews served as a basis for the development of a questionnaire and focused therefore on general, legal, economic and practical aspects of the installment and maintenance of AF parcels in Flanders. The sample for this qualitative data-collection stage was obtained by purposive or judgement sampling, a form of non-probability sampling in which the researcher deliberately selects individuals from the population whom he or she expects to give the most information.

Using the results of the semi-structured interviews a questionnaire was constructed which measured the socio-psychological constructs with respect to alley cropping. The constructs can be measured directly by questions about the construct itself, or indirectly by questions about the underlying foundations. In this research the focus was on the direct measurement of the constructs and this through items in the form of 7-point bipolar scaling questions. Every construct was measured through multiple items which are presented in Table 3 - 1. This increases the reliability but also identifies constructs that are multidimensional such as perceived behavioral control, which is an amalgamation of ‘perceived control’ and ‘perceived difficulty’ (Trafimow et al. 2002). All scale items were based on previous applications reported in the literature (e.g. Wauters et al. 2010, Fielding et al. 2008) and adapted to the context of AF in Belgium. The questionnaire also included Likert-type questions with respect to the advantages, disadvantages and barriers of AF. Furthermore the questionnaire contained questions about the farmer profile, the farm type and knowledge of the term and the concept AF, and the AF subsidy program. After testing the initial questionnaire and some minor adjustments, the final questionnaire was sent out in November 2011 by post to 507 randomly selected farmers in the study area. Those were selected through a two-stage geographical cluster sampling, to ensure an even distribution of the respondents in the study area. The questionnaire was accompanied by a cover letter, which explained the framework of the questionnaire, and an information letter about the concept of AF and its subsidy program. Farmers who didn't respond within a certain amount of time were contacted by phone to increase the response rate.

Table 3 - 1: Latent constructs and hypothesized item structure. TPB variables are based on the hypothesized item structure and calculated as the average item score per construct.

Constructs and associated items
Attitude (A)
Applying practice X is very bad - very good
Applying practice X is very unpleasant - very pleasant
Applying practice X is very useless - very useful
Applying practice X is very negative - very positive
Subjective Norm (SN)
Very few - a lot of people whose opinions I value think I should apply practice X
Very few - a lot of people that I find important think I should apply practice X
It is to a very small - very large extent expected of me that I apply practice X
I think most people outside agriculture think it is very positive - very negative to apply practice X
Perceived behavioral control (PBC)
I think applying practice X is very difficult - very easy
I have very little - very much control over the decision to apply practice X
Social Identity (SI)
I feel myself very little - very much connected to other farmers
I feel myself to a very small - to very large extent farmer
I identify myself very little - very much with the agricultural community
Group norm (GN)
Most farmers would very little - very much approve the fact that I would start applying practice X
Very few - a lot of farmers already apply practice X
Most farmers think it is a very good - very bad idea to apply practice X
Intergroup perceptions (IGP)
Very often - very seldom outsiders decide how agricultural policy is evolving
People who make decisions about agricultural policy know very little - very much about practical considerations in agriculture
I agree to a very small - very large extent with the current agricultural policy
I think that people that influence agricultural policy know very little - very much about agriculture
There is a very large - very small gap between people inside and outside of agriculture

Agricultural policy makers take opinions of farmer to a very small - very large extent into account

I think there is very little - very much understanding from outsiders for people in agriculture

I belief that farmers and agricultural organizations have very little - very much influence on agricultural policy

Moral norm (MN)

I would regret very much - very little the decision to apply practice X

I think it is very good - very wrong not to start applying practice X

I feel personally very little - very much obligated to apply practice X

Response efficacy (RE)

I think practice X is a very good - very wrong way to ensure that agriculture has a more positive impact on the environment

I think that I would very little - very much contribute to a more ecological agriculture by applying practice X

Uncertainty about agriculture (UAg)

I am very unsure - very sure about my future as a farmer

I am very unsure - very sure about the future of agriculture in general

Uncertainty about AF (UAf)

I am very sure - very unsure about the effects of applying practice X on my agribusiness

I am very sure - very unsure about the possible positive or negative effects of practice X

Intention (I)

I intend to a very small - very large extent to start applying practice X in the next 3 years

I am planning very little - very much on starting practice X within the next 3 years

I am very little - very much resolved to apply practice X within the next 3 years

The third part of the data collection was two-fold. First the surface area of AF s.l. was calculated using the Single Application data of 2013 and the Biological Valuation Map (Biologische Waarderingskaart, BWK). The former is an administrative procedure through which farmers register their agricultural plots; it contains information about the destination of each of the agricultural parcels in Flanders in 2013. The latter is the result of an inventory of the biological environment and land use of the Flemish and Brussels region carried out between 2000 and 2010. Secondly, in order to enable a more in-depth evaluation of alley cropping (i.e. the specific type of AF application which is particularly promoted by the subsidy program) a series of telephone and face-to-face interviews were conducted with current pioneers and early adopters, consisting both of farmers in Flanders who already made use of the AF subsidy program and farmers that are actively and consciously engaged in similar AF systems or consider the trees as part of their production system, even without using the subsidy mechanism. The list of farmers contacted in this way is certainly not a complete list of all farmers who combine trees with crops or grazing livestock on the same field, yet, it are these people with whom we had contact from 2011 up to today in the perspective of our AF research and advisory service. To our knowledge, this list of farmers should include nearly all those applying alley cropping. A majority of these 31 open interviews were initially carried out in the summer of 2012, often during field visits in the context of extension. The focus during these interviews was mainly on the pioneers' motivations, encountered obstacles and problems, and thoughts of the subsidy program. In autumn 2013, 2014 and 2015 newly started pioneers were similarly questioned about their AF systems, and additionally, precise characteristics of the pioneers' AF plots were recorded. In 2015 the data gathered in the summer of 2012 were updated through brief telephone interviews.

3.2.4 Data analysis

The semi-structured interviews of the first stage were analyzed manually, and lists were made including the mentioned advantages, disadvantages, tree species, etc. Of each in-depth interview also a one-page summary was made which tells more about these respondents' motivation for and evaluation of AF. These summaries can be found back in annex 5 of the work of Baeyens (2012). This information was subsequently used in the construction of the questionnaire. The results of the questionnaire data were analyzed using a sequence of steps. Validity was not tested here, because similar scales as in Table 3 – 1 already have been used numerous times to assess the constructs of the TPB and associated constructs such as social identity, group norm, intergroup perceptions, moral norm, response efficacy and uncertainty (Lynne et al., 1995; Wauters et al., 2014). First, the results of the questionnaire were analyzed through a reliability analysis, which tests to which extent a set of items accurately measures the concept of interest (Hair et al. 1998). A reliability analysis implies the calculation of reliability estimators such as Cronbach's alpha, which assesses the consistency of the complete scale, and item-to-total and item-to-item correlations which are calculated for every item. Rules of thumb suggest that the item-to-total correlations and inter-item correlations should exceed 0.4 and 0.3 respectively. The generally agreed upon lower limit for Cronbach's Alpha is 0.70, although 0.60 is also acceptable with regard to more exploratory research (Hair et al. 1998). Second, summated scales were calculated for all reliable variables and this happened as the average item score for that variable. With these results descriptive statistics were calculated, during which also skewness and kurtosis of the variables were examined. Third, a regression of the most important TPB variables (attitude, subjective norm, perceived control and perceived difficulty) on the variable intention was performed to test if the proposed TPB model was significant. Since the composite variables are not ordinal anymore and the distributions of the composite variables are often very skewed and not normally distributed, the most appropriate regression technique is a binomial logistic regression. Therefore the dependent scale variable intention was dichotomized. The 70.9% of the respondents that obtained a composite score of 1 for the variable intention (and thus chose 1 for the three items that measure the variable intention), formed one group, whereas all other respondents made up another group.

The data analysis of the last step includes both quantitative and qualitative techniques. First, the open interviews were summarized in lists of frequently recurring motivations, barriers, and thoughts about the subsidy program. Then descriptive analysis was performed on variables such as acreage under AF, tree species, tree density. Finally the surface area of AF in a broad sense was calculated by means of ArcGIS 10.2.2.

2.3 Results

2.3.1 Summary statistics

From the 507 questionnaires sent out, 94 (19%) were received back. Eight of them were excluded for further processing since more than 35% of the questions were not completed. As such 86 questionnaires were taken into consideration for further processing. The summary statistics of the final sample are shown in Table 3 - 2. The farmers in our sample are more or less evenly dispersed over the five provinces, are on average 51 years old, cultivate 42 ha of land of which they rent slightly more than half. A majority of the farmers focus on livestock production, a quarter on arable and horticulture farming and the rest of the farms are mixed (both livestock and arable or horticulture) farms. One third of the farmers in the sample apply agro-environmental measures and 8% of the farmers cultivate their land partially or completely according to the principles and rules of organic farming.

Table 3 - 3 displays the results of the reliability analysis, which measures the internal consistency of each scale. Cronbach's alpha, item-to-total and item-to-item correlations are very high for the scales attitude and intention. For the scales moral norm and uncertainty about AF Cronbach's alpha is under the cut-off value of 0.600 (Hair et al. 1998) and for the scales group norm, intergroup perceptions, moral norm, social identity and subjective norms items-to-total and/or item-to-item correlations don't reach the stated cut-off value by Hair et al. (1998). Schmitt (1996) in contrast argues that there is no sacred level of acceptable Cronbach's alpha and that in some cases low levels of alpha may still be quite useful. Because the above mentioned Cronbach's alphas are close to the cut-off value proposed by Hair et al. (1998) the scales are considered acceptable for further processing, although adjustments of some scales are recommended with respect to future research. The only scale that is not acceptable is 'perceived behavioral control', which has a very low Cronbach's alpha (0.038) and low item-to-total and item-to-item correlations. This indicates that the two items that

should measure the perceived behavioral control actually measure two different concepts, which are perceived difficulty and perceived control (Trafimow et al. 2002).

Table 3 - 2: Summary statistics of the questionnaire sample (based on 86 respondents)

Characteristic	***Statistic***
Geographical distribution (% farms)	
Antwerp	24.40
Limburg	18.60
East-Flanders	22.10
Flemish-Brabant	16.30
West-Flanders	18.60
Farm and farmer characteristics	
Sex (% men)	96.50
Age (years)	50.92 (11.13)
Farm size (ha)	42.11 (43.30)
Percentage leased land	53.02 (34.28)
Assured farm succession (% farms)	26.70
Farm type (% farms)	
Arable and horticultural farming	26.80
Livestock farming	63.40
Mixed farming	9.80
Sustainable farming techniques (% farms)	
Organic farming	8.10
Agro-environmental measures	30.2

Because of the sufficient internal consistency, descriptive statistics of the scales are calculated and presented in Figure 3 - 3 by means of a series of boxplots, except for perceived control and perceived difficulty, which are considered as separate scales. Overall, Flemish farmers have a very low intention (average of 1.42 on a score from 1 to 7) to implement AF on their own farm. Also the attitude towards AF scores is low (2.95), although its distribution of scores is less skewed in comparison to intention. Flemish farmers feel no or little obligation to install AF parcels, neither by themselves (2.48) nor by the farmer community (2.42) nor by other important groups (2.42). Moreover they think to have a lot of control about the choice whether or not to install an AF parcel (5.24). Whereas farmers are relatively sure about the impacts of AF (4.28), they feel less sure about the extent to which these impacts are also effective (3.23). They also perceive the installment and maintenance of AF parcels as quite difficult (2.24). The respondents feel themselves to a large extent part of the farmer community (4.85), whereas they think a certain gap exists between the farmer community and agricultural policy makers

(2.90). This could explain the fact that farmers are quite unsure about the future of agriculture (3.48).

Table 3 - 3: Results of the reliability analysis (Cronbach's alpha, range of item-to-item and item-to-total correlations) of the scales

	Cronbach's Alpha	***Item-to-total correlations***	***Item-to-item correlations***
Attitude	0.979	0.926-0.958	0.883-0.956
Group norm	0.620	0.272-0.557	0.224-0.566
Intention	0.847	0.652-0.759	0.595-0.737
Intergroup perceptions	0.772	0.257-0.640	-0.090-0.570
Moral norm	0.524	0.288-0.469	0.188-0.398
Perceived behavioral control	0.041	0.021	0.021
Response efficacy	0.753	0.607	0.607
Social Identity	0.601	0.349-0.486	0.233-0.414
Subjective norm	0.664	0.310-0.574	0.217-0.583
Uncertainty about agriculture	0.680	0.516	0.516
Uncertainty about AF	0.591	0.421	0.421

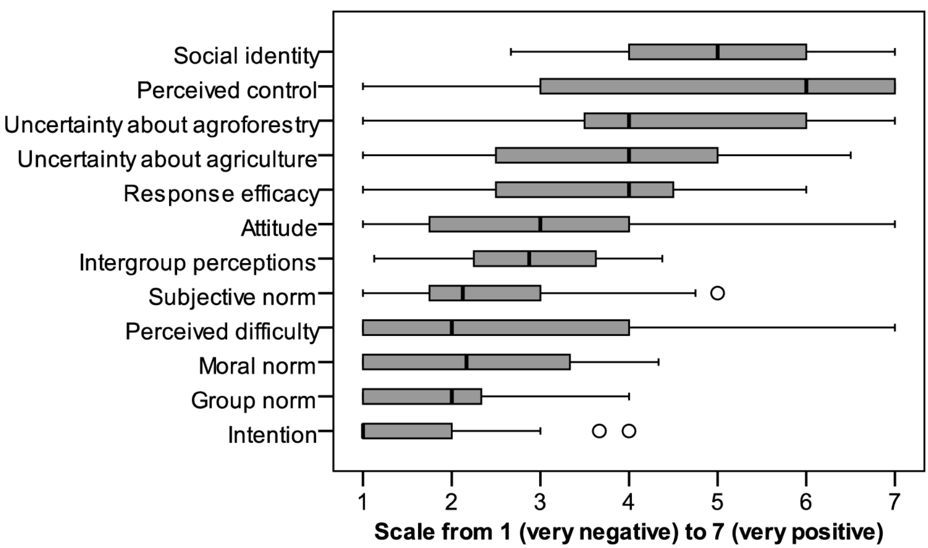

Figure 3 - 3: Boxplots of TPB variables on a scale from 1 to 7 (with little circles and stars representing outliers, respectively, smaller and larger than 1.5 times the interquartile range).

The results of the logistic regression analysis are presented in Table 3 - 4. The logistic regression model is statistically significant, explains 54.4% (Nagelkerke R2) of the variance of intention (I=0 and I>1) and correctly classifies 84.2% of the cases. Of the four predictor variables only subjective norm and perceived control are statistically significant. The odds ratio which informs one of the change of the dependent variable for each increase in one unit of the independent variable, is lower than 1 for perceived difficulty. This is very remarkable as perceived difficulty is expressed on a reversed scale (from 1, very difficult to 7, very easy), i.e. in general respondents with a higher intention to apply AF in the next three years, think AF is more difficult to implement than respondents with a low intention.

Table 3 - 4: Results of the logistic regression predicting the likelihood of Intention being equal or larger than 1, and this based on the predictor variables attitude, subjective norm, perceived control and perceived difficulty.
*** Significant at the 0.05 level; *** Significant at the 0.01 level*

	Odds ratio	***95% Confidence Interval***		$\chi 2$	***p***
		Lower	***Upper***		
Model				36.45	0.000***
Attitude	1.05	0.67	1.64		0.826
Subjective norm	2.48	1.23	5.00		0.011**
Perceived control	2.47	1.36	4.46		0.003***
Perceived difficulty	0.77	0.55	1.09		0.138

3.3.2 Knowledge, perceptions and opinions

The questionnaire showed that 55% of the farmers are not familiar with AF, neither with the term ‘AF’ nor with its principles, while only one third of the famers are familiar with both. Only three of the respondents (4%) indicate they are currently applying AF s.l. on their farm. Farmers mainly learn about AF through agricultural journals (63%), and in a lesser extent through other literature (9%) nature organizations (6%), internet (6%), and government agencies (6%).

According to the respondents the main AF systems that have potential in Flanders (Figure 3 - 4) are trees with grassland (average score of 3.68 on a scale from 1 to 7) and orchards with standard fruit trees (3.42), while they score the potential for trees with arable crops (1.84) and horticultural crops (1.96) very low. According to the respondents, the low potential of AF systems in Flanders is mainly due to excessive shade (18% of respondents) which leads to a loss of yield (19%) and quality (8%), parcels that are too small (13%), a shortage of agricultural land (13%) which leads to a high pressure on (3%) and high prices (5%) for agricultural land, and the application of a too intensive and mechanized type of agriculture (7%) where there is no place and time for increased tillage difficulties (12%).

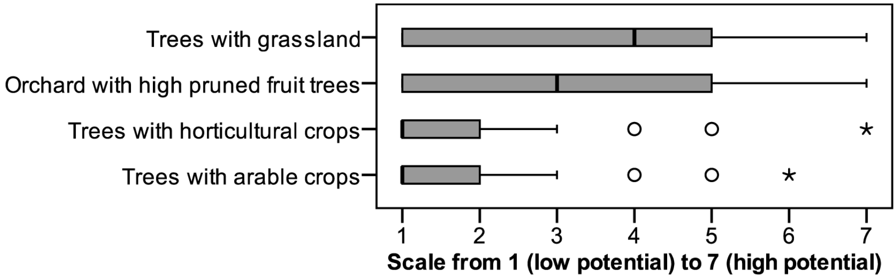

Figure 3 - 4: Boxplots of the perspectives of the respondents about the potential of different AF systems (with little circles and stars representing outliers, respectively smaller and larger than 1.5 times the interquartile range).

The respondents also indicated which trees they would recommend or discourage in an AF system. It is striking that poplar, oak, beech and willow are recommended for use in an AF system by a part of the respondents, while they are at the same time discouraged by other respondents (Figure 3 - 5). There is more unanimity about the advantages of short rotation coppice and trees that deliver fruit or nuts, and the disadvantages of conifers like pine and spruce. In the same way respondents had to indicate characteristics of trees they would recommend or discourage in AF systems and here the same results apply: some characteristics, such as rapid growth, deep root growth and a high crown are recommended as well as discouraged by farmers. On the other hand respondents agree that trees in AF systems should have a narrow crown and should not contaminate crops with easily falling branches and leaves.

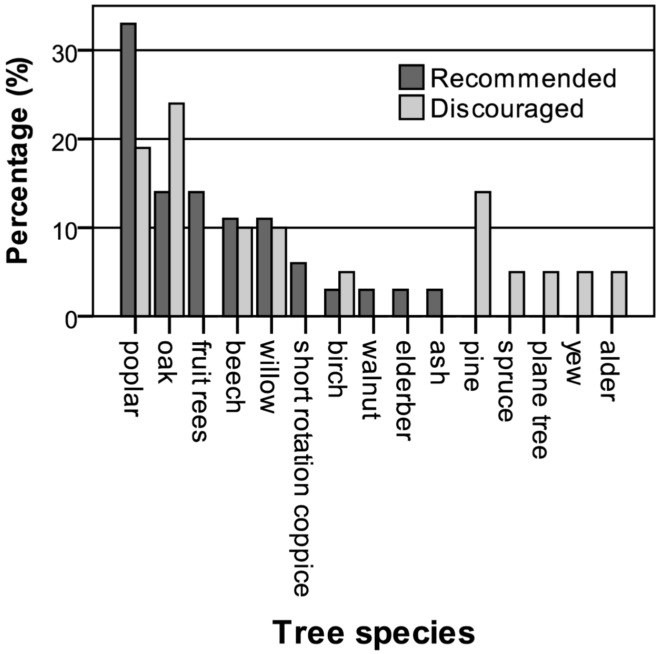

Figure 3 - 5: Share of respondents recommending or discouraging different tree species (or types of management practice) for the application in AF systems in Flanders.

Figure 3 - 6 demonstrates how the respondents think about the extent to which some effects, positive and negative, will actually occur when AF is applied. At first sight one can already determine from the positions of the boxes in Figure 3 - 6 that, in general, the respondents believe less in possible advantages than in possible disadvantages of AF. On a scale from 1 to 7 the average values for the advantages lie, with exception of profitability, between 3.2 and 4.4. This means that the respondents are in general not that convinced about the benefits of AF as listed in Figure 3 - 6. The respondents believe slightly more (average score > 4.0) in the achievement of some advantages of a social (landscape appreciation) and ecological nature (reduction of erosion, more nature and biodiversity), whereas they mutually agree that more profit is not a likely outcome of AF. For the disadvantages average scores on a scale from 1 to 7 lie between 4.0 and 6.1. According to the respondents competition for light, reduced crop production and increased tillage difficulties are serious problems (average score > 6.0) to be expected. The only negative effects of AF which respondents don’t really recognize are a limited market for wood and more pests and diseases.

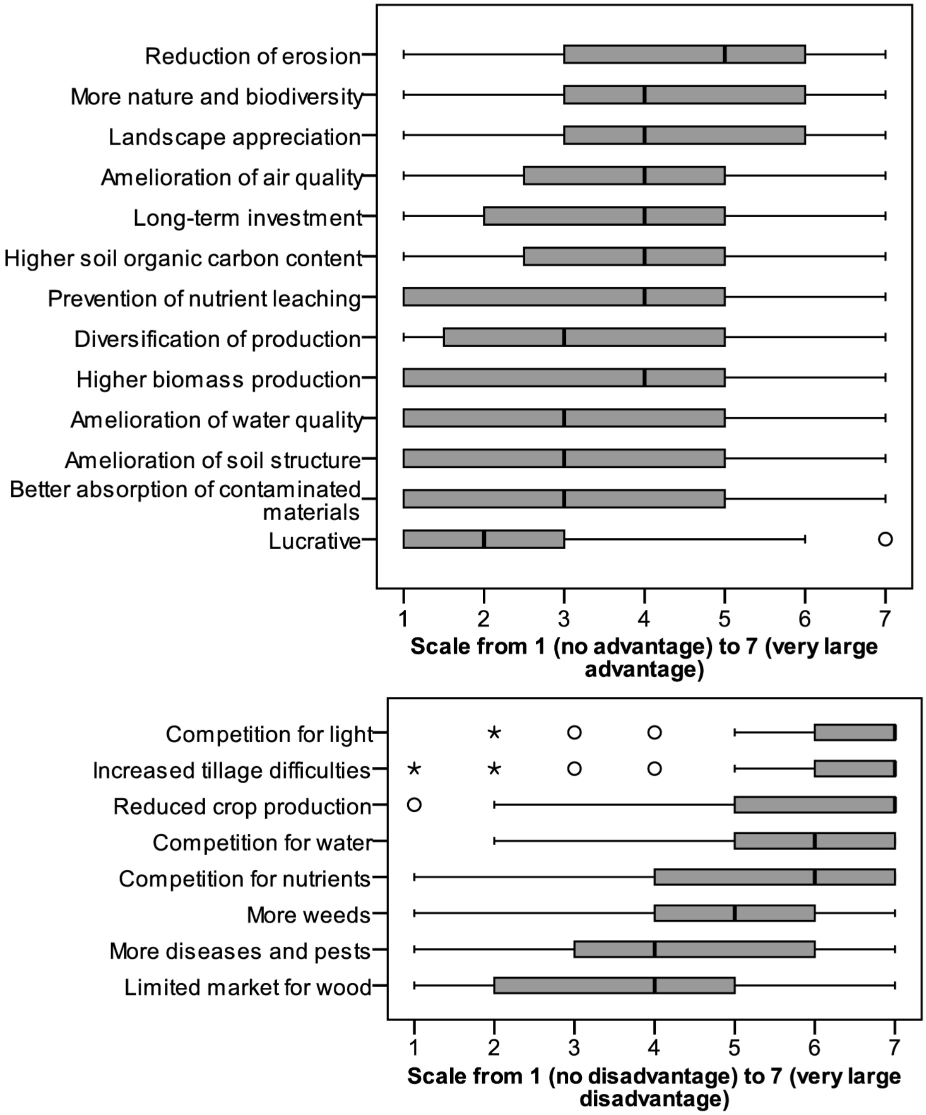

Figure 3 - 6: Boxplots of the perspectives of the respondents about (a) advantages and (b) disadvantages of AF systems (with little circles and stars representing outliers, respectively smaller and larger than 1.5 times the interquartile range).

Finally respondents were also asked to score the subsidy measure on a scale from 1 to 7, which was at that time slightly different than nowadays (only 70% of the costs of the installment was paid back, trees had to be maintained 15 years instead of 10 and there was no compensation for own labor). Figure 3 - 7 shows that the results are very nicely spread with almost as many farmers who think the subsidy makes little sense as farmers who are neutral and farmers who think the subsidy is interesting and decisive.

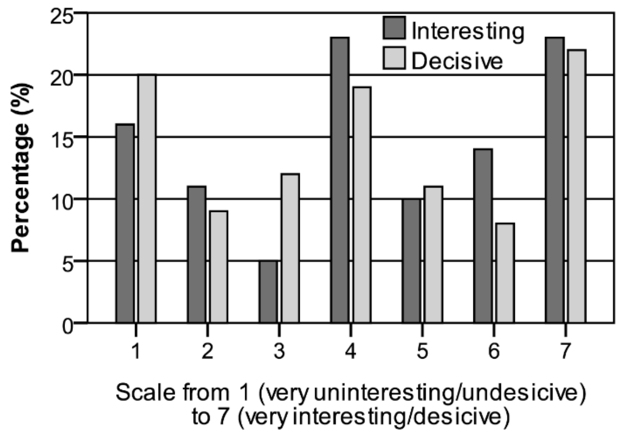

Figure 3 - 7: Scores of the respondents for the subsidy program (2011–2013) on a scale from 1 (very uninteresting and indecisive) to 7 (very interesting and decisive)

3.3.3 Agroforestry in Flanders

AF is a broad concept which does not only cover alley cropping, but includes many other land-use systems in which woody perennials are integrated with crops and/or animals on the same land unit. Table 3 - 5 shows the surface area of the different land uses in Flanders that can be considered as AF s.l., and this according to the destinations indicated by the farmers in the Single Application in the year 2013. The total result of 1924 ha can be considered an underestimation of reality due to the fact that additional destinations only have to be registered by those farmers applying for specific subsidies. As such the information in parentheses in Table 3 - 5 only had to be delivered by farmers applying for the former subsidy for standard orchards. Furthermore the Single Application takes only farmland into account (which exception of ‘garden with standard trees’ referring to non-farmland for which the subsidy for standard orchards was applied). Almost half of the AF s.l. is registered as ‘grassland with standard trees’ which refers to grassland with a tree density of minimum 50 trees/ha. Permanent or temporary grasslands which contain less than 50 trees/ha, but for which the subsidy for standard orchards was applied are second most important with 372 ha.

Additionally the BWK was used for calculating the surface area of all parcels with tree rows at one or more borders. This resulted in a total surface area of 150 690 ha. Whereas the Single Application is considered an underestimation, the BWK may represent an overestimation. This is confirmed by field investigations which showed that also two trees bordering an agricultural parcel were considered as a tree row in the BWK.

Table 3 - 5: Surface area of AF s.l. in Flanders according to the Single Application of 2013

Destination	*Total surface area (ha)*	*Number*	*Average surface area (ha)*
Hedges and hedgerows	186	2468	0.08
Garden with standard trees	121	398	0.3
Grassland with standard trees	987	1593	0.62
Walnut plantations	25	26	0.95
Hazelnut plantations	4	6	0.68
Standard cherry trees	51	81	0.63
Apple trees (standard)	52	65	0.81
Pear trees (standard)	2	3	0.81
Plum trees (standard)	2	5	0.49
Other perennial fruit crops (standard trees)	35	54	0.64
Permanent grassland (with standard trees)	372	273	1.36
Temporary grassland (with standard trees)	67	62	1.08
Other destinations (with standard trees)	20	13	1.53
Total	1924	5047	0.38

Table 3 - 6 shows the characteristics of the farms and AF parcels of all those farmers interviewed in the framework of the third part of our data collection, i.e. those who are to our knowledge at this moment consciously busy with alley cropping. It includes, among others, all farmers which made use of the subsidy program from 2011 till 2015. Among these 31 current adopters motivations and their farm and AF characteristics varied strongly. According to Table 3 - 6 the adopters have on average 1.8 AF parcels of which the sum of the surfaces is on average 4.0 ha. The share of farmers with a mixed and/or organic farm is higher for the AF adopters (respectively 46% and 26%) than for the participants in the questionnaire (respectively 10% and 8%). Regardless of ownership there are currently 55 known AF parcels in Flanders, which have an average size of 2.3 ha. 78% of the parcels were installed with help of the AF subsidy program that exists from 2011 onwards. The on average 68 trees/ha are planted in rows which are on average 21m apart, whereas the main distance between trees in one row is 9m. Among adopters silvopastoral systems are most popular (51%) which is reflected in the most popular crop types, being grass (34%) and grass clover (32%). Furthermore some arable crop types such as corn (14%) and winter cereals (20%) are according to the adopters interesting in AF systems, whereas walnut (51%), fruit trees (30%), oak (17%) and poplar (17%) are the trees

preferred by the adopters. This demonstrates that adopters' motivations vary strongly and that they have often multifunctional objectives, such as production of wood, fruits and nuts.

Table 3 - 6: Characteristics of the farms and AF parcels of the known AF pioneers and early adopters in Flanders (situation 2015-2016). The crop type lists only includes subsidized parcels from 2011-2015, whereas the tree species lists excludes those species occurring only on one parcel

Farm characteristics	***Stat.***	***Crop types and tree species***	***Stat.***
General		**Crop type (% parcels)**	
Number of farms	31	grass	34
Surface area of AF/farm (ha)	4.0 (4.7)	grass-clover	32
Number of AF parcels/farm	1.8 (1.5)	corn	14
Farm type (% farms)		winter cereals	13
Arable and horticultural farming	37	potatoes	3
Livestock farming	17	clover	1
Mixed farming	46	vegetables	1
Sustainable farming techniques (% farms)		soft fruit	1
Organic farming	26	**Tree species (% parcels)**	
AF parcel characteristics		walnut (*Juglans* spp.)	51
General		apple (*Malus domestica* Borkh.)	26
Number of AF parcels	55	plum (*Prunus domestica* L.)	25
Size (ha)	2.3 (2.2)	pear (*Pyrus communis* L.)	23
Use of subsidy program (% parcels)	78	sour cherry (*Prunus cerasus* L.)	19
Leased farmland (% parcels)	15	oak (*Quercus* spp.)	17
Plantation year (% parcels)		poplar (*Populus* spp.)	17
< 2000	8	alder (*Alnus glutinosa* (L.) Gaertn.)	13
2000-2010	8	wild cherry (*Prunus avium* L.)	13
> 2010	83	rowan (*Sorbus aucuparia* L.)	9
AF types (% parcels)		chestnut (*Castanea* spp.)	9
Silvopastoral	51	willow (*Salix* spp.)	9
Silvicultural	41	common hazel (*Corylus avellana* L.)	8
Agrosilvopastoral	8	lime tree (*Tilia* spp.)	6
Plantation design		ash (*Fraxinus excelsior* L.)	4
Density (trees/ha)	68.3 (52.4)	beech (*Fagus sylvatica* L.)	4
Distance between rows (m)	21.1 (11.0)		
Distance between trees in row (m)	9.1 (2.4)		

With regard to encountered obstacles legal issues were mentioned most frequently and these encompass two specific problems. The first problem has to do with the fact that the majority (64%) of farmland in Flanders is leased, whereas farmers only tend to plant trees on farmland they own. As such Table 3 - 6 shows that only 15% of the Flemish AF plots are owned by another person than the farmer. According to the tenancy law in Flanders, farmers who want to plant trees on their leased farmland, always need to ask permission to the landowner. Therefore one condition of the AF subsidy is that the interested farmer-renter has to submit a written permission of the landowner. According to Arbuckle et al. (2008), who measured non-operator landowner interests in AF practices, closer ties to farming, stronger financial motivations for landownership and higher proportion of land planted to row crops were negatively associated with interest in AF, whereas environmental or recreational motivations for landownership and contacts with natural resource professionals were positively associated with interest in AF. Although landowners' interest in AF thus seems to depend on personal values and preferences, in Flanders there is one more important reason for landowners not to give permission, which is the uncertainty about the possibility to harvest the trees. This is considered the second legal obstacle, and it applies equally to farmers with respect to the decision to implement AF. Because of their value for biodiversity, nature and society, trees in the landscape in Flanders are protected through different laws, and whereas AF meanwhile is explicitly excluded from the Flemish Forestry decree and the 'Veldwetboek' (rules neighborhood issues in rural areas, equivalent to the English Countryside Code), there are still a lot of other potentially conflicting rules and decrees that apply to AF systems. As such, in some cases, two different felling permits might be required (under the Nature decree and under the Codex Spatial Planning) and on top of that also the Tenancy law and the Landscape decree have their own rules with respect to trees in the agricultural landscape. Landowners and also farmers fear that, if at the end of the rotation they don't manage to get a felling permit without a replanting or financial compensation obligation, they can never legally go back to the original situation. Also Shrestha (2004) found this kind of legal uncertainty to be the most critical threat towards the adoption of silvopastoral systems in Florida. Furthermore there is a general mistrust in government, which according to farmers does not implement a steady policy, and in their attempts to protect nature on farms only creates more thresholds. Besides the legal obstacles, AF pioneers also had a lot of questions and uncertainties about possible markets and corresponding prices for obtained products, such as wood, fruits and nuts.

3.4 Discussion

The results show that only 55% of the Flemish farmers are familiar with AF and that the intention to engage in AF is very low. Comparison of these results with the results of Graves et al. (2009), who questioned in 2004 264 farmers in seven different European countries about their willingness to integrate trees in their agricultural parcels, shows that the knowledge of Flemish farmers corresponds most with the knowledge of farmers from north-western Europe. Here roughly half of the farmers had never heard of the term or the concept of AF before. In the Mediterranean area farmers were in general more familiar with AF, with only 20% of the farmers that never heard of the term or concept before (Graves et al. 2009). Also the ideas of Flemish farmers about AF are broadly in line with the ideas of farmers in Northern Europe, who found the principal advantage of silvopastoral systems to be environmental benefits and the largest constraints the complexity of the work and the mechanization difficulties. Also in the south-eastern United States, aesthetic, environmental and conservation benefits were considered most important by farmers, rather than profitability (Workman et al. 2003). The situation in the Mediterranean area was different: here farmers felt that the principal benefit of silvoarable systems was farm profitability (Graves et al. 2009), an advantage in which Flemish farmers currently absolutely don't believe. These differences reflect the local agricultural practices and the extent to which tree products are seen as relevant to local economic opportunities (Graves et al. 2009). As such numerous traditional AF systems are found in Southern Europe, such as olive associations in Italy (Rühl et al. 2011), and oak associations in Spain (i.e. 'dehesas') (Plieninger and Wilbrand, 2001) and Greece (Vrahnakis et al. 2014).

The concerns with respect to economic and technical aspects of AF might partially be linked with the lack of experience in Flanders, making the true potential of AF systems in Flanders currently insufficiently acknowledged. In order to make a better judgment on the potential and compatibility of AF in Flanders more research on temperate AF systems is needed. In contrast to tropical AF which is investigated since the 1970s, little study results on technical and biophysical aspects of temperate AF systems are currently available (Smith et al. 2012b). This study shows that also socio-economic research on AF is important. This is confirmed by Nair (1998) and Mercer and Miller (1998), who found that the percentage of socioeconomic articles was maintained at a low 10% and 22% respectively of the overall number of articles on AF published from the beginning of the 1980's till the end of the 1990's. With respect to farmers, future research should target farmers' negative perceptions related to profitability and compatibility. As such local studies covering field trials, market assessments and product sales such as performed by Josiah et al. (2004) are still non-existent. Furthermore, in order to maximally incorporate practical questions and experiences, research should be performed with farmers as equal research partners. In this way it is possible to gain a broad insight into the economic opportunities of AF systems relevant to the Flemish agricultural context and an increased knowledge of the ecological interactions, ecosystems services and technical impact.

Since farmers are different, as well with respect to intrinsic as extrinsic characteristics, a combination of actions and communication strategies is necessary to induce a behavioral change. Some effective intervention strategies are given by the RESET-model, adapted from Van Woerkum et al. (1999) and Leeuwis (2004). A first strategy given by the RESET-model is regulation, which forces people by law to act in a preferred way. It works thus via coercion by authorities leading to a compulsory behavioral change. While regulation in terms of obligations or coercion would not be the preferred strategy, there are other policy measures that could enhance the current AF adoption rate in Flanders. As such there is still some work to find an appropriate place for modern AF in the legal landscape. Although some of these stumbling blocks already have been solved, there are still some conflicting regulations within the nature, forestry, agricultural and spatial planning policy domains. In order to solve these problems, there are currently meetings on a regular basis in Flanders between policy makers, farmer organizations and researchers. Also at European level much has been improved during the last years: whereas Smith et al. (2012b) called the lack of European policy support one of the main barriers to wider adoption of AF, Europe now supports this cultivation system in numerous ways (through among others Pillar 1 and Pillar 2 of the Common Agricultural Policy).

A second strategy to induce a behavioral change in farmers is education. This study demonstrated that 55% of the farmers are currently not familiar with AF, which suggests that extension efforts should focus on dissemination of knowledge and sensitization. This is supported by previous studies which proved that knowledge, information and contact with extension agents are significant factors positively influencing the interest and uptake of AF practices (Hall et al., 2006; Raedeke et al., 2003; Thangata and Alavalapati, 2003; Valdivia and Poulos, 2009; Workman et al., 2003). For those farmers interested in, planning to start with or already engaged in AF, some frequently asked technical or logistical questions need to be addressed. Although it is important that this kind of information is provided in an organized way and made accessible for all interested farmers through a central contact point, it is equally meaningful to give interested farmers the possibility to interact with each other and exchange information and experiences. This strategy is not limited to the provision of information and advice to farmers only, it wants to target all people who deal with agriculture in one or another way. Therefore AF and more generally agroecology should get a clear and appropriate place within agricultural education.

The third letter of RESET stands for social pressure, which influences farmers' norms and values. Currently farmers feel little or no obligation to practice AF which is expressed by the low scores for the variables subjective norm, group norm and moral norm. The logistic regression however demonstrated the importance of social pressure by assigning the largest odds ratio, 2.48, to the variable subjective norm. This means that for every unit increase of subjective norm, the probability to belong to the second group (with a score for intention larger than 1) is 2.48 times larger. Research institutions, agricultural consultants and advisers are thus important for increasing social stimuli by setting up a network and sending the same message with respect to AF. By influencing national and regional dialogues in policy and extension environments, AF can gradually be built into the social norms and identities of the farming profession, thereby making it one of the default options.

Economic incentives make up the fourth strategy in the RESET-model. In Flanders the subsidy program was established as an economic incentive to promote AF. The questionnaire showed that the respondents' opinions are very evenly distributed, with as many farmers finding the subsidy uninteresting and indecisive, as farmers finding the subsidy interesting and decisive. Although the subsidy program is meanwhile already partially adjusted and optimized, it is criticized by farmers that it still does not solve the most pressing obstacles of planting trees on agricultural land. Especially the fact that there is still no compensation for maintenance of trees, is by farmers considered as a substantial drawback. More scientific field data should therefore lead to a more effective subsidy program, based on a more in-depth cost-benefit analysis taking into account the uncertainty, long term investment, crop production losses and maintenance costs related to AF. Economic incentives that are currently not yet addressed in Flanders are alternative contract- and financing options, such as Payments for Environmental Services (PES), crowdfunding, interesting loan conditions, etc. An example of an alternative financing system that was proposed by some farmers is a system in which wood processing companies remain the tree-owners and are responsible for the planting and harvesting of trees, while farmers get an annual compensation for the partial use of the field and for the maintenance of trees. Whereas it is currently unknown if such systems, in which the uncertainty is shared between different actors in the value chain, could be effective in Flanders, it is worthwhile to research in more detail the possible ad- and disadvantages.

The last letter of RESET stands for tools, i.e. means and methods which make AF much easier and attractive to perform. An example of such a tool is a Financial Decision Support Tool, such as the web-based application for AF planning and tree selection developed by Ellis et al. (2005) for the Southeast of the United States. These tools combine growth and yield prediction models with financial decision models. They can instantly show the impact of establishment, management, and harvesting and marketing decisions on the financial performance of the AF system. Such a web-based application could assist interested farmers and extension agents in Flanders to evaluate potential sites and suitable trees species and crops for use in AF systems.

However, the development of a tool requires the availability of detailed, long-term datasets of yields (e.g. timber and crop yields within alley cropping systems over time, etc.) and benefits or drawbacks (animal health in silvopastoral systems, labor, etc.), which are often not available for local conditions. Luckily for Flanders they are now being collected in the context of a large research project about AF development in Flanders. Furthermore tools could address the negative perceptions of Flemish farmers towards mechanization and tillage efficiency. As such machines that are adapted for use in AF systems could be considered as a tool to promote AF. These can be tailor-made for AF systems and made available to the farmer through contractors and manufacturers. Though, this requires a large investment of the farmer, which adds to the drawbacks making interested farmers reluctant to adopt. Therefore the possibilities have to be explored to use and modify existing equipment for use in AF systems instead of investing in new machinery. The availability of adapted or tailor-made machinery acts upon the extrinsic characteristics of the innovation itself, more specifically the complexity of the innovation, and could as such prevent that AF is regarded as a system in which the current mechanization efficiency in agriculture has to be abandoned.

3.5 Conclusion

This research shows that the adoption of AF in Flanders remains rare with only 31 farmers currently known to be involved in alley cropping. They often installed in the last couple of years one or more AF plots that combine a variety of trees with grassland. The low adoption rate of AF in Flanders results logically from a low intention of the general farmer community to engage in AF. Although Flemish farmers believe in certain socio-ecological advantages of AF, they have a lot of concerns with respect to the economic (yield and quality loss, profitability, marketing of wood products) and technical (mechanization difficulties, compatibility) aspects of AF. For the pioneers and those farmers considering to implement AF in the near future, especially legislative issues continue to cause uncertainty, although the last few years already some effort has been done to tackle this problem. To further increase the AF adoption rate, a combination of different actions and communication strategies are necessary. Besides more scientific research on both the ecological and socio-economic aspects of temperate AF, some effective strategies are given by the RESET-model. As such more and better education and extension services, the set-up of a local AF network consisting of both researchers and agricultural advisors, the inclusion of a compensation for maintenance into the subsidy program and the set-up of alternative contract- and financing options are effective means to improve the current low adoption rate of AF in Flanders.

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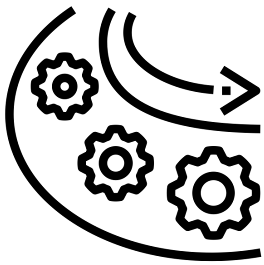
Chapter 4

Nurturing AF systems in Flanders: Analysis from an agricultural innovation system analysis



The shift to industrial agriculture in Europe brought along a range of environmental and social externalities. This led policy makers, researchers and civil servants to consider and explore the potential of diversified farming systems (DFS) to address current problems in agriculture. However, because of multiple obstacles adoption of these DFS by farmers is not obvious. In this study we investigate the case of agroforestry (AF) systems in Flanders, where a government incentive scheme initiated in 2011, did not result in the expected uptake of AF systems by farmers. To understand this implementation gap and the role of the different relevant actors herein, we used the Agricultural Innovation System concept ensuring an integrative and holistic analysis. Through 25 interviews, 2 focus groups and document analysis, a set of qualitative data was gathered and analyzed. This revealed five sets of challenges, which are of a technical, financial, legal, organizational and social nature. For each of these challenges development pathways were formulated to further upscale AF adoption. Although they should be substantiated and fine-tuned through further research, they put forward the importance of (1) investing in research to improve the compatibility and labor productivity of AF systems, (2) engaging private and societal actors in niche markets for agroecological products, (3) developing a full-fledged legal landscape and an effective incentive program, (4) using different communication and education channels to familiarize actors with agroecological practices, and (5) strengthening the dialogue between influential groups.

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4.1 Introduction

Several decades ago, farming systems in many developed regions were very diverse and often included hedgerows and trees as valuable and productive elements (Eichhorn et al., 2006). This changed in the late 20th century, when diversified farming systems (DFS) were increasingly replaced by industrial agricultural systems, characterized by specialization and upscaling (Nerlich et al., 2012). These practices were very effective in raising the levels of food production to meet demand (Horlings and Marsden, 2011). However, soon it became clear that this intensified agriculture is exerting a huge toll on biodiversity, ecosystem functioning and climate, as well as on product quality, human health and the increasing scarcity of natural resources (Duru et al., 2015). Therefore in recent years, a renewed interest emerged in DFS. Such DFS intentionally include functional biodiversity at multiple spatial and temporal scales to maintain ecosystem services that provide critical inputs to agriculture, such as soil fertility, pest and disease control, water use efficiency and pollination (Kremen et al., 2012). Also in Flanders, the northern region of Belgium, located in the center of Europe, concerns arose about the impact of industrial agricultural systems on human health and the environment, which opened up opportunities for research into and experimentation with DFS. As such, over the last decade, many public and private actors started to explore the potential of AF systems as a promising DFS. In AF systems, trees are deliberately combined with crops and/or livestock on the same plot (Lundgren and Raintree, 1983). This results in the delivery of multiple ecosystem services, such as biodiversity conservation, regulation of soil, air and water quality and carbon sequestration (Smith et al., 2012), while the system continues to produce food and other biomass products. The theory behind AF systems is niche differentiation, which states that trees and crops partially use different resources of the environment, often leading to higher overall productivities in comparison to mono-cropping systems (Dupraz and Newman, 1997). Although this higher productivity does not automatically imply financial benefits (Palma et al., 2007), AF systems are increasingly regarded as farming systems that balance productive and protective functions and minimize trade-offs between provisioning and other ecosystem services (Smith et al., 2012). We consider AF here as one example of a DFS or of an agroecological innovation, that has some specific characteristics related to trees – being the essential component of an AF system – but has many things in common with other DFS. Therefore we use the terms 'AF', 'DSF' and 'agroecology' depending on the context and the argument.

Despite its benefits, multiple obstacles exist to the adoption of DFS by farmers, which makes a more large-scale shift from conventional to more diversified farming systems neither simple nor obvious (Iles and Marsh, 2012; Kremen et al., 2012). This is also the case for AF in the region of Flanders. A study by Borremans et al. (2016) showed that the majority of Flemish farmers are unfamiliar with AF, and that their intention to engage in AF is very low. This is mainly due to negative perceptions of farmers about the compatibility and profitability of AF, and major concerns about legal issues such as land tenure. However, these results are mainly based on a survey with farmers, which gives this study – like many earlier studies looking into the adoption of DFS – a strong farmer-focused approach. What these studies have in common is that they limit their analysis to one specific farming practice, and that they seek barriers for a limited uptake of DFS, and as a logical consequence also measures to improve this uptake, very close to the farmers. Although such studies are still implemented and continue to provide valuable insights (e.g. Wauters et al. 2010; Home et al. 2014; Menozzi et al. 2015)and 2, it is increasingly acknowledged that also the role of other actors should be included in the analysis, and that more attention should be drawn to institutional, biophysical, structural and market considerations and their effect on farmers' choices. Consequently an evolution in adoption studies is taking place, for DFS as well as for other agricultural innovations, towards more integrative, systemic and holistic approaches, which put the interplay of farming systems with the broader agricultural innovation system at the center of attention (e.g. Wilson 2008; Bacon et al. 2012; Iles and Marsh 2012; Kremen et al. 2012; Blesh and Wolf 2014).

Based on these insights, and in congruence with other sectors of the economy, the Agricultural Innovation System (AIS) concept was developed, which acknowledges that innovation in agriculture is the outcome of an interactive and co-evolutionary process in which a wide network of actors are engaged. As a result, the corresponding AIS framework takes into account that speed and direction of innovation processes are affected by the divergence in goals of the different actors. Moreover, it recognizes that the extent to which the policy, market, or institutional environment enables an innovation, is shaped by the thoughts and actions of different actors involved (Klerkx et al., 2012; Lamprinopoulou et al., 2014). The AIS framework already has been used to holistically assess and compare national or sectoral agricultural innovation processes (e.g. Kebebe et al. 2015; Turner et al. 2016), or to identify strategies to create a more conducive context for the realization of agricultural innovation networks and a more durable embedding for agricultural projects (e.g. Klerkx et al 2010). However, the AIS framework is to our knowledge not yet used to analyze the capacity of DFS to scale-out. Because of its integrative approach though, it promises to shed a more comprehensive view on the different direct and indirect factors affecting adoption of DFS. Therefore, the AIS framework is applied to the case of AF systems in Flanders, to better understand why AF remains unpopular among farmers despite growing public support (Borremans et al., 2016). More specifically, the aims of this study are (1) to identify the actors and their roles with respect to AF development and (2) to analyze the system failures (and merits) with respect to AF development. To answer these research questions, section 2 first presents the case of AF in Flanders, then it elaborates on the integrated analytical framework developed by

Lamprinopoulou et al. (2014), and it concludes with an overview of the data collection and analysis. Using the presented framework, section 3 describes and discusses the AF innovation system in Flanders. The results of this AIS analysis and its implications are subsequently summarized in section 4, to arrive at a conclusion in section 5.

4.2 Methodology

4.2.1 Study area

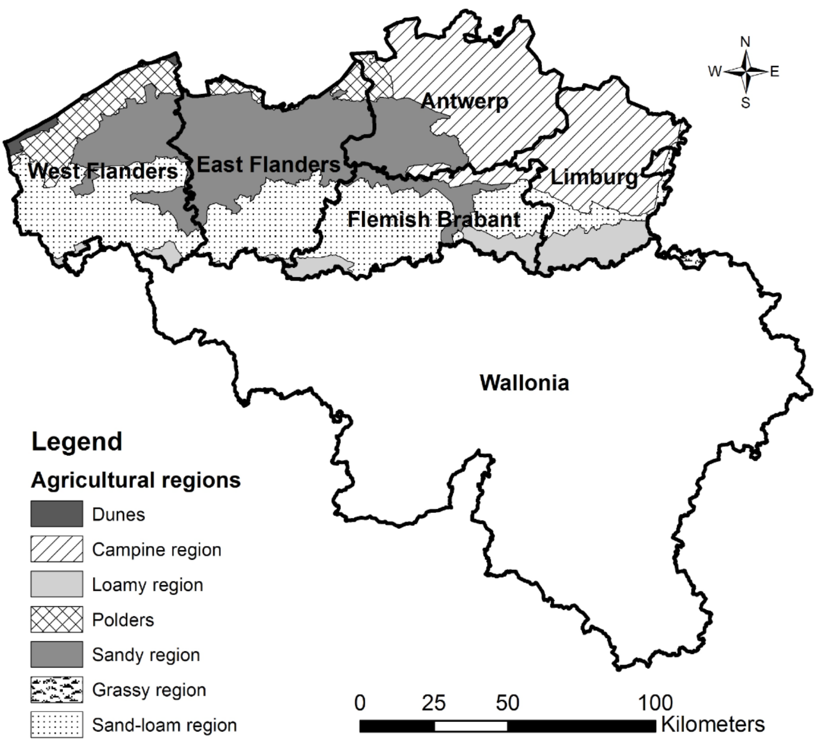

Figure 4 - 1: Provinces and agricultural regions in Flanders, the northern region of Belgium

The study area is Flanders, the northern region of Belgium (Figure 4 - 1), which is administratively divided into five provinces, whereas seven agricultural regions can be distinguished (Peeters, 2010). In Flanders, just like in other regions in Europe, a lot of traditional AF systems have existed in the past, such as hedgerows, rows of pollard willows or grazed orchards (Herzog, 1998). This changed from the 1950's onwards, when land consolidation processes took place in order to increase food supply. This resulted in the disappearance of many traditional hedges and bocage-elements separating different agricultural plots (Pauwels, 2014). The disappearance of these trees and hedges went hand-in-hand with scaling-up practices, which is reflected in the decreasing number of farm units (-30%) and increasing farm size (+42%) over the last 10 years (from 2005 until 2015). Currently half (45%) of the total land area in Flanders is under agricultural use, of which 56% is grassland or serves for the production of fodder crops, 35% is used for the production of arable crops (grains, potatoes and sugar beets), and the remaining 9% is used for horticulture (Platteau et al., 2016).

The status of AF in Flanders in 2015 is reported in Borremans et al. (2016). At that time only about 30 Flemish farmers were known to be consciously engaged in ‘agroforestry *sensu stricto*’, i.e. following the rather limited definition of AF as defined in the Flemish regulation (Departement Landbouw en Visserij, 2017). This thus excludes windbreaks, shelterbelts, dispersed trees in grassland and rows of trees at the border of agricultural fields, which are also considered as valuable farming systems in the context of this research. These systems comply with the AF definition as given by Herder et al. (2015) in the context of European AF research and are here interpreted as ‘agroforestry *sensu lato*’. However, the small number of 30 conscious AF adopters, on a total of 24.000 farm units and a population of 6.4 million in Flanders (Platteau et al., 2016) demonstrates that AF as a farming system in Flanders is still in its very pioneering stage. Focusing on these 30 pioneers, the study found that there are currently 55 plots of AF in Flanders, which have an average surface area of 2.3ha and incorporate on average 68 trees per ha. Among these AF adopters silvopastoral systems are most popular (51%), being reflected in the most popular crop types grass (34%) and grass clover (32%), whereas also some arable crops such as corn (14%) and winter cereals (13%) are planted between the trees. The most common tree species in AF fields area is walnut (present on 51% of the AF plots), followed by fruit trees (30%), oak (17%) and poplar (17%). Overall, the large variety in AF design, management regime and planted tree-crop combinations reveals that adopters’ ideas and motivations about AF vary strongly, although most of them got inspired by AF on the basis of multiple objectives.

4.2.2 Conceptual framework

The framework of Lamprinopoulou et al. (2014) consists of three analytical building blocks – a structural, functional and transformational analysis - for the holistic study of an AIS (Figure 4 - 2).

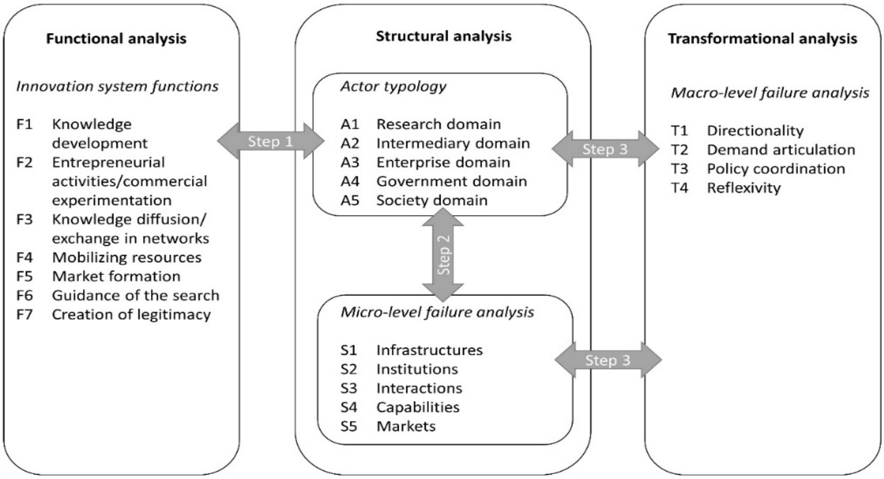

Figure 4 - 2: Integrated framework – conceptual level (adapted from Lamprinopoulou et al 2014)

The central block is a s*tructural analysis* (Step 2 in Figure 4 - 2) and serves to study the structural elements of which innovation systems are made of. This is done by making use of two complementary methodologies: (1) a typology of actors, focusing on their roles and how these roles are shaped by and related to other structures and (2) a micro-level failure analysis, in which failures in innovation systems are identified and classified. This micro-level failure analysis lists five categories: (1) infrastructural failures, referring to obstacles in "framework conditions", for which different dimensions (i.e. physical, knowledge and financial) exist; (2) institutional failures, related to the set of common habits, routines and shared concepts used by humans in repetitive situations (soft institutions) organized by rules, norms and strategies (hard institutions); (3) interaction failures, related to the relationships at the level of networks and individual contacts; (4) capabilities failures, which refer to the lack of appropriate competencies and resources at the actor level (Wieczorek and Hekkert, 2012); and (5) market imperfections, caused by the positions of and relations between market parties.

Second, the framework proposes to enrich the structural analysis with a *functional analysis* (Step 1 in Figure 4 - 2) as structures and functions are very interdependent. This functional analysis targets the dynamics of a number of key processes, related to the development, diffusion and use of new technology, which are important for the system to perform well (Bergek et al., 2008; Wieczorek and Hekkert, 2012). They are considered as "the collective and aggregated outcome of basic innovation activities that innovation actors are engaged in". The seven functions included in the framework and shown in Figure 4 - 2, are F1 – knowledge development (either through research or learning by doing), F2 – entrepreneurial activities/ commercial experimentation; F3 – knowledge diffusion/exchange in networks, F4 – mobilizing resources (e.g. funding, in-kind contributions, supply of human capital), F5 – market formation (i.e. commercialization of innovative products or services), F6 – guidance of the search (i.e. identifying problems, recognizing the potential for change, and showing the direction of search for new technologies, markets, partners) and F7 – creation of legitimacy (i.e. counteract resistance to change and legitimate technologies).

Third, the integrated structural-functional analysis was complemented with a *transformational analysis* (Step 3 in Figure 4 - 2) based on the work of Van Mierlo et al. (2010) and Weber and Rohracher (2012). The latter argue that more attention is needed for coordination, alignment and harmonization between structures and functions. Moreover, the focus of innovation systems should be equally on how the whole innovation system adapts to emerging challenges, and not only on parts of the innovation system (Lamprinopoulou et al., 2014). Four potential transformational failures for innovation systems were formulated, which are related to (1) directionality, which is about the level of shared vision regarding the goals and direction of the transformation process; (2) demand articulation, referring to the available space for anticipating and learning about user needs to enable the uptake of innovations; (3) policy coordination, indicating the level of multi-level policy coordination across different systemic levels and last (4) reflexivity, related to the ability of the system to monitor, anticipate and involve actors in self-governance. These transformational failures were added by Lamprinopoulou et al. (2014) to the failure framework as 'macro-failures', which represent the overall functioning of an innovation system and its capability to renew itself and support major transitions in agricultural systems.

4.2.3 Data collection and analysis

Data were collected in three ways, i.e. through interviews, focus groups, and document analysis. The insights delivered by the three data collection stages were combined in order to do the functional, structural and transformational analysis in a thorough way. In the interviews and focus groups, which took place from July to November 2015, in total 36 people took part, belonging to different stakeholder groups. Table 4 - 1 shows these stakeholder domains and also gives the different institutes, companies or organizations the respondents are affiliated with. Of these 36 respondents, 25 participated in one-to-one interviews, and 16 of them took part in the focus groups, in which different respondents were questioned at the same time. This means that, in order to get a total amount of 36 respondents, six respondents took part in both data collection stages. Overall, care has been taken to include as many believers in as opponents of agroecology; however, it is not always easy to connect with people that are not very familiar with AF as a farming system, and with the right people within organizations, i.e. the people proclaiming the main vision of that organization (e.g. managers) about the topic under study. In general, it was easier to find respondents relating to the research and education domain, intermediary domain and government domain, than those belonging to the enterprise and society domain. The unbalanced sample shown in Table 4 - 1 was partially compensated by the fact that respondents often fulfilled a second role (e.g. as a consumer) and by the fact that they provided as much information on other stakeholders' views and roles as on their own.

As preparation for the interviews, diagnostic questions were formulated about the occurrence, necessity and quality of functions and structures; and presence, necessity, efficiency and effectiveness of coordination mechanisms related to the development of AF systems in Flanders. These diagnostic questions were then pooled into an interview guide for 25 interviews. The semi-structured character of the interviews left ample space for the respondents to elaborate on their perceptions of AF development in Flanders and the role of different stakeholders therein, arguing and illustrating this with examples. Initially, a limited number of respondents were chosen on the basis of expert knowledge and participation in previous AF activities. New respondents were then selected through a snowball sampling technique, i.e. each respondent was asked which other actors are relevant stakeholders that block or enable AF development in Flanders, and this resulted in new contacts and new respondents. This continued until the 25th and last interview, which provided little new information.

The interview data were complemented with data resulting from two focus groups, which took place in November 2015 with 16 participants. The specific goal of the focus groups was to explore more in depth stakeholders' thoughts and opinions about relevant actors and AIS functioning, and uncover new information as respondents now had the possibility to react on and discuss with each other. Although not all stakeholder domains were represented, the focus groups brought people with different views and backgrounds together. To generate discussion a typical tool of stakeholder analysis was used, i.e. the interest-influence matrix (Bryson, 2004; Reed et al., 2009), a two-by-two matrix where the dimensions represent stakeholders' interests and influence. This interest-influence diagram was used in the two main parts of the focus groups, which were (1) a short individual exercise in which the participants had to position the different stakeholder groups on the diagram according to their interests/influence; and (2) a large group discussion in which one by one the different actors and stakeholder groups were discussed.

Table 4 - 1: Overview of the interview and focus groups participants, showing the stakeholder domains and actor groups they belong to, and the institutes, organizations and companies they are affiliated with.

Domain type	***No. respondents***		
Research and education domain			
Universities and educational institutes - Ugent (Department of Forest and Water Management, Department of Environment) (2x)	2	6	36
Research institutes - INBO (Research Institute for Nature and Forest) (2x)	2		
Extension centers - Agrobeheercentrum Ecokwadraat (2x)	2		
Intermediary domain			
Farmer organizations - Boerenbond, ABS, Bioforum, Vlaams Agrarisch Centrum (2x)	5	15	
Environmental organizations - Natuurpunt (largest nature organization in Flanders), Bosgroepen (regional information and advice points for forest owners) (2x), Hubertusvereniging (information and advice point for hunters), Bos+ (Flemish non-profit organization dedicated to forest conservation and sustainable forest management)	5		
Landscape organizations - Landelijk Vlaanderen (Association for land, forest and nature owners), Regionale Landschappen (organizations focused on sustainable regional development)	3		
Transition agriculture organizations - Wervel (Working group for rightful and responsable agriculture) (2x)	2		
Enterprise domain			
Suppliers - Silva (tree nursery), Syngenta (agrochemical and seed producer)	2	9	
Farmers - AF pioneers (3x), conventional farmer (1x)	4		
Buyers - Fedustria (Federation of the textile, woodworking and furniture industries), Decospan (wood veneer processor), Sappi Benelux (paper factory)	3		
Government domain			
Flemish government - Vlaamse Land Maatschappij (Flemish Land Agency), Agentschap voor Onroerend Erfgoed (Agency for Immovable Heritage), Agentschap voor Natuur en Bos (Agency for Nature and Forestry), Departement voor Landbouw en Visserij (Department for Agriculture and Fisheries) (2x)	5	5	
Local government	0		
Society domain			
Local residents	0	1	
Landowners - Hunter	1		
Consumers	0		

The last part of the data collection consisted of a document analysis. First, different relevant documents, including scientific papers, vision and mission statements, policy statements, white papers from influential organizations, documents describing agricultural infrastructure and activities and reports about relevant AF conferences and meetings, were searched for and retrieved. Some of these documents are partially or entirely dedicated to AF or agroecology, whereas others just touch upon it briefly, or even remain silent about the topic and are, precisely because of their silence, very informative about the prevailing visions on AF and DFS.

Data analysis occurred in two steps. First, the documents, together with the transcribed interviews and focus groups were processed and analyzed in Nvivo 11. Pieces of text were coded according to topic and/or stakeholder group, as such creating links and relations between both, and providing a first picture of the AF innovation system. Second, a more extensive analysis was performed based on the conceptual framework. This requests three analytical steps: the identification of (1) key actors of the innovation system, which are then related to functions that are necessary for system innovation; (2) structures, leading to system innovation failures and/or merits and (3) system innovation coordination, alignment and harmonization mechanisms. Tables 2, 3 and 4 give an overview of the identified functions, structures and coordination mechanisms, and give an estimation of the strength of their impact (from a very small/negative impact to a very large/positive impact, i.e. from –- to ++). Similar results over the three analyses led us to number the impacts and mechanisms as unique outcomes (last columns of Table 4 - 2, 3 and 4), allowing for a cross-comparison. Last, the identified outcomes were attributed to five clusters that represent different areas for improvement, on the basis of which lessons learned and potential improvement pathways for AF development in Flanders are formulated.

4.3 Results and discussion

4.3.1 Actors and their contributions to system functions

Different classifications of innovation agents exist, such as the one proposed by Arnold and Bell (2001) which is often used for the analysis of social-ecological systems. This classification includes four broad categories (domains): research domain, enterprise domain, intermediary domain and more distant actors influencing innovation (Lamprinopoulou et al., 2014). In this study the last group was split up in two separate domains, which were considered important by the respondents for AF development, i.e. the government and the society domain. Figure 4 - 3, adapted from Spielman and Birner (2008), visualizes the structure of the AF innovation system and displays the identified actor domains. The subgroups include examples of specific actors and organizations that were considered relevant for AF development by the respondents. They are allocated to one domain for clarity, nevertheless some subgroups play multiple roles (Hall et al., 2006) and thus partially belong to different domains. For each actor domain, their contribution to the innovation system functions are presented in Table 4 - 2 and discussed in the following paragraphs.

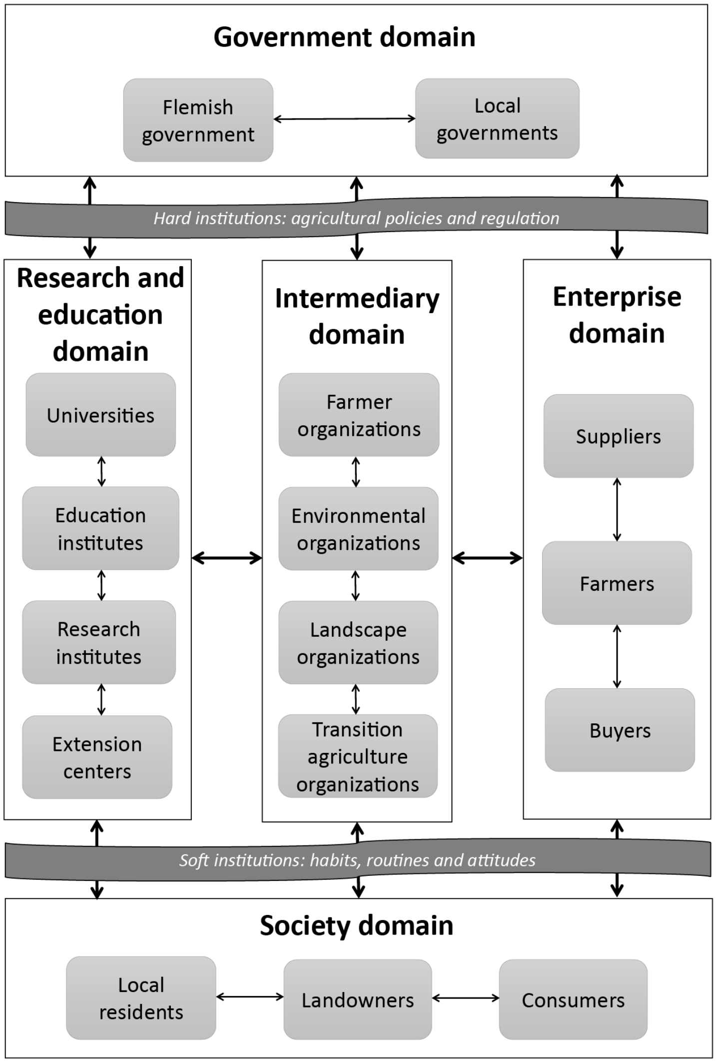

Figure 4 - 3: Structure of the AF innovation system in Flanders (adapted from Spielman and Birner 2008)

Table 4 - 2: Contribution of actor domains to innovation system functions and their impact based on stakeholder perceptions. The mechanisms are numbered as unique outcomes allowing for a cross-comparison of results.

Function		***Impact***	***Mechanism***	***Outcome***
Research and education domain				
F1	Knowledge development	+/-	Lack of local field data, but new research projects have to fill this gap	O1
		+/-	Slow but growing investment in agroecological research	O2
F3	Knowledge diffusion	+	Extension centers publish about AF and organize AF activities	O3
		-	Education system does not pay attention to agroecological practices	O4
F4	Mobilizing of resources	-	Some researchers integrate AF in their research activities, but most remain in their AF activities very distant from DFS	O5
F7	Creation of legitimacy			
Enterprise domain				
F2	Entrepreneurial activities/ commercial experimentation	-	Low farmer adoption rate	O6
F4	Mobilizing resources	-	Lack of demand for AF inputs and outputs holds back AF development	O7
F5	Market formation	-	No formation of niche markets or alternative value chains for AF inputs and outputs	O8
F3	Knowledge diffusion	-	Large agrochemical companies with a vast reach don't use their communication channels in favor of AF development	O9
F7	Creation of legitimacy			
Intermediary domain				
F3	Knowledge diffusion/ exchange in networks	+/-	Increasing awareness among intermediary actors, but activities to boost AF development remain sparse	O10
		+	The establishment of an AF network that unites researchers, policy makers, civil society actors and pioneers	O11
F4	Mobilizing of resources	+	Lobby of the AF network for AF resources and funding	O12
F7	Creation of legitimacy	+	Lobby of the AF network for an appropriate legal framework for AF	O12
F6	Guidance of the search	-	No engagement of farmer organizations to introduce AF to farmers	O13
		-	Advisory boards and industry associations are not involved in AF development	O14
Government domain				
F7	Creation of legitimacy	+/-	Improving legal framework, but some mismatches between the nature, forestry and spatial planning domain persist	O15
F4	Mobilizing resources	+/-	Slow but growing investment in agroecological research	O2
		+	Establishment of a subsidy program for AF systems	O16

F6	Guidance of the search	+	The subsidy program gives visibility to AF as innovative farming system	O16
		+/-	Discrepancy between policy support for agroecological vs. agro-industrial development	O17
F3	Knowledge diffusion/ exchange in networks	-	Local authorities are not familiar with AF	O18
Society domain				
F5	Market formation	-	Little consumer demand for agroecological products	O19
F7	Creation of legitimacy	+	Local residents are generally in favor of a more varied agricultural landscape	O20
		+/-	Reactions of neighbors and colleagues influence farmers' decisions	O21
		-	Landowners need to give permission to farmers to start with AF on leased land	O22

Research and education domain

The research and education domain consists of the different universities, research institutes, educational institutes, and extension services and has as main function *F1 – knowledge development*. Respondents assigned a very important role to this domain, because they perceived the lack of field data about the productivity of AF in Flanders one of the main barriers to adoption. To address this demand for more local data, several master theses concerning AF were conducted from 2010 onwards, culminating in the funding of a 5-year research project about AF in Flanders, which was initiated in September 2014. Besides the organizations involved in this project, respondents consider also all other research and investigation institutions targeting agroecology, ecosystem services, alternative food value chains, etc. as relevant actors of the research and education domain, because they can positively influence AF development in the long term.

A second main function in which the research and education domain is involved, is *F3 – knowledge diffusion*. Several respondents acknowledged the recent efforts of the extension centers to publish about AF in local agricultural journals and organize local AF events, including excursions, information days and trainings. But maybe even more important regarding knowledge diffusion is the role of secondary education and universities to familiarize potential future farmers and agricultural consultants with the concepts of agroecology, which happens according to the respondents at the moment far too little.

A selected group of researchers don't limit themselves to *F1 – knowledge development* and *F2 – knowledge diffusion*, but also engage themselves in some important functions of the intermediary domain, e.g. *F4 – mobilizing of resources* and *F7 – creation of legitimacy*, as such becoming part of a larger community and/or network that is actively advocating for the transition to DFS (see 3.1.3). Nevertheless, the bulk of the agricultural researchers keep a distance from AF and agroecology in their professional activities, and would never consider to integrate trees in field trials or consciously look into the effect of trees on the studied subject. This has amongst others to do with research funding, which is (1) increasingly coming from the private sector, having its own agenda (IPES-Food, 2016); and (2) distributed through research projects with a limited duration, which puts AF as a farming system, that has to be evaluated at the long term, at a disadvantage. As a consequence investment in AF and agroecology research, although increasing in the past few years under influence of the reorientation of the CAP towards the principles of rural development and multifunctionality (Daniel and Perraud, 2009), is still limited. As such, Baret et al. (2015) found that funding available for research into organic farming, which does not coincide completely with agroecology but is easier to delineate, remains at about 2% of the total investment into agricultural research in Flanders.

Enterprise domain

The enterprise domain includes the different value chain actors, which are the farmers, the suppliers of inputs and the buyers of outputs. These actors are very much responsible for the implementation of *F2 – entrepreneurial activities*, but little progress has been made within this area. As such, although every year some new farmers start with AF, the AF adoption rate remains small with currently only around 30 farmers known to be consciously engaged in AF *sensu strictu* (Borremans et al., 2016). This does not imply that AF is a farming system for which every one of the 24.000 farmers should strive, however, the potential surface area of AF in Flanders is certainly much larger than its current implementation. Moreover, a survey showed that only half of the farmers is familiar with AF and that the intention to engage in AF is very low.

Another important function in which the enterprise domain should be engaged is *F5 – market formation*, which is possible through the formation of niche markets (Negro et al., 2007) and implies *F4 – mobilizing resources*. Although the products produced in AF systems are often not new (e.g. fruit, nuts, etc.), the formation of niche markets is an important step because of the stringent product quality standards (e.g. product form and size) and the price competition in the regular markets. Besides the AF farm pioneers though, hardly any other enterprise actors engage themselves in AF activities. Potential buyers of AF products are not familiar with the concept, due to the lack of communication within this sector about AF practices. They are also held back by the lack of demand from consumers for sustainably produced products, often implying higher prices to cover production costs. Last, the long rotation cycle of trees impedes the farmers to capitalize on the immediate demands of the markets. In other words, the long-term horizon of AF is not very compatible with the rather short-term thinking of potential buyers.

But even more than buyers, suppliers of AF inputs could have a more immediate influence on the uptake of AF by farmers, and this by *F3 – knowledge diffusion* and *F7 – creation of legitimacy.* This applies especially to the larger breeding, agrochemical, pharmaceutical and equipment companies with a vast reach. They could give AF a boost by offering crop protection products, tree and crop species or agricultural equipment adapted for use in AF systems and by communicating about and suggesting AF systems as good agricultural systems. However, currently the number of AF adopters remains limited, which makes expenses and investments in this direction for these companies – having often an important profit perspective – difficult to support.

Intermediary domain

The intermediary domain contains a variety of organizations such as NGO's, cooperatives and industry associations, which are in one or another way influential to agricultural innovation in Flanders. These groups and organizations are very diverse and include (1) farmer organizations, (2) environmental organizations engaged in the conservation of biodiversity and the protection of the environment; (3) landscape organizations focusing on the preservation of historical landscapes and rural recreation; and (4) transition organizations lobbying for transition to a more sustainable agriculture.

The intermediary domain has an important role in *F3 – knowledge diffusion/exchange in networks*. In Flanders, the intermediary groups that set up projects specifically centered around AF, and communicate actively about AF are still rare. And if they do so, they often tend to draw special attention to potential AF outcomes that negatively affect matters they are concerned with. For example, environmental organizations mentioned the potential negative effect of trees on the population of birds nesting in open fields, while landscape organizations warn that planting more trees may not always reflect the historical character of a certain region. Nevertheless, recently a majority of the intermediary actors link AF systems with a multitude of productive, ecological and social ecosystem services, and start regarding AF systems as a potential tool to reach their own long-term goals.

Some of these advocates of AF have formed an informal AF network together with some interested researchers, policy makers and AF pioneers. This resulted in a useful communication and innovation platform focused on the development of AF in Flanders, which is very much engaged in *F3 – knowledge diffusion*. This AF network can be considered part of a larger movement favoring the transition towards DFS and agroecology, that is consolidating in Belgium just like in other countries and regions in Europe. A selected group of researchers and civil society actors adhering to this movement put a lot of effort into organizing study days, or speaking about DFS at national and regional agricultural fora (e.g. Agroecology in Action, the largest forum about agroecology in Belgium), where the target audience are not just farmers, but also policy makers, and fellow scientists and civil servants. These advocates are likewise very much involved in writing vision texts in favor of DFS, or arguing against the limited role that is given to DFS by agroecology critics (e.g. Keulemans et al 2015). In these ways they aim to influence the research agenda and the budget allocated to the development of DFS, as such contributing to functions *F7 – creation of legitimacy* and *F4 – mobilizing of resources.* Also the AF network recognizes the importance of these functions and tries to engage policy makers and other influential stakeholders in AF development. Up-to-date, the efforts of the AF network in this area did not remain without results: frequent lobbying activities of the intermediary domain led to the funding of the large research project, the establishment of the subsidy program for AF systems and to a more appropriate legal landscape for AF implementation.

A last task of intermediary domains is providing services, which implies giving direction and personal feedback with respect to questions, as such corresponding to *F6 – guidance of the search*. The intermediary groups which have a major impact on the diffusion of AF through services are the farmer organizations, and this because of their frequent contacts with farmers and high credibility among the farmer community. However, in Flanders the large farmer organizations adopt a wait-and-see approach: although they do not reject AF as a farming system with future potential, they will not actively introduce it to farmers as long as there is not more clarity about the productivity and the financial consequences of the farming system in the long term. Besides farmer organizations also advisory boards (e.g. the SALV, the strategic advisory board for agriculture and fishery, which advises the Flemish parliament and government) and other industry associations (e.g. Fedustria, an association and lobby group representing the textile, wood and furniture industry) should put more emphasis on communication, each within their own field. In this way, messages from different origins can reinforce each other to create a better and more effective *F6 – guidance of the search*.

Government domain

The Flemish government, which is considered as most influential within the government domain, is taking important and concrete steps to make AF more attractive for farmers. First, they are working on a better and appropriate legislative landscape for AF systems, which correspond with *F7 – creation of legitimacy*. As such some of the conflicting regulations within the nature, forestry, agricultural and spatial planning domain, previously applying to AF, have been solved over the last years. Second, the Flemish government created incentives for farmers to start with AF through both pillars of the Common Agricultural Policy: in the first pillar AF systems were added to the list of systems which are eligible as Ecological Focus Area, whereas under the second pillar a subsidy program for AF implementation was established. These incentives make AF implementation from a financial point of view more attractive, and make AF more visible as an innovative farming system, corresponding respectively with *F4 – mobilizing of resources* and *F6 – guidance of the search*. This is also due to the European government, which is steering the Flemish government largely with respect to AF regulation and funding.

However, if we look at the broader picture, some inconsistencies regarding the direction of *F6 – guidance of the search* can be observed. On the one hand the latest agricultural policy letters increasingly focus on the link between multifunctionality and local rural development, and recognize the value of alternative agricultural models. They underline the importance of the strengthening of the organic sector, and the development of niche markets and shorter supply chains. This is a development direction on which AF can capitalize, since its added value remains small if trees are just considered an extra production component, and its products are sold through the regular market channels. On the other hand, the policy letters express a strong support for agri-industrial development, e.g. through a strengthening of the export markets for agricultural products or the continuing investment into biotechnology (e.g. quality of reproduction material) and product innovation. These discrepancies uncover that, although some recognition for DFS and agroecology in the agricultural sector has occurred recently, the Flemish government has not yet made a real shift in their *F6 – guidance of the search* from a sectoral approach to agriculture, based on productivity and efficiency, to a more local and territorial approach based on the implementation of DFS.

Besides the Flemish government, also local authorities such as provinces and municipalities are important stakeholders, which are mainly engaged in the same functions as the Flemish government, but then at the local level. As such local authorities play an important role in *F7 – creation of legitimacy,* since they are responsible for the issuing of felling permits for trees in agricultural landscapes. In addition, provinces and municipalities could have according to the respondents an important catalyzing role. Because of their links and ties with local farmers, they have the power to engage farmers to participate in local or regional projects about trees and hedgerows, whereas they also can easily pass on practical questions and problems of farmers to higher levels within the government domain. In this way, local authorities could form the bridge between the Flemish government and the enterprise domain, thus corresponding with *F3 – knowledge diffusion/exchange in networks.* At the moment though examples of how local authorities can act as catalyzer for the scaling-out of AF systems are hard to find.

Society domain

Before all, the society domain refers to all individuals in society, which collectively have an important influence through their role as consumers. This influence on the development of AF systems cannot be overlooked: evidence from organic farming in Flanders suggests that the uptake of a market-based approach within the organic sector, which is based on sufficient demand, especially has the potential to bridge the agro-industrial and organic sectors and constitutes an important factor in the out-scaling of organic farming (De Cock et al., 2016). It is thus clear that consumers’ role in *F5 – market formation* cannot be underestimated. However, since even a substantial part of the farmers never heard of AF systems before, it is little surprising that AF, and also agroecology in general are still unfamiliar concepts for the majority of the Flemish consumers.

Furthermore two specific groups within the society domain, local residents and private landowners, potentially fulfill an extra role. Whereas local residents are according to the respondents generally in favor of a more varied landscape with more trees and hedgerows, this may not apply for residents having an unobstructed view on agricultural land that may be threatened when turned into an AF plot. A farmer receiving complaints on that, would severely reconsider future AF systems on his land. The second group concerns private landowners, which rent their land out to farmers, making up 66% of the total farmland in Flanders. The tenancy law prescribes that landowners need to give permission to farmers to start with AF on their land, and as a result landowners have a lot of power on the decision-making of farmers with respect to AF. Moreover, the current legal uncertainties with respect to harvesting permits and ownership are as much a barrier for farmers as for landowners. Nevertheless, if farmers get positive feedback from locals about trees they planted, and receive permission of their landowner to start with AF, it may result in positive feedback loops resulting in *F7 – creation of legitimacy.*

4.3.2 Systemic structural failures and merits

The systemic structural failures and merits and their effect on the AF innovation system are presented in Table 4 - 3, and further explained in the following paragraphs.

Table 4 - 3: Systemic structural failures and merits, and their impact on the AF innovation system. The mechanisms are numbered as unique outcomes allowing for a cross-comparison of results.

	Type		*Impact*	*Mechanism*	*Outcome*
S1	**Infrastructure**				
		Physical	-	High pressure on land, beneficial climate and fertile soil do not favor AF systems	O23
			-	Modern farming machinery is not compatible with trees on the field	O24
		Knowledge	+/-	Lack of local field data on AF, but increasing attention for AF in new research projects	O1
			+	An efficient pooling and dissemination of knowledge through online knowledge cloud	O25
			+	Extension officers offer free advice to pioneers regarding AF design and management	O26
			-	No establishment of long-term experimental AF plots in Flanders	O27
		Financial	-	No private investment in AF research because of the low potential of AF to generate profits	O28
			+	Small but growing public investment in agroecological research	O2
			+	Subsidy program for the establishment of AF plots	O16
S2	**Institutions**				
		Hard	+/-	Improving, but still insufficient legislative framework	O15
			-	Permission of landowner for planting of trees on leased land is needed, but difficult to get	O22
		Soft	-	Farmers have a negative image of AF	O29
			-	Farmers fear the critical attitude of peers	O21
S3	**Interactions**				
		Strong network	+	AF network unites researchers, government and civil society actors, and pioneers around AF	O11
			-	Strong bonds between farmers and farmer organizations cause tunnel vision	O13
			-	Strong bonds between farmers and suppliers cause tunnel visions	O9
		Weak network	-	Farmers lack confidence in government actors	O30
S4	**Capabilities**		-	AF is perceived as being more complex and entailing more labor	O31
			-	Farmers have no or too small financial buffers to experiment with trees	O32
S5	**Markets**		-	The long rotation time of trees increases the uncertainty and financial risk for farmers	O33
			-	Externalizations of benefits in agricultural markets puts AF at a disadvantage	O34
			-	Lack of demand for AF inputs and outputs holds back private investments	O7
			-	The low potential of AF to generate profits for the input suppliers holds back private investments	O28

Infrastructure

Regarding physical infrastructure, many respondents, especially farmers, consider AF a poorly suited farming system for Flanders. This has to do with (1) the high pressure on the land in Flanders, (2) the issue of shade creation by the tree canopy, which has according to the respondents a more negative impact on productivity in Flanders than in more southern regions and (3) the small average size of agricultural fields in Flanders, which are not always apt to wide-spaced alley cropping systems, with which farmers often associate modern AF. Looking at existing technologies, some respondents mentioned the positive influence of some new technologies, such as Global Positioning Systems (GPS), on the complexity and efficiency of AF systems. Nevertheless, for a majority of the respondents, the existing technologies, biophysical infrastructure and production systems act together as a serious drawback for the implementation of AF, referring to modern machines which are not very compatible with trees on the fields.

The local knowledge infrastructure benefits largely from the current research projects, focusing on the performance and ecological benefits of agroecological systems in Flanders. Furthermore, whereas the existing theoretical and practical expertise used to be dispersed among different actors of the innovation system, there is now a more efficient pooling and dissemination of AF information through an online knowledge cloud. To further increase the efficient uptake of this knowledge, different extension officers offer as part of the research project free advice to AF pioneers with respect to design and management of AF plots. However, AF systems cover a diversity of tree-crop-soil combinations, and imply long rotation times, all adding to the uncertainty that is inextricably linked to the practice of AF. To achieve a better understanding of the expected productivities in AF systems, the establishment of long-term experimental plots is necessary (Lovell et al., 2017). In that regard Flanders is lagging behind with respect to frontrunner France, that established in 1995 an experimental AF site 'Restinclieres' of about 45ha (Dupraz, 1998).

The funding infrastructure consists to date almost exclusively of public funding. Private funding for AF development is lacking because the private sector does not see how AF investments can create profits. As such, innovations in AF can hardly be patented since their benefits only come in the long-term and are to a large extent of a public nature (Vanloqueren and Baret, 2009). This is confirmed by Levidow (2015) who states that agroecology has been generally locked out from the research agendas of the private sector. However, public and private research funding are not mere substitutes, but strategically complementary (Muscio et al., 2013). As such a lot of successful and innovative agricultural research and development originates in private companies, or is a product of public-private partnerships. The absence of private investment may thus severely slow down AF development and the implementation of more and better DFS.

Of the public funding that is available a large chunk goes to research and innovation projects, which target AF development in a direct or indirect way. The rest of the funding is directed to the AF pioneers in the form of a subsidy program. This subsidy program was first set up in 2011 and is partially funded by the EU as part of the second pillar of the CAP. It includes since 2014 a payment of 80% of the establishment costs of new AF plots, but imposes also a lot of requirements with respect of plot size, the tree species, the tree density, the distribution of the trees on the plot, and minimum amount of years the trees have to be maintained. Some AF pioneers state that these requirements are too rigid and, taking into account that they also entail controls and extensive administration efforts, impede farmers to implement AF according to their own visions. Furthermore respondents criticize the format of the subsidy program, which is only directed toward the installment costs, while neglecting costs for maintenance or yield losses, which makes farmers often more reluctant to adopt than the initial installment costs.

Institutions

Lack of an appropriate legislative framework and legal uncertainties were perceived by the respondents as major obstacles currently impeding wider AF adoption. However, considerable efforts were already deployed by the Flemish government to remove the legal problems. As such, before, AF systems were subject to the Forestry, Landscape and Nature decree, and also the Tenancy law and the Heritage and Spatial planning policy domains had their own regulations with respect to trees in the agricultural landscape. Meanwhile the majority of these stumbling blocks have been removed by the exclusion of AF systems from the Forestry decree, the Rural code (Veldwetboek, rules neighborhood issues in rural areas) and the Codex spatial planning (Codex Ruimtelijke Ordening). Regulation though is still complicated and little transparent, resulting in a continuing uncertainty among AF pioneers about the possibility to harvest their trees without getting a replanting or financial compensation obligation. Furthermore it is criticized that the exemptions for AF systems are only valid for AF plots that were planted with the help of the subsidy program. Last, hard institutional barriers include the fact that permission of landowners for farmers to start with AF is necessary, which remains institutionalized in the Tenancy law.

However soft institutions may impede AF implementation more than pure legislative drawbacks. Indeed, at the moment Flemish farmers don’t feel any obligation or pressure to start with AF or to plant trees, neither by themselves, nor by the farmer community, nor by other important groups (Borremans et al., 2016). The fact that many trees disappeared from the agricultural landscape under influence of amongst others agricultural scaling and intensification, makes that many farmers experience farming systems with trees as something from the past. This is confirmed by Sereke et al. (2015) who found that Swiss farmers don't adopt AF because they fear for their reputation. In this context, Louah et al. (2017) found differences in opinions about AF in Wallonia, i.e. the southern region of Belgium, to be related to the level of ecological knowledge. Louah et al. interpret this as an cognitive lock-in, that may even underlie political, institutional and technological barriers. On the other hand, respondents agree that AF pioneers who successfully implement AF and are able to present it to their peers with vision, play a crucial role in the scaling-out of this farming system.

Interaction

The AF network is a useful communication platform that has led to stronger links and ties between interested policy makers, researchers, civil society groups and AF pioneers. However, to optimize the functioning of this network, all relevant groups from the AIS domain should be represented and actively involved, which is not the case. The private sector for example is largely lacking, resulting from the disinterest in practices that will be only economically relevant for them in the far future. Also farmer organizations and agricultural advisers are largely absent in this network, whereas they are perceived to have the largest influence on farmers with respect to strategic and tactical on-farm decision making. As long as these actors are not actively engaged in the AF network and don't use their communication channels to report to farmers about the practice of AF, a lot of farmers will remain blind for the concept. This explains partially why the 'average' farmer is a notable absentee in the network, this in contrast to AF pioneers who have in general very good contacts with researchers and extension services, and participate actively in AF-related activities. This is an example of a strong network failure, e.g. farmers are locked into their relationship with farmer organizations, agricultural advisors, and input suppliers and output buyers, which are causing tunnel vision and are blocking new information from entering (Hermans et al., 2015).

A second type of failure is the weak link and the lack of confidence between the Flemish government and the farmers. This weak network failure is also called by Hermans et al. (Hermans et al., 2015) 'a vertical network fragmentation', being the expression of a lack of hierarchical communication and coordination from the government towards other domains. As such, in the case of AF, many consulted farmers have experienced that investing in greening with support of the government, results in more control, supervision and administration, and entails obligations or targets which they didn't have to fulfill before. On top of that, the lack of confidence is enlarged by the fact that trees entail a large rotation time, during which regulations concerning trees on agricultural land can change entirely. Without doubt, these considerations have deterred some farmers to further invest in greening with support of the government.

Capabilities

According to the respondents current capabilities of farmers to practice AF fall short, referring to the fact that young farmers are unfamiliar with the management of trees. Together with the disappearance of trees from the agricultural land plots this tacit farmer knowledge extinguished in Flanders. This is related to the limited attention that is given to agroecology and its related competences in agricultural education, that stipulates stringent structures with respect to teaching material. To implement AF, farmers thus have to acquire extra skills and invest in training for which no or little time and funding are available. In addition, farmers perceive AF as not compatible with modern mechanized agriculture, and leading to more labor and complexity. This is not only a result of the increased attention and care that is necessary for cultivating crops without damaging the trees, but also of the extra work that tree management implies.

A second capabilities failure is related to the lack of resources. Also in Flanders farmers often find themselves locked into their present trajectory, which lead to the inability to open up new opportunities. The specialization tendency in Flemish agriculture is the main culprit for that, which makes that the majority of the farmers are busy paying off large loans. As a result farmers have in general no or only small financial buffers available, which they will certainly not deploy to experiment with a farming system such as AF.

Market structure

The limited involvement and interests of the enterprise domain in AF development as discussed before, is related to some properties of AF causing market structure failures. The long rotation time of trees in an AF system is a first example of such a property, because it increases the uncertainty and financial risk for farmers. This is a type of information failure, since nobody is able to predict how the prices of AF products such as wood will evolve over the next 30 or 40 years. On top of that, the long rotation time of trees is in clear contrast to the short-time horizon on which farmers have to pays bills and expect financial returns, which adds to the disadvantages of AF for farmers and other enterprise actors. Another important market structure failure is the externalization of costs, or better, the externalization of benefits. As such many respondents consider the ecosystem services that are delivered by AF systems of an ecological or social nature, e.g. increased biodiversity, climate change mitigation and increased landscape amenities, equally important as the productive services in the form of wood, fruits of nuts. In contrast to the latter though, no one will pay the farmer to produce these. Thus, although the combined benefits that AF systems deliver may far exceed those of conventional farming systems, a pure comparison of the financial returns as done by farmers puts AF systems at a disadvantage.

Also the low potential of DFS to generate profit for the large agribusinesses holds back AF development. On the one hand this is due to the hitherto sparse application of AF, making the demand for AF-compatible inputs negligible. This is especially true for the agribusinesses which concentrate the market at the supply side, which are mainly focused on the production of seeds, chemical fertilizers, pesticides and machines. However, beyond the lack of direct demand, one can also wonder about the intention of the dominant agribusinesses to support the agroecological model, whose breakthrough may decline their own revenues. In the end, the agroecological model assumes the application of fewer external inputs, which are locally grown or self-produced. Moreover the agroecological model is built on the concept of resilience, which implies the application of a wide range of locally-adapted crop varieties, instead of the application of standard varieties of the major cereal crops as produced in bulk by the dominant agribusinesses. Besides the agribusiness companies dominating the market at the supply side, also the global trade and processing industry is a potential source of resistance to change, given that alternative models tend to favor local production and short value chains that reduce the number of intermediaries (IPES-Food, 2016; Vanloqueren and Baret, 2009).

4.3.3 Systemic transformational failures and merits

The different transformational failures and merits that were identified are listed in Table 4 - 4 and explained more in detail in the rest of this section.

Directionality

At this moment few relevant actors believe in AF as a farming system with future potential. While many of the actors agree that farming in Flanders – plunging the past few years from one crisis into another – is at a crossroads, different opinions exist on what are the underlying problems and subsequently on what course to take. Different authors illustrate this by introducing two opposing worldviews or narratives, which they subsequently call productivity vs. sufficiency (Freibauer et al., 2011), efficiency/substitution-based vs. biodiversity-based agriculture (Duru et al., 2015) or weak vs. strong ecological modernization (Horlings and Marsden, 2011). Although the different combinations have their own accents and specificities, in general they tell the same story: the former narrative is focusing more on enhanced productivity and input-output efficiency, the latter more on a greater farm diversity and structural change within food systems and supply chains. As long as important actors in the AF innovation system – with the farmer organizations as frontrunners – doubt about the credibility of the second narrative, wherein diversified farming systems are assigned a central role, they will not actively engage themselves in creating systemic change, and promote DFS. The same is true for agricultural corporations, which are seeking power and financial gain, and might lose if agroecology would be implemented on a larger scale. This systemic change though is very much necessary, since the value of AF remains limited if it just implies – as in the minds of a majority of the farming population - adding trees to a conventional farming system. In other words, to create a maximum of benefits and value out of AF, a complete and holistic re-thinking of the farming system based on agroecological principles is necessary. Only then the true potential of AF is disclosed, and can AF be considered competitive with conventional farming systems. This conservative definition of AF that is often adopted, further adds to the lack of shared vision among the different actors regarding the goal and direction of the transformation process in agriculture.

Table 4 - 4: Systemic transformational failures and merits, and their impact on the functioning on the AF innovation system. The mechanisms are numbered as unique outcomes allowing for a cross-comparison of results.

	Type	*Impact*	*Mechanism*	*Outcome*
T1	**Directionality**	-	Adherence to different discursive spheres causes a lack of shared vision and inhibits a continuous dialogue	O17
		-	The conservative definition of AF that is often assumed does not disclose the true potential of AF	O35
T2	**Demand articulation**	+	Research and education domain places emphasis on the needs of AF pioneers	O36
		-	Strong bonds between farmers and farmer organizations cause tunnel vision	O13
		-	Lack of orienting and stimulating signals of enterprise towards society domain	O37
T3	**Policy coordination**	+/-	Part of the mismatches between legislation of nature, forestry and spatial planning policy domains persist	O15
		+	Europe is steering local AF development through regulation and funding	O38
		-	Corrections and adjustments to European regulation is a cumbersome process	O39
		-	No subsidy for maintenance of AF-plots in Flanders	O40
T4	**Reflexivity**	+/-	Not all relevant actors are involved in the Flemish AF network	O11
		-	A thorough evaluation of the effect of the subsidy program and the research project is necessary	O41

Demand articulation

Within the research projects targeting AF and agroecology, increasingly space is created for anticipating and learning about the needs of different stakeholders. Moreover, special emphasis is placed on the needs of the users of the technology, i.e. the farmers. In fact, several researchers and extension officers offer individual advice to AF pioneers, on the one hand to share their expertise on AF, but an equally important goal is to learn what issues are important for farmers. In this way contacts with the AF pioneers guide further AF research. However, the developments in the broader agricultural innovation system in Flanders and the rest of the world, continues to be strongly steered by the research agendas of agribusinesses (IPES-Food, 2016; Jacobsen et al., 2013). Another dimension of demand articulation is the level of orienting and stimulating signals from public demand, which gets less attention. Whereas it is normal in this development stage that a majority of the consumers never heard of AF, also a majority of the buyers, i.e. intermediaries such as processors of AF products or supermarkets, are unfamiliar with its' concept. Nevertheless, these intermediaries can exert large influence on public demand through orienting and stimulating signals, and thus cannot be disregarded.

Policy coordination

Multiple policy coordination failures exist within the AF innovation system, as well in the horizontal as in the vertical direction. Different examples of horizontal policy coordination failures, i.e. mismatches between the legislation of different policy sectors such as agriculture, nature, forestry, and spatial planning are given in section 4.3.2. The vertical policy coordination failures refer to misalignments between regional, national and European policy. Although respondents consider the influence of the European government very much as steering local AF development, some drawbacks exist. An example is the fact that decisions regarding changes and adjustments to regulation and the subsidy program cannot be taken individually as a region, but only collectively at the level of Europe. This makes decision-making about prevailing policy inconsistencies slow. An example of a prevailing inconsistency is the fact that the maximum density of trees that can be planted under the AF subsidy program under the second pillar of the CAP is 200 trees/ha (in Flanders, maximum density is determined by the member states themselves) (EU, 2013) whereas only 100 trees/ha (and 200 trees/ha in the case of fruit-bearing trees) are allowed to be planted on agricultural fields according to the first pillar of the CAP, at least without losing a part of the basic payments (EU, 2014). With regard to these contradictory policy measures, different regions already raised the issue that 100 or 200 trees is a more than sufficient density at the end of the rotation, but in order to avoid heavy side branches and safeguard sufficient well shaped trees, ideally more than 100 or 200 trees should be planted at the beginning of the rotation (Ruiz and Lawson, 2015). Both problems are meanwhile known at the level of Europe, but adjusting the policy measures accordingly is a cumbersome process.

Another example of vertical misalignment regarding policy regulation is the fact that the Flemish AF subsidy program does not include an annual allowance for maintenance, whereas (1) the European government included the possibility to give annual allowance for maintenance up to five years after planting (EU, 2013), and (2) many respondents found the absence of a maintenance allowance a drawback of the subsidy program. The latter argue that initial investment costs are small in comparison to the time and effort that the farmer will have to spend on maintenance of the trees. Policy makers on the other hand argue that the limited amount of subsidy applications does not justify the introduction of an annual allowance, at least from a financial point of view, since it would imply annual controls and extra administration efforts. In this way AF pioneers miss out on a maintenance subsidy and thus fall victim once more to the fact that AF in Flanders is still very much in a pioneering stage.

Reflexivity

Whereas the AF network is regarded as an innovative think tank and an interesting platform for interaction, and the research project as a space for experimentation, monitoring and learning, still not all relevant actors of the AIS are involved in these communication platforms or aware of its existence, especially the actors from the enterprise domain. Without strengthening the ties with the enterprise actors, it is impossible to engage these groups in processes of reflection and self-governance. In the context of research and policy making, reflexivity also refers to 'learning from past experiences' (Lamprinopoulou et al., 2014). As such, respondents stress the need to evaluate the contribution of the subsidy program and the AF project to AF development. Based on these evaluations, policy makers should adjust and improve the subsidy program, while researchers should develop improved research projects, which can follow up the current AF project.

4.3.4 Improvement pathways

When comparing the outcomes of the functional, structural and transformational analysis, summarized respectively in Table 4 - 2, Table 4 - 3 and Table 4 - 4, a lot of overlap and coherence can be observed. When filtering out similar results of the three analyses, 41 different outcomes can be distinguished. These 41 outcomes collectively describe the actual state of the AF innovation system in Flanders. The overlap and interconnectedness of results of these three analyses is not accidental: we have learned during this study that functions, structures and transformations are very interdependent, and that an alteration of a structure is only possible if certain functions are strengthened and if enough transformational power is available. Figure 4 - 4, that gives an graphic overview of the functioning of the AF innovation systems, illustrates this interconnectedness: actors strengthen system functions (step 1), in order to alter structures (step 2) and steer transformations (step 3).

To define potential improvement pathways, the outcomes were clustered into 5 areas of improvement for AF development in Flanders (Table 4 - 5). For each of these areas, potential improvement pathways are suggested based on the findings of the AIS analysis. These pathways deliver insights into which steps to take to further improve AF adoption. However, further participatory research is required to add new and inventive development pathways, to create support, to substantiate and fine-tune them and to set priorities and assign roles. Nevertheless, previous research shows that also in other (temperate) regions the same challenges and barriers exist, and that similar improvement pathways are put forward (column 6 of Table 4 - 5.

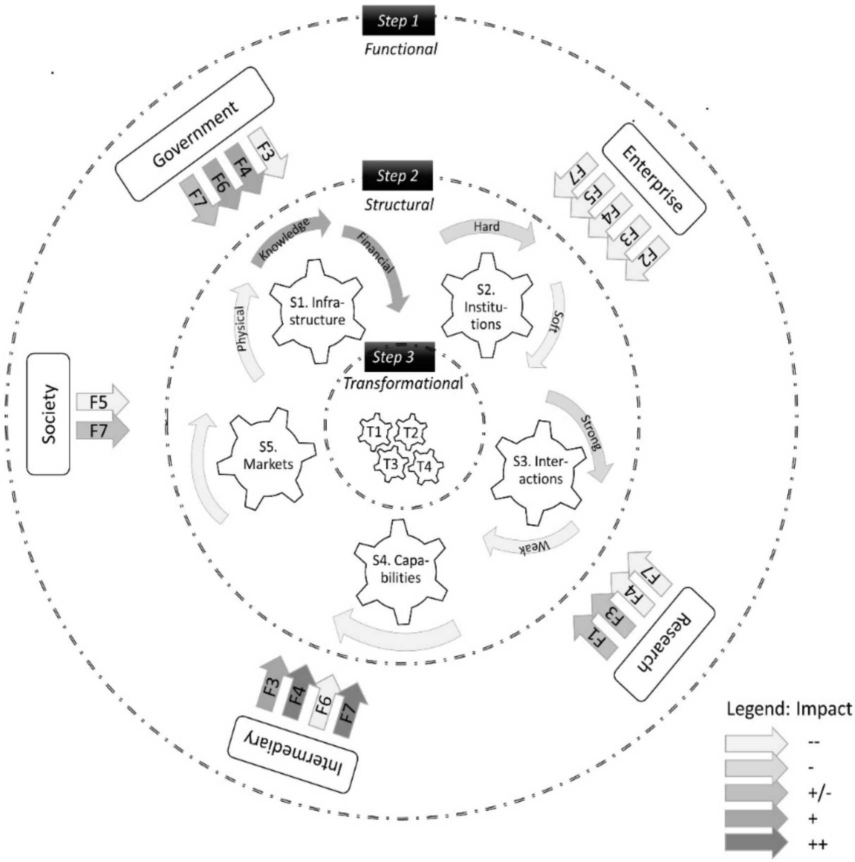

Figure 4 - 4: The functioning of the AF innovation system, where actors can strengthen system functions (Step 1: functional analysis) in order to alter structures (Step 2: structural analysis) and steer transformations (Step 3: transformational analysis)

Table 4 - 5: Clusters bundle outcomes of the functional, structural and transformational analysis according to five different themes, for which lessons learned and potential improvement pathways are formulated.

Clusters	***Outcome***	***Functions, structures and transformations to strengthen***	***Lessons learned***	***Potential improvement pathways***	***References***
C1: Science – Technological	O1 O2 O5 O23 O24 O26 O27 O31 O36	Functions • F1 • F2 • F4 • F7 Structures • S1 • S4 Transformations • T2	Further investment in research is necessary, especially targeting the productivity and compatibility of AF systems, and this in active collaboration with farmers	• Fund new participative and transdisciplinary research projects that incorporate AF and agroecological principles • Develop and distribute machines that are tailor-made for AF systems • Develop applications for AF planning, design and management	• Warner 2006 • Duru et al 2015b • Ellis et al 2005 • DeLonge et al 2016 • Haggar et al 2002 • Larcher and Baudry 2013
C2: Market – Financial	O6 O7 O8 O19 O28 O32 O33 O34 O37	Functions • F2 • F4 • F5 Structures • S1 • S4 • S5 Transformations • T2	Market mechanisms have to be created in which landscape and biodiversity aspects are valued, while stimulating private investment and consumer demand.	• Develop niche markets for AF products • Create a label for AF-products to enhance consumer awareness • Provide tax exemptions for private AF investors	• Gold et al 2004 • Aguilar et al 2010 • Sinclair et al 2015 • Nigh and González Cabañas 2015 • Bowman and David Zilberman 2013 • Holderieath et al 2012 • Millard 2011

C3: Policy – Institutional	O15 O16 O18 O30 O38 O39 O40	Functions • F3 • F4 • F6 • F7 Structures • S1 • S2 • S3 Transformations • T1 • T3	A full-fledged legal landscape has to be created for AF, which should be clear and steadfast into the future, and should complement an attractive and effective incentive program	• Give farmers the certainty that trees in AF systems can be removed without a replanting obligation • Make subsidy program effective and attractive, but simple and flexible • Work on an extended greening policy that favors nature creation and uptake of agroecological practices	• Van Vooren et al 2016 • Lehrer 2009 • Iles and Marsh 2012 • Fragoso et al 2011 • Clark 2006 • Thiel et al 2012 • Huber et al 2013
C4: Educational – Organizational	O3 O4 O10 O11 O12 O25 O35 O41	Functions • F3 • F4 Structures • S1 • S3 Transformations • T2 • T4	Multiple communication and education channels have to be used to inform the relevant actors and familiarize them with agroecological practices and their benefits for society.	• Dedicate more attention to agroecology in agricultural education • Establish learning networks of farmers and communities of practice focused on AF and agroecological farming techniques • Monitor and evaluate the AF innovation system to guide further policy	• Reid 2016 • Warner 2006 • Vrahnakis et al 2016 • Francis et al 2011 • Calle et al 2013 • Eksvärd et al 2014
C5: Social – Behavioral	O9 O13 O14 O17 O20 O21 O22 O29	Functions • F3 • F6 • F7 Structures • S2 • S3 Transformation • T1 • T2	The dialogue between influential groups has to be strengthened in order to restore mutual confidence, build up common visions, unlock current dependencies and open up collaboration opportunities	• Assign an innovation broker to assist in vision formulation and network formation • Foster and facilitate communication between farmers and different extension agents, and between farmers and AF pioneers • Connect local authorities, farmers, landowners and local residents around topics such as greening	• Sereke et al 2015 • Laroche et al 2015 • Frey et al 2012 • Barbieri and Valdivia 2010 • Trozzo et al 2014 • Welsch et al 2014 • Borremans et al 2016 • Arbuckle et al 2008

A first scientific-technological cluster links the importance of research with negative perceptions on the compatibility and (labor) productivity of AF in Flanders. Although there is a growing investment in local agroecological research, the demand for more data on productivity and compatibility of AF among farmers remains high. Therefore the research and education domain should continue to look into favorable tree-crop combinations, and formulate recommendations with respect to AF design and management. Furthermore research should, to a larger extent than is happening today, be conducted in close collaboration with farmers and AF pioneers in order to ensure that the severest drawbacks are addressed first. Also a better dissemination of these results among farmers is indispensable.

The second cluster entails the outcomes related to markets, finances, and entrepreneurial activities, and shows the low involvement of the enterprise domain in the AF innovation system. Whereas the subsidy program overcomes initial plantation costs, it is not enough for farmers to launch themselves into AF. What is really necessary to engage farmers and private actors, are market mechanisms that take into account biodiversity and landscape values and consider these as part of the product. Niche markets and an AF label are possible examples, but depend very much on sufficient demand and support from consumers, which is currently not the case. The government and intermediary domain therefore have to work together in order to create extra financial incentives to private actors to invest in sustainable agriculture, while stimulating local demand for sustainable agricultural products.

Institutional, legal and policy- outcomes are united under the third cluster, which shows that the government domain already did substantial efforts to stimulate AF uptake. Nevertheless, modifications of the subsidy program, which is considered as complex and inflexible, and the AF legislation, which is not fully developed yet, are welcome. These should always be carefully examined with respect to its impact on farmers, and this in order to restore farmers' confidence in government actors. Furthermore, the government domain has to work towards strengthening the expertise of local officials, who have the power to connect farmers, landowners and local residents around greening.

The fourth cluster includes outcomes centered around organization and education. Herein, the creation of the informal AF-network proved to be a useful communication platform. The actors from the enterprise domain are largely missing though, which goes together with an education system that underexposes agroecological practices. Therefore the intermediary and research and education domain have to draw upon multiple communication and education channels, which have to inform and familiarize these actors with agroecological practices and their benefits for society. Also, a better monitoring of the impact of research, the uptake of AF by farmers, etc. is necessary in order to inform policy and enhance the organization of the AF innovation system.

A fifth and last cluster is dedicated to relations, behavior and social pressure. Landowners, residents, farmer organizations and farmer colleagues are important groups that could deter farmers to implement AF. This happens because of the different discursive spheres important actors adhere to, under influence of differences in relations, goals, access to communication channels, education level, etc. To connect different discursive spheres again, the dialogue between influential groups has to be strengthened. In the long term this will result in the built-up of mutual confidence and common visions, the unlocking of current dependencies and the opening up of collaboration opportunities.

Comparison of the current contribution of the different actors to the development of the AF innovation system, reveals that the actor domains currently being in the limelight with respect to AF development are the research, intermediary and government domain. This is mainly because of their role in the progress regarding hard institutions, funding and knowledge infrastructure in the last few years – not forgetting that still a lot of work needs to be done. By contrast, the enterprise and society domain, are to date little involved and engaged because of the lack of financial incentives and a general unawareness with respect to AF. Exceptions exist of course, such as the AF pioneers, who are potential showcases with respect to other farmers, and the farmer organizations, whose passive attitude has a considerable effect on farmers' agency with respect to AF. Nevertheless, without the active involvement and collaboration of both the enterprise and the society domain, it will be difficult to overcome the remaining failures and turn them from hindering into enabling factors. To break this deadlock, the research, government and the intermediary domain should engage even more in important innovation system functions like knowledge diffusion (F3), mobilizing of resources (F4), guidance of the search (F6) and creation of legitimacy (F7). This can initiate various processes of change, which can strengthen each other and can lead to the building up of momentum for bridging the horizontal and vertical gaps, creating a shared vision and in the end engaging the stakeholders from the enterprise and society domain.

4.4 Conclusion

The AIS analysis led to an identification of the different relevant actors, the innovation system functions they are involved in, and the present structural and transformational merits and failures. Overall, the combined functional-structural-transformational analysis uncovered that five important areas of improvement exist, which are of a technical, financial, legal, organizational and social nature. Although the first steps towards a better performing innovation system, favoring AF systems and DFS, are put forward by the research, government and intermediary actors, there are still numerous hindering factors which impede the active involvement of the society and enterprise domain. To further enhance the performance of the AF innovation system, and thus to scale out AF uptake in Flanders it is important to (1) invest in research to improve the compatibility and labor productivity of AF systems, (2) engage private and societal actors in markets for agroecological products, (3) develop a fully-fledged but stable legal landscape and an attractive and effective incentive program, (4) use different communication and education channels to familiarize actors with agroecological practices, and (5) increase social innovation by strengthening the dialogue between influential groups.

The AIS concept was originally developed as a holistic analytical tool that builds on complementary analytical frameworks to understand and evaluate the performance of national and sectoral agricultural innovation systems. In this study we proved that the AIS concept is also useful to study the enabling environment in relation to the transition to more diversified and agroecological farming systems, such as AF systems. This analysis was hampered by the fact that AF is in a pioneering stage for the moment, bringing up a lot of chicken-and-egg deadlocks. This made a qualitative approach towards data collection, involving a limited number of stakeholders through interviews and focus groups, the most useful and informative. Despite the pioneering stage of the system under study, the framework revealed itself as a useful tool that enables the systemic multi-level identification of all relevant moving parts of the ‘cogwheel’ and the analysis of whether these moving parts turn in directions that nurture or hinder the transition to AF systems. The analysis allowed to formulate preliminary general recommendations regarding potential development pathways, targeting different functions of an AIS and identifying the structural and transformational failures involved. Further research engaging a wider and more representative sample of stakeholders will be necessary to design more concrete pathways and strategies and to assess their effectiveness.

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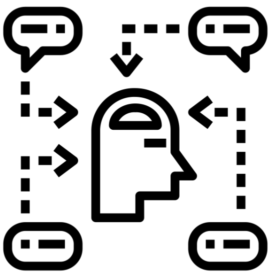
Chapter 5

Unravelling and linking perspectives on agroforestry and agriculture: a Q-methodological approach for the case of Flanders



The potential of integrated farming systems to address different problems in agriculture, could stimulate a large-scale comeback of agroforestry (AF) systems in temperate regions. However, despite increasing research efforts and government support, the uptake of modern AF by farmers in Flanders, the northern part of Belgium, and other regions in Northwestern Europe remains limited. Going beyond mere structural barriers, this may be attributed to the discord between guiding worldviews on agriculture, which inhibit or spur the acceptance of AF as an innovation by farmers. We seek clarification through Q-methodology, which allowed us to (1) delineate different perspectives on AF in Flanders, and (2) learn about their embeddedness in general agricultural discourses. Three AF perspectives were differentiated, grouping stakeholders that (1) favor small-scale high-value AF (AF idealists), (2) recognize the potential of large-scale mechanized and subsidized AF (AF opportunists) and (3) reject AF if not applied as small landscape elements or in the context of extensive livestock systems (AF sceptics). In the short term, policy mixes that take these perspectives into account and focus on an array of AF systems, could increase farmers' adoption rate. However, the embeddedness of AF perspectives in general agricultural perspectives suggests that in the long term, the mainstreaming of AF systems will depend on a shift in the dominant frame of reference from the neoliberal and productivity towards the multifunctional and sufficiency stance. This shift is very much necessary since only the latter reference frame favors high value systems that bring about benefits for both farmers and society.

This chapter is currently under review.

Borremans, L., Wauters, E., Marchand F., and Visser, M. Unravelling and linking perspectives on agroforestry and agriculture: a Q-methodological approach for the case of Flanders.

5.1 Introduction

Although the term 'agroforestry (AF) systems' is often linked to tropical regions, the practice of cultivating trees and crops on the same field is also a traditional form of land use in many temperate regions such as those in Northwestern Europe (Herzog, 1998). Also in Flanders, the northern region of Belgium, integrated land use systems have existed, such as poplar or willow rows lining agricultural parcels and fruit orchards with grazing livestock. However, through scale enlargement and intensification many trees on and between agricultural fields have disappeared and traditional forms of AF slowly vanished from the Flemish landscape (Nerlich et al., 2012). In recent times though, AF systems are increasingly recognized as a way to balance the production of commodities (food, feed, fuel, fiber, etc.) with non-material ecosystem services such as environmental protection and landscape amenities (Smith et al., 2012). Therefore, AF systems are currently supported through both pillars of the Common Agricultural Policy (CAP). With these funds, the Flemish government set up a subsidy program for alley cropping systems. In 2014 a large interdisciplinary project was initiated, which includes the provision of free advisory services to AF pioneers. Although the subsidy program and the project seem to be strong incentives for AF implementation in Flanders, farmers' interest in AF remains limited. Between 2011 and 2015, only 100 ha of AF was planted compared to the Rural Development programs' target of 250 ha of AF by 2013 (Borremans et al., 2016).

The current low uptake of AF in Flanders illustrates the slow advancement of agroecological transitions in temperate regions (Miles et al., 2017; Vanloqueren and Baret, 2009), and indicates the need for more coherent and thought-through policy measures. This is acknowledged by Jørgensen (2012) who found that multi-domain and multi-level changes are necessary to steer sustainability transitions. 'Multi-domain' refers to the influence of different types of stakeholders on the development of AF in Flanders, and thus to the importance of including all relevant actors in the development process (Borremans et al., 2018). 'Multi-level' refers to the different levels of functioning of the societal system, which all can entail barriers for AF development, and require change for transition. Rotmans (2006) and van Raak (2009) defined three levels: (1) structures, i.e. the formal, physical, legal and economic aspects of functioning, restricting and enabling practices, (2) cultures, the cognitive, discursive, normative and ideological aspects of functioning involved in the sense-making of practices and, (3) practices, the routines, habits, formalisms, procedures and protocols by which actors maintain the functioning of the societal system. To increase AF uptake and change practices, current efforts of researchers and policy makers are merely focused on eliminating structural barriers, such as getting rid of conflicting regulation within different policy domains or providing financial or organizational support (Borremans et al., 2016). However cultures, i.e. guiding visions of and perspectives of farming systems, are often the underlying cause inhibiting or spurring the acceptance of innovations, and are thus of great importance for the transition to more agroecological farming systems (Hermans et al., 2012). In this study we focus on 'cultures' by investigating AF perspectives in Flanders, and their links with more general discourses on agriculture and agricultural policy. We thus pursue two objectives: (1) to delineate and elucidate the different perspectives on AF in Flanders, and (2) to learn about the embeddedness of these AF perspectives in general agricultural discourses. We seek answers through Q-methodology, a method to unravel the different perspectives on a particular subject based on the rank-ordering of statements by respondents (Hermans et al., 2012). This methodology was already used by Louah et al. (2017) to disclose what splits the conversation on AF in Wallonia, i.e. the southern region of Belgium. Insights cannot readily be translated to Flanders though, because Flemish agriculture is more capital intensive and soil-less, with widespread hydroponics in horticulture, dominance of factory farms (poultry and pigs) and zero-grazing cattle farms. Vice versa, there are strong differences with respect to the uptake of organic farming (1.5 % in Flanders versus 10% in Wallonia) (Timmermans and Van Bellegem, 2017) and the institutional and civil society support for agroecology (Stassart et al., 2018). With these contextual differences in mind, this analysis will help in explaining why AF incentive schemes are currently not successful in Flanders and contribute to the development of a broader array of policy instruments that are better targeted.

In the context of this research, discourses, cultures, perspectives, narratives and visions are used interchangeably as the way people see something or talk about it, reflecting the underlying worldviews or paradigms (Barry and Proops, 1999). In Q-methodology one usually speaks of discourses, which Frouws (1998) interprets as "an organized set of social representations, the terms through which people understand, explain and articulate the complex social and physical environment in which they are immersed". Discourse analysis has been particularly useful in analyzing the visions that underlie the different definitions and approaches to farming and sustainable development in agriculture. As such, a range of articles has been published about e.g. rurality perspectives (Frouws, 1998; Zografos, 2007), farmer management styles (Brodt et al., 2017; Darnhofer et al., 2005; Fairweather and Keating, 1994; Rourke et al., 2012) and environmental perspectives of farmers (Barnes et al., 2017; Davies and Hodge, 2007; Pedersen et al., 2012; Walder and Kantelhardt, 2018). Several of these studies (Brodt et al., 2017; Darnhofer et al., 2005; Rourke et al., 2012) suggest that general opinions about food production could have an important influence on perspectives on specific farming systems and practices, and hence their adoption. Following this logic, stakeholders adhering to different views on agriculture might hold different or even opposing perspectives on AF, what it is (or what it should be) and if and how AF should be incentivized. Q-methodology allows to investigate this link by gauging respondents' opinions about both aspects and by measuring relative differences in responses.

To learn more about the different views on agriculture, we performed an extensive literature review. This revealed different sets of agricultural discourses that are relevant for this study. To make the link with AF perspectives more meaningful and explicit, we selected the discourses of Freibauer et al. (2011) and of Potter and Tilzey (2005) to represent in this study the different views on agricultural development, and agricultural policy and markets respectively. Freibauer's narratives about agricultural development, which are labelled the productivity and sufficiency narrative, both acknowledge that world population is growing, however they relate it to different problems and propose different solutions. These narratives coincide to a certain extent with other (opposing) sets of discourses on agricultural development described in literature, such as weak vs. strong ecological modernization (Horlings and Marsden, 2011), efficiency/substitution-based agriculture vs. biodiversity based agriculture (Duru et al., 2015), ecological intensification vs. agroecology (Bernard and Lux, 2016), sustainable vs. ecological intensification (Tittonell, 2014), bio-economy vs. eco-economy (Kitchen and Marsden, 2011; Marsden, 2012) and entrepreneurship vs. peasantry (Niska et al., 2012; Van Der Ploeg, 2017):

1. **Productivity narrative:** The world population will increase whereas the rate of increase of agricultural output per hectare is slowing down because of resource constraints and climate change. Hence, there is a serious threat that food demands will not be met in 2050, leading to hunger and political instability. Especially new technologies can boost productivity by addressing resource scarcities and environmental problems. Therefore, investment in research and development, and increased technology adoption by farmers are the solutions to focus on.
2. **Sufficiency narrative:** The world population will increase, which will lead to serious environmental problems, resulting in massive health problems, poverty and conflict. More than in science and technology, solutions must be sought in behavioral and structural change in food systems and supply chains. The government has a role to play in internalizing both negative and positive environmental externalities in markets and in addressing the disruptive effects of trade.

The discourses of Potter and Tilzey (2005) on the other hand structure the selection and operationalization of policy measures and markets within the agri-food domain. Although they may be linked to a greater or lesser extent with Freibauer's narratives, they have no one-to-one relationships (Dibden et al., 2009):

1. **Neoliberal discourse:** Agricultural practices are evaluated along the standards of the global competitive market economy with a focus on economic growth. Therefore, farmers are considered real entrepreneurs who must differentiate, capture value and pursue new opportunities.

2. **Neo-mercantilist discourse:** Agricultural development is associated both with protectionism as with a socio-economic solidarity. Rather than entrepreneurs, farmers are considered policy takers that serve national interests by ensuring food security.
3. **Strong multifunctionality:** Agriculture has a key role to play in integrating social and ecological processes, which should result in an economically viable agricultural sector. The existing power relationships within the agricultural sector should be rebalanced with a more important role for civil society.

In relation to these general agricultural discourses, different AF perspectives will be delineated and elucidated, which allows us to learn more about the extent to which AF perspectives are embedded in general agricultural discourses.

5.2 Material and Methods

Q-methodology was developed by William Stephenson in the 1930's to assist in the examination of human subjectivity (Brown, 1980). Q-methodology possesses both quantitative and qualitative dimensions bringing along its respective advantages, i.e. its qualitative component makes the method more holistic than traditional surveys, while its quantitative component provides better structure, replicability and a more rigorous analytical framework, especially for researchers trained in natural sciences (Cross, 2005; Louah et al., 2017). This combination makes it an increasingly popular method to identify different groups and their shared perspectives (Hermans et al., 2012). The method involves a rank-ordering exercise (i.e. Q-sort) that is performed by a group of stakeholders (i.e. the Q-sorters), which is followed by correlation and factor analysis and interpretation of the factor scores. In this study, the research process is split up in six different steps, as was done by Hermans et al. (2012) and Louah et al. (2017). These different steps are (1) generating the communication concourse, i.e. a collection of statements about the issue at stake, (2) setting up the Q-set, i.e. the final set of statements to present to the Q-sorters, (3) selecting the Q-sorters, (4) the ranking of statements by the respondents, which generates the Q-sorts, (5) factor analysis and (6) factor interpretation.

5.2.1 Step 1: Generating the communication concourse

Several sources were used to create the communication concourse, which should capture the full range of viewpoints and perspectives that different stakeholders might have (Hermans et al., 2015). First, the data that were collected in the context of the agricultural innovation system analysis, presented in CH 4, were analyzed, resulting in a large list of statements on different aspects of AF systems. Second, academic and well as non-academic literature was consulted, including local, regional and international agricultural journals and reports about AF systems and its framing as an agroecological farming practice. From literature, especially the statements about agriculture originated, which were added to the communication discourse if they related to the selected narratives about agricultural development (productivity, sufficiency) and the selected discourses on agricultural policy and markets (neoliberalism, neomercantilism and multifunctionality). Combining these sources led to a communication concourse of more than 300 statements.

5.2.2 Step 2: Setting up the Q-set

From the concourse of about 300 statements, we needed to select 30 to 60 statements. This is considered a manageable number to present to the respondents and considered sufficient to elicit the different existing viewpoints (Hermans et al., 2012). According to Paige and Morin (2014) and McKeown and Thomas (2013) two different approaches exist to select statements, i.e. (1) an inductive or unstructured approach, which is used when no predefined theory exists about the subject of interest, or (2) a deductive or structured approach, which is used when taking into account relevant concepts, frameworks or theories. In this study, both approaches were combined. An inductive approach was used to select statements related to AF, which were ordered according to four different themes that emerged: (1) AF design and management, (2) AF policy and institutions, (3) AF economy and markets and (4) AF sociology and ecology. These statements were primarily drawn from the interviews and focus groups and selection was done based on the expected level of dissensus. A deductive approach was used to select statements about agriculture, ensuring that the whole diversity of paradigms was represented. Moreover, the selection was based on the extent to which statements capture the selected narratives about agricultural development (efficiency, sufficiency) and the selected discourses on agricultural policy and markets (neoliberalism, neomercantilism, multifunctionality). This led to a Q-set of 43 statements (Table 5 - 3). This approach towards selecting the Q-set, i.e. combining inductive and deductive statements, was explicitly chosen to link AF discourses with agricultural discourses described in literature, unlike the approach of Louah et al. (2017) and other Q-methodology studies.

5.2.3 Step 3: Selection of Q-sorters

In Q-methodology, in contrast to standard survey methods, the quality depends less on sample size, but more on the extent to which the full diversity of existing perspectives is captured by the sample (Brown, 1996). Therefore respondents were drawn from the different stakeholder domains that we identified in CH 4, although stakeholder type is certainly not always a good proxy for the type of perspective (Cuppen et al., 2010). In total 38 respondents finished the Q-sort as shown in Table 5 - 1.

Table 5 - 1: Overview of the Q-sorters, showing the stakeholder domains and actor groups they belong to, and the institutes, organizations and companies they are affiliated with.

Domain type	***No. respondents***		
Research and education domain			
Universities and educational institutes - KU Leuven (Division of Crop Biotechnics, Divison of Bioeconomics, Department of Biology) (3x)	3	6	38
Research institutes - INBO (Research Institute for Nature and Forest) (2x)	2		
Extension centers - Agrobeheercentrum Ecokwadraat	1		
Intermediary domain			
Farmer organizations - Boerenbond, ABS, Vlaams Agrarisch Centrum	3	11	
Environmental organizations - Natuurpunt (largest nature organisation in Flanders), Bosgroepen (information and advice point for forest owners) (2x), Hubertusvereniging (information and advice point for hunters)	4		
Landscape organizations - Landelijk Vlaanderen (Association for land, forest and nature owners), Regionale Landschappen (organizations focused on sustainable regional development)	2		
Transition agriculture organizations - Bond Beter Leefmilieu (organization focused on sustainability transitions), Wervel (Working group for rightful and responsable agriculture)	2		
Enterprise domain			
Suppliers - Silva (tree nursery), Syngenta (agrochemical and seed producer)	2	16	
Farmers	14		
Buyers	0		
Government domain			
Flemish government - Agentschap voor Natuur en Bos (Agency for Nature and Forestry) (2x), Departement voor Landbouw en Visserij (Department for Agriculture and Fisheries)	3	4	
Local government - Forest ranger	1		
Society domain			
Local residents	0	1	
Landowners - Hunter	1		
Consumers	0		

Eleven of these Q-sorters already participated in the interviews and/or focus groups done in the context of agricultural innovation system analysis presented in CH 4. The contacts of the remainder were gathered using a snowball sampling technique, i.e. each respondent was asked which other actors should be included, and this resulted in new contacts and new respondents. Potential respondents were invited to participate through mail or telephone, with brief explanations of the used method and the research topic, i.e. ‘trees on farms’. We included a large share of farmers, 12 out of 38, taking into account that differences between perspectives within this group may be large, and considering that policy instruments to support AF development target primarily a behavioral change in farmers. Within this group, diversity was sought by selecting farmers based on (1) their farm type (arable farming, livestock farming, mixed farming), (2) their management style (entrepreneurial or peasant) (Van Der Ploeg, 2017), and (3) their experience with and knowledge of trees on farms.

5.2.4 Step 4: Ranking of statements by respondents (i.e. the Q-sort)

Respondents were asked to sort the 43 statements on a predefined grid containing 43 cells, ranging from - 4 (most disagree) to + 4 (most agree) as shown in Figure 5 - 1. A normal distribution was forced on the rating of the statements, which is common in Q-methodology and results in a more careful consideration of attitudes by respondents (Barry and Proops, 1999; McKeown and Thomas, 2013). The Q-sort was performed in two different ways. The 27 participants that were not consulted before in the context of the stakeholder analysis were invited for an interview, consisting of a brief introduction and the Q-sort. For the Q-sort the statements were printed on small cards, which were presented in a random order to each participant. The Q-sorts were realized with the direct assistance of the same researcher, who encouraged the respondents to elaborate on their interpretation of statements and reasoning behind scores, while at the same time ensuring internal consistency of the ranking. The 11 respondents that already participated in the interviews and/or focus groups, performed the Q-sort online with the use of FlashQ-software (Hackert and Braehler, 2007). This software allows to collect some basic information on the respondents, and gives them the opportunity to explain their interpretation of statements, at least for the statements assigned to the most extreme categories (in this case +4 and -4).

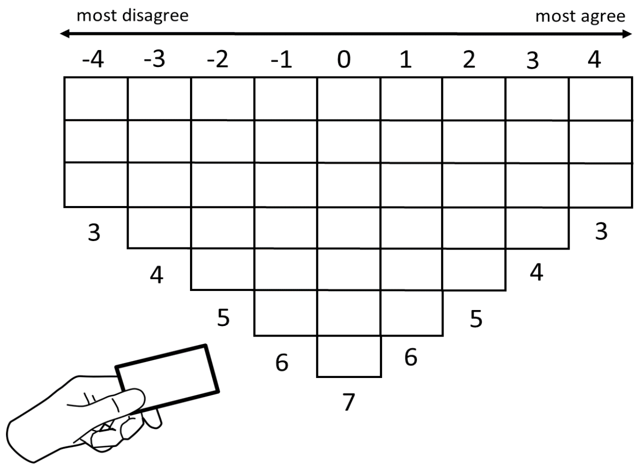


Figure 5 - 1: Response grid used during the Q-sort process (adapted from Louah et al., 2017)

5.2.5 Step 5: Factor analysis

Factor analysis was performed using PQ-method (version 2.35), which is a software developed to analyze data generated by Q-sorts (Schmolck, 2002). To do the analysis, the software first builds a correlation matrix with the Q-sorts. Second, the correlation matrix is subjected to a Principal Component Analysis, meaning that the data are rearranged by ordering components according to the variability they explain. Third, a specific number of components is chosen, which are rotated, here by means of a standard varimax rotation, to obtain a clearer and simpler picture of the data (Hermans et al., 2012; Zabala, 2014). Of fundamental importance is the decision on the amount of components or factors to retain, which is usually based on different criteria, such as the eigenvalue of factors (should exceed 1) and the amount of Q-sorts loading on a factor (minimum 2) (Brown, 1980; Watts and Stenner, 2012), but also the meaningfulness of factors (section 5.2.6). To further substantiate this decision, the loading plots were visually inspected as was done by Louah et al. (2017) and Visser et al. (2011, 2007). More information on how the factor analysis was done through PQ method can be found in Annex 1.

5.2.6 Step 6: Interpretation of factor scores

To interpret the data, PQ method provides the user with z-scores and Q-sort scores for each factor and statement. The z-scores are the standardized and weighted averages of the scores of the respondents that load significantly on that specific factor, the Q-sort scores are the corresponding positions on the response grid (from -4 to +4). The combination of Q-sort scores per factor results in idealized Q-sorts, representing the perspectives captured by the factors. To facilitate the interpretation, PQ-method also calculates the distinguishing statements, which are most indicative of a factor (Hermans et al., 2012). These are the statements for which the z-scores of factors are significantly different based on the standard error of difference (test explained in Brown, 1980 on p245). This interpretation process was done for different amount of factors, to ensure theoretically meaningful and relevant factors (Zabala and Pascual, 2016). To increase the validity of the results, data triangulation was done by (1) letting different people interpret the data and compare the results and (2) cross-check with the qualitative data gathered during the Q-sorting process. This allowed us to make a decision on the amount of factors to retain. More information on how the interpretation process was done can be found in Annex 1.

5.3 Results

5.3.1 Interviews and Q-sorts

The majority of the people who were contacted in the context of this study agreed to participate. However, the fact that we mentioned the main research topic may have influenced some respondents, e.g. those with little knowledge of AF, to decline. Overall, the assisted Q-sorts happened in a good atmosphere, in which Q-sorters grew gradually more confident in the task they were assigned. The statements and the process of ranking them often provoked many thoughts and considerations. Q-sorts lasted usually between 1h15 and 1h45. The non-assisted Q-sorts, i.e. the Q-sorts that were conducted through the Flash-Q software, yielded stories that are largely consistent with the content of the interviews (conducted previously in the context of the stakeholder analysis). Although this approach towards collecting Q-sorts will always be less holistic, the information that was gathered through the software and in the previous interviews was considered sufficient to interpret the Q-sorts.

5.3.2 Factor analysis

In this study the number of factors with an eigenvalue exceeding one amounted up to 11. On the other hand, a minimum of two loading Q-sorts on each factor corresponds with retaining a maximum of six factors. Inspection of the loading plots (Figure 5 - 2) showed that a majority of the Q-sorts load on the first factor, and that significant loadings of the other Q-sorts are spread over the rest of the factors. We explored the possibilities of a 2-, 3- and a 4-factor solution more in-depth, about which more information is given in Annex 1. After intense testing of the outcomes and going back and forth between analysis and interpretation, we decided to retain the first three factors. This three-factor solution explains 46.3% of the total variance (Table 5 - 2). Two thirds of this variance are attributed to the first factor, on which 25 Q-sorts load significantly (at significance level P>0.01, corresponding with a minimum loading of 0.299 in our study) (Watts and Stenner, 2005; Zografos, 2007). Making use of the same significance level, respectively 7 and 3 Q-sorts load on factor 2 and 3. However, one Q-sort was attributed manually to the last factor[1], which resulted in a more consistent interpretation of that factor and reduced the number of confounded and non-significant loading Q-sorts from three to two.

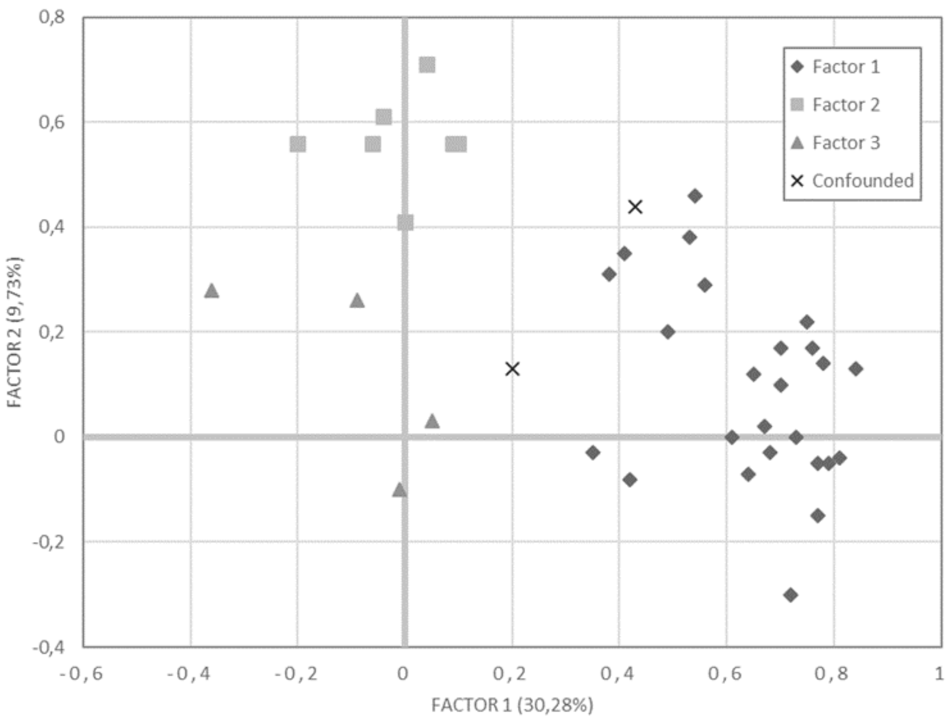


Figure 5 - 2: Loading plot of the Q-sorts on the first two factors

1 The Q-sort loads significantly on factor 3 (loading factor 3 = 0.370>0.299 = significance level), but also to a certain extent on factor 2 (loading factor 2 = 0.280) and negatively on factor 1 (loading factor 1 = -0.360). Because the sum of the squares of the loadings on factor 1 and 2 is larger than the square of the loading on factor 3, the Q-sort is not automatically attributed to factor 3, but added to the confounded and non-significant loading Q-sorts (Watts and Stenner, 2012; Zabala, 2014). However, we consider this Q-sort to fit very well with the perspective that is captured by the third factor. The manual attribution of this Q-sort to the third factor resulted in more distinctive scores and a more consistent interpretation of that factor.

Table 5 - 2: Summary information for a three-factor solution with one Q-sort manually attributed to factor 3. Values for automatic flagging, if different, are shown between brackets.

		Factor 1	*Factor 2*	*Factor 3*
Number of loading Q-sorts		25	7	4 (3)
Eigenvalue		11.51	3.70	2.37
Variance explained (%)		30.28	9.73	6.23
No. distinguishing statements		29 (25)	29 (25)	26 (18)
Correlation	*Factor 1*	1	0,06	-0,15 (-0,09)
	Factor 2	0,06	1	0,18 (0,15)
	Factor 3	-0,15 (-0,09)	0,18 (0,15)	1

The z-scores, Q-sort scores and distinguishing statements are presented in Table 5 - 3 and form the basis for the interpretation. For each of the three factors many distinguishing statements were found. Consensus statements on the other hand were few, and seem in retrospect rather a result of poorly chosen statements (that Q-sorters found difficult to interpret) (e.g. S26, S27) rather than a real consensus between factors (e.g. S38). Eventually, the interpretation of the results led to three idealized discourses, which were labelled “agroforestry idealist perspective”, “agroforestry opportunist perspective” and “agroforestry sceptic perspective”. These labels reflect how AF and its enabling environment are interpreted by the perspectives, which is explained in detail in the following paragraphs. Because of the many distinguishing statements, the results were structured according to the themes through which the AF statements were selected into the Q-set. However, the interpretation of the factors happened on the basis of the complete set of statements, as all the statements refer to each other, and may be interpreted differently from one perspective to another. Finally, Table 5 - 4 shows that the different perspectives are more or less randomly distributed over the different stakeholder domains, showing no direct link between stakeholder domain and perspective.

*Table 5 - 3: Statement scores for each factor. * indicates distinguishing statements at significance level p<0.05; ** indicates distinguishing statements at significance level p<0.01 (significance test explained in Brown, 1980, p245). 'Di.' stands for discourse, and indicates the discourse for the last two themes; 'No.' indicates the statement number; 'So.' stands for sources indicates if the statement originates from respondents (R) or from literature (L).*

Theme				***Factor 1***		***Factor 2***		***Factor 3***	
Di.	***No.***	***So.***	***Statement***	***AF idealist***		***AF opportunist***		***AF sceptic***	
				z-score	***Q-sort score***	***z-score***	***Q-sort score***	***z-score***	***Q-sort score***
Design and Management									
	1	R	AF must be implemented on large plots, because then it becomes feasible and financially viable.	-1	-2	1,39	3**	-1	-3
	2	R	AF is especially useful on less valuable plots, which are too small, too wet or too far away.	-1,1	-2*	-0,5	-1*	0,64	2**
	3	R	Only in the context of extensive livestock farming there are opportunities in AF.	-1,1	-2	-1,1	-3	0,23	0**
	4	R	If you implement AF, you must choose fast-growing species, i.e. species with a fast yield.	-1,3	-3*	0,54	1**	-0,8	-2*
	5	R	The cultivation of standard fruit trees is too labor-intensive to be economically interesting.	-0,4	-1*	0,12	0*	2,02	4**
	6	L	AF plots must always match as closely as possible the landscape character of a region.	0,88	2	-1,5	-3**	1,1	3
	7	R	To implement AF solely because of wood production is short-sighted.	0,36	1*	1,04	2**	-0,2	-1*
	8	R	AF is more than the cultivation of trees on farmland, it requires a system approach and a redesign of your farming system.	0,88	2	0,7	2	0,08	0*
	9	R	AF is only feasible and financially viable if the distance between the tree rows is adjusted to the width of farming machinery.	0,08	0	1,56	4**	0,04	0
Policy and Regulation									
	10	R	The fact that AF is recognized as ecological focus area is for quite some farmers an incentive to adopt.	0,91	2**	-0,1	0*	-0,8	-2*
	11	R	Subsidy levels for AF systems should be coupled to the level of ecological and landscape value created.	0,98	3**	-0,6	-1**	0,27	1**

12	R	The high subsidy that exists for AF systems cause farmers to spend large amounts of money on plantations at the expense of society.	-1,3	-3*	-1,7	-4*	1,25	3**
13	R	It should be allowed at all times to harvest trees on farmland.	0,12	0**	1,6	4*	0,95	2*
14	L	As a farmer, I would never consider to plant trees on land that is not mine.	-0,8	-2	-0,9	-2	0,46	2**
Market and Economy								
15	R	AF must be considered a long-term saving account.	0,51	1**	-0,5	-1	-0,6	-2
16	R	AF is especially meant for hobby farmers.	-1,8	-4	-1,6	-4	0,12	0**
17	R	The added value of AF is not financial, but lies in a higher biodiversity and a healthier ecosystem.	-0	0**	0,59	1**	-0,8	-2**
18	L	The consumer is not willing to pay more for products coming from an AF system.	-0,4	-1	1,27	3**	-0,5	-1
19	R	The emergence of novel marketing systems such as farm shops, urban agriculture and community-supported agriculture is an opportunity for AF.	0,72	1**	-1,4	-3**	-0,5	-1**
20	R	Nobody is waiting for food or wood products with an AF label.	-0,3	0*	0,74	2	0,68	2
Sociology and Ecology								
21	R	A farmer planting rows of trees on farmland can expect criticism of his colleagues.	0,21	0*	1,03	2**	-0,3	-1*
22	L	AF can boost the image of the agricultural sector.	0,91	2**	0,36	1	-0,2	-1
23	R	The real advantages of AF are for society, not for the farmer.	-0,9	-2**	-0,2	0*	0,39	1*
24	R	The insurmountable disadvantage of AF is the long term, you cannot simply try it out for a year.	0,25	1	0,66	1	0,45	1
25	R	Planting trees results in a value increase of the farmland.	-0,1	0**	-1,1	-2**	-2,4	-4**
26	R	AF means maximizing the biomass yield per ha.	0,02	0	-0,5	-1	0,03	0
27	R	Rows of high trees in the landscape have a negative impact on prey animals.	-0,6	-1	-1,1	-3*	-0,2	-1
28	R	Taking into account climate and soil in Flanders, that are advantageous for classical crop production, AF is a poorly suited agricultural system for Flanders.	-1,2	-3**	-0,1	0**	1,67	4**
29	R	AF offers protection against pests and diseases of agricultural crops.	0,94	2**	-1,8	-4	-1,6	-3
30	L	Trees ensure fertile soils by restoring organic matter content and recycling nutrients.	1,52	3**	-0,2	0**	-2,1	-4**
Productivity (P) and Sufficiency (S)								

P	31	L	Research in agriculture must focus on new technologies that produce more food with less inputs.	0,25	1**	1,18	2**	2,06	4**
P	32	L	A farmer who wants to farm efficiently focuses on scaling and intensification.	-1,5	-4**	-0,9	-2**	0,24	1**
P	33	L	Only by increasing the production in existing agricultural regions, space can be safeguarded in Flanders for the development of nature and biodiversity.	-1,4	-3	-0,4	-1**	-1,8	-4
S	34	L	The agricultural sector must focus on the production of higher quality food with more attention for the social and ecological impact.	1,96	4**	-0,3	-1**	0,88	2**
S	35	L	To make farms resilient again, one has to start with healthy soils, animals and plants, and work hand in hand with nature.	1,82	4**	-1,1	-2	-1,1	-3
Neo-liberalism (NL), Neo-mercantilism (NM) and Multifunctionality (MF)									
NL	36	L	The agricultural sector must compete in the international market, just like other sectors.	-0,6	-1**	1,22	3	1,07	3
NL	37	L	Agricultural policy should encourage the economic growth and competitiveness of farms.	-0,4	-1**	0,41	1	0,44	1
NL	38	L	Farmers always must be looking for new opportunities on the market and be consumer-oriented.	1,06	3	1,62	4	1,07	3
NM	39	L	Irrespective of the public services carried out, income support for farmers is justified.	-1,5	-4*	0,36	0**	-0,9	-3*
NM	40	L	The abolition of market and price support in the agricultural sector would have an unacceptable impact on the income of farmers.	-0,5	-1*	1,19	3**	0,15	0*
MF	41	L	The power in the food chain must be shifted to the local level, where producer and consumer can interact again with one another.	1,44	3**	0,49	1*	-0,2	0*
MF	42	L	The role of agricultural policy is to guaranty the application of environmental standards and to pay for ecosystems services that cannot be traded on the market.	0,58	1	-0,6	-2**	0,23	1
MF	43	L	In the future, efforts related to biodiversity, soil, animal welfare, climate and water will become services as important as food production.	1,57	4**	0,32	0**	-0,7	-2**

Table 5 - 4: Relation between stakeholder domain and perspective

	AF idealist	*AF opportunist*	*AF sceptic*	*Confounded/No significant loading*
Research domain	4	1	1	
Intermediary domain	9	1	1	
Enterprise domain	8	5	1	2
Government domain	4			
Society domain			1	
TOTAL	25	7	4	2

5.3.3 Factor interpretation

The interpretation of the results led to three idealized AF discourses, which we labeled “AF idealist perspective”, “AF opportunist perspective” and “AF sceptic perspective”. These labels reflect how AF and its enabling environment are interpreted by the perspectives. In the following paragraphs, differences in interpretations between perspectives are explained in detail for each AF theme that we distinguished, and for both sets of agricultural discourses that we selected.

Design and Management

AF idealists are very open with respect to the kind of AF system that is possible or desirable in Flanders (S1, S2, S3, S4), which depends on the local context (S6) and the personal goals of farmers. They show equal interest in extensively grazed orchards (S5) as in very labor-intensive and complex integrated land use systems. **AF opportunists** see this differently and consider the ideal AF plot to have a large surface area (S1). In this respect, one of the respondents explained: *“It is impossible to plant trees on an agricultural field smaller than a hectare, in this case little would remain for the farmer to work with.”* With this in mind, adapting the AF design to the normal agricultural activity and machinery is an absolute precondition for AF to be feasible and viable (S9). To shorten as much as possible the time span between investment and return on investment, AF opportunists reason that fast growing tree species have to be selected (S4). However, at the same time they question the financial returns of such an investment (S7). This is also an important issue for **AF sceptics** (S4, S7). They underpin their reasoning by referring to grazed orchards, whose disappearance proves that financial returns are difficult to achieve in labor-intensive systems (S5). Consequently, they believe that AF is only advantageous if implying small landscape elements bordering agricultural fields, or if it is applied on agricultural fields that are small (S1) and wet (S2), or used for extensive grazing (S3).

Policy and Regulation

AF idealists evaluate the current support for the establishment of AF systems overall as positive (S10, S12). However, AF idealists believe that a differentiation in the subsidy level, depending on the ecological and landscape values that are being created, is legitimate and would result in a more effective spending of public money (public money for public services) (S11). Some even urge to adopt a system approach with respect to subsidies, which is illustrated by the following statement: *"Subsidies should be coupled to a management plan, and be dependent on valuable tree-crop interactions rather than solely tree species as in the case today."* Also **AF opportunists** recognize the usefulness of greening support, but downplay its effect on the general farmer community (S10). To increase the scope of the current incentive program, AF opportunists suggest (1) raising the subsidy levels and coupling it to an annual maintenance compensation (S12), (2) simplifying and loosening up stringent preconditions and regulations (S11) and (3) eliminating legal uncertainty and the need for harvest permits (S14). **AF sceptics** are less optimistic: they are convinced that the subsidy program and the greening measures will not change farmers' intentions to (not) plant trees (S10). In this respect, the subsidy program, which incites farmers to make use of more expensive planting material, is not a very cost-efficient measure (S12).

Economy and market

AF idealists consider properly managed AF systems as long-term investments (S15). However, they recognize that, for AF systems to scale out, they must be financially viable already in the relatively short term (S17). This could be brought about through new innovative marketing approaches that allow farmers to charge a fee for the ecosystem services produced through AF. AF idealists doubt if a label for AF products is already on the agenda (S20), but are aware of short supply chain mechanisms such as farm shops and community supported agriculture (S19). However, for those mechanisms to succeed a change of mindset of consumers is necessary, as explained by a respondent: *"In Flanders the consumer wants to have nice apples, without any bumps or scratches. We have to teach the consumer again how normal apples look like."* **AF opportunists** are convinced that consumers will not pay a premium for AF products (S18) and downscale the scope of alternative marketing mechanisms to niche products (S20, S19). In this case, the financial viability of an average AF depends on very uncertain wood revenues achieved at the end of the rotation (S15). With this in mind, AF opportunists request more financial support for AF systems. **AF sceptics** are much opposed to this. Moreover, they consider financial viability the most important aspect of farming (S17). If the added value of its products is not rewarded through the conventional supply chains, AF sceptics consider AF is not an option for professional farmers (S16). Although the weak position of the farmer in the supply chain should be addressed, AF sceptics stress the efficiency and usefulness of supermarkets to reach out to the consumer (S19).

Sociology and ecology

AF idealists believe AF to entail advantages for society (landscape amenities, biodiversity conservation, etc.), but also for farmers (S23). They assume that well-designed and managed AF systems could result in fertile agricultural soils (S30) and protection of crops against pests and diseases (S29). Additionally, the image of farmers and the agricultural sector as a whole could benefit (S22). Because of these synergies, AF idealists are convinced that AF is a very appropriate farming system for Flanders (S28). Regarding the ecological benefits of AF, **AF opportunists** disagree (S29), or are at least more doubtful (S28). Also in the social sphere AF opportunists see barriers to planting trees, especially within the farming community (S21, S25). Overall, if the advantages and disadvantages of the farming system are listed, AF opportunists conclude that the farmer must deal with a set of disadvantages, whereas most of the advantages of AF are for society (S23). **AF sceptics** on the other hand note with regret that, in the case of AF, some of the best farmland needs to be sacrificed (S28). One of the respondents even mentioned: *"From a corporate social responsibility perspective, it's just unacceptable to not use our fertile farmland for food production."* AF sceptics also foresee the depreciation of the value of agricultural land when planting trees (S25) because of negative effects of trees on crop production (S29). Although AF sceptics recognize the biodiversity and landscape value of AF (S23), they do not consider AF as an appropriate or efficient farming system in Flanders (S22).

Productivity and Efficiency

The priority of **AF idealists** goes to producing high quality food while minimizing its social and ecological impact (S34). According to AF idealists this can be achieved through relying on natural processes, which increases farm resilience (S35). Producing efficiently also has its place in this story, but this does not necessarily require the use of big machinery or adoption of the newest technologies (S31). Because of the large financial investments, the acquisition of large machinery would stimulate farmers to scale up and specialize their production, which is a development direction that is rejected by AF idealists (S32). Also **AF opportunists** believe that scaling and specialization, being imposed to farmers in the past, is not the right way to go (S32). The fact that still a lot of farms go out of business proves this. However, AF opportunists think that new technologies focusing on substituting labor and reducing resource inputs are not to blame for this. Although AF opportunists do not fully stand behind the productivity narrative, they reason that, in a world where labor is expensive and resources are limited, technologies can offer new opportunities and perspectives to farmers (S31). The view of **AF sceptics** matches largely with the productivity narrative with its focus on land and labor efficiency. These efficiencies are expressed by AF sceptics in output/ha and output/man hour respectively, which is very different from AF idealists, which evaluate land and labor efficiency rather in income/ha and income/man hour respectively. Because of this interpretation, progress implies for AF sceptics the development of new technologies (S31). These are to be deployed in those regions best suited for production, which clarifies AF sceptics' support for international agricultural trade. In this respect one of the respondents reasoned: *"For each product an efficiency-assessment has to be made. From an ecological point of view it might be better to produce a certain product on the other side of the world and to ship it here, than to produce it locally."* Overall, AF sceptics stand for minimizing resource use, without compromising the quality of food production (S34). However, the new technologies and machinery that bring the necessary land and labor efficiency are not cost-effective if they cannot be used on a reasonable surface area. Therefore AF sceptics consider scaling-up practices and specialization necessary processes (S32).

Neoliberalism, Neomercantilism and Multifunctionality

The **AF idealists'** view coincides largely with the multifunctionality discourse by openly questioning the current organization of the food system. According to AF idealists, change and redesign is necessary for farmers to gain some bargaining power over food prices, and for the public to reconnect with the origins of food. This is possible by eliminating some of the intermediaries in the food chain (S41). For AF idealists, a good agricultural policy has attention for public services, which they consider as important as food production in itself (S43). **AF opportunists** attach a lot of value to a decent income for farmers as producers of food, which is according to the neo-mercantilist discourse the priority of an agricultural policy (S37). Towards foreign sales markets AF opportunists adopt a positive attitude, because some agricultural sectors need them to run a viable business (S36). However, one of the respondents expressed his doubts about the matter in the following way: *"Why would we support our own farmers, and at the same time invite farmers overseas to market their products here? More import taxes and quota for the sake of our local farmers would be appropriate."* Overall, producing high quality food under stringent regulations is interpreted by AF opportunists as a very important public service, therefore subsidies and compensations to farmers are entirely justified (S39). Last, **AF sceptics**' opinion on food chains corresponds with the neoliberal discourse, in the sense that current food systems are, despite its flaws, efficiently organized. Moreover, AF sceptics do not plan to scale back the participation of farmers in agricultural export markets (S36), or to oblige the population to buy all of its food in farm shops (S41). According to AF sceptics, the most efficient way to work towards a sustainable food production is by means of environmental standards and a positive incentivizing system (S42), this in contrast with the direct subsidies that are disbursed to farmers today (S39).

Table 5 - 5: Summary of perspectives

Perspective	*AF idealist*	*AF opportunist*	*AF sceptic*
AF design and management	Complex integrated land use systems	Large scale mechanized alley cropping systems	Small landscape elements, extensive livestock systems
Policy and Regulation	More support for valuable and locally adapted AF systems	Less stringent regulations and preconditions, higher subsidies, more legal certainty	Subsidies are not attractive and cost-efficient
Economy and Markets	Costs payed by consumer through shorter supply chains	Financial support is necessary	Not financially viable, thus not desirable at a professional level
Sociology and Ecology	Social and ecological synergies result in advantages for society and farmer	Advantages for society, disadvantages for farmer	Not optimal solution for farmer neither for society
Productivity and Sufficiency	Sufficiency	Productivity	Productivity
Neoliberalism, Neomercantilism and Multifunctionality	Multifunctionality	Neomercantilism	Neoliberalism

5.4 Discussion

5.4.1 Stakeholders interpret agroforestry and its enabling environment differently

A first goal of this study was to delineate and elucidate different perspectives on AF that exist in Flanders. The results show that there are three different perspectives according to which AF and its enabling environment are interpreted. Considering the design and management of AF in Flanders (theme 1), AF sceptics downplay the scope of AF to small landscape elements on the border of agricultural fields and extensive livestock systems. AF opportunists on the other hand are more open to AF systems, and also show interest in more complex systems, e.g. large-scale alley cropping systems, or traditional farming systems, e.g. standard orchards. But the AF idealists broaden the scope the most, and take into account systems that are both complex and labor-intensive e.g. multifunctional woody polycultures. Table 5 - 5 demonstrates that these different ideas about the design and management (theme 1) are closely linked with ideas about AF policy and regulation (theme 2), AF economy and markets (theme 3) and AF sociology and ecology (theme 4). Moreover, differences between perspectives are found at different levels, from the definition and type of AF up to its broadest enabling environment. For all four AF themes, the scope, extent and impact of interventions suggested by the respondents seem to broaden from the AF sceptic up to the AF idealist perspective. With this in mind, the AF perspectives would fit very well into three progressive stages in the transition towards sustainable agriculture described in literature, labelled ‘efficiency’, ‘substitution’ and ‘redesign’, and documented and merged by Hill and MacRae (1996) into the ‘Efficiency-Substitution-Redesign’ (ESR) framework. Originally, these strategies were focused solely on farm management, but later on Hill (2014) declared they also include social and institutional aspects. However, the question remains if, in the same way as the strategies of the ESR framework, farmers’ discourses can also evolve over time, and if they are subsequently reflected in farmers’ practices. In this respect, a study of Lamine (2011), in which farmers’ trajectories are coupled to the strategies of the ESR framework, suggests at least that both are associated, i.e. that a redesign of technical agricultural systems goes hand in hand with changes in interactions, including perspectives, within larger agri-food systems.

Louah et al. (2017) found similar results for Wallonia, Southern Belgium, despite the differences between both regions with respect to support for agroecology. Three discourses were identified, the ‘transformational viewpoint’ discourse (TV) which corresponds with the AF idealist perspective, the ‘political correctness’ (PC) discourse matching the AF opportunist perspective, and the discourse maintaining the ‘status quo’ (SQ), coinciding with the AF sceptic perspective. Nevertheless, differences can be found, e.g. in the interpretations of the AF opportunist and PC perspectives. Inconsistencies in the sorting of statements by these perspectives are attributed by Louah et al. (2017) to the fact that PC, while adhering to the productivity narrative, is aware of the international debates on challenges in the food system. We, on the other hand, experienced that the inconsistencies in the sorting of the AF opportunists is a result of their sense of powerlessness to change food systems from the bottom-up. This is different for AF idealists, who believe they can make a difference and set an example by changing their own practices. Differences between the outcomes of the studies also relate to the distribution of Q-sorters over the perspectives. In contrast with the study of Louah et al. (2017), a large majority of the respondents in our study loads significantly on the first factor, indicating that their viewpoint coincides to a large extent with the AF idealist perspective. It cannot be concluded though that among stakeholders this is also the prevailing perspective. On the contrary, our experiences throughout the data collection stage and previous AF studies indicate that in Flanders, the AF opportunist and AF sceptic perspectives are dominant, although this should be confirmed through further research. This could be a result of the difference in openness and availability for AF-interviews between stakeholders adhering to different perspectives, or of social desirability in the Q-sorts, i.e. a response bias, consisting of the tendency of respondents to answer questions in a manner that will be viewed favorably by the interviewer (e.g. Walder and Kantelhardt, 2018).

5.4.2 Agroforestry perspectives are associated with discourses on agricultural food production

Our second goal was to learn more about the embeddedness of AF discourses in general agricultural discourses. In this respect, Louah et al. (2017) already found that differences in AF perspectives do not only concern AF, but farming in general. We wanted to build further on these insights, by linking AF discourses with specific agricultural discourses described in literature. Although we cannot substantiate that AF perspectives are definitely a result of general opinions about agricultural food production, the results at least strongly suggest that they are associated. First, there is the AF idealist perspective, which seems to be grounded in the sufficiency narrative by keeping a broad and open, thus holistic view on the practical and financial feasibility and organization of AF in Flanders. In accordance with the sufficiency narrative, AF idealists stand for a redesign of the agricultural policy framework and market organization (Potter and Tilzey, 2005), rather than agricultural development through incremental changes in the organization of agricultural policy and markets (Altieri et al., 2017). AF idealists also support the multifunctionality discourse, which is interpreted by AF idealists in its stronger sense i.e. as the need for a farmer-society co-management model, rather than a liberal environmentalist model as in the context of the CAP (Daniel and Perraud, 2009).

Second, there is the AF sceptic perspective that coincides to a large extent with the productivity narrative and the neoliberal discourse. These views complement each other: technologies that improve yield while reducing negative externalities, can result in a sustainable economic growth in the context of a liberalized agricultural trade (Freibauer et al., 2011). AF sceptics take these discourses as a frame of reference when rejecting AF as an appropriate farming system in Flanders: by focusing on how agricultural markets function today, AF systems indeed do not add value for farmers. The productivity narrative also dictates land sparing as the solution to cope with the trade-off between crop production and biodiversity conservation (Kremen and Miles, 2012). The negative score of the AF sceptic perspective on S33 in Table 5 - 3 suggests that AF sceptics disagree in this regard with the productivity discourse, however closer examination of respondents' explanations reveals that this is not exactly the case: quotes such as "*land sparing where possible, land sharing where necessary*" show that overall AF sceptics endorse land sparing as part of the productivity narrative. This anomaly in AF sceptics' sorting patterns can be explained by the specific situation is Flanders, where also among AF sceptics it is common sense that agricultural productivity is reaching its limits, this in contrast to other parts of the world.

Third, there are the AF opportunists, whose viewpoint seems to be less clear-cut. A deeper look into the respondents' sorting patterns and explanations reveals that AF opportunists find themselves in between the productivity and sufficiency stance. On the one hand AF opportunists are convinced that farmers overall are doing a good job which would make a redesign of the system superfluous. On the other hand AF opportunists think that agricultural scaling and intensification, in which farmers have little choice than to participate, leave the farmer without bargaining power. This view on agriculture, with its focus on the farmer as the most important but also weakest link, is very well portrayed by Frouws (1998) and Hermans et al. (2009) as the agri-ruralist discourse. It also clarifies AF opportunists' strong support for the neomercantilist discourse, with its focus on protectionism and socio-economic solidarity with farmers (Freibauer et al., 2011). From this reference frame, AF opportunists understand AF as an interesting farming system on the condition that farmers are compensated through subsidies or through the market, which has to be organized by the government and/or market players.

5.4.3 Policy implications

In this study we identified three idealized perspectives that include very different ideas on what AF is, how it can be useful and how it should be incentivized. This allows to develop a more differentiated and better targeted approach towards AF extension (Fairweather and Klonsky, 2009). Our results suggest that farmers adhering to the AF opportunist perspective will be more prone to implement AF if the subsidy program would include a maintenance compensation, if its regulations and preconditions would be simplified, and if specialized machinery, and professional advice and support for AF design and management would be available. On the other hand, for farmers adhering to the AF idealist perspective, a more enabling environment could be created by developing and showcasing innovative market outlets and mechanisms for AF-products. These innovative market models often include shorter supply chains, often implying consumers passing by and stopping over at the farms, which would reinforce the development of green farm infrastructure. Farmers adhering to the AF sceptic perspective may not be interested in AF systems as such, but may advocate result-oriented schemes for small landscape elements or hedgerows. For all three groups, but for the latter two in particular, more scientific and practical research about the productivity and benefits of AF in the context of Flanders will be necessary in order to involve them in the public debate. These measures coincide to a large extent with three improvement pathways for AF development, proposed by Borremans et al. (2018), i.e. (1) the science-technological pathway, focusing on further investment in research targeting the productivity and compatibility of AF systems; (2) the market-financial pathway, addressing the need for new market mechanisms in which landscape and biodiversity aspects are valued; and (3) the policy-institutional pathway, implying the creation of a full-fledged legal landscape and an attractive and effective incentive program for AF systems. We can conclude that, in the short term, a mix of policy instruments focusing on an array of AF systems has the highest potential in reaching the goal of more trees being planted on farmland.

However, to give AF a chance in the long term, it will take more than just a mix of different policies. We experienced in this study that AF systems are interpreted by AF opportunists and AF sceptics as adding trees to conventional farming systems. This partial co-opting of agroecological practices in conventional systems may result in AF systems that may not reach their full potential (Giraldo and Rosset, 2017). This potential is then often evaluated against standard performance measures instead of systemic or holistic measures, which would be more relevant in the case of agroecological systems (Brym and Reeve, 2016). Our results suggest that, in order to mainstream high-value AF in the long term, also stakeholders' interpretation of AF, and the criteria against which they evaluate AF as a good farming system have to change. This line of thinking is followed by Kivimaa and Kern (2016), who argue that policy instruments should not just aim at the creation or diffusion of innovations, but at transforming entire socio-technical systems towards sustainability. Louah et al. (2017) found the same result, and interpreted it as a cognitive lock-in, i.e. an ideational path dependency that may underlie political, institutional and technological lock-ins. The same insights made Sereke et al. (2015a, 2015b) and Warren et al. (2016) conclude that subsidies will not change farmers' behaviors as long as farmers' poor expectations of and knowledge of AF systems are not addressed. In this light, we argue that a real mainstreaming of AF adoption in Flanders depends on a shift in the dominant frame of reference from the neoliberal-productivity towards the multifunctional-sufficiency stance (Levidow et al., 2014; Marsden and Sonnino, 2008; Seuneke et al., 2013). This is possible by inducing long-term processes of learning within multi-actor innovation networks (Louah et al., 2017). Commitment to the two remaining improvement pathways that are proposed by Borremans et al. (2018) are therefore essential, i.e. (1) the educational-organizational pathway, that focuses on the creation of creation of multiple communication and education channels to inform the relevant actors and familiarize them with agroecological practices and their benefits for society; and (2) the social-behavioral pathway, that proposes to strengthen the dialogue between influential groups to restore mutual confidence, build up common visions and open up collaboration opportunities.

5.5 Conclusion

Making use of Q-methodology, we distinguished three different perspectives on AF systems that exist among stakeholders in Flanders. Those perspectives reflect how stakeholders interpret AF as a farming system, with (1) AF idealists favoring small-scale high-value AF, (2) AF opportunists recognizing the potential of large-scale mechanized and subsidized AF, and (3) AF sceptics rejecting AF if not applied as small landscape elements or in the context of extensive livestock systems. These different views on the scope and appropriateness of AF in Flanders are closely linked with stakeholders' evaluations of the need for policy support, the financial viability, and the social and ecological values of AF as a farming system. In the short term, policy mixes that take these different perspectives into account, and that focus on an array of AF systems, could improve the amount of trees planted on farmland. However, our results also suggest that AF perspectives are steered by, and thus embedded in general discourses on agriculture and food production. With the current neoliberal-productivity narrative as the dominant frame of reference, the expected scope of AF uptake among farmers remains limited. This scope can be broadened by inducing a long-term process of learning within multi-actor innovation networks. Communication and education within and throughout different domains and levels, will enable the different stakeholders to get on the same track of sustainability, moving gradually from neoliberal-productivity towards the multifunctional-sufficiency stance. This is very much necessary for mainstreaming AF systems, since only the latter frame of reference supports farm models that favor high value AF systems, and bring about benefits for both farmers and society.

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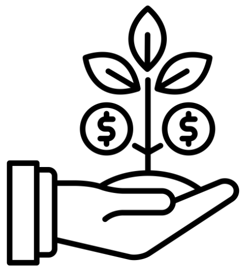
Chapter 6

Using the values of AF systems to create economic incentive pathways for farmers: an exploratory study for Flanders



Although the overall productivity in agroforestry (AF) systems generally exceeds that of conventional systems, this is often not translated into economic and financial benefits for the farmer. In Flanders, this uncertainty about the profitability is considered as one of the main barriers hampering AF adoption. Therefore, in this study, we explore, from an economic and institutional perspective, the potential of different instruments – both traditional and innovative – to convert the values of AF into direct economic incentives for farmers. First, through exploratory brainstorm sessions, we found that a wide range of instruments – financed by either the government, the market or the community – could be developed that may give economic incentives to farmers to adopt AF systems. Second, we selected four different economic instruments - a subsidy program, a carbon trading scheme, an AF label and a cooperative AF farm - and compared them with respect to suitability (i.e. the extent to which they target valuable AF systems), acceptability and feasibility. This showed that instruments have different strengths, which may complement and reinforce each other mutually. We conclude that creating space for further development and tailoring of AF pathways can help to turn AF into a more solid economic agricultural system for farmers.

This chapter is currently under review.

Borremans, L., Reubens, B., Visser M. and Wauters, E. Using the values of AF systems to create economic incentive pathways for farmers: an explorative study for Flanders.

6.1 Introduction

Agroforestry (AF) is increasingly considered as a sustainable agricultural innovation which can address social, ecological, and biodiversity-related challenges in intensive agricultural regions (Torralba et al., 2016). It has been shown that with careful design and management, the overall productivity in AF systems can exceed that of conventional systems (Smith et al., 2012). However, this is not always translated into economic and financial benefits for the farmer (Palma et al., 2007; Van Vooren et al., 2016), while these benefits are key issues that farmers consider in their decision-making about alternative cropping or land use systems (Graves et al., 2011).

There are at least two important aspects contributing to the generally low profitability of AF systems in a conventional farming context in Flanders. First, there is the long duration between investment costs and pay-off, which greatly exceeds the usual planning horizon for traditional farming systems. Indeed, depending on the intended output of the AF system (timber, biomass, fruit, nuts, …), it can take up to decades before harvesting can take place. Taking into account that over such a period of time regulation might change or trees can be damaged by machinery, diseases, wildlife or storms, the farmer is confronted with relatively high risk and uncertainty. Farmers can also not rely upon a well-functioning wood and timber value chain, that has experience with the management of trees in a farming context, and can guarantee farmers a reasonable price for their wood product at the end of the rotation. Usually, the risks of and time preferences of investments are taking into account through discounting, i.e. calculating the net present value of the cash flows in the future. However, positive outcomes are hard to achieve in AF systems when applying discount rates normally used in agriculture (5-6 %) or even in forestry (3 %) (Hauk et al., 2014; Van Vooren et al., 2016).

Second, the lack of profitability could be a result of the way in which regular agricultural markets function. On the one hand, regular market channels are not adapted to the processing and handling of products which are presented in small parties and which are not sufficiently uniform. But, as AF as a farming system lends itself to crop diversification, it often happens that parties of products derived from AF systems are small and less uniform (Rois-Díaz et al., 2017). On the other hand, regular market channels often only allow for the valorization and trading of specific goods and services. Moreover, markets do not reward farmers for the societal value creation during the production process, this while it often implies extra costs for the farmer (Anil et al., 2017). The functioning of regular markets thus generally does not benefit AF systems, which deliver a wide range of ecosystem services that are beneficial for society. Through a meta-analysis Torralba et al. (2016) found erosion control, biodiversity conservation and soil fertility to be important regulating ecosystem services provided by AF systems in Europe. Also nutrient retention, carbon sequestration, pollination, pest control and fire risk reduction are regulating ecosystem services frequently attributed to AF systems (Kay et al., 2017; Smith et al., 2012). More specifically for Flanders, Pardon et al. (2019, 2017) measured significantly higher soil organic carbon and nutrient concentrations, and a higher arthropod abundancy around trees in AF systems. Cultural ecosystem services are less widely studied, but overall AF systems have proven to increase recreational, aesthetic and cultural heritage values of landscapes (Fagerholm et al., 2016). However, the extent to which these ecosystem services are effectively delivered, and thus the extent to which AF is valuable, depends off course on the type of AF that is implemented, and whether or not if forms part of an agroecological transformation at farm level (Wilson and Lovell, 2016).

Taking into account the functioning of the markets and the long rotation time of trees, it is no surprise that Flemish farmers consider the uncertainty about the profitability of the farming system to be one of the main barriers to AF adoption (Borremans et al., 2016). Therefore, in this study, we explore, from an economic and institutional perspective, the potential of different economic instruments – both traditional and innovative – that might convert the values of AF into direct economic incentives for farmers. This analysis will help policy makers, civil society actors and researchers to gain insights in the strengths and weaknesses of different economic incentive pathways.

6.2 Methodology

This study exists of two main steps. In a first step we organized three focus groups in which we brainstormed about different instruments that can give economic incentives for AF adoption. The goal of this step was to give a broad overview of the whole diversity in economic instruments that could exist. In the second step, we selected four instruments that are already implemented in practice, and analyzed and compared their potential impact on AF adoption. This second step complements the first step by providing a more in-depth analysis of the economic instruments, and this through case study research.

In a first step, we identified a range of different economic instruments that can give incentives for AF adoption, and this through focus groups involving people with different backgrounds. These focus groups were organized as part of three conferences: (1) the Transdisciplinary Agroecology Meeting (November 2015 in Leuven, Belgium), (2) the North American Agroforestry Conference (July 2017 in Virginia, US), and (3) the Belgian Agroecology Meeting (November 2017 in Gembloux, Belgium). The large time gap between the first and the second focus group is due to the fact that the first focus group was organized as a workshop as part of the conference, and was not specifically designed to generate input for this research.

Surprisingly the workshop yielded very interesting results, and in 2017 we decided to repeat the approach to further identify economic instruments. The total numbers of attendants of the focus groups was 54, including scientists, representatives of civil society organizations (e.g. NGO's), students and farmers. However, no farmers attended the last focus group. The structure of the three focus groups was similar: they started with a short introduction of the goal, were followed by a brainstorming session in smaller groups of 4 up to 6 people, and were concluded with a larger group discussion. In the first two focus groups, the brainstorming session was organized according to the '6-3-5 brainwriting' method (Heslin, 2009; Wodehouse and Ion, 2012). This method is an idea generation technique in which participants brainstorm in silence in groups of six people, i.e. they get five minutes to write down three ideas in a concise way, after which pages are passed on to the next person in the group, who reacts to the idea, e.g. by stating agreement of disagreement, giving recommendations, formulating requirements or giving examples. In the third focus group, participants discussed their ideas in small groups to save time for the larger group discussion. After the brainstorming session, the small groups presented their top ideas to the rest of the group, and these ideas were arranged on a blackboard according to different themes, e.g. cooperatives, subsidies, labels, etc. The focus groups concluded with a large group discussion on the (dis)advantages, feasibility and the impact of different categories of proposals. After the focus groups, the data were processed. First, instruments were categorized according to the stakeholder financing the instrument, which could be (1) the government, (2) the market or (3) cooperatives and groups of people of the local community, which we refer to in this study as 'community instruments'. As for the market instruments, a differentiation was made between private actors such as companies, banks and civil society organizations benefiting from the regulating services of AF systems (sector-oriented market instruments) on the one hand, and private actors purchasing and consuming the provisioning services delivered by AF systems (consumer-oriented market instruments) on the other hand. Second, lists were made of the advantages, disadvantages and potential impact of instruments according to the respondents. This happened especially at the level of the different categories identified, although sometimes respondents attributed these characteristics to specific instruments within these categories.

In a second step, we did case study research in order to provide a more in-depth analysis of different economic instruments, and learn from the experiences of people already involved in the implementation of such instruments. We selected four case studies, one from each (sub)category that was described in the first step. These cases represent instruments that are at the moment implemented or under development, that are specifically promoting AF adoption, or creating conditions that favor the implementation of AF systems. Although cases of all categories could be found in Flanders, we selected case studies from the UK and Austria for the categories 'sector-oriented market instruments' and 'community instruments' respectively, as they represent well-established initiatives that offer better insights in success factors. Qualitative data to learn about the case studies were collected in two ways, i.e. through interviews and document analysis. Eight interviews were organized with actors fulfilling a key role with respect to the implementation, set-up or monitoring of the instruments. This included three civil society actors, two policy makers, two researchers and one farmer. The interviews happened face-to-face for the case studies in Flanders, and through telephone or mail for the case studies in the UK and in Austria. For the case studies respectively 2, 1, 3 and 2 interviews were performed, differing from each other with respect to length and deepness. For the second case study only one actor was interviewed since it was difficult to find other stakeholders involved in the project in Austria without being able to meet in person. However as this interview was quite extensive, the information provided was considered sufficient to do an in-depth analysis. The interview guide was structured based on the suitability, acceptability and feasibility (SAF) model of Johnson and Scholes (Johnson et al., 2007; Wu, 2010). This model, which is often used in the context of business management, features suitability, acceptability and feasibility as the three criteria to determine the optimal strategic choice for a company to reach a certain goal. The criteria are concerned with, respectively, (1) whether a strategy addresses the key issues relating to the strategic position of the organization, (2) whether a strategy meets the expectations of stakeholders, and (3) whether a strategy could work in practice. In accordance with the SAF model, in this study we consider the four selected instruments as possible strategic choices to reach the goal of more trees being planted on farmland. Taking this into account the criteria can be translated into the following questions: (1) how effectively does the instrument target valuable AF systems and systemic transformations at farm level (i.e. that go beyond simply adding of trees to common farming systems and imply the creation of synergies)? (2) how acceptable is the instrument for farmers?; and (3) how feasible is it to set up or implement the instrument? Since the SAF criteria are still quite broad and can be interpreted in different ways, sub-criteria were introduced which were defined based on properties that were considered relevant during the focus groups and in literature. To answer all the questions, the information that was obtained through the interviews was supplemented with information provided by documents, including agreements, reports, leaflets, brochures, etc. These sources were not analyzed in detail through coding, but were regularly consulted in order to fill-in missing gaps and to validate, i.e. triangulate, our results.

6.3 Results and discussion

6.3.1 Exploratory analysis

Table 6 - 1 shows the different instruments that were identified during the brainstorm sessions. They are categorized according to the type of stakeholder that is financing the instrument.

Table 6 - 1: Output of brainstorm sessions about potential instruments that could provide economic incentives for farmers to adopt agroforestry. The instruments are categorized according to the financing party, which could be the government, the market or the community.

	Government	***Market***		***Community***
		Sector-oriented	***Consumer-oriented***	
Type	Agri-environment schemes: • AF investment subsidy (case study 1) • AF maintenance subsidy	Payment for Ecosystem services / Emission trading schemes: • Carbon markets (case study 2) • Water quality trading • Biodiversity offsets	Standards and certification: • Carbon label • Animal welfare or quality label: e.g. Woodland eggs (case study 3) or pata negra ham	Farmer-consumer agreements: • Community Supported Agriculture • 'Adopt a tree' initiatives
	Greening measures • Ecological Focus Area	Funds and trusts • Green seats of airline companies • e.g. Woodland trust in the UK	Agritourism/ Direct marketing: • Farm shops • Farmers' markets • Vegetable/food boxes	Farmer-consumer cooperatives: • Cooperative AF business, e.g. Pomona (case study 4)
	Land incentives • Prioritizing public land for agroecology	Insurance discounts • e.g. smaller premiums for more resilient systems	Niche and specialty markets • e.g. buckthorn berries, nuts	Farmer-forester/ investor cooperatives • e.g. annual compensation for maintenance of trees
	Tax incentives • Based on the amount of trees on farmland	Interest-free loans • e.g. for investing in AF systems		Local currency systems • e.g. trading off AF produce for farm labor
Financing source	Public	Private (companies, NGO's, banks, etc.)	Consumers	Community/ Cooperative
Participation incentives	Incentive payments (/regulatory threats)	Incentive payments	Consumer demand	Benefits from cooperation

Government schemes include all instruments that are financed by the government, i.e. with public money. The most traditional instrument in this category is an AF subsidy program (see case study 1), in analogy to other agri-environment schemes. Besides the subsidy for AF systems, also support is granted by the VLIF (the Flemish Agricultural Investment Fund) for non-productive investments such as hedgerows and tree rows, covering up to 100% of investment costs. Another, more innovative idea is a land incentive program, in which publicly owned farm land is prioritized for sustainable farming systems. This implies that the lessor of the land, e.g. provinces, municipalities or church administrations, lowers the rent charged to the farmer on the condition that the land is farmed in a sustainable or agroecological way, or even imposes sustainable farming through an 'environmental clause' in the contract. Not only taking into account publicly owned farmland, the government could also impose sustainability conditions on farmers' practices and management approaches in exchange for financial support. In Europe, this concerns, amongst others, the greening measures on arable land in the context of the current Common Agricultural Policy (CAP), resulting in farmers losing some of their basic payments in the case of non-compliance. Another government measure, which could increase the uptake of AF systems more directly, are tree density-based tax incentives for farms, in line with forest property tax incentives in the US (Locke and Rissman, 2012). However, voluntary approaches are considered by the respondents as more appropriate and effective (Segerson, 2013), especially taking into account the former promotion of scale enlargement and land consolidation processes, incentivizing in the opposite direction.

Market schemes include instruments that create a market for regulating and cultural ecosystem services, or use existing and new market channels to reward farmers for value creation through AF practices. Based on the financing source, they can be divided into sector- and consumer-oriented schemes. *Sector-oriented schemes* include all instruments in which private actors like companies, civil society organizations and banks incentivize farmers to plant trees on their land. This includes emission trading, an arrangement implying financial transfers between companies as environmental polluters, and farmers as implementers of environmental mitigation measures. Carbon markets, in particular, could provide incentives for AF systems because of the large potential of trees to store carbon (both in their biomass and in the soil) and hence mitigate climate change (Hernández-Morcillo et al., 2018; Pardon et al., 2017). The government could oblige companies to participate in these markets by issuing compulsory tradable permits (Holderieath et al., 2012). However, respondents argued that, given the high negotiation and enforcement costs involved, in the short term, the establishment of voluntary funds and trusts for tree plantation on farmland might be more effective (Cappon and Leinfelder, 2008). An example of the latter are green surcharges of airline companies, through which they allow passengers to compensate for the generated carbon emissions (Chen, 2013). Respondents also believed banks have a role to play by offering interest-free loans to farmers to invest in agroecological farming systems, among which AF systems. Insurance companies on the other hand could lower insurance premiums for AF systems as robust and resilient farming systems (Müller et al., 2017).

Consumer-oriented schemes are a group of marketing approaches that persuade the consumer to pay a higher price for an added-value product. In the case of AF systems this added value could e.g. be the wide range of ecosystem services potentially delivered throughout the production process. Labels, which attract consumers' attention on a product's special attributes, belong to this group of approaches (Amstel et al., 2007). In some EU countries these labels already exist, e.g. 'woodland' eggs in the UK, 'Label Rouge' in France or 'pata negra' ham in Spain, reflecting especially animal welfare and quality aspects. Also direct marketing approaches that bridge the gap between producers and consumers are considered valuable, and a way to transfer the extra production costs directly from consumer to producer. In this respect, because of its landscape value, AF systems are boosted especially by farm shops, which imply consumers passing by and stopping over at the farm (Barbieri and Valdivia 2010a, b). Finally, respondents emphasized the importance of the development of special markets for niche and specialty products (Gold et al., 2004), such as developing market outlets for e.g. buckthorn berries. The same is true for products which are not new, but for which hardly any formal value chains exist yet in Flanders, as is the case for different kinds of nuts.

Community-based schemes bundle a range of initiatives that imply the formation of a community or a cooperative structure that will finance or invest in AF systems. The best known example of such a structure is community-supported agriculture (CSA), in which harvesting shares for a season are sold to a community of consumers. Although CSA's may be arranged in different ways from a practical point of view, e.g. including self-harvesting by the consumers or not, they always have in common that risk is shared between the farmer and the consumers purchasing the harvesting shares (Bloemmen et al., 2015; Vanderveken, 2016). Although often (fruit) trees are planted on a CSA farm, they are not assigned a central role. This is different for Pomona, a citizen cooperative initiative that was recently established in East-Flanders (Belgium) specializing in AF systems. Less binding agreements could also exist, in which families adopt a fruit tree and later on are allowed to harvest the fruits. Two farmers can make similar agreements when one of them allows the other one to plant fruit trees on his or her farmland on the condition that the fruit harvest is shared between them. A cooperative agreement can also be arranged between a farmer on the one hand, and a forester or an investor on the other hand, the latter taking care of tree management or annually compensating the farmer for the labor involved. To further stimulate local value generation, local currency systems could be designed, in which AF products can be traded off against local services (Hudon and Lietaer, 2006; Mauldin, 2015). These ideas however are rather outside the box, and need careful planning before they can be implemented in practice.

6.3.2 Case study analysis

In the next few paragraphs, the different case studies are presented and analyzed. The results are summarized in Table 6 - 2.

Agroforestry plantation subsidy

The first case study concerns the AF plantation subsidy (BLS, i.e. boslandbouwsubsidie) as defined within the CAP (sub-measure 8.2, previously measure 222), and implemented in Flanders since 2011. It is financed for 50% by the Flemish government, and for 50% by the European Agricultural Fund for Rural Development, therefore belonging to the category of the government schemes. At the moment, the plantation subsidy implies a reimbursement of 80% of the plantation costs if several conditions with respect to the agricultural plot (e.g. minimum surface area of 0.5 ha, farmer is owner of the plot or has written permission of owner to implement AF) and the AF design and management (e.g. homogeneous tree distribution, tree density between 30 and 200 trees/ha, trees have to be maintained for at least ten years) are met (Departement voor Landbouw en Visserij, 2018). Although the original objective of the Flemish government was to establish 250 ha of modern AF through this subsidy program by the end of 2013, from 2011 until 2013 merely 32.2 ha of AF was established. The objective of the new program period (2014–2020) is to establish 300 ha, but taking into account that between 2014 and early 2018 an extra 94.4 ha was planted, also reaching the target surface area in 2020 seems to become difficult.

With respect to *suitability*, the plantation subsidy stands out because it is the only instrument that directly targets AF as a farming system in Flanders. However, it is also the only instrument that allows AF as an incremental measure, i.e. adding trees to an otherwise conventional farming system. Many farmers interpret AF as such, and evaluate AF systems according to the standard performance measures of conventional farming systems (instead of more systemic and holistic measures which would be more relevant in the case of agroecological systems), which contributes to the limited appeal of the subsidy program among farmers. *Acceptability* is considered less of a barrier, although sometimes the terms and conditions are not flexible enough from an administrative or sylvicultural point of view. Nevertheless, because of European funding involved, it is not easy to set-up, arrange or adapt its terms based on feedback from the bottom-up. Its *feasibility* is proved by the successful set-up of the subsidy program in 2011 and its continuity since then. Overall, the subsidy program is an instrument that may persuade farmers that got inspired by AF to try it out, or experienced pioneers to plant another plot, but it is not considered as an instrument that will convince the average farmer. The acceptability and feasibility results of this case study can be extrapolated to the other instruments belonging to the group of government incentives. However, this is not true for suitability: with the exception of the AF maintenance subsidy, the other instruments in this category do not target AF as a farming system, but rather the values that are generated by AF systems.

Table 6 - 2: Comparative analysis of case studies according to the SAF model

	AF subsidy	***Humusaufbau***	***Woodland eggs***	***Pomona***
Mechanism	80% of costs of plantation are reimbursed to the farmers, which is funded for 50% for the European Agricultural Fund for Rural Development (Submeasure 8.2 in Pillar II of the CAP).	Farmers receive carbon certificates (of a value of 30€/ton CO_2), payed for by companies, for the extra carbon they store in farmland.	Price-premium brand for eggs produced by hens having access to a free range with > 20% tree cover.	Cooperative farm with a focus on agroforestry as a farming system, of which farmers and consumers are shareholders and in which decisions are made collectively.
Where and when?	Flanders, since 2011	Austria, since 2009	UK, since 2004	Flanders, since 2018
References	Departement voor Landbouw en Visserij, 2018	Ökoregion Kaindorf, 2018	Burgess, 2017; Sainsbury's, 2018; Smith, Gerrard, & Westaway, 2016	Bauwens et al., 2018
Suitability (How effectively does the instrument target valuable AF systems and systemic transformations at farm level?)				
Target values	Environmental, social and productive	Environmental, climate change mitigation	Animal welfare	Human and environmental health, social equity and righteousness
Target farming system	AF systems that comply with the AF definition as stated by regulation, i.e. with a surface area of min. 0.5 ha, a tree density between 30-200 trees/ha, a uniform tree distribution, and excluding conifers, short rotation coppice and some potentially invasive exotics	Farming systems that maximally store carbon, AF no yet targeted as a measure.	Free range area with dispersed trees and shrubs offering protection against weather and predators	Polycultural systems with perennial plants, often fruit and nut trees, with a lot of biodiversity and landscape value
Target farm transformation	Subsidy allows tree planting as an incremental measure	Agroecological transformation in a narrow sense (i.e. implementation of set of practices)	Implies system thinking since tree planting affect bird health and egg quality and yield	Agroecological transformation in a broad sense (i.e. embedding food systems locally)

Target farmers	Farmers interested in AF systems	Farmers concerned with climate change, and interested in sustainable farming practices	Poultry farmers with a free range	Farmers concerned with the functioning of the agri-food system, willing to share decision-making and open up the farm, and possessing leadership and communication skills, often new farmers without land
Acceptability (How acceptable is the instruments for farmers?)				
Certainty	After approval and control, reimbursement of 80% of investment costs is certain	Financial rewards are results-based, and thus uncertain	Fixed price premium	Radical change in farm model resulting in high uncertainty
Flexibility	Limits to eligibility and many preconditions	Flexibility with respect to which measures are implemented.	Flexibility with respect to design as long as sufficient cover is created	Very high flexibility with respect to design and management, at least if supported by the cooperative
Implementation difficulty	A file needs to be submitted with details of AF plantation and estimated costs	Soil samples need to be taken to measure the initial carbon content	Initial investment and plantation costs may be high	Brainstorming about and developing the cooperative requires a lot of thought and effort
Compatibility	Management of trees requires extra labor, but no significant changes at farm level are necessary	Different carbon capture measures need to be combined, affecting different aspects of farming.	Higher risk on hens staying and laying their eggs outside	Sharing decision-making may imply radical changes at both farm-technical and -economic level
Feasibility (How feasible is it to set-up the instrument?)				

Financial feasibility	Financially feasible if small planting material is used	It is challenging to find enough sponsors	It is not evident to create sufficient demand for added-value eggs with a higher price	It is challenging to find enough shareholders, because of the rigid format of the food boxes, the high initial lump sum and the required long-term commitment
Administration, governance and control	Instrument set up by the government, responsible for applications and controls	Instrument set up by the regional government, which act as a coordinating and controlling unit	Instrument set up by food retailers and supermarket chains, conducting compliance controls	Instrument set up by the cooperative itself, cooperative coordinates and controls
Infrastructure and capacity	Concept of agricultural investment subsidies well known and frequently implemented	Dense networks of farmers and potential certificate buyers are necessary but not yet existing	Concept of labels is well known, but in Flanders there are no general labels that position themselves in between conventional and organic	Because of their innovativeness cooperative farms may encounter a lot of problems. Capacity has to be built up by the cooperative itself.
(Potential) effect on agroforestry adoption in Flanders	Instrument that may persuade pioneers but not easily the majority of farmers	Instrument that may attract a larger share of farmers to invest in greening, on the condition that networks of farmers and sponsors are created	Instrument that may convince poultry farmers with a free range to plant trees, in case there is consumer demand	Instrument that may result in very valuable farming systems supported by the community, but may fit only a limited amount of farmers

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Humusaufbau project

The second case study is 'Humusaufbau' ("humus formation"), a carbon-trading initiative in Austria, which was established by the association Ökoregion Kaindorf. With the 'Humusaufbau' initiative, Ökoregion Kaindorf engages in climate change mitigation by incentivizing farmers to sequester more carbon in farmland. This is possible through the implementation of good farming practices like the application of compost or manure (instead of chemical fertilizers), the adding of Mycorrhiza (instead of fungicides), low or no tillage, the use of catch crops, the rotation and mixing of crops, etc. For each additional ton of CO_2 that farmers have sequestered during periods of three to seven years, measured through soil samples, they receive a carbon certificate that is worth 30 €. Taking into account that an organic matter enrichment of 3% at 25 cm soil depth corresponds with an extra 125 tons of CO_2 stored in the soil, the potential gain of farmers participating in the project can be large (Ökoregion Kaindorf, 2018). The carbon certificates, plus an additional fee for the administration involved, are payed for by sponsors. These are mostly companies emitting CO_2, but willing to underscore their focus on sustainability and their aspiration to be carbon-neutral by buying these certificates, creating in this way a competitive advantage. Ökoregion Kaindorf acts as a middleman by connecting farmers and sponsors, and is also responsible for administrative tasks and the organization of networking activities. In Austria around 200 livestock and arable farmers are participating in the project, corresponding to 2500 ha of agricultural land that is cultivated in a sustainable way.

The *suitability* of the Humusaufbau project centers around one specific value that is delivered by AF systems, i.e. carbon sequestration. To generate this value, multiple measures are conveyed to farmers. This includes the mixing of crops but not (yet) the mixing of trees and crops. This while AF was identified by Aertsens et al. (2013) as the agri-environment measure with the highest potential of storing carbon in agricultural land. Because of the wide range of measures the farmers can choose from, the instrument scores at first sight high on *acceptability*. However, financial rewards are results-based, which steers towards maximal efforts but brings along uncertainty for farmers. On the upside, farmers are encouraged to implement different measures at the same time, stimulating as such an agroecological transformation at farm level -all be it a narrow one because of the unilateral focus on carbon sequestration in the soil. The most important barrier comprises the organizational and financial *feasibility*, which is hampered in Flanders by the fact that currently no networks exist between farmers and sponsors that are willing to invest in carbon sequestration. The case study is exemplary for the other sector-oriented market mechanisms in the sense that the greatest challenge lies in feasibility, i.e. to find people to set up and finance the instrument. However, once established, they have the potential to attract the attention of a larger share of farmers, which should be encouraged to not only opt for the most straightforward measures.

'Woodland eggs' brand

The third case study is 'Woodland eggs', a brand for eggs that are produced by hens having access to a free range with at least 20 % tree cover. This improves animal welfare, since chickens prefer an environment with a dense vegetation, which provides shelter against adverse weather conditions and aerial predators (Stadig et al., 2016). In addition, the better use of the free range by laying hens may also result in better quality eggs, with a higher nutrient content and a stronger shell (Bright and Joret, 2012; Perić et al., 2016). In the UK, 'Woodland eggs' have been marketed by different retailers and supermarket chains, such as respectively the 'Happy Egg Co' and 'Sainsbury's'. Besides through the 'woodland eggs' brand, tree planting in the free range of poultry is also stimulated in the UK by the 'RSPCA animal welfare standards' (i.e. the Freedom Food label), which prescribe that at least 5% of the free range area should be covered with trees (RSPCA, 2017).

When assessing *suitability*, it is worth noting that the 'Woodland eggs' brand does not only target one specific value, i.e. animal welfare, but also one specific group of farmers, i.e. poultry farmers with a free range (although in theory all soil-based farmers are allowed to participate). This should not limit its applicability though, with other brands and labels targeting different values such as taste superiority and landscape quality among different groups of farmers. Furthermore, the instrument induces a certain amount of systems' thinking in farmers since the planting of trees may affect bird health and egg quality and yield. With respect to *acceptability*, farmers should thus not underestimate compatibility with the remainder of the farm. Nevertheless, overall the instrument scores relatively well on this criterium with a fixed price premium for the woodland eggs and a high flexibility with respect to the AF design in the free range. Conversely, the price premium for farmers lowers the financial *feasibility*, as sufficient demand has to be created for value-added, more expensive food products. Although Flemish consumers are increasingly concerned about environmental impact and animal welfare, their purchasing behavior does not automatically change (Departement Omgeving, 2018). Nevertheless, at least in the UK and the Netherlands, this barrier seems surmountable with general welfare labels that prescribe a certain amount of tree or shrub cover in the case of free-range poultry (e.g. the RSPCA label and the 'Beter Leven Keurmerk'). The generated insights can be readily translated to other brands and labels. However, the other instruments belonging to the consumer-oriented market instruments, i.e. agritourism, and niche and specialty marketing, score lower on acceptability, as the farmer personally has to organize sales, but conversely higher on feasibility, because they depend less on the cooperation of other parties.

Pomona

The last case study is Pomona cvba, a cooperative AF farm that was recently (spring 2018) established in Flanders. The founders got inspired on the one hand by Mark Shepard's perennial AF farm in Wisconsin (Shepard, 2013) and on the other hand by the farm model of the 'Herenboeren' in the Netherlands, a cooperative farm in which farmers and consumers are shareholders and in which important decisions are made collectively. Making use of this farm model and approach, the founders want to address the different environmental and social challenges in agriculture from a grassroots level. At this moment Pomona is still looking for consumers to become shareholders in the cooperative, until around 200 families - corresponding with about 500 people - are involved. This amount of consumers corresponds with a farm surface area of 20 ha, which is supposed to be the minimal surface area necessary to keep the farm functioning in a circular way, without bringing in organic material from outside of the system. By joining forces with one of the first AF pioneers in Flanders with 14 ha of farmland, including several AF plots, Pomona already came into operation, however, the remaining farmland still has to be acquired by the cooperative. These kinds of investments are paid for by the consumers, who pay a lump sum when becoming shareholder in the farm. In addition, consumers pay a weekly fee in exchange for weekly food boxes, which should cover about 80 % of the needs of the shareholders when the farm is fully established. With this money, the other costs of the cooperative are paid, including a proper wage for the farmer.

With respect to *suitability*, the cooperative farm Pomona stands out for the agroecological transformation it induces in a broad sense, i.e. not only through the implementation of sustainable practices (often going beyond those encouraged by Humusaufbau, e.g. striving towards circular economy at farm level, an increasing amount of perennial plants, etc.) but also in its striving for a better and fairer food system that is locally embedded. However, sharing decision-making could imply radical changes at farm-technical and -economic level, which has its consequences for *acceptability*. Besides the uncertainty and risk, especially the establishment and management of the cooperative farm model, which both involve a lot of brainstorming, negotiation and coordination efforts, may deter interested farmers. However, if farmland is purchased by the cooperative, the prospect of land may compensate for the low acceptability. This creates especially opportunities for the increasing group of new farmers with a background outside of farming and thus without land (Rodrigo and Rioufol, 2017). However, *feasibilit*y may still be the hardest hurdle to take. In this respect, Pomona struggles especially with the financial feasibility, i.e. finding enough shareholders that are willing to pay the lump sum and whose lifestyles and family situations fit the quite rigid format of the weekly food boxes. However if farmers and consumers are on equal footing, it could result in very valuable AF systems, which deliver a wide range of ecosystem services to society. This is also true for the other instruments belonging to the category of the community instruments, although acceptability and feasibility depend on how widely the concept is elaborated, and the extent to which it is already implemented in practice. Community instruments may also vary in the extent to which they specifically target AF systems, an aspect in which Pomona may outperform other community instruments.

6.3.3 Insights and policy recommendations

Combining and upscaling these results delivers important insights. First, this research indicates that only few of the potential economic instruments encouraging AF adoption are in place in Flanders. Moreover, at the moment, the focus in Flanders is especially on some mechanisms which are financed by the government and directly target AF systems, such as the subsidy program and the greening measures (Borremans et al., 2016; Van Vooren et al., 2016). However, insufficient attention has been given to economic instruments in which AF is used as a tool to reach broader sustainability goals (Borremans et al., 2018; Ovando et al., 2016). Many stakeholders overlook the role AF can play in this regard, and only take into account the productive services and direct subsidies when assessing AF as an investment. In this respect, AF should be conveyed and communicated to a larger extent than is happening today, as a tool to generate value and reach a variety of sustainability goals. This is possible by building it into and tailoring it for new sustainability pathways. It should be noted that, if AF pathways are to work effectively, i.e. stimulate AF adoption rather than other farm interventions to reach a certain sustainability goal (e.g. carbon sequestration in the Humusaufbau project), the instrument and the AF system, respectively from an economic and an agricultural point of view, should not be developed separately of each other. Moreover, the AF system should be developed to maximize the values targeted by the economic instrument; whereas the economic instrument should be developed taking into account the agronomy of AF systems. This is possible by creating space at different levels, e.g. with respect to research, legislation and regulation, market creation and network formation. In the Netherlands this is done through 'Green Deals', i.e. initiatives for green growth in which government and society collaborate interactively from the outset, among others to guide policies on societal challenges (Ministry of Economic Affairs, 2016). The central idea is thus that the government facilitates and accelerates initiatives by removing barriers. Meanwhile in the Netherlands already more than 208 Green Deals have been implemented, of which 30 about food production. Because of its success, the 'Green Deal' concept was recently translated to a Flemish context (Departement Omgeving, n.d.), where it could help to bring the different instruments that were identified into practice.

Second, we found that the different instruments differ widely with respect to suitability, acceptability and feasibility. These differences make them complementary and reinforcing, since their respective strengths can be used to eliminate barriers. We give an example: the biggest challenge for Pomona as a cooperative is to find enough shareholders who are willing to pay the quite substantial lump sum. This money is necessary to pay investments, of which the largest and the most important one is the acquisition of farmland (Verhoeve et al., 2015). This is preferred over land renting because of the long-term character of AF systems. The lump sum that is requested of shareholders in 'Herenboeren' is substantially lower. This is due to the fact that the 'Herenboeren' are allowed to rent 20 ha of agricultural land, which is part of a landscape park owned by the 'Margraff' foundation. This foundation gave 'Herenboeren' the certainty that they can rent the land for many years into the future, and this against favorable conditions because of their innovative approach and focus on sustainability (Van Vijfeijken, 2015). There is an increasing attention for this kind of instruments, in which local governments safeguard publicly owned farmland for sustainable farming initiatives ('land incentives'), or in which land is acquired through crowdfunding and rented out on a long-term basis to agroecological or organic farmers ('funds and trusts') (Rodrigo and Rioufol, 2017), as is done in Flanders by the foundation 'De Landgenoten' (2017). Another example of how different instruments could reinforce each other is given by the 'Woodland eggs' case study. Although the brand 'Woodland eggs' is used by different retailers and supermarket chains, Sainsbury's is the most famous one in the context of AF. This has to do with their partnership with the Woodland Trust, the largest woodland conservation charity in the UK, concerned with the creation, protection and restoration of native woodland heritage, both in forests and on agricultural land. Their partnership, which exists since 2004, implies that for each dozen of 'Woodland eggs' that is sold, one pence is donated to the Woodland Trust (Burgess, 2017). This is multiplied with a factor 2 and 10 for respectively broiler chickens and turkeys raised under trees (Smith et al., 2016). In December 2017 already more than 7 million pounds of income were raised in this way for the Woodland Trust, with which already more than 3 million trees were planted, among others on farmland. The consumers thus stimulate the development of AF in two ways, i.e. by financing existing AF initiatives but at the same time contributing to the establishment of new AF projects. This may improve again the acceptability of other AF projects, which do not qualify for the AF subsidy program, e.g. because of an innovative plating design of which initial tree density exceeds the maximal amount of 200 trees/ha. In this way, the partnership with the Woodland Trust clearly reinforces 'Woodland eggs' as a branding and marketing tool.

6.4 Conclusion

Through exploratory brainstorm sessions, we found that a wide range of instruments – financed by either the government, the market or the community – could be developed to give economic incentives to farmers to adopt AF systems. Then, by comparing four case studies, we uncovered how diverse instruments differ widely in terms of suitability, acceptability and feasibility. Combining and upscaling the results, showed (1) that insufficient attention has been given to instruments, which target AF indirectly, i.e. by using it as a tool to generate value and reach certain sustainability goals; and (2) that instruments have different strengths, which may complement and reinforce each other mutually. We conclude that creating space for further development and tailoring of AF pathways can help to turn AF into a more solid economic agricultural system for farmers.

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Chapter 7

Discussion

In the first part of this discussion chapter we integrate the results of the previous chapters according to the five development pathways as presented in chapter 4, i.e. the science and technological pathway, the market and financial pathway, the policy and institutional pathway, the educational and organizational pathway and the social and behavioral pathway. In this way, we answer the last research question, i.e. which pathways have to be followed to give incentives for the breakthrough of AF systems in Flanders? In the second part of this discussion chapter we reflect on agroecological transformations, farming systems research, and the contribution of this thesis to temperate AF literature. These are three topics about which important insights were gained throughout this thesis.

7.1 Introduction

Although temperate AF often do not convince on all fronts, it is increasingly recognized as a farming system that has the potential to address different challenges in modern agriculture. Moreover, it is interpreted as an agroecological innovation that may improve the total amount of ecosystem services delivered to farmer and society, and the local embeddedness of the farm. In this way, AF systems may form part of the solution to a better and fairer food system. However, despite its opportunities and the subsidy program that was established to minimize plantation costs, adoption of AF systems by farmers in Flanders remains limited. To address this, in 2014 a systemic, interdisciplinary and participatory research project was set up (CH 1). As part of this project, this thesis bundles the insights related to AF adoption and development with FSR as central thread. In this respect, the central research objective of this thesis is to gain a better understanding of the unfavorable environment for AF adoption and development making use of a farming systems research approach.

This general research objective was translated into four research questions:

RQ 1 – APPROACH:	***How can we study AF adoption and development making use of a farming systems research approach?***
RQ 2 – DIAGNOSIS:	***Why do AF systems, despite their societal values, currently not break through in Flanders?***
RQ 3 – DESIGN:	***Which specific organized or market-based governance models can foster AF implementation by using the benefits of AF to create value for society?***
RQ 4 – PATHWAYS:	***Which pathways have to be followed to give incentives for the breakthrough of AF systems in Flanders?***

We address **RQ 1** in CH 2, by presenting FSR as our central research approach. Then, we answer **RQ 2** throughout CH 3, 4 and 5. In CH 3 we give a first overview of the current state of AF adoption and development in Flanders. Then, in CH 4, we use the Agricultural Innovation System (AIS) concept to analyze the development of AF in a more integrative and holistic way. Last, in CH 5, we create additional insights by digging into the different perspectives that exist among stakeholders in Flanders. We go from diagnosis to design in CH 6, and address **RQ 3** by looking into a wide range of institutional and economic instruments that can give incentives to farmers to adopt AF. Finally there is **RQ 4**, which we address in the next section of this discussion chapter. As centerpiece of this chapter it brings together the results and insights from the previous chapters, while at the same time giving recommendations for the different stakeholders involved. After this main section, we make some reflections about agroecological transitions, the research approach and the contributions of this thesis to temperate AF literature.

7.2 Development pathways and recommendations

The idea to center our discussion around different development pathways is inspired by CH 4. In this chapter we look into adoption and development from an agricultural innovation systems perspective, thus in a holistic and integrative way. It differs from CH 5 and 6, which zoom in on one specific aspect, and provide the reader depth rather than a general overview. In this section, we give a broader and deeper perspective by combining the insights generated in all research chapters and structure them according to the development pathways. These were identified by clustering the outcomes of the structural-functional and structural-transformational analysis according to five different themes: (C1) science and technology, (C2) market and finances, (C3) policy and institutions, (C4) education and organization, and (C5) sociology and behavior. In this way, we address the last research question:

RQ 4 – PATHWAYS: ***Which pathways have to be followed to give incentives for the breakthrough of AF systems in Flanders?***

With this section, we try to give more than just a summary of our findings. Per pathway and thus per theme the different insights gained throughout the thesis are pooled and compared to literature. This will result in recommendations to advance AF development in Flanders, which will be specified for the different stakeholder domains involved.

7.2.1 The science and technological pathway (S&T)

The science and technological pathway centers on the creation of knowledge about the agronomic and ecological effects of AF systems in the context of Flanders. It also focuses on the translation of this knowledge into tools that make AF easier to perform.

The need for more knowledge and tools is already demonstrated in CH 3. Making use of a questionnaire (involving 86 respondents), we found in CH 3 that most farmers consider competition for light, reduced crop production and increased tillage difficulties as serious problems to be expected in AF systems. In CH 4 we explain that also the Flemish context, with its high pressure on land, beneficial climate and fertile soils does not favor AF systems. Combining the insights of both chapters, it seems that a lack of knowledge on the agronomic and ecological effects of AF and a lack of the compatibility of AF systems are important matters of concern for the further development of AF in Flanders.

The AF project looked into these barriers by focusing its research on the collection of quantitative field data and largely qualitative socio-economic data. Whereas the socio-economic data are mainly presented in this thesis, the agronomical and ecological results are presented in the thesis of Pardon (2018). Based on measurements in the field, Pardon (2018) found that the presence of a row of poplars on agricultural fields significantly increases the soil nutrient stock, and that an increase of 7 ton of soil organic carbon can be expected in a silvoarable poplar field after a rotation of 25 years. Pardon (2018) also looked into the effect of a tree row on the abundance and diversity of potentially beneficial arthropods in arable AF systems. He found a large increase in the abundance and species richness of isopods in the tree row as compared to the arable zone, a similar but smaller trend for millipedes, but mixed effects for carnivorous arthropods. Last, Pardon (2018) studied the effect of tree row presence on crop yield and quality. He found that for a distance of 2.5 to 12 m from the trees relative yields, when compared to treeless control zone, varied between 85 and 35 % for maize, 94 and 61 % for winter wheat, and 93 and 86 % for winter barley. Also the quality of the crop was in general lower than in the arable zone. The loss in crop yields is partially compensated by the woody biomass produced by the trees, as such Pardon (2018) found the Land Equivalency Ratio for a virtual poplar AF field to be between 1.01 and 1.12. Overall, the research of Pardon (2018) shows that indeed, several soil- and biodiversity-related benefits can be expected, but that the impact of the tree row on crop productivity can be substantial. In order to minimize these effects, a well thought-out design and crop rotation plan seems to be essential, which requires knowledge that should be gained throughout further research.

The current AF project also goes beyond research in the participatory change and knowledge diffusion clusters (Figure 1 - 6). As part of the participatory change cluster, extension agents offer currently free advice to pioneers regarding AF design and management. These extension agents have access to the newest data collected in the context of the research cluster, which they can use in the context of extension. At the same time, extension agents transfer the most important obstacles for and issues of farmers to the research cluster, on the basis of which research priorities within the project are being set. The AF project thus seems to a first good step towards the construction and pooling of AF expertise, and making it easily accessible for farmers. Also for other agroecological practices, whose developments may affect AF adoption, similar projects are being set up. Nevertheless, we have to keep in mind that most agricultural researchers remain in their activities still very far from agroecology or diversified farming systems.

To further support AF research and AF adoption by farmers, the **science and technology pathway** thus has to be further developed. This stands for investing in more AF research, especially targeting the productivity and compatibility of AF systems, and this in active collaboration with farmers. Core functions that have to be strengthened are knowledge development and diffusion, the mobilization of resources and the creation of legitimacy. Whereas the **research and education domain** has a central role in all of these functions, support from the other domains in the development of the pathway is indispensable. The roll-out of the science and technology pathway may include:

- The **funding and setting-up of new participative and transdisciplinary research projects** that incorporate AF and other agroecological principles. In November 2018 the AF consortium submitted a new VLAIO project proposal on AF, that would start in 2019 if accepted, and thus would follow-up the current AF project. The project consortium made the project even more participatory and transdisciplinary than the current one, by collaborating with new research institutes and extension centers, and by giving the farmers an active steering role by letting them operate as project ambassadors. In the project there will also be room for action-research by exploring the potential of some of the economic instruments more in detail and to initiate a process to put them into practice. Also in other agricultural research projects, researchers have to be encouraged to integrate trees and other agroecological practices into their experiments, even if agroecology is not their main topic of interest.
- The **development of tools and applications that help in AF planning, design and management**. Within the current AF project, a web-based decision support system is being developed, that may help farmers and extension agents in the design and management of AF systems. In the South-East of the US a similar kind of application was developed to help in the evaluation of potential sites and suitable tree and shrub species for AF planning (Ellis et al., 2005). Also the development and distribution of machines that are tailor-made for AF systems could incentivize farmers to adopt AF. This may be important for AF opportunists for which AF is at the moment only possible on large-scale plots and with mechanization. But also in the context of fruit and nut orchards specialized machines for collecting the fruits or nuts may be of use, because especially the high labor costs to collect the fruits or nuts make standard orchards at the moment often not financially viable.
- The **creation of long-term experimental AF fields**. In the context of the current AF project, data collection happened on fields of real farmers. However, because of a lack of appropriate AF fields in Flanders, especially in the older age categories, also fields with one tree row on the border were selected in the sample. In this respect,

long term experimental AF fields which are created and managed for scientific purposes, as at the University of Illinois in the US and the Restinclières domain near Montpellier, have their advantages and value (Dupraz, 1998; Lovell et al., 2017). In practice though, these long-term experimental fields are difficult to establish and maintain because of limited project time and funds.

7.2.2 The market and financial pathway (M&F)

The market and financial pathway focuses on economic instruments that turn AF into a more profitable option for farmers. The market and financial pathway thus wants to address the low profitability of AF, which is often considered as the most important barrier holding back AF adoption by farmers.

In CH 1 an overview is given of the surface area of AF planted with the subsidy program from 2011 up to 2017 (Figure 1 – 4). It shows that the amount of applications and the corresponding AF acreage is increasing steadily from year to year. However, despite this increase, the current total surface area of 126.6 ha remains a negligible fraction of the farmland in Flanders. Taking into account the conceptual opportunities of AF, AF adoption thus is lagging behind. The low adoption of AF in Flanders is often related to the uncertainty about the profitability of AF systems for farmers in a conventional farming context. Although also the profitability of other diversified or agroecological farming systems is questioned, AF systems stand out because of their long rotation times. These greatly exceed the usual planning horizon of traditional farming systems and therefore increase the uncertainty and financial risk for farmers.

We can find evidence for this in the profiles of the current AF adopters. We learned a little bit about these adopters in CH 3, but the focus in this chapter is more on the types and characteristics of the AF systems implemented, and to a lesser extent on the profiles of the adopters themselves. However, over the course of the AF project, we have met and talked to a lot of these pioneers, and gradually got to know them better. We did not analyze their profiles more in-depth, however, they seem to be very well described by the 'innovator' adopter category, one of five adopter categories outlined by Rogers (1962). According to Rogers (1962), a central characteristic of innovators is venturesomeness, i.e. eagerness to try out new ideas, which leads them out of a local circle of peer networks and into more cosmopolite social relationships. However, being an innovator has according to Rogers (1962) also two prerequisites, which is (1) control of substantial financial resources to absorb the possible loss owing to a profitable innovation, and (2) the ability to understand and apply complex technical knowledge. This coincides largely with our view of the profile of AF pioneers: they operate in different social networks than the average farmer, they have problem-solving capabilities and practical insights, and they often have enough financial leeway to absorb a possible failure. In the context of this market and financial pathway, especially the latter prerequisite is important. Taking into account the successive crises in agriculture, there are few farmers that have the necessary financial buffers to accept this financial uncertainty and experiment with trees.

The apparent lack of profitability for farmers is also a result of the way in which agricultural markets function, only allowing for the valorization and trading of specific goods and services. Moreover, agricultural markets taking into account the complete range of ecosystem services would thus benefit AF as a multifunctional farming system to a much larger extent. At the moment though, investing in AF systems thus only becomes economically interesting when there is enough demand for agroecological products from consumers, which is growing but still very small in Flanders. Also intermediaries such as supermarkets are unfamiliar with its concept, this while they can exert large influence on public demand through orienting and stimulating signals. Support can also not be expected from agribusinesses at the supply side or private investors, because of the low potential of AF to generate profits.

It is clear that the **enterprise domain** needs to be engaged to work together with the other stakeholders on a real **market and financial pathway** for AF systems in Flanders. To achieve this, functions that have to be reinforced are commercial experimentation, the mobilization of resources and market formation. In CH 6 we further focused on the design of the market and financial pathway, by exploring and evaluating the potential of different instruments to generate financial incentives for AF adoption. Four categories of incentives were identified, financed respectively by the government, the sector, the consumer and the community. By zooming in on one case study of each category, and comparing them with respect to suitability, acceptability and feasibility, we found that the different categories of instruments are complementary and reinforcing. To reach out to and convince as many farmers as possible, we thus have to put each one of them into practice. Not taking into account the role of the government (which is explained as part of the policy and institutional pathway), commitment to the market and financial pathway implies:

- The **development of sector-oriented market instruments**, which are instruments financed by actors like companies, civil society organizations and banks. This includes emission trading, an arrangement implying financial transfers between companies as causers, and farmers as mitigators of environmental pollution. However, given the high negotiation and enforcement costs involved, the establishment of voluntary funds and trusts for tree plantation on farmland may be more effective in the short term. Banks and insurance companies could also play a role in the financing of AF systems by offering interest-free loans and by lowering insurance premiums for AF as robust and resilient farming systems.

- The **development of consumer-oriented market instruments,** which are a group of marketing approaches that persuade the consumer to pay a higher price for an added-value product. Labels, which attract consumers' attention to a product's special attributes, belong to this group of approaches. Also direct marketing approaches that bridge the gap between producers and consumers are considered valuable and a way to transfer the extra production costs directly from consumer to producer. Finally, special markets for niche and specialty products, e.g. buckthorn berries, should be developed . The same is true for products which are not new, but for which no formal value chains exist yet in Flanders, as is the case for different kinds of nuts.
- The **development of community instruments**, which bundle a range of initiatives that imply the formation of a community or a cooperative structure that will finance or invest in AF systems. The best known example of such a structure is community-supported agriculture (CSA), in which harvesting shares for a season are sold to a community of consumers. Agreements could also be more binding, as is the case for Pomona, a cooperative farm specializing in AF systems, or less binding, e.g. arrangements in which families adopt a fruit tree and later on are allowed to harvest the fruits. Finally, local currency systems could be thought out, in which AF products are traded off against local services.

7.2.3 The policy and institutional pathway (P&I)

The policy and institutional pathway is centered on the creation of a more enabling institutional and policy environment for AF, in which governmental actors have a central role to play through regulation and the allocation of grants.

In CH 3, we explained that the subsidy program can address the low profitability, which is considered one of the most important barriers holding back AF adoption. However, in CH 6 we found that the subsidy program does not convince farmers to launch themselves into AF. Thus, the subsidy program is an instrument that may persuade pioneers, but not the average farmer. Furthermore, it is often criticized that there is no subsidy for maintenance of AF systems, which would hold back farmers to a larger extent than the initial plantation costs.

Also the current legal landscape for AF still has room for improvement. In this respect, we found in CH 3 that pioneers find two legal issues to be pertaining drawbacks. The first issue has to do with the fact that the majority of farmland in Flanders is leased, whereas farmers only tend on plant trees on farmland they own. The second issue is related to the uncertainty about the possibility to harvest the trees in a AF system. Because of their value for biodiversity, nature and society, trees in the Flemish landscape are protected through different laws. And although AF meanwhile is explicitly excluded from the Flemish Forestry decree, the rural code (rules neighborhood issues in rural areas) and the codex spatial planning, there are still a number of other conflicting rules and decrees that apply to AF systems.

But government support does not only imply financial and legal support at the regional level, it should manifest itself also in different ways and at different levels. In this regard local authorities could play an important role, by uniting farmers, local residents and other stakeholders around topics such as greening. Through these channels AF is not yet covered though, because the local authorities are not very well informed about AF as a farming system. This is a missed opportunity, as local authorities have the trust of the farmer, at least to a larger extent as is the case for the Flemish government. Also the support coming from the other end of the spectrum, i.e. the European support for AF through regulation and funding cannot be underestimated. It is true that European regulation may slow down AF development in the sense that there is often little flexibility to correct and adjust regulation taking into account the local context. Nevertheless, it has to be said that in the last few years European policy makers and researchers give an overall positive vibe to AF development and prominence throughout Europe. However, currently European policy makers are developing a new Common Agricultural Policy for after 2020 (CAP post 2020), in which member states get more flexibility in meeting 9 central EU-wide goals (European Commision, 2018; McEldowney, 2018). This implies also a new way of working with administrative processes that are simplified, i.e. in which both pillars are merged into one strategic plan per country covering direct payments, rural development and sectorial strategies. Although AF relates to many of the goals that are put forward, i.e. climate change action, environmental care, preservation of landscape and biodiversity, and vibrant rural areas, the extent to which this new CAP will steer AF support at the local level remains to be seen.

Although the **governmental domain** contributes in different ways to AF development in Flanders, actions of different governmental organizations and actors should be coordinated and translated into a real **policy and institutional pathway**. This implies strengthening functions such as knowledge diffusion, mobilizing resources, guidance of the search and creation of legitimacy. The policy and institutional pathway may include:

- The **development of economic instruments** which are financed with public money, presented in CH 6 as government instruments. Hereto belongs the AF subsidy program. From CH 5 we learn that idealists, opportunists and sceptics would design the subsidy program in different ways, which calls for a more targeted approach, a more context- and farmer-specific approach. Without losing the concerns of the nature and forestry sector out of sight, we thus have to move away from the current rigid structure of subsidy program to one that is more flexible. Also the greening measures in the context of the CAP, through which sustainability conditions are imposed on farmers' practices and management approaches in exchange for financial support, belong to this category. But also more innovative ideas should be studied more in detail, such as land incentive programs in which publicly owned farming land is prioritized for sustainable farming systems. This implies that the lessor of the land, e.g. provinces, municipalities or church administrations, lowers the rent charged to the farmer on the condition that the land is farmed in a sustainable or agroecological way.

- The **elimination of legal uncertainties** as an important barrier for AF pioneers. Although conflicts in the forest decree, the rural code and the codex spatial planning have been eliminated by specifying AF as an exception, there is certain reluctance from the forest- and nature sector to further change law and decree conflicts to safeguard existing small landscape elements on farmland. Whereas it will take some time to find an agreement among the different parties, in the short term government actors be clear and open towards farmers about the pertaining conflicts and the actions that farmer will have to undertake when they intend to harvest trees in an AF context.
- The **creation of space at different levels, e.g. with respect to research, legislation and regulation, market creation and network formation**. In Netherlands, this is done through "Green Deals", initiatives for green growth in which government and society collaborate interactively from the outset, among others to guide policies on societal challenges (Ministry of Economic Affairs, 2016). The central idea of the concept is that the government facilitates and accelerates initiatives by establishing supporting structures. Moreover, for each initiative a supporting committee, working group and facilitator is appointed, who have to collaborate and steer the different actors and policy domains involved towards change. This may result in initiatives being exempted from specific legislation, getting extra funding to invest in projects, enter markets which were inaccessible, etc. At least in the Netherlands, the concept seems successful with more than 208 Green Deals currently under implementation, of which 30 about food production. These kind of initiatives which result in active collaborations between government actors and other stakeholders, may also help in the restoration of trust and confidence in government actors.

7.2.4 The educational and organizational pathway (E&O)

The educational and organizational pathway revolves around the limited knowledge of farmers and the agricultural sector about AF and agroecological practices more in general. As such, through data collected in 2013 and analyzed in CH 3, we found that 47 out of 86 surveyed farmers are not familiar with AF, neither with the term nor with its principles.

However, this might be improved by now under influence of the current AF project. This AF project laid the foundation for a real AF network in Flanders, which has grown out of the project's user group. This is a group of researchers, policy makers and civil society actors that are meeting up at least once a year to monitor the progress of the project towards its goals. In the context of the AFINET project (i.e. AgroForestry Innovation NETworks), also a RAIN (Regional Agroforestry Innovation Network) was established, i.e. a thematic network aimed at fostering the exchange and knowledge transfer between scientists and practitioners in AF. This opened up the AF network to farmers, of which many already are implementing AF.

The main goal of the AF network is advancing AF development in Flanders. This implies first of all working on education and dissemination of information about AF, as formal agricultural education does not pay attention to agroecology. Extension centers and other organizations that belong to the AF network try to fill in this gap by publishing about AF and by organizing AF activities. To make AF information easily available to farmers and help in AF extension, the project also established an online knowledge cloud, in which all the AF data and knowledge, relevant for Flanders, is pooled. Because of these efforts, many stakeholders in the agricultural sector now know what AF stands for. However, in CH 5 we have seen that, because of a lack of knowledge, many stakeholders do not interpret AF as an agroecological transformation, but rather as adding trees to an otherwise conventional farming system. Because of this conservative definition that is assumed the true potential of AF is often not considered. Besides investing time in education and dissemination of information, the AF network also invests time in lobbying for AF funding and for the removal of legal barriers. In the past this lobbying already has been effective with the funding of the AF project and the AF subsidy program, and the exclusion of AF from the forest decree, the rural code and the codex spatial planning.

Whereas both the research and education domain and the entrepreneurial domain have important roles to play in the AF network, it is clear that the **intermediary domain** can act as a catalyst by strengthening functions such as knowledge diffusion and the mobilizing of resources. In this respect, the intermediary domain should take the lead in the development of a real **educational and organizational pathway**. This may include:

- The **coaching of teachers in educating agroecology and agroecological competences** in agricultural education**.** The limited knowledge of AF is amongst others a result of the fact that the formal agricultural education in Flanders, does not have enough resources and time to give attention to agroecology and the development of competences that are important for agroecology, e.g. experiential learning, innovation management and holistic thinking (Triste et al., 2017). We should thus show teachers how to teach these competences and put them on the right track e.g. by developing specialized packages with which teachers can experiment in their classes. This is exactly what will be done in the context of the new AF project funded by the LIFE climate action program of the EU, which initiated in September 2018.
- The **creation of learning networks of farmers on AF and agroecological practices**. The impact of networks on the daily operations of farmers cannot be underestimated: in a study about agroecological education in Flanders networks of farmers were mentioned most frequently as principal source of inspiration (Triste et al., 2017). Although the AF network has brought a range of different actors together to work towards a more enabling environment for AF, it is not designed as a learning network that pays central attention to the practical questions farmers are confronted with. The AFINET project, which initiated in January 2017 exactly wants to fill in this gap. Because of its value for farmers and AF pioneers, efforts have to be made to keep the network active and functioning after the end of the project in 2019.
- The **creation of an action plan for AF development in Flanders**. Given the large effects of AF on crop production as measured by Pardon (2018), AF is certainly not the best farming system for every farmer. Therefore, the AF network should work in collaboration with government actors on an action plan for AF development. This action plan should stipulate where the priorities lie, i.e. where in Flanders and in which farming contexts AF systems deliver maximal benefits and entail minimal drawbacks, and thus where and in which farming contexts it should be specifically promoted. It is also the tasks of the AF network to monitor and evaluate the progress towards the goals of this action plan, point out unexpected side effects, and make changes where necessary. As far as these problems cannot be solved by AF network itself, they should be passed on to government actors, who may be able to handle them or use them to guide further AF policy.

7.2.5 The social and behavioral pathway (S&B)

The social and behavioral pathway concerns the differences in perspectives about the right development direction for the agricultural sector in Flanders, and its impact on the opportunities for AF and agroecology in Flanders. It differs from the educational and organizational pathways in the sense that it does not only imply educating and sensitizing farmers and the agricultural sector, but society as a whole, as each individual has a role to play as a consumer, as a resident, as a tourist, etc.

We found evidence for the link between general agricultural discourses and perspectives on AF by making use of Q-methodology in CH 5. First we showed that three different perspectives exist on AF and its enabling environment in Flanders: (1) AF idealist perspective, to which actors adhere who believe in complex, small-scale and high-value AF systems; (2) the AF opportunist perspective, to which actors adhere who show interest in large-scale mechanized AF systems or traditional AF systems; and (3) the AF sceptic perspective, to which actors adhere who downplay the scope of AF in Flanders to small landscape elements on the border of agricultural fields and extensive livestock systems. Then, we found strong indications that these AF perspectives are embedded and grounded in general agricultural discourses, from respectively the multifunctionality-sufficiency stance to the neoliberal-productivity stance. And although the government now advocates both development directions, there is still a discrepancy between the policy support for agroecological versus agro-industrial development.

The general distribution of farmers over the three perspectives cannot be deducted from CH 5. Nevertheless, our experiences throughout the AF project suggest that AF generally has a negative image among farmers. This is confirmed in CH 3, which shows that Flemish farmers have low scores on attitude towards AF (average of 2.95 on a scale from 1 to 7). It also shows that farmers feel no or little pressure by other farmers or by the farmer community to start with AF. Indeed, farm advisors, such as representatives from agricultural organizations, input suppliers (e.g. agrochemical companies) and buyers of outputs (e.g. auctions, supermarkets) do not use their contact moments with farmers to convince them of the potential of agroecological farming systems. Also landowners are reluctant towards AF systems, because of the potentially downward pressure of trees on farmland prices.

Generally though it seems people are in favor of a more varied agricultural landscape with more trees. Especially at the local level new grassroots initiatives suggest that attention is being paid to the creation of a more healthy and locally embedded food system. An example is Pomona, a cooperative farm focused on AF as a regenerative farming system (CH 5). Especially CSA farms, in which risks are shared between farmer and consumers through harvesting shares, are popping up increasingly throughout Flanders. However, the question remains to what extent these initiatives can be mainstreamed and grow out of the niche level.

This should be investigated as part of **a social and behavioral pathway,** which should aim towards a shift in the dominant frame of reference from the neoliberal-productivity towards the multifunctionality-sufficiency stance. The social and behavioral pathway is a task of all stakeholder domains, but targets primarily the **society domain**, as it depends on a wide social consensus and a broad support. Creation of legitimacy, guidance of the search and knowledge diffusion are thus the main functions to strengthen. The social and behavioral pathway implies creating awareness and tightening the bonds between citizens and the origin of food, which might imply:

- The **introduction of an agriculture and food systems class** in the general formation of children and youngsters, from kindergarten up to university. This needs to be thought at all school levels, and the content and practical implementation of the classes should be adapted to the respective level. This might imply growing vegetables in a school garden, an excursion to an agroecological farm or helping farmers in their daily activities (Triste et al., 2017). In contrast to the classes organized as part of the educational and organizational pathway, which encourage especially students in agriculture to develop agroecological competences, this class is meant for all other students, to show them how modern agriculture is organized and encourage them to participate in the debate and take action on different fronts.
- The **assignment of food experts within companies and institutions** (e.g. schools, hospitals, etc.), who must ensure that food and drinks come largely from locally embedded and/or fair food systems. In many of these companies and institutions there are already sustainability experts, who focus on environmental sustainability (e.g. minimal use of resources). The consumption of healthy, fresh and local food is in this context often not considered, even though they are also important from a social sustainability perspective. In this respect, the hospital of Knokke and Blankenberge gives a good example by consciously committing to fresh, healthy and locally produced food.
- The **development of initiatives that bond consumers with local farmers.** In a time in which the agricultural sector is confronted with a sequence of crises, it is high time to showcase local positive and innovative examples. This may help in breaking the spiral of negativity with which the sector is confronted, and restore the trust and confidence of consumers in local agriculture. This can be done through open farm days, in which the farmer opens up the farm for interested people and gives guided tours. Another example are agricultural learning paths, which are marked hiking and cycling routes from three up to 50 kilometers that lead past carefully selected farms, which are equipped with information boards that tell you about a certain activity or characteristic of these farms. Agricultural learning paths could be centered around a certain crop, but also around a certain theme, such as agroecology.

7.3 Reflections

7.3.1 Reflections on agroecological transitions

Leveling the playing field for AF systems in Flanders

Throughout this thesis we tried to argue that AF systems as innovative farming systems do not get the attention they deserve in light of the different ecosystem services they deliver. We tried to explain this lack of attention to AF through mainly qualitative research, involving a diversity of stakeholders. However, throughout our research, we experienced that it was much easier to get in contact with people that know AF and see opportunities in AF, than those people that are not familiar with AF or are radically against it. This may have led to the creation of a (too) positive, i.e. an idealist picture of AF as a farming system. However, this does not imply that we consider AF systems as being the best choice for every farmer in Flanders. What we wanted to prove in this manuscript is that the current state of agriculture and the organization of the food system do not leave space for AF, i.e. that there is an unequal playing field that impairs agroecological innovations like AF systems. However, once this playing field is leveled, AF systems should have off course enough assets to compete with other innovative farming systems. And in this light, sufficient research on the technical and agronomic impact of AF becomes, as was done by Pardon (2018) becomes of crucial importance. Although on the long terms tools may be developed that make AF more compatible with modern farming systems and less labor-intensive, losses in crop production with respect to monocropping systems will always exist and remain a disadvantage of the farming system. In this light, we stress the need for a Flemish action plan for AF systems in Flanders, one of the recommendations given as part of the educational and organizational pathway. This action plan should stipulate for which farm types and marketing models, and in which regions the potential of AF systems is highest, i.e. in which situations its advantages especially outweigh its disadvantages. This action plan can then be used to set priorities and can be used as a guideline for the different actors involved in the policy and institutional, science and technology, and educational and organizational pathway.

Holistic versus reductionist agroecology

The debate about which development direction to choose in agriculture is carried out at different levels. Moreover, it does not only focus on whether agroecology is the right develop direction in agriculture as compared to further agro-industrial development, but also on what kind of agroecology we want in Flanders, and how policy should address this. In this section, we give our opinion about how to address this in order to maximize the opportunities of AF systems in Flanders in the long term.

The Q-methodology analysis in CH 5 showed us that three different perspectives exist on AF systems in Flanders. Whereas AF sceptics do not really believe that AF as a farming system has opportunities in Flanders, the discussion between AF opportunists and AF idealist centers more around the question ‘What kind of AF do we have to implement in Flanders?’ In this respect AF idealists adopt a holistic perspective, and support AF systems which deliver a maximum amount of ecosystem services and are locally embedded, requiring a redesign at farm level. Opportunists on the other hand adhere more to a reductionist perspective, and believe that adding trees to conventional farming systems has value for society and at the same time minimizes the impact on the farmer. The systems that AF opportunists have in mind would thus fit in the third or fourth quadrant of the framework of Therond (2017) (see CH 1) and can be applied on large-scale commercial farms, those that AF idealists have in mind belong to the first quadrant of Therond (2017) and rather fit into small-scale family farms. Although these two approaches towards AF systems have to be interpreted as two extremes of a continuum, the attention is increasingly focused on their differences, and how policy should deal with this.

The same question is being raised for other agroecology practices and their enabling environment, and, as already stated before, for agroecology in general, which has become a “territory in dispute” (Giraldo and Rosset, 2017). In this respect, Stassart et al. (2018) elucidated agroecology discourses for Belgium, with on the one extreme (1) the ‘Radical Agroecology’ (RA) discourse, which rejects the co-optation of agroecology (Giraldo and Rosset, 2017), i.e. which disqualifies “other forms of agroecology which perpetuate some of the principles that peasant agroecology contests, i.e. the ongoing concentration of land, seed, patenting, or technoscience-based and top-down solutions” e.g. Nyéléni declaration (2015); and on the other extreme (2) the ‘Narrow Ecological Modernization’ (NEM) discourse, in which agroecology is characterized as one of the interesting technical solutions in which one can improve production by making smart use of ecological interactions. Both discourses are about which pathways to choose to resolve the global food crisis, which is a discussion that can be brought back to two discords according to the framework of Therond (2017), i.e. (1) external inputs or ecosystem services and (2) global market or local embeddedness. Confronted with these discords, the RA discourse will pursue both ecosystem services and local embeddedness, whereas the NEM discourse also supports improvements towards one of both directions. In the same way, the RA discourse centers its attention on the redesign approach to realize agroecological transformations, whereas the NEM discourse equally values efficiency and substitution approaches (Hill and MacRae, 1996).

The best strategy to maximize the opportunities of AF in Flanders though might lay in our opinion in between of these two options. This is portrayed by Stassart et al. (2018) as Strong

Ecological Modernization (SEM), defending a “radical move towards a new type of regionally embedded agri-food eco-economy. This is one that includes rethinking market mechanisms and organizations in an altered institutional context and is interwoven with active farmers and consumers’ participation.” We agree thus with the RA discourse that in the long term a holistic approach, implying a redesign at farm level will pay off and make sense for farmers. We should therefore make work of an agricultural policy that encourages holistic thinking and triggers a redesign of farming systems. This is for example possible by bundling existing subsidy programs (i.e. direct payments, VLIF-support, agri-environment schemes, etc.) into one payment that depends on a well thought-out farm business plan with a focus on sustainable development (following the example of forest management plans in Flanders). However, holistic thinking is only gradually pervading the Flemish agricultural innovation system, and instruments supporting this development direction are still met with resistance.

In the short term, we should therefore in our view not reject development directions that imply an efficiency or a substitution approach rather than a redesign approach. In this respect, Lamine (2011) points out it is far more complicated than depicting the paradigms of efficiency or input substitution as mere “greenwashing”, where nothing changes fundamentally. First, because of the fact that efficiency and input substitution and practices would still have a general positive impact on the environment when compared to conventional practices. In this respect, each tree that is added to a farming system has value and has to be interpreted as a step into the right direction. Second, because of the fact that a farmer’s position in a paradigm has to interpreted as a stage in a longer trajectory, which is subject to change and overlapping. This change may be sudden when it is the result of a ‘trigger event’, or change may come progressively, when the farmer’s trajectory evolves from input reduction and efficiency, over input substitution, towards redesign (Lamine, 2011; Sutherland et al., 2012). The last step from input substitution towards redesign might happen in farmers’ perspectives, but might be harder for the farmer to implement in practice because of the presence of a series in lock-ins. Nevertheless, it is only in this step of the trajectory that farmers will get conscious of the presence of these lock-ins. The more farmers and stakeholders reach this stage and become aware of this problem, the more support can be generated for systemic change in order to eliminate lock-ins. Essential in this regard are networks of farmers at the local level, where difficulties, solutions and doubts can be shared. The AF network for example brings together AF pioneers with different trajectories and may inspire farmers to gradually move from a reductionist towards a holistic AF approach, both in terms of the practical implementation in the field as in terms of marketing modes. The AF network thus helps to grow awareness about the fact that, over a longer time period, efficiency and substitution practices might prove rather unsustainable (in agronomical, environmental and social terms), and result in AF systems that may not reach their full potential.

Bottom-up versus top-down approach for agroecological transitions

Through exploratory brainstorming sessions and case study research, we found in CH 6 that a wide range of instruments – financed by either the government, the market or the community - could be thought out to give incentives to farmers to adopt AF systems. Zooming in on the government support for AF systems in Flanders, we found that the attention goes currently mainly to the subsidy program and the greening measures. Government support for other tangible agroecological practices follows the same format and happens through Ecological Focus Area and agri-environment schemes. This points out that government support for agroecology in Flanders is fragmented and compartmentalized, which is not consistent with a holistic vision on agroecology. In this respect, agroecology is not fully institutionalized at the level of Flanders.

When adopting a more holistic vison on agroecology, it is much easier to focus on agroecology development at the local level. In this respect, it is logical that agroecological experiments and initiatives which are studied in literature often take place at the level of the farm, or in the remaining cases at the level of the community (Gonzalez de Molina, 2013): At the crop and plot level, attention is being paid to the development of technical solutions, which help in the design of sustainable systems. At the farm level, the focus shifts to farmers' transitioning processes, both from a technical, environmental as from a socio-economic point of view. At community level, the impact of individual and family food consumption patterns is studied, just like collective action, i.e. through the creation and strengthening of producers and consumers associations (Gonzalez de Molina, 2015). However, at higher landscape level, in Flanders and in other intensive agricultural regions, the establishment of agroecology experiments and initiatives remains sparse. Especially at national and global level, the global market and food system does not leave a lot of space for agroecology. There is thus need for the development of an appropriate institutional framework, that takes into account the holistic nature of agroecology and that drives agroecological transitions at higher levels forward (Gonzalez de Molina, 2013).

How can we now scale up agroecology initiatives at the local level to affect and transform the neoliberal-productivity regime? Laforge et al. (2017) analyzed this by studying the interactions between government actors and local grassroots initiatives. They categorized these interactions in four distinct types, i.e. (1) containing, i.e. governments contain the developments of alternative food systems by direct and indirect regulatory measures that support the neoliberal and industrial food paradigm; (2) co-opting, i.e. governments co-opt, i.e. dilute, ideas from the bottom-up and thus undermine the transformative potential of alternative local food systems; (3) contesting, i.e. farmers and other civil society actors take individual and collective action to challenge government and its complicity in serving the interests of powerful actors in the dominant system; and (4) collaborating, i.e. government and grassroots actors work in authentic and balanced partnerships to build local food economies together. It is clear that, while containing and coopting are interaction mechanisms that reinforce the status quo, both collaborating and contesting reflect opportunities to affect or even transform the dominant regime. The transformative potential of local grassroots initiatives depends thus on grassroots actors transcending the local, becoming politicized and working with and alongside actors at multiple levels. These insights are also confirmed by the IPES-report (2016), which recognizes that the most-promising bottom-up, grassroots initiatives reach across divides and create new constituencies of pooled interest. Therefore food planning processes and 'joined-up food policies' should be developed at multiple levels.

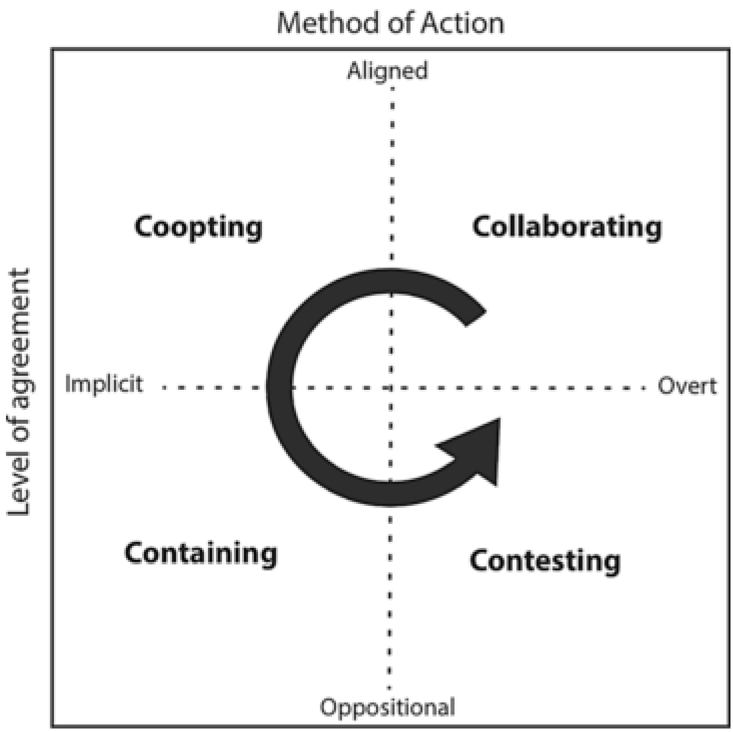

Figure 7 - 1: Typology of containing, co-opting, contesting and collaborating as levels of agreements between grassroots actors and governments against methods of action (Laforge et al., 2017)

Realizing through AF the promise of an agroecological approach

The above reflections deliver some further insights for AF transformations. To explain these insights, we use the labels of the AF perspectives in CH 5 to indicate three levels of enabling environment, i.e. (1) "AF skepticism" indicates the current, not very enabling environment for

AF, (2) "AF opportunism" indicates an enabling environment for reductionist AF approaches, and (3) "AF idealism" indicates an enabling environment for holistic AF approaches.

Although we have seen that there are many stakeholders that have a role to play in the development of AF systems in Flanders, the role of two stakeholders seems to stand out in order to realize the promise of an agroecological approach (Figure 7 - 2). On the one hand this is the **government**, which can steer towards general AF "skepticism" or "opportunism" through respectively containment or co-optation, but can also collaborate with other stakeholders to trigger AF idealism. At the moment there seems to be government support for AF systems (i.e. through the subsidy program and greening measures), however, compartmentalized thinking steers towards 'AF opportunism', i.e. adding trees to an otherwise conventional farming system. On the other hand there is the **AF network**, which should guard over the direction of AF developments through contesting co-optation and encouraging collaboration. Based on collective action and the formation of partnerships, the AF network has to continue to contest current inconsistencies and incompatibilities and collaborate with government actors to further institutionalize AF systems as holistic agroecological farming systems.

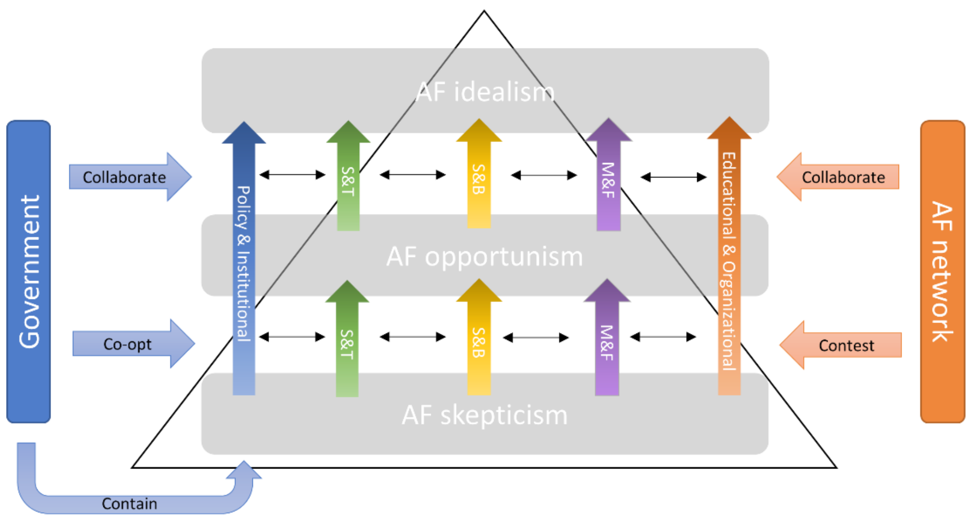

Figure 7 - 2: To realize the promise of an agroecological approach through AF, and move from AF skepticism to AF idealism, the role of two key stakeholders stand out, i.e. the government and the AF network. They have transformative power respectively through the policy and institutional pathway and the educational and organizational pathway.

The government and the AF network play a central role in respectively the **policy and institutional pathway** and **educational and organizational pathway**. Those pathways are therefore essential to create opportunities for AF systems in Flanders. Moreover, they hold the power to transform the enabling environment for AF system from AF skepticism towards AF opportunism, and from AF opportunism to AF idealism. This may be in contrast with our choice to further explore the **market and financial pathway** in CH 6, however, this pathway remains most important for the upscaling of AF. Nevertheless, as long as the research domain cannot give conclusive evidence of the profitability of AF as a farming system, the entrepreneurial domain is not spontaneously going to engage itself in AF development. An exception are the AF pioneers, who often practice AF out of personal conviction, and want to call into question the functioning of the agricultural markets and the food system through these grassroots initiatives. However, in this role, these pioneers rather belong to the AF network than the entrepreneurial domain. We thus need the AF network (and broader the intermediary domain) to collaborate with the government domain, in order to spur and create leeway for the entrepreneurial domain. Initiatives that already came in this way into existence are the Humusaufbau project, the Woodland eggs brand and the cooperative farm Pomona (explained in CH 6), in which respectively Ökoregion Kaindorf, the Woodland Trust, and a local VELT organization are the intermediary organizations encouraging entrepreneurial actors to engage in AF (and agroecological practices in general). All three projects also have room to grow and scale-up, on the condition that leeway is created by the government at different levels, e.g. through Green Deals.

Based on these insights we can conclude that - although all five development are heavily interrelated and indispensable - the policy and institutional, and educational and organizational pathways form the foundation on which the other three pathways are rooted. Paying extra attention to these two pathways may therefore help to put the cogwheel of AF development into motion, spur the entrepreneurial domain and in this way scale-up AF adoption by farmers.

7.3.2 Reflections on the research approach

The AF project of which this thesis forms part is designed to include some important FSR characteristics, i.e. systems thinking, interdisciplinarity and a participatory approach. Additionally, FSR requires a key character of the researcher, which is reflexivity. In this thesis we adopted FSR as central thread, and this by (1) selecting appropriate methodologies and concepts that are built on the core principles of FSR (systems thinking, interdisciplinarity and a participatory approach) and (2) combining them in such a way that AF development is studied from different perspectives (reflexivity).

Overall, we perceived that this FSR approach led to a deeper, broader and more truthful perspective on AF adoption and development in Flanders. We also perceived FSR to be more effective, in the sense that the value of this research not only lies in the final policy recommendations, but in all research activities through which researchers, farmers, policy makers and other stakeholders got together to talk about AF. This thesis and the AF project it forms part of are thus not only gather knowledge on AF, they should be considered as a first trajectory towards an agricultural innovation system that supports AF development.

With reflexivity as core characteristic of the farming systems researcher, we should not forget to evaluate to what extent the core characteristics of FSR are represented. Moreover, as the three core characteristics of FSR often imply trade-offs, they may not be represented in every part of the AF project to the same extent. Also in this thesis, research chapters may address different FSR characteristics to different extents, and complement each other in this regard. Therefore, in the rest of this section, we analyze to which extent the project took on a FSR approach and to which extent this thesis contributed. This may generate insights that should be considered in the design of future AF research projects .

Systems thinking

Arnold and Wade (2015) defined systems thinking “a set of synergistic analytical skills used to improve the capability of identifying and understanding the systems, predicting their behaviors, and devising modifications to them in order to produce desired side effects”. They defined four of these skills, for which they give further recommendation in a subsequent study (Arnold and Wade, 2017):

1. **Identifying** systems
2. **Understanding** systems
3. **Predicting** systems behavior
4. **Devising modifications** to systems to produce desired effects.

At the level of the AF project, very different system levels are considered. The majority of the technical and agronomic research takes place at the plot level, although an integration of results is done at the farm level. The socio-economic research on the other hand starts at farm level, and extends to landscape and policy level. In this thesis, the different research chapters integrate systems thinking to different extents and in different ways. First, CH 3 focuses on the first systems thinking skill by identifying the different system components contributing to the unfavorable environment for AF systems in Flanders. The first chapter has to be understood as an preview of CH 4, which really lays the foundation for a systems approach by focusing on the second systems thinking skill, i.e. understanding systems. Moreover, the structure of the system is analyzed by identifying and characterizing relationships and feedback loops between the different components of the systems. The other two systems thinking skills are presented respectively in the two next chapters, although in a less ubiquitous and striking way. The Q-methodology analysis in CH 5 predicts system behavior by laying a link between AF perspectives and general perspectives on agriculture. In this respect, we learned that the support for AF as a farming system may grow if the dominant frame of reference in agriculture shifts from the neoliberal-productivity to the multifunctionality-sufficiency stance. The exploratory analysis in CH 6 on the other hand accounts for the last systems thinking skill by exploring how economic incentives can be created for farmers to adopt AF. Economic incentives for AF can thus be interpreted as the desired effect, which can be attained through customized government, market and community schemes and instruments.

Participation

The AF research project's aim is, as mentioned in CH 1, the breakthrough of feasible, profitable and effective AF systems in Flanders, and this in the relatively short term. The research type is thus applied, gearing towards action. Moreover, ILVO and the other project members want to be responsive to existing problems and create change in Flemish agriculture. This is only possible if a participatory research approach is applied, in which a wide range of stakeholders are considered. Which types of participatory research are implemented in the context of the project, can be evaluated making use of the typology of Lambrou (2001). This typology includes seven grades of participation that are possible in agricultural research projects:

1. **Positivist theoretical research:** the least inclusive type of approaches
2. **Passive information sharing:** farmers are informed of the processes and outcomes of the research
3. **Consultative stage:** farmers are consulted and their needs may be included in the project design
4. **On-farm testing:** researchers continue to dominate the research process, but farmers' expertise is recognized
5. **Evaluation:** farmers are involved in assessing the process and results of the research
6. **Collaborative planning:** scientists join hands with farmers in defining problems and in designing the research process
7. **Partnerships:** scientists join in a long-term mutual learning and research process

Different research and extension activities correspond with different grades of participation. The agronomic research, in which the effect of trees on crops is measured, takes place on plots which are managed by real farmers. The agronomic research thus belongs to the fourth grade of participation, i.e. 'on-farm testing'. This could have been the fifth grade of participation though, if the selection of plots in the sample not only depended on biophysical characteristics (i.e. the presence of a tree row of the right species and in the right direction at the border of the agricultural plots) but also on the interests of the farmer involved. The socio-economic research in this thesis is especially of a consultative nature. This does not mean that the socio-economic research activities were less participatory than the agronomic ones. From a participatory perspective, the strength of the socio-economic research activities lays especially in the different types of stakeholders that were reached, rather than the 'grade of participation'. The exploratory analysis in CH 6, in which scientists, farmers and other stakeholders were brainstorming about the design of new economic instruments for AF, also has elements of collaborative planning. These workshops can be considered as precursors for real design trajectories, focused on bringing these instruments into practice. Last, project activities which are not part of the scientific cluster include knowledge dissemination and extension. Knowledge dissemination belongs to the second stage of participation, i.e. passing information sharing. Most important with respect to participation however are the extension activities, in which extension agents work together with farmers on the design of an AF project. These extension activities guide further research activities and show that AF pioneers have a crucial role to play in the development of AF in Flanders. This is also why the new VLAIO project proposal for AF will center around AF pioneers as "project ambassadors".

In this context, we want to stress that a more participative approach is not always the better approach, especially in the context of limited project time and funds. Taking into account the diversity and dynamics of agricultural research projects, Neubert and Neef (2010) propose a new framework that looks at six participatory research elements, i.e. (1) project type, (2) research approach, (3) researchers' characteristics, (4) researcher-stakeholder interaction, (5) stakeholders' characteristics and (6) stakeholders' benefits. Rather than maximizing the adoption of participatory methods, the framework can be used to optimize the use of participatory approaches in agricultural research.

Interdisciplinarity

Whereas AF is clearly a subject that relates to different disciplines, such as forestry and agriculture, not all projects centered around the topic will have an interdisciplinary approach. To assess the interdisciplinary character of a research project Huutoniemi et al. (2010) developed a typology with three qualitative indicators:

1. The **scope of interdisciplinarity**, i.e. what is integrated.
    a) In **narrow interdisciplinarity**, the participating fields are conceptually close and represent the same domain of scholarly work
    b) In **broad interdisciplinarity**, the participating fields cross the boundaries of broad intellectual areas.
2. The **type of interdisciplinarity**, i.e. how it is integrated.

a) The type is **multidisciplinary** when the ingredients of new knowledge are imported, exported or pooled across boundaries without being substantially adapted in the course of interaction.

b) The type is **interdisciplinary** (in the strict sense), when there is active interaction across fields, when research integrates separate bodies of data, methods, tools, concepts and theories in order to create a synthetic view of common understanding of a complex issue.

3. The **type of goals**, i.e. why interdisciplinarity takes place.

   a) In **epistemologically oriented research** the goal of interdisciplinary research is that it increases our knowledge about the research object.

   b) In **instrumentally oriented research**, the purpose of interdisciplinary research is to achieve some extra-academic goal.

   c) **Mixed orientation research** posits the improvement of knowledge and the solution to an extra-scientific problem as equally important goals

In the AF research project AF systems are being analyzed from an agronomic and sylvicultural perspective on the one hand, and from a social and economic perspective on the other hand. As these are epistemologically and methodologically different fields that cross the boundaries of intellectual research domains, the scope of interdisciplinarity in the project is broad. The research that is carried out in the context of this thesis also draws from different fields, i.e. sociology and economy, but they belong to the same intellectual domain, in which similar concepts, theories and methods are used. In the context of this thesis, we thus have to speak of a narrow interdisciplinarity.

For both the project as the thesis the goals that are pursued are both epistemologically as instrumentally oriented. On the one hand, the thesis and the project it forms part of, should result in a more profound scientific understanding of the feasibility of AF as a farming system in Flanders. On the other hand, the AF project and the thesis have to be considered as a first trajectory towards an agricultural innovation system that supports AF development, and this through extension efforts, the elimination of barriers and dissemination of knowledge.

The type of interdisciplinarity of the AF project is less clear-cut. On first sight, there seems to be a regular interaction between the different researchers and extension agents involved in the project. These point towards integration of knowledge, and thus a real interdisciplinary approach. A closer look however reveals that these contact moments are coordinated, rather than dialogic. They are meant to discuss and evaluate the progress with respect to different tasks, for which people from different fields are responsible. The execution of these tasks, just like the formulation and analysis of results is thus done by separate fields. This is confirmed by the structure of the project, which is built up of separate, disciplinary work packages, carried out relatively independent of each other. The interdisciplinary character of the project could have been improved for example if the technical and agronomic field data were collected on an AF plot of a pioneer, for which economic models and market instruments were developed at farm level. This kind of research integrates the three different components of the project (agronomic research, socio-economic research and extension), which are at the moment conducted relatively independent of each other. The same is true for the research performed in the context of this thesis, i.e. knowledge and experiences that are gained in each analysis are taken into account for the next study, but the different studies cannot be interpreted as an integrated whole.

Reflexive note

Overall, we perceived that the FSR approach led to a deeper, broader and more truthful perspective on AF adoption and development in Flanders. Evaluating this thesis and the project it is part of on the basis of the three core characteristics of FSR, showed that in future project design there is room for optimizing especially the participatory and interdisciplinary approach. It is important to be aware of and reflect on these shortcomings. Nevertheless, often the available time for and funding of PhD and research projects is limited, which obligates researchers to make practical choices and trade off different key elements of FSR for fast and reliable results.

7.3.3 Contributions to temperate agroforestry literature

Nair and Garrity (2012) studied the developments in AF research from the 1980s onwards and they differentiated three “decades” (Figure 7 - 2). During the first decade (1980-1990) research efforts were based on inductive and experiential reasoning. Efforts were focused on gathering information from successful existing AF systems, resulting in databases from a descriptive nature. At the same time efforts were spent on developing appropriate concepts, principles and methodologies, such as the “Diagnosis and Design” approach. During its second decade (1990-2000), AF research moved on to more empirical research, focusing on hypothesis development and testing in order to strengthen AF’s theoretical foundations. Whereas biophysical studies continued to dominate AF research, also socio-economic evaluations and programs achieved more prominence. The focus during the third decade (2000-2010) shifted to application-oriented research, focusing on problem-solving and adaptation, but without reducing the importance of making advances in science.

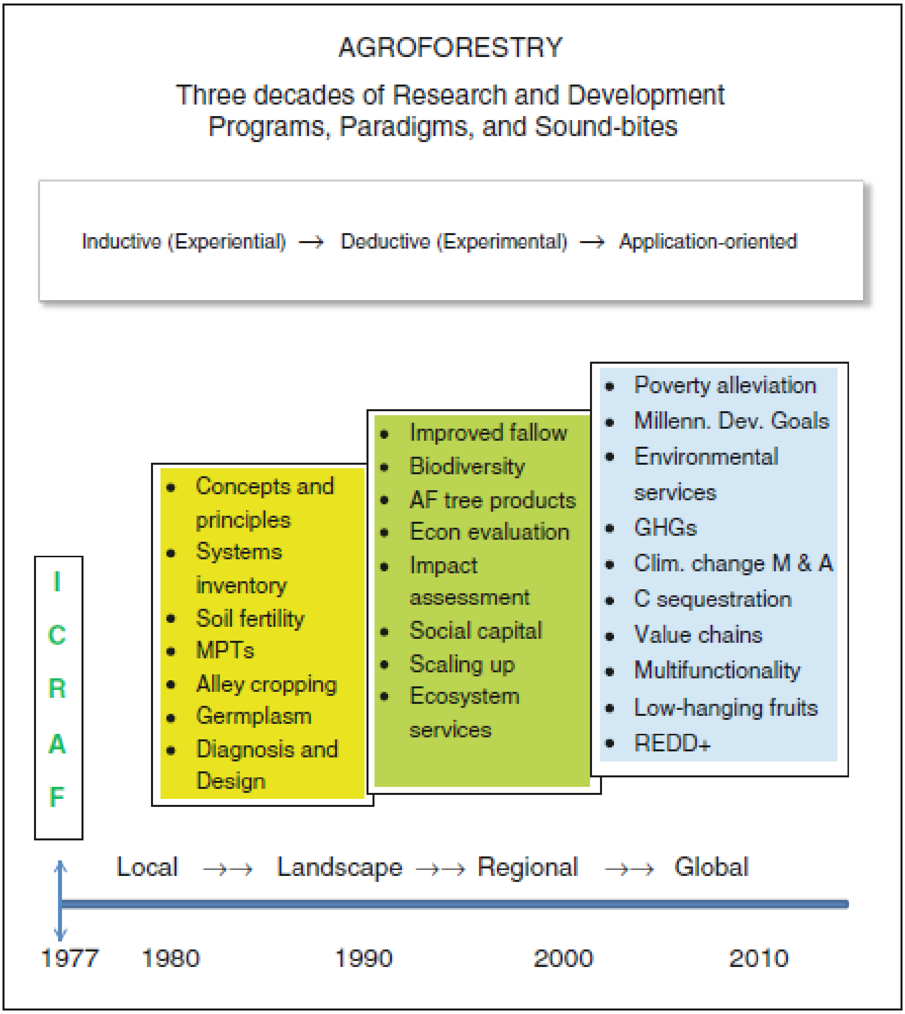

Figure 7 - 3: Major programs, paradigms and talking points in AF research and development during the three decades since the beginning of such organized global efforts (Nair and Garrity, 2012)

Throughout these 30 years the importance of socio-economic studies on temperate AF has been growing, and evolving from literature reviews, qualitative and purely descriptive quantitative research, at the local scale toward more rigorous statistical analyses of better and larger data sets, at the regional, landscape and global scale (Mercer and Miller, 1998). At the same time, socio-economic research become more focused, on topics such as **farmer and stakeholder perceptions** (Anil et al., 2017; Camilli et al., 2017; Rois-Díaz et al., 2017; Tsonkova et al., 2018), **AF policy and governance** (Mosquera-Losada et al., 2018; Nicola Galluzzo, 2015; Santiago-Freijanes et al., 2018), **AF education, extension and networks** (Hemmelgarn et al., 2018; Khasa et al., 2017; Vityi and Borek, 2017), and **economic valuation of ecosystem services** delivered by AF (Joao et al., 2017; Ovando et al., 2016).

Taking into account the trend of upscaling the research level and narrowing down the focus in AF research, Montambault and Avalapati (2005) already expressed in 2005 the challenge to provide **integrative results** with both scientific depth and a broad appeal to ensure its relevance. In this context, based on a systematic study of ecosystem services assessments around European AF, Fagerholm et al. (2016), propose some key actions which can contribute to make AF research more relevant and integrative. These include amongst others: (1) stronger consideration of stakeholder participation to define, map, value and foster ecosystem services, (2) diversification of assessment approaches that go beyond biophysical assessment and monetary valuation, and (3) coverage of a broader suite of ecosystem services, in particular integration of cultural ecosystem services and aspects of human wellbeing as well as consideration of trade-offs, synergies, bundles, beneficiaries and power relations around ecosystem services. These are three actions that can be linked to the three key principles of farming systems research, i.e. (1) a participatory approach, (2) interdisciplinarity and (3) systems thinking. In contrast to the average trend in AF socio-economic research, we return thus in this thesis to the more local scale of Flanders, where we provide through FSR a holistic and integrative perspective on AF development in Flanders. Although barriers and their relative importance may be different in other regions, this thesis may provide readers insights in, and understanding of system functioning and the enabling environment for AF systems. In this respect, the structure of the in this chapter outlined development pathways could be used in other regions when developing an action plan for the upscaling of AF in other regions. The five development pathways should thus be interpreted as five interconnected steppingstones towards a more enabling environment for AF systems, which should “filled-in” and translated into actions taking into account the local context.

7.4 Conclusions

This chapter answers the last research question of this thesis, i.e. “*Which pathways have to be followed to give incentives for the breakthrough of AF systems in Flanders?”.* By answering this research question we integrated the insights gained in the different research chapters and translated them into recommendations. Moreover, to each of the five development pathways, different actions were coupled, which should be put into practice by the different stakeholder domains involved. This integration exercise resulted in further insights on agroecological transitions, on FSR as research approach, and on the contributions of this thesis to temperate AF literature. We learned that the AF network and the government should be considered as key stakeholders, as they have a lot of transformative power and may realize the promise of an agroecological approach. We evaluated the FSR approach as positive, and contributing to a deeper, broader and more truthful perspective. On the other hand, we also recognize that the FRS design, both at the project and the thesis level could have been improved, especially with respect to participation and interdisciplinarity. Last, we reflected on the contributions of this thesis to temperate AF literature and found the strength of this thesis to lie in its holistic and integrative nature, this in an age where the trend in temperate AF research is to scale-up and narrow down the focus. We conclude that despite the context of Flanders, the structure of the development pathways is useful for policy makers and researchers from other regions and countries, at least when they interpret the development pathways as five interconnected stepping stones towards a more enabling environment for AF, which should be adapted taking into account the local context.

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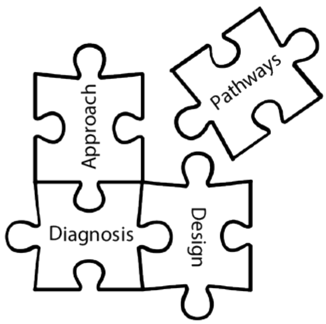
Chapter 8

Conclusion



This final chapter revisits the four main research questions and gives in this way a brief overview of the findings of this thesis. The chapter concludes this thesis with some suggestions for further research relating to the theme, i.e. AF adoption and development in temperate regions, and the research approach, i.e. farming systems research.

8.1 Take-home messages

The overall research objective of this thesis was to gain a better understanding of the unfavorable environment for AF adoption and development making use of a FSR approach. To address this overall objective, we specified four research questions, which we addressed in CH 3, 4, 5, 6 and 7. In this conclusion-chapter, we will summarize our findings in brief take-home messages. Based on the overall methodological and AF development insights, we conclude this thesis with some suggestions for further research.

THM 1 The current state of agriculture does not leave space for AF adoption

In this thesis we wanted to learn about the different barriers holding back adoption. We started with investigating some direct barriers of AF adoption, such as the lack of a policy framework for AF systems, the lack of knowledge on the productivity of AF systems for the context of Flanders, and the lack of tools to make AF manageable. However, over the course of this PhD we experienced that these more easily detectible direct barriers are just the expressions of a more important underlying barrier, which is the current state of agriculture. The way the agricultural sector and the agri-food system are organized with its short time horizon and focus on standardized products, leaves little space for farming systems that excel primarily in the production of regulating and cultural service, or of which the provisioning services are not valued through the regular market chains. In this context, one cannot really investigate the willingness of farmers to implement AF systems, as many farmers feel they just do not have a choice, i.e. that the choice for AF systems is just not a valid one.

THM 2 The adoption of valuable AF depends on changing perspectives on agriculture

We found evidence that the extent to which stakeholders see opportunities in AF systems and interpret them as good farming systems depend on their general view on agriculture. These different perspectives on agriculture are often translated into different farm organizations, from family farms focusing on a range of different products and ecosystem services and short supply chains, towards specialized large-scale agricultural businesses. We believe that there will always be a need for a diversity in farming systems that cover both ends of the spectrum and that exist next to each other. However, innovative, modern and economically viable agriculture is still mainly associated with the second development direction, in which we have moved steadily over the last few decades. This made the agricultural sector vulnerable for shocks and threats. Counteracting this move and restoring the balance between small-and large-scale, and diversified and specialized agriculture, i.e. between neoliberal and multifunctionality perspectives among stakeholders may help farmers to see opportunities in AF systems.

THM 3 Creating opportunities for AF requests systemic change and collaborative action

The fact that the current agricultural climate does not leave space for AF adoption, calls for systemic change and collaborative action. The current state of agriculture should be understood as a giant cogwheel, which is hold in place because of different stakeholders giving impulse in different directions depending on their own goals and perspectives. Thus, to put the cogwheel into motion and create opportunities for AF systems, we need the different stakeholders to communicate, collaborate and take action. We found that in this process especially the government and the AF network can play a catalyzing role. Both contributed to the start-up of the AF project, which brought many of the relevant stakeholders together, and which can be considered as a first trajectory towards a more enabling environment for AF systems. However, to further create opportunities for AF, we need these stakeholders to collaborate in the long-term in five different fields, focusing respectively on (1) science and technology, (2) market and finances, (3) policy and institutions, (3) education and organization, and (5) communication and behavior.

THM 4 New economic instruments can create leeway for AF adoption

Although with a good design and management the productivity in AF systems can exceed those of monocropping systems, this is often not translated into financial benefits for the farmer. This is due to the current state of agriculture, whose short time horizon does not take into account wood production and whose markets do not valorize regulating and cultural ecosystem services. As a result, the uncertainty about the profitability of AF systems is often perceived as the most important barrier holding back AF adoption in Flanders. We found that many alternative arrangements could be developed to compensate for this and make AF systems also from an economic point of view attractive for farmers. These alternative arrangements could be financed by different group of stakeholders, such as the government, private entities, consumers and cooperatives. Their diversity in ways of operation results in different strengths, that compensate for other initiatives' barriers and which may appeal to different kind of farmers. Therefore investing in the further development of these instruments through action-oriented research can create leeway for the out-scaling of AF adoption.

8.2 Suggestions for further research

By way of conclusion, we give some suggestions for further research, both for the subject under study, i.e. AF adoption and development, as for the overall research approach, i.e. farming systems research.

8.2.1 Suggestions for agroforestry adoption and development research

Conducting comparative case study analyses

In the discussion section we explained that the structure of the development pathways can be used by researchers in other regions to develop an action plan for the upscaling of AF systems, and this without doing such an intensive and holistic analysis of the enabling environment for AF systems as in this thesis. However, this does not mean that repeating this all-encompassing analysis for other countries or regions would not be useful and deliver valuable insights. A comparative case study with Wallonia for example could be very interesting, as agriculture there is in general more extensive, with a much larger share of the agricultural land being cultivated organically than in Flanders (1.2 % in Flanders versus 10 % in Wallonia) (Timmermans and Van Bellegem 2017). Also valuable insights might be delivered by repeating this holistic analysis in Flanders, but for other agroecological practices. Cross-comparing the results may result in a better understanding of the aspects in which AF systems clearly differ from other agroecological practices (e.g. long rotation time of trees). Extra attention should then be paid to these characteristics, and their consequences for the upscaling of AF systems in Flanders.

Developing tailored actions plans for agroforestry pathways

As explained in the discussion section, the strength of this thesis lies in the holistic and integrative view that is given on the enabling environment for AF systems in Flanders. The drawback of this approach, is that the recommendations that are given often remain quite theoretical, and offer no concrete and practical action plans for the stakeholders involved. In the CH 6, we move a little bit more in this direction, by initiating a design-process and putting forward different financial instruments for progress with regard to the market and financial pathway. Still, the actual translation of these financial instruments into concrete action plans remains to be done. Also for the other development pathways the set-up of a design process in which development directions are further specified and translated into action plans would have value. These translation processes should be steered by participatory action research, an approach that engages research and non-research partners in an iterative process of research, reflection and action (Bacon et al. 2005).

8.2.2 Suggestions for farming systems research

Developing multi-dimensional frameworks for evaluating FSR

In the discussion chapter of this thesis we evaluated the extent to which the different characteristics of FSR are represented, which uncovered that there is room for improving the interdisciplinary and participatory set-up of the project and the thesis. However, trade-offs often have to be made between including different key characteristics of FSR versus obtaining fast and reliable results. The inherent claim of “the more participation, systems-thinking and interdisciplinary collaboration, the better” is thus not necessarily always true. Therefore, linear frameworks, e.g. the typology of Lambrou (2001), (which we have used for evaluating the participatory approach in CH 7), should be replaced increasingly by frameworks that look at FSR characteristics along different dimensions and attributes, and take into account the goals and dynamics of agricultural research projects. For stakeholder participation, Neef and Neubert (2010) already developed such a framework, which contributes through its six different dimensions to better self-reflection, informed discussion and decision-making. We are convinced that also for systems thinking and interdisciplinarity, investing in the development of a framework that takes into account the diversity of agricultural research projects would increase reflexivity and help in achieving specific research goals.

Developing appropriate research performance measures

At the moment, it is not self-evident for mainstream researchers to engage in FSR taking into account the academic structure and its reward system, which is mainly based on quantitative indicators, e.g. the amount of papers published in A1-journals. However, farming systems researchers do not have the power to change how research is organized on their own. Therefore it is really important for farming systems researchers to familiarize their colleagues with the key principles of FSR. In this respect, ILVO gave a good example by organizing a ‘systems thinking’ class, open for all interested researchers affiliated with ILVO. These kind of actions may help other researchers to recognize that the success of research cannot be grasped solely in quantitative indicators, but also is reflected e.g. in the enhanced learning and decision making ability of stakeholders. In this regard, farming systems researchers are called upon to develop qualitative criteria to assess the actual impact of research, which should complement the traditional quantitative indicators.

8.3 References

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Annexes

Annex 1- Factor analysis and interpretation

The factor analysis and interpretation in CH 5 was done making use of PQ-method, which is a software developed to analyze data generated by Q-sorts. We explain the factor analysis and interpretation process here in more detail, step per step.

A.1.1 Factor analysis

Step 1: Input table

The input the user has to give PQ-method is a table with the statements as rows, and the respondents as columns. The cells then contain the score of the corresponding respondent on that particular statement.

Step 2: Matrix with correlation coefficients

PQ method correlates each Q-sort with each other Q-sort in the sample, and calculates a correlation coefficient. Afterwards a matrix is built containing all correlation coefficients.

Step 3: Principal component analysis

From this correlation matrix, unrotated factors are extracted using principal component analysis (PCA). PCA is a dimension-reduction tool that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set. It is thus a mathematical procedure that transforms a number of (possibly) correlated variables into a smaller number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component adds more variability. Figure A – 1 illustrates the PCA process graphically. Table A – 1 shows us the eight largest components that PQ methods gives us, which account for 68% of the variability in the data set.

Step 4: Varimax rotation

In the next step, a specific amount of factors is chosen and rotated by means of a varimax rotation, which is by far the most popular orthogonal rotation method. It implies a rotation of the coordinate system that maximizes the variance of the loadings, with the loading representing the association between a Q-sort and the different factors. As a result, each factor will have a small number of large loadings and a large number of zero or small loadings.

This simplifies the interpretation because each original variable, i.e. each Q-sort tends to be associated with one, or a small number of factors. The varimax rotation is graphically illustrated in Figure A – 2.

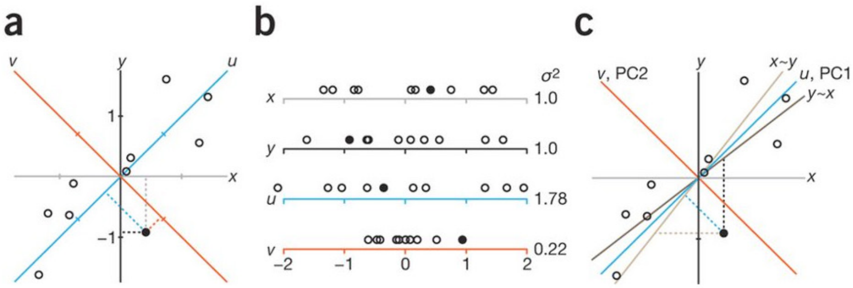

Figure A - 1: PCA geometrically projects data onto a lower-dimensional space. (a) Projection is illustrated with 2D points projected onto 1D lines along a path perpendicular to the line (illustrated for the solid circle). (b) The projections of points in a onto each line. The variance for projected points can vary (e.g. high for u and low for v). (c) PC1 maximizes the variance of the projection and is the line u. The second is perpendicular to PC1 (v, PC2). Dashed line indicates distances being minimized (Lever et al. 2017).

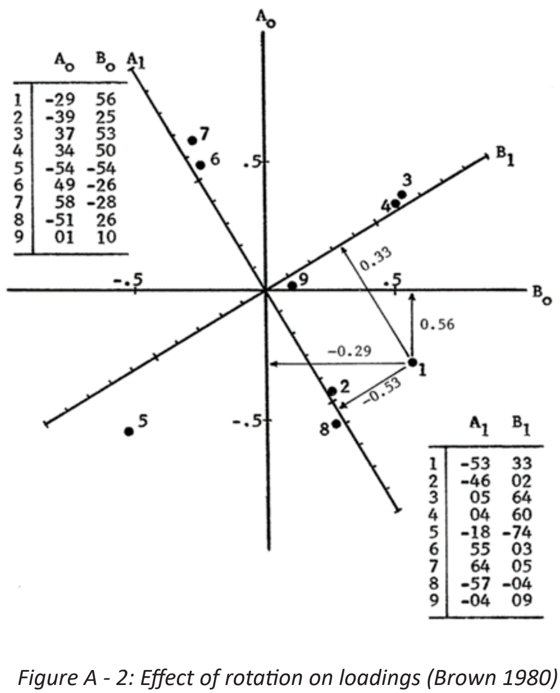

Figure A - 2: Effect of rotation on loadings (Brown 1980)

A.1.2 Factor interpretation

Factor loadings

We did a varimax rotation for a 2-, 3- and a 4-factor solution. The result is Table A – 2, which shows for each Q-sort the factor loadings. With the values in this table, the different statement scores are calculated. This is done for each factor, but only taking into account those Q-sorts that load significantly on that factor, i.e. those Q-sorts that are significantly associated with that factor. The preconditions for significant loadings are the following equations, with l the loading on a factor, N the amount of statements in the Q-set, and l_i the loading on factor i:

$$l > \frac{1.96}{\sqrt{N}}$$

$$l_j^2 > \sum l_i^2 - l_j^2$$

In our study the loadings thus have to be larger than 0.299, and they have to be larger than the sum of the squares of the loadings on the other factors. The Q-sorts that satisfy these conditions for a factor are "flagged". They are shown in grey for the three solutions in Table A – 2.

Q-sort scores

In a subsequent step the z-scores for each statement per factor are calculated. The z-score is a weighted average of the score given by the flagged Q-sorts to a particular statement. Thus how larger the loading of a Q-sort on a factor, how larger the extent to which that Q-sort will contribute to the score for that factor on each of the statements. The weighst are calculated as given by Brown (1980), with w the weight, f the loading, and f_L the largest loading on that factor:

$$w = \frac{f}{1-f^2} \cdot \left|\frac{1-f_L^2}{f_L}\right|$$

The score T for a factor on a statement is then, with p the total amount of loading Q-sorts on that factor, n_i the score of a loading Q-sort, and w_i the weight:

$$T = \sum_i^p n_i * w_i$$

The score T is afterwards normalized to obtain the z-score, with X_T the mean of the different scores of that factor, and s_T the standard deviation:

$$z = \frac{T - \bar{X}_T}{s_T}$$

The final factor scores, i.e. the Q-sort scores are obtained by rounding the z-scores towards the array of discrete values in the grid, which would be for our study c(-4, -4, -4, -3, -3, -3, -3, -2, …, 2, 3, 3, 3, 3, 4, 4, 4). The Q-sort scores for the different factors, for both the 2-, 3- and 4-factor solution are given in Table A - 3.

Distinguishing statements

Last, PQ-method calculates the distinguishing statements, which have to facilitate the interpretation. The distinguishing statements are calculated based on the standard error of differences, which is a statistical test specifically developed for Q-methodology (Brown 1980; Zabala 2014). The calculation of the distinguishing statements starts with the reliability coefficient r of a person with himself, which has proved to range from 0.80 upward . Given correlations of this magnitude, the reliability of a factor can be estimated as below, with p the number of Q-sorts defining a factor:

$$r_x = \frac{0{,}80 \cdot p}{1 + (p-1) \cdot 0{,}8O}$$

Factor reliability is of importance since the standard error of factor scores is given by the following expression, with s_x the standard deviation of the q-sort distribution:

$$SE = s_x\sqrt{1 - r_x}$$

Now in order to determine whether scores in two factors are significantly different, it is necessary to combine their respective errors into the standard error of differences, which is:

$$SED_{x-y} = \sqrt{SE_x^2 + SE_y^2}$$

Difference scores are expected to follow a normal curve. We will thus accept those scores as significantly different (p<0.05 and p<0.01), that differ by an amount that is larger than respectively 1.96* SED and 2.58*SED.

The reliability coefficients for the 3-factor solution are in our study respectively 0.99; 0.97 and 0.94. The standard deviation of the Q-sort distribution is 2.26. However, we calculate especially with normalized z-scores, of with the standard deviation is 1.Therefore, the standard error of factor scores for the three factors of the 3-factor solution are respectively 0.1; 0.19; and 0.24. With these numbers the standard error of difference between factor 1 and 2, 1 and 3, and 2 and 3 can be calculated, which has to be multiplied with 1.96 to get the minimum difference in scores between factors at the $p<0.05$ level, and multiplied with 2.58 to get the minimum difference in scores between factors at the $p<0.01$ level. The necessary differences in z-scores of statements between factors to be significantly different are given below.

	$p < 0.01$	$p < 0.05$
factor 1-2	$2.58 * \sqrt{0.10^2 + 0.19^2} = \mathbf{0.54}$	$1.96 * \sqrt{0.10^2 + 0.19^2} = \mathbf{0.41}$
factor 1-3	$2.58 * \sqrt{0.10^2 + 0.24^2} = \mathbf{0.68}$	$1.96 * \sqrt{0.10^2 + 0.19^2} = \mathbf{0.51}$
factor 2-3	$2.58 * \sqrt{0.19^2 + 0.24^2} = \mathbf{0.79}$	$1.96 * \sqrt{0.10^2 + 0.19^2} = \mathbf{0.60}$

A.1.3 Decision on the amount of factors to retain

For deciding about the amount of factors to retain, some general rules of thumb exist. As such, the eigenvalue of factors should exceed one, and the amount of Q-sorts loading on a factor should be minimum two. In our study the number of factors with an eigenvalue exceeding one amounts up to 11, whereas a minimum of two loading Q-sorts on each factors corresponds with retaining a maximum of six factors.

To further decide on the amount of factors to retain, we looked further at the number of loading Q-sorts and the variance explained (Table A – 1 and Table A – 2). This showed that the majority of the Q-sorts load on the first factor and that significant loadings of the other Q-sorts are spread over the rest of the factors. Especially the 5- and 6-factor solutions contained one or more factors with only a minimum of two loading Q-sorts. Taking into account that our Q-sort is relatively large (with 38 respondents) and that AF is a farming system that is still in its early stage of diffusion (which would make the existence of five or more perspectives on AF unlikely), the 5- and 6-factor solutions were discarded.

For the remaining 2-, 3- and 4-factor solutions, the loading plots (based on Table A – 1, see Figure 5 – 2), the Q-sort scores and distinguishing statements marked in Table A – 2 were studied more in detail. Looking at the amount of Q-sorts loading on the different factors, it is clear that the 2-factor solution is more balanced in comparison with a 3- and a 4-factor solution. However, looking at the 2-factor solution, we see in Table A – 2 that almost all statements are distinguishing, even those for which scores between the factors are (almost) identical e.g. S12 (-3**, -3**), S14 (-2*, -1*), S24 (1**, 2**) and S38 (3**, 4**). If we look at the scores for these same statements in the 3-factor solution, then we see we see the following: S12 (-3*, -4*, 4**), S14 (-2, -2, 2**), S24 (1, 1, 1) and S38 (3, 4, 2). For S12 and S14 (and for many other statements) there seems to be a perspective that is not captured by the 2-factor solution, whereas the three-factor solution shows that S24 and S38 are actually consensus statements. For the 4-factor solution the amount of distinguishing statements is reducing considerably, especially for factor 3 and 4. For a 4-factor solution there is also only one statement for which scores are significantly different for all factors, whereas there are 15 statements with significantly different scores between factors for the 3-factor solution. The statistics thus guides us to the 3-factor solution.

However, before making a definite choice, all factors of the 2-, 3- and 4-solutions were interpreted, based on the most distinguishing statements per factor. This happened by three different researchers separately based on Table A - 3. The main researcher, who performed the interviews, also compared the different factor interpretations with the worldviews of the respondents loading on that factor. Throughout these exercises it became clear that a 3-factor solution was easiest to interpret and formed more consistent perspectives than those of the 2- and 4-factor solutions. Thus, the combination of better statistical results and a logical interpretation made us to choose for a 3-factor solution.

A.1.4 References

Brown SR (1980) Political Subjectivity: Application of Q-methodology in Political Science. Yale University, New Haven, London

Lever J, Krzywinski M, Altman N (2017) Points of Significance: Principal component analysis. Nat Methods 14:641–642. doi: 10.1038/nmeth.4346

Zabala A (2014) qmethod: A Package to Explore Human Perspectives Using Q Methodology. R J 6:163–173.

Table A - 1: Unrotated factor matrix after PCA

	F1	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*	*F8*
R1	0.7319	-0.1407	-0.0404	0.0765	0.0116	0.1511	-0.0611	0.2996
R2	0.7858	-0.2228	-0.0655	-0.2611	0.0775	-0.1837	-0.0828	0.1059
R3	0.5832	0.2536	-0.1451	-0.0394	0.4794	0.2094	-0.0345	0.0448
R4	0.8077	-0.0426	-0.1267	-0.1635	-0.2056	0.0633	0.0794	0.1276
R5	0.2186	0.1071	0.0018	-0.2678	0.4315	0.4337	-0.1174	-0.2776
R6	-0.1085	0.5059	0.4674	-0.3051	-0.1826	0.3536	0.0955	0.1531
R7	0.6400	0.0149	0.2491	0.0612	0.2241	0.0186	0.2276	-0.0956
R8	0.8080	-0.1932	-0.0170	-0.0353	-0.0980	0.2097	-0.0316	-0.1190
R9	0.4658	0.4741	0.1628	-0.1223	-0.2429	-0.0559	-0.0980	0.2831
R10	0.1963	0.4290	-0.3478	0.3992	-0.2953	-0.1849	-0.1027	-0.0337
R11	0.4548	0.3055	-0.0185	0.2790	0.5158	0.0606	0.1666	0.0982
R12	0.7391	-0.1003	0.1909	-0.2848	0.0163	-0.2281	-0.1863	-0.1005
R13	0.7415	-0.2657	0.0712	-0.0654	0.0445	-0.2645	-0.0994	-0.2003
R14	0.0179	0.1830	0.3459	0.3632	0.0400	-0.2842	0.3995	0.1681
R15	0.0404	0.4559	-0.3696	-0.2021	-0.0720	-0.1131	0.4557	-0.1219
R16	-0.0929	0.2075	0.6961	0.0566	-0.0344	0.0821	0.2224	-0.3029
R17	-0.1414	0.6590	0.0476	-0.2664	0.3605	0.0587	-0.2325	-0.1811
R18	-0.3447	0.4435	0.1737	0.0724	0.0820	0.0761	0.0895	0.3452
R19	0.5414	0.0161	-0.2494	0.0718	-0.1487	0.1396	0.3552	-0.3024
R20	0.6621	0.0248	0.0080	0.4116	-0.1318	0.2118	0.0938	-0.0817
R21	0.6434	0.0159	-0.4575	-0.2262	0.1469	-0.0156	0.0557	0.0320
R22	0.5892	0.4329	0.0484	-0.1447	-0.0039	-0.2986	-0.3136	-0.0298
R23	0.7795	0.0754	-0.0847	0.0886	0.0404	-0.0136	0.0621	-0.2547
R24	0.6082	-0.0750	0.2444	-0.3581	-0.1500	0.0116	0.1183	0.0717
R25	0.7188	0.0604	-0.0191	0.1091	-0.0434	0.4200	0.0898	-0.0730
R26	0.6424	-0.2478	-0.3168	-0.1371	-0.2731	-0.0270	0.1303	0.1754
R27	0.8352	0.0882	0.2094	0.1920	0.0970	-0.1147	0.0201	0.0366
R28	0.1381	0.6681	-0.2134	0.0541	-0.1092	-0.3123	-0.3292	-0.1767
R29	0.4245	0.2494	-0.0588	0.4942	0.3066	0.1181	-0.1778	0.3740
R30	0.6646	-0.0899	0.1283	0.1052	0.2675	-0.3847	0.0060	0.1482
R31	0.1549	0.5974	0.0080	-0.2668	-0.2197	0.1600	-0.0535	-0.1313
R32	0.6366	-0.2420	0.4588	-0.0542	0.0029	-0.1077	-0.2634	-0.0809
R33	0.0369	0.6584	-0.0303	-0.1120	-0.1715	-0.3080	0.3057	-0.0052
R34	0.7976	-0.0318	-0.1831	0.1157	-0.0387	0.0168	0.1910	-0.1820
R35	0.3025	0.0767	0.3699	0.4541	-0.1661	-0.0618	-0.1258	-0.3537
R36	0.6870	0.0841	0.1995	-0.2680	-0.1061	0.0679	0.0930	0.3826
R37	0.3960	-0.0755	0.1797	0.1715	-0.5395	0.2443	-0.2173	0.0672
R38	0.0796	0.3171	-0.2769	0.2592	-0.2175	0.3115	-0.3144	0.0460
Eigenvalues	**11.5071**	**3.6972**	**2.3677**	**2.0450**	**1.9217**	**1.6357**	**1.4574**	**1.4067**
% expl.Var.	**30**	**10**	**6**	**5**	**5**	**4**	**4**	**4**

Table A - 2: Factor loadings for 2, 3 and 4 factors with x indicating a loading q-sort

	2-factor solution		***3-factor solution***			***4-factor solution***			
	F1	F2	F1	F2	F3	F1	F2	F3	F4
R1	0.7403X	-0.0867	0.7275X	0.0018	-0.1671	0.7188X	-0.1148	-0.0015	0.1820
R2	0.8000X	-0.1647	0.7849X	-0.0544	-0.2290	0.8312X	-0.0305	-0.2081	-0.0667
R3	0.5630X	0.2956	0.5252X	0.3773	-0.0855	0.5179X	0.2643	-0.0869	0.2852
R4	0.8086X	0.0166	0.7787X	0.1364	-0.2127	0.8035X	0.0779	-0.1792	0.1146
R5	0.2101	0.1228	0.2042	0.1303	0.0238	0.2343	0.2321	-0.1130	-0.0969
R6	-0.1452	0.4966X	-0.0861	0.2580	0.6420X	-0.0982	0.6272X	0.3188	-0.2731
R7	0.6372X	0.0618	0.6659X	0.0149	0.1683	0.6340X	0.0534	0.2582	0.0646
R8	0.8200X	-0.1336	0.8112X	-0.0432	-0.1750	0.8197X	-0.1020	-0.0461	0.0857
R9	0.4298	0.5069X	0.4347	0.4379	0.2957	0.4095	0.5209X	0.1638	0.1316
R10	0.1644	0.4422X	0.0960	0.5559X	-0.1588	0.0309	0.1694	-0.0125	0.6878X
R11	0.4312X	0.3380	0.4132X	0.3547	0.0633	0.3504	0.1680	0.1886	0.4379X
R12	0.7445X	-0.0459	0.7660X	-0.0513	0.0584	0.7937X	0.1120	0.0149	-0.1763
R13	0.7589X	-0.2107	0.7667X	-0.1539	-0.1182	0.7794X	-0.1469	-0.0009	-0.0269
R14	0.0044	0.1838	0.0521	0.0327	0.3868X	-0.0324	0.0311	0.5082X	0.1581
R15	0.0069	0.4577X	-0.0634	0.5648X	-0.1521	-0.0394	0.4575X	-0.3381	0.2484
R16	-0.1079	0.2001	-0.0054	-0.0999	0.7254X	-0.0663	0.2234	0.6475X	-0.2565
R17	-0.1893	0.6469X	-0.1986	0.5567X	0.3275	-0.2000	0.6976X	0.0098	0.0294
R18	-0.3762	0.4171X	-0.3571	0.2803	0.3737	-0.4004	0.3519	0.2492	0.0683
R19	0.5388X	0.0557	0.4922X	0.1966	-0.2733	0.4895X	-0.0094	-0.1582	0.3098
R20	0.6585X	0.0732	0.6495X	0.1219	-0.0484	0.5801X	-0.1233	0.2369	0.4478
R21	0.6405X	0.0630	0.5604X	0.2940	-0.4722	0.6125X	0.1125	-0.4839	0.2296
R22	0.5559X	0.4749	0.5426X	0.4647	0.1628	0.5286X	0.4911	0.0519	0.1860
R23	0.7719X	0.1322	0.7455X	0.2225	-0.1234	0.7244X	0.0680	0.0044	0.3145
R24	0.6121X	-0.0303	0.6430X	-0.0698	0.1303	0.6782X	0.1650	0.0236	-0.2753
R25	0.7125X	0.1129	0.6975X	0.1737	-0.0640	0.6710X	0.0483	0.0663	0.2750
R26	0.6588X	-0.2001	0.6079X	-0.0005	-0.4527	0.6542X	-0.1455	-0.3636	0.1093
R27	0.8265X	0.1491	0.8442X	0.1271	0.1430	0.7891X	0.0662	0.3085	0.2528
R28	0.0888	0.6764X	0.0351	0.7108X	0.0668	-0.0012	0.5488X	-0.0378	0.4596
R29	0.4051X	0.2798	0.3829X	0.3150	0.0067	0.2948	0.0133	0.2549	0.5814X
R30	0.6694X	-0.0410	0.6821X	-0.0288	0.0133	0.6570X	-0.0700	0.1621	0.1206
R31	0.1108	0.6072X	0.0929	0.5624X	0.2369	0.0942	0.6590X	-0.0272	0.0909
R32	0.6526X	-0.1947	0.7208X	-0.3010	0.2533	0.7086X	-0.0974	0.3329	-0.2344
R33	-0.0114	0.6593X	-0.0352	0.6144X	0.2388	-0.0565	0.6294X	0.0273	0.2195
R34	0.7978X	0.0267	0.7590X	0.1668	-0.2584	0.7460X	-0.0479	-0.0820	0.3444
R35	0.2960	0.0986	0.3464X	-0.0290	0.3367	0.2502	-0.0829	0.5639X	0.2301
R36	0.6790X	0.1341	0.6974X	0.1043	0.1471	0.7118X	0.2638	0.0602	-0.1038
R37	0.4005X	-0.0463	0.4245X	-0.0777	0.0925	0.3889X	-0.1003	0.2357	0.0861
R38	0.0562	0.3221X	0.0035	0.4086X	-0.1289	-0.0374	0.1353	-0.0458	0.4784X
Defining Q-sorts	**24**	**10**	**25**	**7**	**3**	**22**	**7**	**3**	**4**

Table A - 3: Statement scores for a 2-, 3- and a 4-factor solution

		2-factor solution		***3-factor solution***			***4-factor solution***			
No.	Statement	F1	F2	F1	F2	F3	F1	F2	F3	F4
1	AF must be implemented on large plots, because then it becomes feasible and financially viable.	-2**	2**	-2	3**	-3	-2	2**	-3*	-2
2	AF is especially useful on less valuable plots, which are too small, too wet or too far away.	-2	-2	-2*	-1*	2**	-2	-3	0	1
3	Only in the context of extensive livestock farming there are opportunities in AF.	-2	-2	-2	-3	0**	-2	-2	-1	-4
4	If you implement AF, you must choose fast-growing species, i.e. species with a fast yield.	-3**	0**	-3*	1**	-1*	-3**	0	0	0
5	The cultivation of standard fruit trees is too labor-intensive to be economically interesting.	-1**	1**	-1*	0*	4**	-1*	3	4	0*
6	AF plots must always match as closely as possible the landscape character of a region.	2**	-2**	2	-3**	3	2	-1*	2	-3*
7	To implement AF solely because of wood production is short-sighted.	1	1	1	2**	0	1	0	3	1
8	AF is more than the cultivation of trees on farmland, it requires a system approach and a redesign of your farming system.	2	1	2	2	1	3	2	-1	-2
9	AF is only feasible and financially viable if the distance between the tree rows is adjusted to the width of farming machinery.	0**	4**	0	4**	-1	0	3**	1	0
10	The fact that AF is recognized as ecological focus area is for quite some farmers an incentive to adopt.	2**	0**	2**	0	-2	2	-1**	2	3
11	Subsidy levels for AF systems should be coupled to the level of ecological and landscape value created.	2**	-1**	3	-1**	1	2	-1**	3	2
12	The high subsidy that exists for AF systems cause farmers to spend large amounts of money on plantations at the expense of society.	-3**	-3**	-3*	-4*	4**	-3	-2	1**	-4
13	It should be allowed at all times to harvest trees on farmland.	0**	4**	0**	4	3	1	4**	-1	0
14	As a farmer, I would never consider to plant trees on land that is not mine.	-2*	-1*	-2	-2	2**	-1*	0	1	-3*

15	AF must be considered a long-term saving account.	1**	-2**	1**	-1	-3	1*	-3*	-1	-1
16	AF is especially meant for hobby farmers.	-4	-4	-4	-4	0**	-4	-4	1**	-3
17	The added value of AF is not financial, but lies in a higher biodiversity and a healthier ecosystem.	0**	1**	0**	1**	-2**	0	1	0	0
18	The consumer is not willing to pay more for products coming from an AF system.	-1**	3**	-1	3**	-2	-1**	2**	-4**	4**
19	The emergence of novel marketing systems such as farm shops, urban agriculture and community-supported agriculture is an opportunity for AF.	1**	-3**	1**	-3**	-1**	1**	-3	-2	-1
20	Nobody is waiting for food or wood products with an AF label.	0**	2**	0*	2	2	0**	1	2	2
21	A farmer planting rows of trees on farmland can expect criticism of his colleagues.	0**	2**	0	2**	-1	0*	1**	-2	-1
22	AF can boost the image of the agricultural sector.	2**	0**	2**	1	0	2	1	2	1
23	The real advantages of AF are for society, not for the farmer.	-2**	0**	-2**	0	1	-2*	-1*	1	2
24	The insurmountable disadvantage of AF is the long term, you cannot simply try it out for a year.	1**	2**	1	1	1	1	3**	-1	1
25	Planting trees results in a value increase of the farmland.	0**	-4**	0**	-2**	-4**	0**	-4	-4*	-3
26	AF means maximizing the biomass yield per ha.	0**	-1**	0	-1	0	0	-1	-2	0
27	Rows of high trees in the landscape have a negative impact on prey animals.	-1*	-3*	-1	-3*	-1	-1	-3	-1	-2
28	Taking into account climate and soil in Flanders, that are advantageous for classical crop production, AF is a poorly suited agricultural system for Flanders.	-3**	1**	-3**	0**	3**	-3**	1	1	-4**
29	AF offers protection against pests and diseases of agricultural crops.	3**	-4**	2**	-4	-3	3**	-4**	-2	-1
30	Trees ensure fertile soils by restoring organic matter content and recycling nutrients.	4**	-1**	3**	0**	-4**	4	-2**	-3**	4
31	Research in agriculture must focus on new technologies that produce more food with less inputs.	1**	3**	1**	2**	4**	0*	4	3	3
32	A farmer who wants to farm efficiently focuses on scaling and intensification.	-4**	1**	-4**	-2**	1**	-4*	0	0	-2*

33	Only by increasing the production in existing agricultural regions, space can be safeguarded in Flanders for the development of nature and biodiversity.	-3**	-1**	-3*	-1**	-4*	-3*	-1	-4*	0
34	The agricultural sector must focus on the production of higher quality food with more attention for the social and ecological impact.	4**	0**	4**	-1**	3**	4	0*	4	1*
35	To make farms resilient again, one has to start with healthy soils, animals and plants, and work hand in hand with nature.	4**	-3**	4**	-2	-3	4**	-2	-3	-1
36	The agricultural sector must compete in the international market, just like other sectors.	-1**	2**	-1**	3	2	-2**	1	4**	3
37	Agricultural policy should encourage the economic growth and competitive-ness of farms.	-1**	3**	-1	1	0	-1	3**	0	-2
38	Farmers always must be looking for new opportunities on the market and be consumer-oriented.	3**	4**	3	4	2	2	4	3	2
39	Irrespective of the public services carried out, income support for farmers is justified.	-4**	0**	-4*	0**	-2*	-4**	0	0	1
40	The abolition of market and price support in the agricultural sector would have an unacceptable impact on the income of farmers.	-1**	3**	-1	3**	-1	-1**	2	-3**	3
41	The power in the food chain must be shifted to the local level, where produc-er and consumer can interact again with one another.	3**	1**	3**	1	0	3*	2*	0	-1
42	The role of agricultural policy is to guaranty the application of environmental standards and to pay for ecosystems services that cannot be traded on the market.	1**	-2**	1	-2**	1	1	-2**	2	2
43	In the future, efforts related to biodiversity, soil, animal welfare, climate and water will become services as important as food production.	3**	0**	4**	0**	-2**	3	0	-2	4
	Distinguishing statements (p<0.05)	**37**	**37**	**25**	**25**	**18**	**20**	**17**	**9**	**7**
	Consensus statements (p<0.01)	**6**		**2**			**1**			

Annex 2 - Curriculum Vitae

Lieve Borremans was born in Leuven, Belgium on December 5, 1990. In 2008, she obtained her secondary school degree in Latin and Mathematics at Don Bosco Haacht. Then she enrolled in a Bachelor and a Master program in Bio-science Engineering at the KU Leuven, of which she obtained the degree respectively in 2011 and 2013. Her focus during these studies was mainly on land and forest management (major) and agricultural economics (minor). In the context of these studies she resided half a year in Vienna, where she followed classes at the BOKU University as part of the Erasmus program, and four months at the University of Burundi for the data collection for her master thesis. In the summer of 2014 she applied for a PhD-position on the VLAIO agroforestry project at ILVO, where she got selected amongst others because of her interests in both forestry and agricultural economics. Since then, she is working at the Social Siences Unit of ILVO, where she is responsable for the social and economic research in the context of the VLAIO agroforestry project. Her PhD is conducted in collaboration with the Unit of Landscape Ecology and Plant Production Systems of the ULB, given their expertise in agroecology and sustainable food systems research. During her PhD, Lieve has participated and presented her work in different conferences, such as the European and North American Agroforestry Conferences. At the Euraf conference in Nijmegen in 2018 she was the recipient of the best poster award.

Annex 3 - Doctoral training results

Peer-reviewed publications

Borremans, L., Marchand, F., Visser, M., Wauters, E., 2018. Nurturing agroforestry systems in Flanders: Analysis from an agricultural innovation systems perspective. Agric. Syst. 162, 205–219. doi:10.1016/j.agsy.2018.01.004

Borremans, L., Reubens, B., Van Gils, B., Baeyens, D., Vandevelde, C., Wauters, E., 2016. A Sociopsychological Analysis of Agroforestry Adoption in Flanders: Understanding the Discrepancy between Conceptual Opportunities and Actual Implementation. Agroecol. Sustain. Food Syst. 40, 1008–1036. doi:10.1080/21683565.2016.1204643

Publications currently under review

Borremans, L., Wauters E., Marchand F., and Visser M. Unravelling and linking perspectives on agroforestry and agriculture: a Q-methodological approach for the case of Flanders

Borremans, L., Reubens B., Visser, M. and Wauters, E. Using the values of agroforestry systems to create economic incentive pathways for farmers: an exploratory study for Flanders.

Oral presentations at (inter)national conferences

Borremans, L., Visser M., Wauters, E. 2015. The development of agroforestry systems in Flanders. A farming systems research approach to social, institutional and economic inquiry. Presented at the 4th Belgian Agroecology Meeting in Leuven, 17 November 2015

Borremans, L., Wauters, E. 2016. Nurturing agroforestry systems in Flanders: an Agricultural Innovation Systems approach. Presented at the European Agroforestry Conference in Montpellier (France), 23-25 May 2016

Borremans, L., Wauters, E., Visser, M. 2016. Nurturing agroforestry systems in temperate regions: an analysis of discourses for an enabling environment in Flanders, Belgium. Presented at the Interantional Farming Systems Association Symposium in Newport (UK), 12-15 July 2016

Borremans, L., Visser, M., Wauters, E. 2016. Nurturing agroforestry systems in temperate regions: an analysis of discourses for an enabling environment in Flanders, Belgium. Presented at the 5th Belgian Agroecology Meeting in Ghent, 20 september 2016

Borremans, L., Meus, K, Wauters, E. 2017. Designing valuable agroforestry systems through integration of modeling and participatory approaches. Presented at the 15th North American Agroforestry Conference in Blacksburg (Virgina, US), 27-29 June 2017

Poster presentations at (inter)national conferences

Borremans, L., Reubens, B., Visser, M., Wauters, E. 2015. Designing appropriate agroforestry systems: a systematic understanding of adoption decisions. Poster presented at the 5th International Symposium for Farming Systems Design in Montpellier (France), 7-10 September 2015

Borremans, L., Reubens, B., Wauters, E. 2018. How to make agroforestry pay off? Using it values to create economic incentive pathways. Poster presented at the 4th European Agroforestry Conference in Nijmegen (the Netherlands), 28-31 May 2018

Participation in summer schools

Integrated Land Use Systems (ILUS) summmer school in Freiburg (Germany)

- organized by the university of Freiburg, more specifcally the faculty of Environment and Natural Resources and the Chair of Silviculture in cooperation with international experts
- Format: 3 week full time seminar (1-19 June, 2015)
- 5 ECTS credits

Summer school “Choice Experiments in Agricultural and Food Economics” in Leuven

- organized by the Divison of Bioeconomics at the KULeuven
- Format: 2-day workshop (28-29 June, 2016)

PhD course “Systems Thinking and Practice in Research” in Newport (UK)

- organized by members of the International Farming Systems Association (Prof. Ray Ison, Prof. Nadarajah Sriskandarajah and senior lecturer Chris Blackmore)
- Format: 3.5 days of workshops organized in congruence with the IFSA symposium (12-15 July, 2016)
- 4 ECTS credits

Annex 4 - English summary

Because of the multiple values and services that trees deliver to society, AF is increasingly interpreted as an agricultural innovation that can help to address challenges in modern agriculture. Despite its potential opportunities in Flanders, many farmers remain skeptical though, resulting in adoption rates that are lagging behind. Therefore the objective of this thesis is to gain a better understanding of the unfavorable environment for AF adoption and development making use of a farming systems research approach (FSR). In Chapter 2 we explain FSR as our general research approach, which implies the consideration of three key characteristics, i.e. systems thinking, interdisciplinarity and a participatory approach. Taking into account the general FSR characteristics, Chapter 3, 4 and 5 “diagnose” the AF implementation gap more in detail. In chapter 3, we gain some first insights by assessing farmers’ intentions ot engage in AF and by giving an overview of the current AF acreage in Flanders. In chapter 4, we use the Agricultural Innovation Systems concept as general framework to identify the different stakeholders and their respective roles, and to give an overview of the different merits and failures with respect to AF development. Afterwards Chapter 5 elucidates the different perspectives that exist on AF systems among Flemish stakeholders, and links them with general discourses on agriculture in Flanders. Diagnostic analyses were followed up by design exercises in Chapter 6, which looks into different instruments that may give economic incentives to farmers to adopt AF. Taking into account the gathered insights, we present in the main discussion chapter five development pathways to further stimulate AF adoption and development: (1) the science and technology pathway, which stands for investing in research, especially targeting the productivity and compatibility of AF systems, and this in active collaboration with farmers; (2) the market and financial pathway, which implies the creation of market mechanisms in which landscape and biodiversity aspects are valued, while stimulating private investments and consumer demand; (3) the policy and institutional pathway, which aims for the creation of a fully-fledged legal landscape for AF, which is clear and steadfast into the future, and which should be complemented with an attractive and effective subsidy program; (4) the educational and organizational pathway, which stimulates the use of multiple communication and education channels to inform the relevant actors and familiarize them with agroecological practices and their benefits for society; and (5) the social and behavioral pathway, which encourages strengthening the dialogue between influential groups to restore mutual confidence, build up common visions, and open up collaboration opportunities. Through further systemic, interdisciplinary and participatory research, the identified development pathways should be translated into concrete action plans to eliminate adoption barriers and close the AF implementation gap in Flanders.

Annex 5 - Résumé français

Parce que les arbres rendent une pluralité de services à la société, l'agroforesterie se positionne de plus en plus comme une innovation agricole pouvant répondre aux défis de l'agriculture moderne. Malgré ce potentiel, de nombreux agriculteurs flamands hésitent à adopter l'agroforesterie. L'objectif de cette thèse de doctorat est de comprendre mieux pourquoi, et ce à travers une approche de systèmes agraires (ou FSR : Farming Systems Research). Au Chapitre 2, nous explicitons FSR et ses trois dimensions principales: la systémique, l'interdisciplinarité et l'approche participative. A travers cette démarche FSR, les Chapitres 3, 4 et 5 approfondissent les raisons de la non-adoption de l'agroforesterie par les agriculteurs flamands. Le Chapitre 3 évalue les intentions des agriculteurs vis-à-vis l'agroforesterie en tant qu'innovation et explore l'état de l'art de son adoption en Flandres. Le chapitre 4 utilise le concept de Systèmes d'Innovations Agricoles comme cadre théorique pour identifier les différents acteurs institutionnels et leurs rôles respectifs. Il analyse les différents obstacles et leviers que ces acteurs représentent par rapport au développement de l'agroforesterie. Le Chapitre 5 identifie et décrit les différentes perspectives qui existent autour des systèmes agroforestiers parmi les acteurs flamands, et les lie avec des discours plus vastes sur les défis de l'agriculture en Flandres. Après ces analyses de diagnostic, le chapitre 6 consiste en une série d'exercices de design d'instruments économiques favorisant l'adoption de l'agroforesterie. La discussion développe cinq trajectoires de développement complémentaires pour favoriser l'adoption de l'agroforesterie: (1) la trajectoire de science et technologie, qui consiste en des recherches axées sur la productivité et la compatibilité des systèmes agroforestiers, en collaboration active avec les agriculteurs; (2) la trajectoire financière et du marché, impliquant la création de mécanismes de marché valorisant les valeurs paysagères et de biodiversité tout en stimulant les investissements privés et la demande des consommateurs; (3) la trajectoire institutionnelle et des politiques, pour créer un cadre légal, clair et stable pour lever les obstacles légaux créant de la confusion et l'incertitude quant au statut des arbres à long terme; (4) la trajectoire de l'éducation et de l'organisation, stimulation l'usage d'une diversité de canaux d'éducation et de communication pour informer et familiariser les acteurs avec des pratiques agroécologiques et leurs bénéfices pour la société; et (5) la trajectoire sociale et comportementale, qui encourage le dialogue entre les groupes d'influence pour restaurer un climat de confiance mutuelle, construire des visions communes et créer des opportunités de collaboration. Plus de recherches systémique, interdisciplinaire et participative sont requises pour traduire les trajectoires de développement ainsi définies en des plans d'action concrets pour éliminer les barrières à l'adoption de l'agroforesterie en Flandres.