School of GeoSciences

Social perceptions of Agroforestry: A case study in Germany using Q-Methodology

Dissertation

for the degree of

MSc in Ecological Economics

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Ethical statement:
The experimentation and work associated with this thesis has been conducted in accordance with the Ethical Guidelines of the School of Geosciences. A self-assessment of the work was conducted and considered within the project planning process. A copy of the self-assessment can be made available upon request.

THE UNIVERSITY OF EDINBURGH

ABSTRACT OF THESIS

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ABSTRACT OF THESIS

Agroforestry systems, an integrative and disruptive approach, are equipped to tackle the socioecological and socioeconomic issues pressuring the German agricultural sector, induced by industrial farming. To understand what the social perspectives around this system are in Germany and whether there is support on which future work can be built, a Q-study has been carried out in due course. Twenty participants from diverse stakeholder groups sorted forty-seven statements according to their understanding of the field, which the subsequent quali-quantitative analysis narrowed down to three distinct social perspectives: (1) Optimists, characterised by their strong belief in the possible mainstreaming success of AFS in Germany, (2) Systemic Transformists, understanding the hurdles connected to its implementation, however seeing them as mainly short-term restrictive whilst emphasising the diverse potential entailed in a holistic transformation of agriculture towards AFS in generating diverse benefits for societies. Lastly, (3) Sceptics, aligned in their perception of the diverse risks connected to AFS implementation as too high and restricting farmers to adopt it. Overall, stakeholders collectively supported the general approach of AFS and understood the diverse potential connected to it, which represents a basis for future efforts regarding the mainstreaming of AFS in Germany. Important points of consensus and polarisation were elicited, among them the need for broad communication work aiming at educational and awareness-raising campaigns, thereby potentially reducing the number of points of polarisation between stakeholders as well as increase the commitment to the approach. The study concludes with the presentation of several areas of future research based on the outcomes of the study aiming at delivering a holistic understanding of the field to effectively increase the sustainability of German land-use systems.

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List of Abbreviations

AFS	Agroforestry Systems
CAP	Common Agricultural Policy
EE	Ecological Economics
ES	Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IQS	Idealised Q-Sort
IQSP	Idealised Q-Sort Position
NEP	New Environmental Pragmatism
NRE	New Resource Economics
PES	Payments for Ecosystem Services
Q	Q-Methodology
R	R-Methodology
SEE	Social Ecological Economics
SPI	Social Perspective I
SPII	Social Perspective II
SPIII	Social Perspective III
WTA	Willingness-to-accept
WTP	Willingness-to-pay

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PART I –

ECOLOGICAL ECONOMICS CONTEXTUALISATION

1 Positioning Agroforestry Systems within the Ecological Economics' Philosophy of Science

The investigation of social perceptions around modern Agroforestry Systems (AFS), an integrative land-use system combining forestry and agriculture, connects to the field of Ecological Economics (EE) in diverse ways (Funtowicz and Ravetz, 1994; Kay *et al.*, 2019). Those will be elaborated below.

AFS entails potential to deliver multiple socio-ecologic benefits, such as improving agricultural land's productivity as well as halting and reversing environmental degradation (Nair, 2007; Elevitch *et al.*, 2018). They touch on social, ecological and economic systems whilst acknowledging their diverse interdependencies (Rigueiro-Rodríguez *et al.*, 2009; Mosquera-Losada *et al.*, 2012). Attention to those three systems characterises the field of EE (Cosme *et al.*, 2017; Elevitch *et al.*, 2018), where the importance of considering the complex connections and dependencies between the environment, societies and their economies is emphasised (Spash, 2020). These three systems are harmonising in the EE worldview, referred to as the "embedded economy" (Cosme *et al.*, 2017). The embedded economy demonstrates the dependency of long-term successful economies on functioning societies, which again depend on resilient ecosystems (Costanza *et al.*, 2014; Spash, 2020). Therefore, EE perceives societies and economies as integral parts of the environment and not isolated of it (Spash, 2011). This worldview is essential to the approach of EE tackling socio-ecological problems (Cosme *et al.*, 2017), whilst also characterising the approach of AFS (Rigueiro-Rodríguez *et al.*, 2009; Mosquera-Losada *et al.*, 2012).

As Spash and Ryan (2012) discussed in their work, the field of EE can be divided into three branches, differentiated by their interpretation of the philosophy of science: the ontological, epistemological and methodological foundations of the field. Those are Social Ecological Economics (SEE), New Resource Economics (NRE) and New Environmental Pragmatism (NEP), which can be placed between the former two (Spash and Ryan, 2012; Buchs *et al.*, 2020). The AFS approach is closer in line with the ontological and epistemological understanding of the SEE branch, which advocates for paradigm shifts and distances itself the most from neoclassical economics and its corresponding tools and assumptions, such as monetary valuation of nature's Ecosystem Services (ES) and the homo oeconomicus model of human behaviour (Spash and Ryan, 2012; Levrel and Martinet, 2021; Tubenchlak *et al.*, 2021). Representatives of the SEE approach see the urgent need to completely detach new approaches to solving multidimensional sustainability problems from neoclassical roots (Spash and Ryan, 2012; Pirgmaier, 2017). SEE acknowledges the importance of approaching controversial problems interdisciplinary, it accepts the complexity of environmental problems, the incommensurability of values, uncertainty of knowledge creation and allows methodological pluralism, provided that it fits into its ontology (Costanza, 1991; Martinez-Alier *et al.*, 1998; Spash, 2011, 2020; Spash and Ryan, 2012; Buchs *et al.*, 2020; Levrel and Martinet, 2021). The application of Q-Methodology in this research, a method using quali- and quantitative data equipped to discover the subjective values and viewpoints existent around controversial issues (Webler *et al.*, 2009; Levrel and Martinet, 2021), fits well into the SEE approach. This is especially valid as the SEE branch acknowledges value pluralism and emphasises approaches, such as Q-Methodology, enabling engagement with it (Spash, 2013). As a land-use system generating diverse benefits for all three above-mentioned systems and interdisciplinary approaching the task of generating food by combining agriculture, forestry, and nature conservation practices, AFS also acknowledge value pluralism (Rigueiro-Rodríguez *et al.*, 2009; Mosquera-Losada *et al.*, 2012). This makes Q-Methodology a promising approach for investigating social perceptions on AFS through the EE lens. The AFS approach rejects industrial agriculture's focus on maximising quantity at the expense of environmental degradation, thereby embracing new approaches entailing paradigm shifts (Nair, 2007; Tubenchlak *et al.*, 2021). At the same time, it is crucial for AFS to integrate traditional knowledge, accepting path dependence and the existence of different knowledge perceptions, which is also a crucial understanding of SEE (Schulz *et al.*, 1994; Liebowitz and Margolis, 1995; Levrel and Martinet, 2021).

However, even though the idea behind AFS entails a paradigm change in agriculture and a return to imitating natural processes more closely to long-term secure the planet's health, the institutional and social setting in Germany and other European countries is neoclassical (Spash, 2013; Louah *et al.*, 2017; Heise, 2020). This forces EE and the AFS approach into pragmatism when prioritising large-scale implementations of AFS to generate environmental, social and economic benefits over a strict rejection of concepts rooting in conventional economics (Spash, 2013; Kay *et al.*, 2019). Therefore, the sole application of the SEE understanding in this context is not sufficient. The NEP branch contributes important concepts to the approach, which are necessary for a successful paradigm change in land-use systems. NEP representatives understand complex sustainability issues and the necessary scientific support for relevant decision-making (Spash, 2013). Simultaneously, they emphasise that the biggest hurdle for system change is to successfully translate research findings into real-world applications in a capitalist-driven environment (Spash and Ryan, 2012; Spash, 2013; Buchs *et al.*, 2020). NEP advocates focus on the need for a pragmatic, albeit careful approach to neoclassical tools such as monetary valuation of ES, enabling economic instruments like Payments for Ecosystem Services (PES) to facilitate behavioural change (Costanza *et al.*, 1997; Zografos and Howarth, 2010; Spash and Ryan, 2012; Spash, 2013; Buchs *et al.*, 2020).

Considering the arguments put forward by SEE and NEP, the approach of AFS can be situated in their overlap, which is justifiable as the three branches are not shaped by clear boundaries (Spash, 2013; Levrel and Martinet, 2021). Whilst accepting the necessity to pragmatically using monetary valuation of nature to reach a larger scale adoption of AFS, AFS acknowledge interdisciplinarity, the risks associated with concepts such as the commodification of nature and the rational economic man seeking to maximise utility (Gómez-Baggethun and Ruiz-Pérez, 2011; Spash, 2013; Kay *et al.*, 2019). AFS approaches are seen as a holistic and integrative approach to address current sustainability challenges in agricultural systems (Elevitch *et al.*, 2018). It prioritises the aim of generating land-use systems that are equitable for current and future generations, whilst respecting nature's carrying capacity, thereby emphasising intergenerational justice and bequest value, which are also relevant to the field of EE (Nair, 2007; Spash, 2011; Mosquera-Losada *et al.*, 2012; Ollinaho and Kröger, 2021).

2 The Relevance of Understanding Social Perceptions for EE

This dissertation aims at investigating the range of opinions, points of consensus and polarisation among the stakeholders involved in AFS in Germany. Thus, the relevance of considering social perceptions for the field of EE needs to be elaborated.

Firstly, understanding the diversity of perspectives around AFS in Germany has the potential to enable more inclusive and participatory decision-making for all stakeholder groups, i.e., at agricultural, private and policy levels (Hyland *et al.*, 2016). The consideration of social perspectives on controverse issues is important in the field of EE given its focus on interdisciplinary approaching complex socio-ecological problems (Daly, 1992; Funtowicz and Ravetz, 1994; Pirgmaier, 2017). Secondly, knowing what drives involved stakeholders behaviour and including this knowledge in the design of new agricultural policies can deliver a higher degree of social acceptance of new policy regulations, potentially leading to a higher AFS uptake (Gall and Rodwell, 2016; Hyland *et al.*, 2016). Understanding the subjectivity and incommensurability of values attached to AFS, different knowledge perceptions of farming and corresponding conflicts can individualise incentive systems and thereby increase its voluntary uptake (Martinez-Alier *et al.*, 1998; Hyland *et al.*, 2016). The consideration of knowledge diversity, its uncertainty, and value pluralism are important concepts of EE, which are perceived as crucial when addressing socio-ecological problems such as the sustainability of land use systems (Levrel and Martinet, 2021). The post-normal science, of which EE is seen as a part of, advocates for this acceptance of uncertainty, the consideration of knowledge subjectivity and iterative processes to tackle controversial environmental problems (Funtowicz and Ravetz, 1994). Here, investigating the diversity of social perspectives on a controverse issue is seen as a crucial part of post-normal thinking aiming at creating pluralistic dialogues to arrive at fair and sustainable outcomes (Funtowicz and Ravetz, 1994). The present interdisciplinary investigation of social perceptions about AFS in Germany through Q-Methodology can therefore deliver valuable insights into this subjectivity of stakeholder's opinions, which can bring the approach closer to the two core EE goals of sustainable scale and distributional justice (Daly, 1992; Hyland *et al.*, 2016). This has to date not been done in Germany, enabling this dissertation to fill a research gap in a dynamic time considering the mainstreaming efforts of AFS, where its potential to combat climate change symptoms and secure ES provision for future generations are promising (Nair, 2007; Mosquera-Losada *et al.*, 2012).

3 Social, ecological and economic contributions of AFS to the field of EE

Besides the importance of considering social perspectives for EE, the following sections will elaborate on the diverse contributions of AFS to the social, ecological, and economic systems and their importance to EE.

3.1 Social contributions

The European Common Agricultural Policy (CAP) strongly characterises the agricultural policies of its member states, who can choose policies and funding options from it and thereby shape their individual agricultural policy landscape, whilst being strictly required to align with the ecological requirements of the CAP to access subsidies (Mosquera-Losada *et al.*, 2018). Following the description of Meadows (2008) regarding system dynamics, systemic approaches of controversial issues and potential traps resulting from malfunctioning systems, it becomes evident that complex policy frameworks are endangered to miss their initial objective. Some systems can result in citizens refusing to align with regulations or systems failing to achieve their original aim, resulting in a policy trap being created by the political system (Meadows, 2008). This can, to some extent, be applied to the CAP (Lankoski and Thiem, 2020; Commission on the Future of Agriculture, 2021). The complexity of this policy framework established to channel collective efforts into a more sustainable and resilient European agricultural sector is strongly influencing present decision-making mainly shaped by neoclassical economic thinking and the use of monetary instruments (Commission on the Future of Agriculture, 2021). Thus, the EE concept of path dependence is applicable in this context, as this policy system trap results from prior decision-making still influencing current decision-making (Liebowitz and Margolis, 1995; Drechsler and Wätzold, 2020). Regarding the subsidy options for AFS, the CAP leaves little room for creativity or flexibility, forcing this multifunctional approach into a niche (Mosquera-Losada *et al.*, 2016, 2018). The framework is, when judged considering the principles of EE, missing its initial purpose of upscaling sustainability and socio-ecological resilience in the European agricultural sector (Mouysset, 2014; Kay *et al.*, 2019). Symptoms of this CAP policy trap are the diverse socio-ecological problems emergent in Europe and the surpasses of several planetary boundaries (Millenium Ecosystem Assessment, 2005; Mouysset, 2014). Planetary boundaries are an important concept for EE (Rockström *et al.*, 2009), which will be elaborated in more detail in the 'Ecological Sphere' section below. Those surpasses are, among other things, fuelled through climate change partly induced by industrial farming combined with ineffective policies (Billeter *et al.*, 2008; Mosquera-Losada *et al.*, 2012, 2016; Commission on the Future of Agriculture, 2021). Agricultural intensification has severely degraded ground water quality through nutrient surpluses, created weed resistances through the overuse of artificial fertilisers, leading to overall soil depletion (A. Rigueiro-Rodríguez *et al.*, 2009; Rosenstock *et al.*, 2019). These problems were initiated through past agricultural policies focusing on maximising agricultural production for a growing population, mechanisation of agricultural processes and the use of chemicals (IPBES, 2018; Elbakidze *et al.*, 2021). The CAP and current land-use systems are unable to long-term benefit current and future societies through the resilient provision of ES, which is automatically forcing them to expire (Mosquera-Losada *et al.*, 2012).

Simultaneously, symptoms of malfunctioning systems offer potential to be transformed and system traps can be escaped through so-called leverage points (Meadows, 2008; Commission on the Future of Agriculture, 2021). Following the principles of EE, respecting planetary boundaries and avoiding tipping points within the planets carrying capacity need to prioritised whilst tackling complex sustainability issues (Steffen *et al.*, 2015; Cosme *et al.*, 2017). AFS as an integrative land-use system entail potential to transform the current system to benefit the environment, the well-being of our societies and their agricultural economies (Fagerholm *et al.*, 2016). AFS can reduce pressure on anthropocentric ecosystems and make them more resilient, provide a higher amount of ES and equip societies with tools, that allow to sustain and regenerate our planetary health for current and future generations (Rigueiro-Rodríguez *et al.*, 2009; Nair, 2011).

3.2 Ecological contributions

Introducing AFS into ecologically degraded or pressured land-use systems offers potential to restructure anthropocentric land-use systems, increase their ecological resilience towards climate change and decouple economic growth from environmental degradation (Nair *et al.*, 2009; Raworth, 2017). Following Steffen *et al.* (2015), there are nine planetary boundaries, of which two have already been severely surpassed. Those are 'Biogeochemical flows', i.e., nitrogen and phosphorus overshoots resulting in heavy eutrophication effects, and 'Biosphere integrity' leading to an irreversible loss of genetic diversity (Steffen *et al.*, 2015). Those surpasses expose societies to a high risk of uncertainty, meaning that tipping points could be crossed resulting in unpredictable and irreversible ecological collapse (Rockström *et al.*, 2009). Further, the boundaries 'Climate Change' and 'Land-System Change' also already surpassed their safe operating space to an extent exposing them to increased uncertainty of rapid changes (Steffen *et al.*, 2015). The AFS approach could make the agricultural sector less sensitive to surpassing planetary boundaries by increasing the resilience of ecosystems (Mosquera-Losada *et al.*, 2016). While the concept of acknowledging uncertainty in all ecological systems is crucial to the ontological understanding of EE (Spash, 2011), the consideration and understanding of land-use systems such as AFS are particularly relevant to the field of EE by entailing potential to reduce uncertainty of crossing ecological tipping points and maintaining earths carrying capacity (Leclère *et al.*, 2013). Staying within planetary boundaries and arriving at a sustainable scale of the throughput are key concepts in EE and are also found in the AFS approach (Raworth, 2017; Rosenstock *et al.*, 2019). Regenerating and creating resilient and sustainable ecosystems is one of its core principles, aiming at fairness towards the next generations by leaving them at least the same ecological conditions (Ollinaho and Kröger, 2021). Acknowledging uncertainty whilst generating knowledge is important in EE, thereby enabling acceptance for new approaches such as AFS (Schulz *et al.*, 1994; Nerlich *et al.*, 2013). Thus, considering the constantly evolving nature of knowledge to arrive at approaches generating the most sustainable outcome unifies AFS and the field of EE (Isaac *et al.*, 2007).

3.3 Economic contributions

Farm economics in Germany have reached uneconomic growth, leading to a level of resource throughput that is depleting soils and reducing yields, thereby making farms dependant on public subsidies (Mouysset, 2014; Commission on the Future of Agriculture, 2021). This results from a linear and commercial use of terrestrial resources in the past (IPBES, 2018; Commission on the Future of Agriculture, 2021; Elbakidze *et al.*, 2021), where the economic success of modern industrial agriculture was and is built on the use of artificial fertilisers and pesticides (Kay *et al.*, 2019). However, due to this overuse of artificial means, soils in Germany and other European countries are becoming less productive, leading to decreased yields (Nair *et al.*, 2009; Klages *et al.*, 2020; Commission on the Future of Agriculture, 2021). This has led to an even higher application of artificial fertilisers to substitute the yield losses to still generate profits and economic growth (Vogel and Meyer, 2018). Thereby, environmental damage such as groundwater acidification and soil erosion appear more frequently (Klages *et al.*, 2020). The neglection of Georgescu-Roegen’s thermodynamics of finite and entropic energy systems and ecological system dynamics led to uneconomic growth in modern agriculture, which is an important concept in the field of EE (Perrings, 1997; Daly, 2013). AFS offer potential to degrow from this intensified system to a more extensive, resilient system offering the potential to decouple food production and economic growth in farms from environmental degradation and reach an agricultural sector with a steady amount of throughput (Nair, 2007).

To conclude, AFS, although not being a panacea, could contribute to the development of more resilient land-use systems, equipped for the most pressing challenges in this sector whilst generating diverse ecological, social as well as economic benefits for current and future societies (Muschler and Bonnemann, 1997; Mosquera-Losada *et al.*, 2012; Porro *et al.*, 2012). Following Costanza (1991), the awareness for constant evolution enabling societies to adapt to new circumstances and find new balances plays a vital role in the dynamic field of EE. This is especially valid in the context of this dissertation research, as the ecologically pressured land-use systems threaten the well-being of societies and increase the division between farmers and consumers (Mosquera-Losada *et al.*, 2012; Vogel and Meyer, 2018; Commission on the Future of Agriculture, 2021). On the one hand, consumers are asking for more sustainable products coming from the agricultural sector, criticising farmers for their behaviour towards the planet and simultaneously not being able to relate to the work of farmers (Otter and Langenberg, 2020; Commission on the Future of Agriculture, 2021). Farmers on the other hand are facing a situation without an obvious way out, financially often depending on public subsidies, exposure to market price dynamics and price dictating food trading companies (Commission on the Future of Agriculture, 2021). The field of EE is concerned and involved with such sustainability issues, their impact on the environment and societies as well as their potential to adapt and arrive at resilience and sustainability (see Leclère *et al.*, 2013; Monsalve *et al.* 2016; Lankoski and Thiem, 2020). As elaborated above, AFS combined with EE's school of thought offer a chance to holistically transform current land-use systems towards being distributional just at a sustainable scale (Daly, 1992; Mosquera-Losada *et al.*, 2012). Understanding the different perspectives around AFS in Germany is therefore deeply connected to EE and an important step to arrive at consensus facilitating better decision-making in politics as well as farming in times where the approach is at a strong emergence.

REFERENCE LIST PART I

Billeter, R., Liira, J., Bailey, D., Bugter, R., Arens, P., Augenstein, I., Aviron, S., Baudry, J., Bukacek, R., Burel, F., Cerny, M., De Blust, G., De Cock, R., Diekötter, T., Dietz, H., Dirksen, J., Dormann, C., Durka, W., Frenzel, M., Hamersky, R., Hendrickx, F., Herzog, F., Klotz, S., Koolstra, B., Lausch, A., Le Coeur, D., Maelfait, J. P., Opdam, P., Roubalova, M., Schermann, A., Schermann, N., Schmidt, T., Schweiger, O., Smulders, M. J. M., Speelmans, M., Simova, P., Verboom, J., Van Wingerden, W. K. R. E., Zobel, M. and Edwards, P. J. (2008) 'Indicators for biodiversity in agricultural landscapes: A pan-European study', *Journal of Applied Ecology*, 45(1), pp. 141–150. doi: 10.1111/j.1365-2664.2007.01393.x.

Buchs, A., Petit, O. and Roman, P. (2020) 'Can social ecological economics of water reinforce the "big tent"?', *Ecological Economics*, 169(December 2019), p. 106553. doi: 10.1016/j.ecolecon.2019.106553.

Commission on the Future of Agriculture (2021) *Zukunft Landwirtschaft. Eine gesamtgesellschaftliche Aufgabe - Empfehlungen der Zukunftskommission Landwirtschaft*. Rangsdorf.

Cosme, I., Santos, R. and O'Neill, D. W. (2017) 'Assessing the degrowth discourse: A review and analysis of academic degrowth policy proposals', *Journal of Cleaner Production*. Elsevier Ltd, pp. 321–334. doi: 10.1016/j.jclepro.2017.02.016.

Costanza, R. (1991) 'Ecological economics: A research agenda', *Structural Change and Economic Dynamics*, 2(2), pp. 335–357. doi: 10.1016/S0954-349X(05)80007-4.

Costanza, R., D'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P. and van den Belt, M. (1997) 'The value of the world's ecosystem services and natural capital.', *Nature TA - TT -*, 387(6630), pp. 253–260. Available at: https://www-nature-com.ezproxy.royalroads.ca/articles/387253a0.pdf.

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S. J., Kubiszewski, I., Farber, S. and Turner, R. K. (2014) 'Changes in the global value of ecosystem services', *Global Environmental Change*, 26(1), pp. 152–158. doi: 10.1016/j.gloenvcha.2014.04.002.

Daly, H. (2013) 'A further critique of growth economics', *Ecological Economics*, 88, pp. 20–24. doi:

10.1016/j.ecolecon.2013.01.007.

Daly, H. E. (1992) ‘Allocation, distribution, and scale: towards an economics that is efficient, just, and sustainable’, *Ecological Economics*, 6(3), pp. 185–193. doi: 10.1016/0921-8009(92)90024-M.

Drechsler, M. and Wätzold, F. (2020) ‘Biodiversity conservation in a dynamic world may lead to inefficiencies due to lock-in effects and path dependence’, *Ecological Economics*, 173(October 2019). doi: 10.1016/j.ecolecon.2020.106652.

Elbakidze, M., Surová, D., Muñoz-Rojas, J., Persson, J.-O., Dawson, L., Plieninger, T. and Pinto-Correia, T. (2021) ‘Perceived benefits from agroforestry landscapes across North-Eastern Europe: What matters and for whom?’, *Landscape and Urban Planning*, 209, p. 104044. doi: 10.1016/j.landurbplan.2021.104044.

Elevitch, C. R., Mazaroli, N. D. and Ragone, D. (2018) ‘Agroforestry standards for regenerative agriculture’, *Sustainability (Switzerland)*, 10(9), pp. 1–21. doi: 10.3390/su10093337.

Fagerholm, N., Oteros-Rozas, E., Raymond, C. M., Torralba, M., Moreno, G. and Plieninger, T. (2016) ‘Assessing linkages between ecosystem services, land-use and well-being in an agroforestry landscape using public participation GIS’, *Applied Geography*, 74, pp. 30–46. doi: 10.1016/j.apgeog.2016.06.007.

Funtowicz, S. and Ravetz, J. R. (1994) ‘The worth of a songbird : ecological economics as a post-normal science’, 8009(93).

Gall, S. C. and Rodwell, L. D. (2016) ‘Evaluating the social acceptability of Marine Protected Areas’, *Marine Policy*, 65, pp. 30–38. doi: 10.1016/j.marpol.2015.12.004.

Gómez-Baggethun, E. and Ruiz-Pérez, M. (2011) ‘Economic valuation and the commodification of ecosystem services’, *Progress in Physical Geography: Earth and Environment*, 35(5), pp. 613–628. doi: 10.1177/0309133311421708.

Heise, A. (2020) ‘Minimum wages and the resilience of neoclassical labour market economics. Some preliminary evidence from Germany’. Available at: https://rwer.wordpress.com/comments-on-rwer-issue-no-93/.

Hyland, J. J., Jones, D. L., Parkhill, K. A., Barnes, A. P. and Williams, A. P. (2016) 'Farmers' perceptions of climate change: identifying types', *Agriculture and Human Values*, 33(2), pp. 323–339. doi: 10.1007/s10460-015-9608-9.

IPBES (2018) *Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Europe and Central Asia of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.* Edited by M. Fischer, M. Rounsevell, A. Torre-Marin Rando, A. Mader, A. Church, M. Elbakidze, V. Elias, T. Hahn, P. A. Harrison, J. Hauck, B. Martín- López, I. Ring, C. Sandström, I. Sousa Pinto, P. Visconti, N. E. Zimmermann, and M. Christie. IPBES secretariat, Bonn, Germany.

Isaac, M. E., Erickson, B. H., Quashie-Sam, S. J. and Timmer, V. R. (2007) 'Transfer of knowledge on agroforestry management practices: The structure of farmer advice networks', *Ecology and Society*, 12(2). doi: 10.5751/ES-02196-120232.

Kay, S., Graves, A., Palma, J. H. N., Moreno, G., Roces-Díaz, J. V., Aviron, S., Chouvardas, D., Crous-Duran, J., Ferreiro-Domínguez, N., García de Jalón, S., Măcicăşan, V., Mosquera-Losada, M. R., Pantera, A., Santiago-Freijanes, J. J., Szerencsits, E., Torralba, M., Burgess, P. J. and Herzog, F. (2019) 'Agroforestry is paying off – Economic evaluation of ecosystem services in European landscapes with and without agroforestry systems', *Ecosystem Services*, 36(January). doi: 10.1016/j.ecoser.2019.100896.

Klages, S., Heidecke, C. and Osterburg, B. (2020) 'The impact of agricultural production and policy on water quality during the dry year 2018, a case study from Germany', *Water (Switzerland)*, 12(6), pp. 1–20. doi: 10.3390/W12061519.

Lankoski, J. and Thiem, A. (2020) 'Linkages between agricultural policies, productivity and environmental sustainability', *Ecological Economics*, 178(October 2019), p. 106809. doi: 10.1016/j.ecolecon.2020.106809.

Leclère, D., Jayet, P. A. and de Noblet-Ducoudré, N. (2013) 'Farm-level Autonomous Adaptation of European Agricultural Supply to Climate Change', *Ecological Economics*, 87, pp. 1–14. doi: 10.1016/j.ecolecon.2012.11.010.

Levrel, H. and Martinet, V. (2021) 'Ecological Economists: The Good, The Bad, And The Ugly?', *Ecological Economics*, 179(October 2019), pp. 2019–2022. doi: 10.1016/j.ecolecon.2020.106694.

Liebowitz, S. J. and Margolis, S. E. (1995) 'Path dependence, lock-in, and history', *Journal of Law, Economics, and Organization*, 11(1), pp. 205–226. doi: 10.2139/ssrn.1706450.

Louah, L., Visser, M., Blaimont, A. and de Cannière, C. (2017) 'Barriers to the development of temperate agroforestry as an example of agroecological innovation: Mainly a matter of cognitive lock-in?', *Land Use Policy*, 67(May), pp. 86–97. doi: 10.1016/j.landusepol.2017.05.001.

Martinez-Alier, J., Munda, G. and O'Neill, J. (1998) 'Weak comparability of values as a foundation for ecological economics', *Ecological Economics*, 26(3), pp. 277–286. doi: 10.1016/S0921-8009(97)00120-1.

Meadows, D. H. (2008) *Thinking in Systems: A Primer*. White River Junction.

Millenium Ecosystem Assessment (2005) *Ecosystems and human well-being: synthesis.* Washington, DC: Island Press.

Monsalve, F., Zafrilla, J. E. and Cadarso, M. Á. (2016) 'Where have all the funds gone? Multiregional input-output analysis of the European Agricultural Fund for Rural Development', *Ecological Economics*, 129, pp. 62–71. doi: 10.1016/j.ecolecon.2016.06.006.

Mosquera-Losada, M. R., Moreno, G., Pardini, A., McAdam, J. H., Papanastasis, V., Burgess, P. J., Lamersdorf, N., Castro, M., Liagre, F. and Rigueiro-Rodríguez, A. (2012) 'Past, Present and Future of Agroforestry Systems in Europe', in Ramachandran Nair, P. K. and Garrity, D. (eds) *Agroforestry - The Future of Global Land Use*. Springer Science + Business Media Dordrecht, pp. 285–312. doi: 10.5860/choice.50-6172.

Mosquera-Losada, M. R., Santiago-Freijanes, J. J., Pisanelli, A., Rois-Díaz, M., Smith, J., den Herder, M., Moreno-Marcos, G., Malignier, N., Mirazo, J. R., Lamersdorf, N., Ferreiro-Domínguez, N., Balaguer, F., Pantera, A., Rigueiro-Rodríguez, A., González-Hernández, M. del P., Fernández-Lorenzo, J. L., Romero-Franco, R., Chalmin, A., Garcia-de-Jalón, S., Garnett, K., Graves, A. R., Burgess, P. J., Ruiz-Mirazo, J., Lamersdorf, N., Ferreiro-Domínguez, N., Balaguer, F., Pantera, A., Rigueiro-Rodríguez, A., González-Hernández, M. del P., Fernández-Lorenzo, J. L., Romero-Franco, R., Chalmin, A., Garcia-de-Jalón, S., Garnett, K., Graves, A. R. and Burgess, P. J. (2016) 'Extent and

Success of Current Policy Measures to Promote Agroforestry across Europe', *EU FP7 Research Project: AGFORWARD 613520*, Deliverabl(8.23), p. 95. Available at: https://www.agforward.eu/index.php/en/extent-and-success-of-current-policy-measures-to-promote-agroforestry-across-europe.html.

Mosquera-Losada, M. R., Santiago-Freijanes, J. J., Pisanelli, A., Rois-Díaz, M., Smith, J., den Herder, M., Moreno, G., Ferreiro-Domínguez, N., Malignier, N., Lamersdorf, N., Balaguer, F., Pantera, A., Rigueiro-Rodríguez, A., Aldrey, J. A., González-Hernández, M. P., Fernández-Lorenzo, J. L., Romero-Franco, R. and Burgess, P. J. (2018) 'Agroforestry in the European common agricultural policy', *Agroforestry Systems*, 92(4), pp. 1117–1127. doi: 10.1007/s10457-018-0251-5.

Mouysset, L. (2014) 'Agricultural public policy: Green or sustainable?', *Ecological Economics*, 102, pp. 15–23. doi: 10.1016/j.ecolecon.2014.03.004.

Muschler, R. G. and Bonnemann, A. (1997) 'Potentials and limitations of agroforestry for changing land-use in the tropics: Experiences from Central America', *Forest Ecology and Management*, 91(1), pp. 61–73. doi: 10.1016/S0378-1127(96)03887-X.

Nair, P. K. R. (2007) 'The coming of age of agroforestry', *Journal of the Science of Food and Agriculture*, pp. 1613–1619.

Nair, P. K. R. (2011) 'Agroforestry Systems and Environmental Quality: Introduction', *Journal of Environmental Quality*, 40(3), pp. 784–790. doi: 10.2134/jeq2011.0076.

Nair, P. K. R., Kumar, B. M. and Nair, V. D. (2009) 'Agroforestry as a strategy for carbon sequestration', *Journal of Plant Nutrition and Soil Science*, 172(1), pp. 10–23. doi: 10.1002/jpln.200800030.

Nerlich, K., Graeff-Hönninger, S. and Claupein, W. (2013) 'Agroforestry in Europe: a review of the disappearance of traditional systems and development of modern agroforestry practices, with emphasis on experiences in Germany', *Agroforestry Systems*, 87(2), pp. 475–492. doi: 10.1007/s10457-012-9560-2.

Ollinaho, O. I. and Kröger, M. (2021) 'Agroforestry transitions: The good, the bad and the ugly', *Journal of Rural Studies*, 82, pp. 210–221. doi: 10.1016/j.jrurstud.2021.01.016.

Otter, V. and Langenberg, J. (2020) ‘Willingness to pay for environmental effects of agroforestry systems: a PLS-model of the contingent evaluation from German taxpayers’ perspective’, *Agroforestry Systems*, 94(3), pp. 811–829. doi: 10.1007/s10457-019-00449-6.

Perrings, C. (1997) ‘Georgescu-Roegen and the “Irreversibility” of material processes’, *Ecological Economics*, 22(3), pp. 303–304. doi: 10.1016/S0921-8009(97)00105-5.

Pirgmaier, E. (2017) ‘The Neoclassical Trojan Horse of Steady-State Economics’, *Ecological Economics*, 133, pp. 52–61. doi: 10.1016/j.ecolecon.2016.11.010.

Porro, R., Miller, R. P., Tito, M. R., Donovan, J. A., Vivan, J. L., Trancoso, R., Van Kanten, R. F., Grijalva, J. E., Ramirez, B. L. and Gonçalves, A. L. (2012) *Agroforestry in the Amazon Region: A Pathway for Balancing Conservation and Development*. doi: 10.1007/978-94-007-4676-3_20.

Raworth, K. (2017) *Doughnut economics: 7 ways to think like a 21st century economist*. London: Penguin Random House.

Rigueiro-Rodríguez, A., McAdam, J. and Mosquera-Losada, M. R. (2009) *Agroforestry in Europe: Current Status and Future Prospects*. Edited by J. McAdam, M. R. Mosquera-Losada, and A. Rigueiro-Rodríguez. Springer Science + Business Media B.V. Available at: http://www.springerlink.com/index/10.1007/978-1-4020-8272-6.

Rigueiro-Rodríguez, Fernández-Núñez, E., González-Hernández, P., McAdam, J. H. and Mosquera-Losada, M. R. (2009) ‘Agroforestry Systems in Europe: Productive, Ecological and Social Perspectives’, *Agroforestry in Europe: Current Status and Future Prospects*, pp. 43–65. doi: 10.1007/978-1-4020-8272-6_3.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., De Wit, C. A., Hughes, T., Van Der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R. W., Fabry, V. J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. and Foley, J. A. (2009) ‘A safe operating space for humanity’, *Nature*, 461(7263), pp. 472–475. doi: 10.1038/461472a.

Rosenstock, T. S., Dawson, I. K., Aynekulu, E., Chomba, S., Degrande, A., Fornace, K., Jamnadass, R., Kimaro, A., Kindt, R., Lamanna, C., Malesu, M., Mausch, K., McMullin, S., Murage, P., Namoi, N., Njenga, M., Nyoka, I., Paez Valencia, A. M., Sola, P., Shepherd, K. and Steward, P. (2019) 'A Planetary Health Perspective on Agroforestry in Sub-Saharan Africa', *One Earth*, 1(3), pp. 330–344. doi: 10.1016/j.oneear.2019.10.017.

Schulz, B., Becker, B. and Götsch, E. (1994) 'Indigenous knowledge in a "modern" sustainable agroforestry system-a case study from eastern Brazil', *Agroforestry Systems*, 25(1), pp. 59–69. doi: 10.1007/BF00705706.

Spash, C. L. (2011) 'Social Ecological Economics: Understanding the Past to See the Future', *American Journal of Economics and Sociology*, 70(2), pp. 340–375. doi: 10.1111/j.1536-7150.2011.00777.x.

Spash, C. L. (2013) 'The shallow or the deep ecological economics movement?', *Ecological Economics*, 93, pp. 351–362. doi: 10.1016/j.ecolecon.2013.05.016.

Spash, C. L. (2020) 'A tale of three paradigms: Realising the revolutionary potential of ecological economics', *Ecological Economics*, 169(May 2019), p. 106518. doi: 10.1016/j.ecolecon.2019.106518.

Spash, C. L. and Ryan, A. (2012) 'Economic schools of thought on the environment: Investigating unity and division', *Cambridge Journal of Economics*, 36(5), pp. 1091–1121. doi: 10.1093/cje/bes023.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., De Vries, W., De Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B. and Sörlin, S. (2015) 'Planetary boundaries: Guiding human development on a changing planet', *Science*, 347(6223). doi: 10.1126/science.1259855.

Tubenchlak, F., Badari, C. G., de Freitas Strauch, G. and de Moraes, L. F. D. (2021) 'Changing the Agriculture Paradigm in the Brazilian Atlantic Forest: The Importance of Agroforestry', *The Atlantic Forest*, pp. 369–388. doi: 10.1007/978-3-030-55322-7_17.

Vogel, E. and Meyer, R. (2018) 'Climate change, climate extremes, and global food production-Adaptation in the agricultural sector', in *Resilience: The Science of Adaptation to Climate Change*. Elsevier Inc., pp. 31–49. doi: 10.1016/B978-0-12-811891-7.00003-7.

Webler, T., Danielson, S. and Tuler, S. (2009) ‘Using Q Method to Reveal Social Perspectives in Environmental Research’, *Social and Environmental Research*, 01301(November), pp. 1–54. Available at: http://www.seri-us.org/pubs/Qprimer.pdf.

Zografos, C. and Howarth, R. B. (2010) ‘Deliberative ecological economics for sustainability governance’, *Sustainability*, 2(11), pp. 3399–3417. doi: 10.3390/su2113399.

PART II –

SOCIAL PERCEPTIONS OF AGROFORESTRY: A CASE STUDY IN GERMANY USING Q-METHODOLOGY

1 INTRODUCTION

1.1 Agroforestry Systems: a way out of the ecological crisis?

The recently published report of the Intergovernmental Panel on Climate Change (IPCC) reinforces its prior warnings considering the irreversible knock-on effects of human-induced climate change on the environment and societies (IPCC, 2021). According to the report, extreme measures must be taken by governments and societies to avoid environmental collapse and mitigate climate change (IPCC, 2021). These threats also confront agriculture with challenges that the current European land-use systems, shaped by industrial production, are not equipped to cope with (Rigueiro-Rodríguez *et al.*, 2009; Vogel and Meyer, 2018; Le Gouis *et al.*, 2020; IPCC, 2021). Industrial farming and the corresponding exploitation of environmental resources, reinforced by agricultural policies focusing on yield maximisation allowed for short-term prosperity of societies but simultaneously triggered multidimensional sustainability issues, such as soil depletion, eutrophicated water bodies due to nutrient surpluses from agriculture, and air pollution (IPBES, 2018; Otter and Langenberg, 2020; Commission on the Future of Agriculture, 2021). Additionally, more efficient machinery reduced the structural diversity of agricultural landscapes and the development of artificial fertilisers made the maintenance of diverse and resilient ecosystems substitutable (Briggs, 2009; Nerlich *et al.*, 2013; Esser, 2020). This unsustainable behaviour towards nature resulted in the decline of about 60% of global ecosystem services (ES) (Millenium Ecosystem Assessment, 2005; Billeter et al., 2008; Holland et al., 2017; Klement et al., 2017; Klages et al., 2020). This possibly irreversible decline of ES threatens to compromise the well-being of current and future societies, forcing land-use systems to adapt in order to remain within planetary boundaries in the long-term (Millenium Ecosystem Assessment, 2005; Steffen *et al.*, 2015).

When tackling those multidimensional sustainability issues, respecting planetary boundaries and decoupling environmental degradation from economic growth are key aspects in order to secure a viable future for humanity on this 'Spaceship Earth' (Boulding, 1967; Rockström *et al.*, 2009; Raworth, 2017). Given the urgency to address those complex sustainability issues in land-use systems, reinforced by the recent IPCC report, there are ongoing efforts to avoid surpassing ecological tipping points and change the paradigm of agriculture into a more holistic, extensive way of farming called 'regenerative agriculture' (Elevitch *et al.*, 2018; Duke, 2020; Jennifer O'Connor, 2020; IPCC, 2021). If managed accordingly, regenerative land-use practices offer potential to increase the resilience of ecosystems as well as secure the provision of ES (Elevitch *et al.*, 2018; Kay *et al.*, 2019; Jennifer O'Connor, 2020). Agroforestry Systems (AFS), a nature-based solution, are considered a multifunctional regenerative agricultural practice delivering social, ecological, and economic benefits

(Elevitch *et al.*, 2018; Hübner, 2021). AFS present the focus of this dissertation research and originate in traditional farming practices, combining food production and nature conservation by integrating trees into agricultural land (Nair, 2007; Mosquera-Losada *et al.*, 2012; Borremans *et al.*, 2016; Elevitch *et al.*, 2018; Tubenchlak *et al.*, 2021). Traditional AFS landscapes, such as wood pastures, hedgerows or meadow orchards used to be frequent in European and especially German landscapes, entailing cultural heritage (Reeg, 2011; Nerlich *et al.*, 2013; Hübner, 2021). Those were, however, sacrificed for the sake of profit maximisation and technical efficiency in the industrialisation of the 20^{th} century which led to a spatial and cognitive separation of forestry and agriculture (Briggs, 2009; Grünewald and Reeg, 2009; Reeg, 2011). Recently, modern AFS based on traditional knowledge have regained interest as a promising approach to address the socio-ecological problems triggered by industrial farming, actively discussed in European and German policy, agriculture and research (Nair, 2011; Nerlich *et al.*, 2013; Louah *et al.*, 2017). They enable land-use systems to meet societies demand for primary (i.e., food provision) as well as secondary (i.e., nature conservation, ES provision and climate change mitigation) tasks of agriculture (Borremans *et al.*, 2016; Louah *et al.*, 2017; Otter and Langenberg, 2020). If accordingly managed, the system has been found to significantly increase the availability of ES for societies (Table 1). Modern AFS are implementable in diverse ways, with the following being common in Europe: (1) Silvoarable systems, where crops are combined with woody components, also referred to as 'alley cropping'; (2) Silvopastural systems, where animal husbandry is combined with meadows; (3) forest farming; (4) riparian buffer stripes or (5) windbreaks (Nerlich *et al.*, 2013; Sereke *et al.*, 2016; Elevitch *et al.*, 2018; Tubenchlak *et al.*, 2021).

Table 1 – Ecosystem Services provided by AFS (Fisher *et al.*, 2009; Nair *et al.*, 2009; Rigueiro-Rodríguez *et al.*, 2009; Nerlich *et al.*, 2013; Fagerholm *et al.*, 2016)

Category	**Ecosystem Service provided through AFS**
Provisional	Food, water, and timber
Regulating	Natural hazard prevention, increased carbon sequestration, Enhanced water quality, improved pest control and micro-climates
Supporting	Improved soil formation, increased photosynthesis, and improved nutrition-cycle
Cultural	Improved landscape aesthetics, recreation, cultural identity, and education

1.2 Investigating social perceptions around AFS in Germany

Despite the evident need of a paradigm change in agriculture and the potential of AFS to contribute to this, its uptake has been low across Europe (Louah *et al.*, 2017; Mosquera-Losada *et al.*, 2018). This can partly be explained by ineffective policies addressing AFS uptake, lacking incentives within the European Union Common Agricultural Policy (CAP) or lacking interdisciplinary participation whilst designing those policies (Hyland *et al.*, 2016; Mosquera-Losada *et al.*, 2018). In order to understand this low AFS uptake, investigating the social perspectives is crucial and entails potential to improve the design of future agricultural policies aiming at increasing AFS uptake (Hyland *et al.*, 2016).

This research will therefore address a novel question in the German context, as despite the increasing policy interest in AFS, the existing social perceptions of AFS in Germany have so far not been investigated. This will be done using Q-Methodology, a quali-quantitative method equipped to investigate subjectivity around controverse issues (Webler *et al.*, 2009). Thereby, the different social perspectives, areas of consensus and polarisation between the main stakeholders involved in AFS in Germany will be analysed. The subsequent chapter of this study will introduce the existent peer-reviewed literature addressing AFS perceptions. Chapter three will elaborate on the principles of Q-Methodology, the data collection and analysis procedure to arrive at the results, which are presented in chapter four. This will be followed by a discussion containing its main findings, general limitations, and potential areas for future research, and thereafter closed by a brief conclusion.

2 LITERATURE REVIEW

Considering the diverse social perceptions is crucial to understanding and addressing complex issues such as the long-term sustainability of land-use systems (Hyland *et al.*, 2016; Otter and Langenberg, 2020). Regarding the disruptive AFS approach equipped to rethink the conventional[1] way of food production (Mosquera-Losada *et al.*, 2012), multiple studies have to date investigated the diverse aspects of the fields perceptions, which are synthesised below. The approach’s conceptual limitations and the contributions of this dissertation research to existing literature are further elaborated.

2.1 Limited uptake of AFS in Europe

Despite the potential of AFS to relieve many of the above-described problems, several barriers are perceived as limiting AFS uptake in Europe (Reeg, 2011; Otter and Langenberg, 2020). The monocausal and industrialised understanding of agricultural food production can be seen as part of their origin (Sereke *et al.*, 2016; Otter and Langenberg, 2020).

Intrinsic barriers: Social acceptance and cognition. Following Beer and Theusen (2018), the social environment of farmers and the acceptance from peers as well as society are key factors influencing farmers decision-making to implement AFS. Addressing this, Otter and Langenberg (2020) conducted a study to elicit the willingness-to-pay (WTP) of German taxpayers for benefits obtainable from AFS and found that there is large support (i.e., 65.1 %) to help subsidise AFS. Several studies further found that the German society generally approves the AFS approach (Otter and Langenberg,

[1] conventional in this context includes all land-use systems that are not regenerative, meaning conventional as well as organic agricultural systems relying on annual short-rotating crops.

2020; Deutsch and Otter, 2021), supported by Sereke *et al.* (2016), who also found that Swiss farmers expect the public to appreciate AFS adoption. This adds to the findings of Otter and Langenberg (2020), stating that the secondary tasks of agriculture gain more importance in society, thus increasing their WTP for land-use systems generating those benefits, such as AFS. Opposite to this positive attitude of society stands the attitude of farmers. Regarding the before-mentioned required acceptance from peers, Sereke *et al.* (2016) were able to elaborate on the findings from Beer and Theusen (2018), emphasising that farmers are sceptical and perceive AFS implementation as a reputational risk. However, many farmers approve the approach in general but are unwilling to adopt it themselves without sufficient external support (Graves *et al.*, 2009; Langenberg *et al.*, 2018). Several studies find that the cognitive barrier, i.e., farmers being unaware or lacking ecological knowledge about AFS is a major constraint to its mainstreaming success (Borremans *et al.*, 2016; Louah *et al.*, 2017). Regarding this, Isaac *et al.* (2007) identified peer-to-peer learning as a common communication structure within farming communities, suggesting the promotion of demonstration farms and other collective learning opportunities around AFS, thereby addressing farmers' perceptions of reputational risks when implementing AFS as well as the cognitive barrier (Langenberg *et al.*, 2018).

External barriers: Perceived loss of flexibility, financial risks, and insecure land tenure. Following, Otter and Langenberg (2020), the long-term commitments accompanying the implementation of trees in short-rotation fields entails a perceived loss of flexibility for farmers, which is often seen as constraining its adoption. This can be explained with the financial dependence of farmers to flexibly adjust their supply to market dynamics, reinforced by the above-mentioned cognitive separation of long-term forestry and short-term agricultural practices due to the clearing of fields (Grünewald and Reeg, 2009; Reeg, 2011; Schmidt, 2011; Nerlich *et al.*, 2013). Following an investigation from Borremans *et al.* (2016), who looked into the reasons behind the low AFS uptake in Flanders, the complexity of long-term land tenure security is perceived as a large barrier for farmers. Additionally, Langenberg *et al.* (2018) found that farmers see a risk in land-owners unwilling to long-term lease their land for AFS purposes. This again connects to the perceived loss of flexibility when implementing AFS, reinforced by land tenure complexity in Germany (Borremans *et al.*, 2016; Otter and Langenberg, 2020). The work associated with AFS has further been found to be perceived as complex (Graves *et al.*, 2009). Farm economics are another important external barrier influencing the decision making of farmers (Borremans *et al.*, 2016). Following Otter and Langenberg (2020), farmers generally estimate AFS as financially disadvantaging and risky, explainable with high upfront investments connected to its implementation (Langenberg *et al.*, 2018).

2.2 Perceived social, economic, and ecological potential of AFS

According to Lindemann-Matthies *et al.* (2010) and Junge *et al.* (2011), sceneries are perceived as more beautiful by the public if structural diversity exists. This argues in favour of heterogeneity in agricultural landscapes instead of intensified monocultures (Lindemann-Matthies *et al.*, 2010; Junge *et al.*, 2011). An improved scenic vision has been found to be supported by the public, especially in landscapes close to urban areas (Junge *et al.*, 2011). According to Otter and Langenberg (2020), this visual improvement is accomplishable with AFS. Langenberg *et al.* (2018) further found that stakeholders involved in farming practices approve the potential of biodiversity enhancement, habitat creation and soil preservation through AFS. Those scenic improvements could lead to increased rural tourism, potentially counteracting the depopulation of rural areas as well as protecting cultural heritage entailed in traditional European AFS (Rigueiro-Rodríguez *et al.*, 2009; Mosquera-Losada *et al.*, 2012; Borremans *et al.*, 2016; Elbakidze *et al.*, 2021). The agricultural sector in Germany is under a lot of social pressure pushing for a more sustainable approach for food production (Nair *et al.*, 2010; Spiller *et al.*, 2015; Otter and Langenberg, 2020). Regarding this public demand, Otter and Langenberg (2020) and Langenberg *et al.* (2018) found that AFS offer potential to leverage this bad public perception and thereby increase farmers' reputation in Germany. The literature further suggests that AFS offer potential to improve the human-nature relationships by delivering first and secondary tasks of agriculture (Takeuchi, 2010; Brown *et al.*, 2018). This is essential as current societies, especially in urbanised areas, are distant from nature's processes (Bourdeau, 2004; Gomez-Baggethun and De Groot, 2010). AFS entail the potential to secure food provision and a healthy environment for current and future generations, thereby entailing bequest value, which has been found to be important to farmers (Etienne and Rapey, 1999; Reeg, 2011). Rigueiro-Rodríguez *et al.* (2009) and Borremans *et al.* (2016) found that the ecological resilience created through AFS can secure and increase future yields and thereby increase output diversity as well as income diversity of farms, if initial high upfront investments for AFS are accepted (Nair, 2007; Rigueiro-Rodríguez *et al.*, 2009). Lastly, Kay *et al.* (2019) found the profitability of AFS could be increased, if provided intangible ES would be financially compensated, thereby potentially increasing its uptake.

2.3 Conceptual limitations of the AFS approach

Despite its socio-ecological benefits, there are several conceptual limitations to the approach of AFS. The literature is unified in their understanding that AFS cannot be seen as a panacea for complex socio-ecological issues around land-use sustainability (Torquebiau, 2000; Bishaw and Abdelkadir, 2003; Nair, 2007; Porro *et al.*, 2012). However, AFS do entail potential to leverage some of those issues, if combined with diverse policies addressing the full extent of the issues (Nair, 2007; Porro *et al.*, 2012). The success of AFS further depends on the correct implementation and management of the systems' complexity (Bishaw and Abdelkadir, 2003; Palma *et al.*, 2007). This requires a high degree of ecological knowledge and constant engagement to avoid unwanted synergies between the different integral parts of the system, which makes it a complicated endeavour (Louah *et al.*, 2017). Regarding this aspect of complexity, the detailed tracking and monetarisation of intangible ES delivered by modern AFS is challenging and time consuming, especially as there is to date no consistent framework to measure provided ES (Fagerholm *et al.*, 2016; Göbel, 2016). Fagerholm *et al.* (2016) further state that restricted access to European AFS reduces the availability of cultural ES for society, thereby weakening the earlier argument made.

2.4 Addressing research gaps

The present study aims at adding to this literature by investigating the diverse social perceptions existent around AFS in Germany. Through Q-Methodology, a broad range of different stakeholders involved in AFS in Germany will be integrated, contrary to the focus of past studies on farmers and their distinct perceptions of AFS (Sereke *et al.*, 2016; Beer and Theusen, 2018). Understanding the full range of opinions of involved stakeholder groups enables this study to find points of consensus, thereby assessing if efforts to channel collective efforts for AFS are realistic, as well as find points of polarisation to enable efficient decision-making, education and communication efforts (Hyland *et al.*, 2016). The recently published report of the German Commission on the Future of Agriculture (2021) emphasises the need of interdisciplinary efforts for a successful transition of the agricultural sector. This is represented in this study through the diverse set of stakeholders. The individual context of AFS perceptions in Germany has to date not been investigated, enabling the results of this dissertation to update and individualise studies from other European countries on the matter, such as Louah *et al.* (2017) or Sereke *et al.* (2016). Understanding what drives behaviour, i.e., how involved stakeholders decide whether to adopt or support AFS in Germany is important to build an information basis enabling decision-makers to better guide future behaviour supporting a transformation of the agricultural sector and increasing the efficiency and acceptance of new policies (Hyland *et al.*, 2016).

3 METHODOLOGY AND DATA COLLECTION

Q-Methodology (hereafter Q) is a quali-quantitative method that examines subjective opinions, i.e. existing social perspectives around a certain topic (Webler *et al.*, 2009; Watts and Stenner, 2012). It has its origins in psychology, where it was established in 1935 by William Stephenson, who built it on a factor analytical method used in R-Methodology (hereafter R) (Watts and Stenner, 2012). Q is nowadays frequently used in diverse contexts, one of them being environmental sustainability problems, where complex and controversial debates are very frequent (see for example Webler *et al.* (2009); Louah *et al.* (2017); Zabala *et al.* (2017)). Q is an appropriate fit for investigating the social perceptions that exist in Germany around AFS, a land-use system equipped to address the complex sustainability challenges emergent in the agricultural sector (Sereke *et al.*, 2016; Kay *et al.*, 2019). The following sections will elaborate on the theoretical framework of the method and the detailed procedure of the data collection process used in this study.

3.1 The principles of Q-Methodology

Q approaches its objective of structuring subjectivity by combining quantitative and qualitative data through an inverted factor analysis (Brown, 1993). Q is reversing the approach of R by being representative for the range of different subjective opinions about a certain issue rather than a certain population (Webler *et al.*, 2009). It focuses on the subjectivity of knowledgeable participants (i.e., the P-Set) regarding the topic of interest (Webler *et al.*, 2009; Watts and Stenner, 2012; Moser and Baulcomb, 2020). Those opinions are gathered via an inclusive set of statements (i.e., the Q-Set), developed by the researcher and with which the P-Set interacts through a so-called forced-choice distribution grid that resembles a normal distribution, called Q-Grid (Brown, 1996; Watts and Stenner, 2012; Lutfallah and Buchanan, 2019; Moser and Baulcomb, 2020). Q sees participants as variables and statements as subjects, therefore inverting their role compared to R (Webler *et al.*, 2009). The P-Set is asked to sort the Q-Set into the Q-Grid according to their subjective strength of opinion on the content addressed in each statement (Brown, 1993). This sorting process generates the quantitative data for the subsequent analysis (Webler *et al.*, 2009). Q aims at eliciting the range of opinions on a given topic, which is justified as the number of different opinions existent on a certain topic is understood as finite (Barry and Proops, 1999; Watts and Stenner, 2012). Q consists of several steps: (1) definition of the studies' objective, i.e., the research question, (2) development of a concourse covering the full range of opinions on the issue, (3) selection of the final Q-Set from the concourse, (4) identification of the P-Set, (5) conduction of interviews entailing the Q-sorting process (Webler *et al.*, 2009; Watts and Stenner, 2012). Finally, (6) data analysis, i.e., inverted factor analysis for quantitative data and content analysis of qualitative data, bundling individual into idealised Q-Sorts (i.e., factors) (Webler *et al.*, 2009; Watts and Stenner, 2012). Those quantitatively extracted factors are then iteratively complemented with the qualitative content provided by the share of the P-Set characterising each factor, thereby revealing different social perceptions on the issue as well as points of consensus and/or polarisation among participants (Webler *et al.*, 2009; Watts and Stenner, 2012).

The comparably small P-Set required for a Q study, often ranging from eight to thirty participants, marks one strength of the method, making it time and resource efficient (Brown, 1993; Webler *et al.*, 2009). Further, the researcher's personal interference potential is assessed as low within the design of the Q-Set and the sorting process of the P-Set (Webler *et al.*, 2009; Moser and Baulcomb, 2020). This enables a Q-Sort to be highly representative for each respondents' subjective viewpoint (Webler *et al.*, 2009; Moser and Baulcomb, 2020). Furthermore, Webler *et al.* (2009) state that the fixed shape of the Q Grid as well as the fixed set of statements is another advantage, enabling comparisons of the way participants engage with the Q-Set. The method also entails some weaknesses, of which some are applicable in the present context. The different opinions on the specific matter grasped by Q are bound to space and time, therefore not easily transferable to other contexts with different spatial or temporal settings (Webler *et al.*, 2009; Ramlo, 2016). This applies in the AFS context found in Germany, as it is currently a very dynamically and ever-evolving topic, partly due to the forthcoming update of the CAP (see Louah *et al.*, 2017; Kay *et al.*, 2019; Otter and Langenberg, 2020; Elbakidze *et al.*, 2021). This dynamic political and social environment around AFS in Germany is likely going to influence and shape future social perceptions (Hyland *et al.*, 2016). Investigating social perceptions in such dynamic times is, however, appropriate as corresponding findings can be integrated into future decisions enabling them to better guide future behaviour (Hyland *et al.*, 2016). Besides this limitation of temporal constraint, the fixed shape of the Q-Grid might appear restrictive for the creativity of some participants during the sorting process (Watts and Stenner, 2012). However, this forced distribution grid is simultaneously seen as sufficient regarding the number of available sorting options for participants as well as helpful in terms of managing and standardising the Q-Sorts (Watts and Stenner, 2012).

3.2 The Q-Set: Collection and selection of statements

The present Q-Set was developed following a structured approach in which the main themes relevant to AFS in Germany were analysed to enable a sufficient coverage of the full concourse (Brown, 1993; Webler *et al.*, 2009; Watts and Stenner, 2012; Moser and Baulcomb, 2020). Thereby, the following different key themes were included, broadly categorised into barriers and benefits of AFS: (1) Economic and political barriers, (2) social and practicability barriers, (3) ecological barriers, (4) ecological advantages, (5) social advantages, (6) economic advantages and, (7) cultural heritage. For each theme, a subset of statements was selected to ensure sufficient representativity of each group (Webler *et al.*, 2009). In order to find appropriate statements for the above-mentioned key themes, an inductive exploratory research strategy was used (Moser and Baulcomb, 2020), where diverse daily newspapers articles as well as agricultural grey literature was analysed for coverage of AFS. A major focus was put on German literature; however, other European coverage of the topic was also extensively read. Furthermore, peer reviewed articles on similar studies were integrated, e.g., Louah *et al.* (2017) as well as listening to online panel discussions around AFS. Thereby, a total number of 80 statements was gathered and sorted into the different themes, representing the full concourse on the matter. After the elimination of repetitive and redundant statements, the number of statements was reduced to 47. An overview of the final Q-Set is presented in Table 2. Statements were initially developed in English and translated into German once the final set was built to make the study most convenient for the P-Set.

3.3 The P-Set: Identification of participants

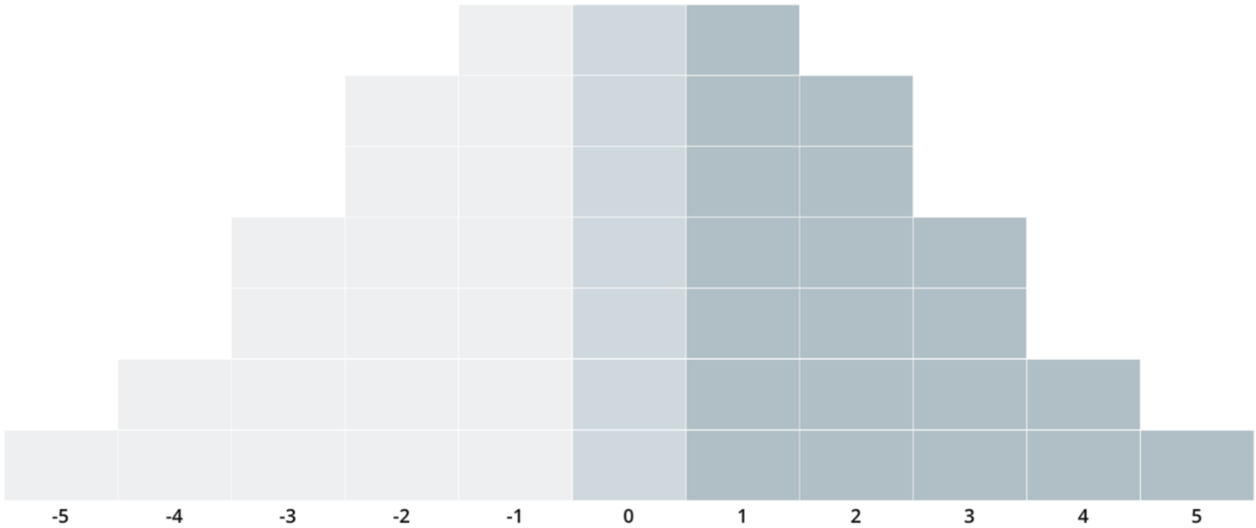
The process of identifying appropriate participants was initiated by researching the AFS landscape in Germany. The different stakeholder groups involved in the agricultural sector and AFS were analysed and potentially knowledgeable representants of each group were identified. A major focus during the creation of the P-Set was put on maintaining the inclusiveness of the different existing opinions about the topic in Germany (Webler *et al.*, 2009; Watts and Stenner, 2012). Throughout the study, it was ensured that representatives of all involved stakeholder groups were integrated sufficiently to ensure the inclusion of the range of opinions existing around that topic. Seven stakeholder groups were identified, which are described further below, each group playing a crucial part in the dynamic field of AFS in Germany. As farmers are situated in the centre of this issue and farming practices and the feeling of identification and purpose has been found to vary across different farming groups (i.e., conventional, organic, regenerative) (Niederist and Helmle, 2011; Hyland *et al.*, 2016; Lin and Hülsbergen, 2017), all of these different groups are considered in this study to secure a balanced coverage of farmers range of opinions on AFS in Germany. Before participants were contacted, it was ensured that they had a robust knowledge about AFS in Germany to be able to effectively contribute to the study. This was done via researching the participants professional environment, their interests connected to AFS as well as references connecting them to AFS. Participants were found via newspaper articles, both agricultural and daily newspapers as well as social media platforms (Instagram) referring to AFS projects implemented in Germany, listening to panel discussions on the topic of regenerative agriculture and doing online research about farmer associations, companies and initiatives involved in AFS. Contact to participants was initiated via e-Mail containing information about the study and consent forms providing data protection details. Some of the first participants were able to recommend further potential participants, who were subsequently contacted. This snowballing technique was a necessary step towards generating a diverse P-set (Webler *et al.*, 2009; Watts and Stenner, 2012). Overall, 32 participants were contacted, of which 20 agreed to participate. The final P-Set consisted of representatives of the following stakeholder groups, where the number in brackets indicates the number of participants per group: Academic (5), farmers associations (2), private initiatives/ business (5), politicians or government employees (2), conventional farmers (2), organic farmers (1), farmers practicing regenerative agriculture (3).

3.4 Data collection process and analysis

Due to the ongoing Covid-19 pandemic and corresponding restrictions to doing research face-to-face, interviews were scheduled online using the video conferencing platform ‘Zoom’ combined with the

'QMethod Software', equipped to doing Q-methodological research online (Zoom Video Communications Inc., 2016; Lutfallah and Buchanan, 2019). Interviews took place in June 2021 and lasted around 45 minutes per participant. After introducing the study and its objectives, participants were presented an overview of the study, which was designed to consist of three parts. Those were (1) the 'Pre-Sort', familiarising the P-Set with the set of statements via pre-sorting them depending on their general agreement, disagreement or neutrality towards each statement (Brown, 1993), (2) the 'Final-Sort', where the P-Set had to sort the statements into the 11-point forced distribution Grid ranging from +5 ('I agree the most') to –5 ('I disagree the most') visible in Figure 1 (Watts and Stenner, 2012). Here, it was explained to participants that the locations of the statements were relative to each other, i.e., placing a statement into the -1 column did not necessarily mean that the statement was rejected but rather that it was less agreed with than all other statements located further to the right (Watts and Stenner, 2012). It was further emphasised that the order within a column is not decisive, but only the positions along the horizontal axis indicate a different strength of opinion (Watts and Stenner, 2012).

Figure 1 – Forced Choice Distribution Grid utilised in QMethod Software (Lutfallah and Buchanan, 2019)



The final part of the study presented the (3) 'Survey', where participants were asked to briefly justify why the corresponding statements were placed at the most extreme positions of the grid, i.e., the +5, +4 and –5, –4 positions. The Q-Grid was designed to only ask for three most extreme statements on each side to reduce the cognitive effort for participants and the length of the interview. Throughout the sorting process, it was observed where the transition of agreed, not agreed and neutral statements was located at each participants Q-Grid (Watts and Stenner, 2012). This was done to ensure the researchers' awareness for positive/ neutral and negative statements among participants to secure an appropriate interpretation of the results (Watts and Stenner, 2012).

The analysis for the quantitative data was initiated in the R Studio software supported by the ‘qmethod’ package (Moser and Baulcomb, 2020; RStudioTeam, 2021). Here, the total number of 20 Q-Sorts were subject to an inverted factor rotation using the Spearman correlation type, the Principal Component Analysis (PCA) extraction method and the varimax rotation method to arrive at factor arrays. Thereafter, the qualitative data sheets documented during interviews were coded in the NVivo software (Jackson and Bazeley, 2019). Here, an open coding approach was chosen to iteratively develop codes for the interviews and adjust and revise them throughout the qualitative data analysis (Soliman and Kan, 2002). The main themes extracted via this analyses were used to build the discourses around the different factors (Watts and Stenner, 2012).

4 RESULTS

4.1 Quantitative Results

The analysis arrived at a 3-factor solution representing the social perceptions of AFS in Germany. Those factors, their defining Q-Sorts and corresponding factor loadings are displayed in Table 2. Arriving at this 3-factor solution took several tests into account, aiming at validating their significance. Those tests were applied to the quantitative output generated through the analyses in RStudio (see Appendix A and B for the code and full results) and were the following: (1) Kaiser-Guttmann criterion [2], (2) Humphrey’s Rule [3], and (3) the significant loading of at least two Q-Sorts into each factor (Watts and Stenner, 2012). Thereby, the initial amount of twenty individual viewpoints, i.e. Q-Sorts, was reduced to three idealised Q-Sorts (IQS), i.e., factors (Watts and Stenner, 2012; Louah *et al.*, 2017). Each factor shares a similar understanding of the issue around AFS in Germany (Watts and Stenner, 2012). The three factors explained a total of 55.5% of the study variance. Eighteen Q-Sorts loaded significantly into one of those three factors with 2 Q-sorts not loading significantly into any factor. It is worth noting that most of the P-Set agreed with more statements than they disagreed with, leading to the consideration of the statements in the neutral column as being agreed with. Table 3 displays the statements, their Idealised Q-Sort Position (IQSP) for each factor, and the z-Score [4].

[2] Only factors with Eigenvalues ≥ 1 are considered as having sufficient explanatory power and being statistically relevant (Watts and Stenner, 2012).
[3] The product of the two highest loadings must be ≥ twice the standard error (Watts and Stenner, 2012)
[4] The z-score is the ‘standard score’ showing the score of each statement regarding its standard deviation from the middle of the distribution for the IQS (Webler *et al.*, 2009; Moser and Baulcomb, 2020).

Table 2 – The three factors, their defining Q-Sorts and significant factor loadings

Q-Sorts significantly loading into each factor building one social perspective		**Stakeholder Group**	**Factor I**	**Factor II**	**Factor III**
Social Perspective I:					
	Stakeholder01	Politicians	*0.65*	0.04	0.2
	Stakeholder06	Private Initiatives	*0.62*	0.22	- 0.31
	Stakeholder08	Regenerative Farmers	*0.77*	0.34	0.01
	Stakeholder09	Regenerative Farmers	*0.79*	0.29	0.13
	Stakeholder11	Private Initiatives	*0.66*	0.39	- 0.08
	Stakeholder13	Academic	*0.79*	0.03	- 0.06
	Stakeholder18	Farmers Associations	*0.79*	0.22	0.02
	Stakeholder19	Private Initiatives	*0.76*	0.09	0.2
Social Perspective II:					
	Stakeholder04	Academic	0.35	*0.65*	0.15
	Stakeholder16	Academic	- 0.4	*0.53*	0.18
	Stakeholder17	Private Initiatives	0.2	*0.67*	- 0.17
	Stakeholder20	Private Initiatives	0.36	*0.67*	0.01
Social Perspective III:					
	Stakeholder05	Academic	0.14	0.09	*0.65*
	Stakeholder07	Farmers Associations	0	0.3	*0.6*
	Stakeholder10	Organic Farmers	- 0.12	- 0.45	*0.58*
	Stakeholder12	Conventional Farmers	- 0.21	0.02	*0.63*
	Stakeholder14	Conventional Farmers	0.12	- 0.18	*0.65*
	Stakeholder15	Academic	0.27	0.28	*0.6*
Eigenvalues *			**5.3**	**3**	**2.7**
Variance (%) *			**26.5**	**15.1**	**13.7**
Number of defining Q-Sorts			**8**	**4**	**6**

* Rounded to the first decimal

Table 3 – Statements, ISPQ and z-Score per factor and corresponding points of consensus and polarisation

Q	Statement	Factor I		Factor II		Factor III		Significance[3]			Consensus/ Distinguishing
		ISPQ	z-Score	ISPQ	z-Score	ISPQ	z-Score	F1:F2	F1:F3	F2:F3	
1	One of the main barriers to agroforestry is that there is no distinct market for the products.	**-3**	-1.42	**-2**	-0.78	**-2**	-0.77	*	*		Distinguishing F1
2	The lack of monetary compensation for provided ES is a major barrier to the adoption of AFS.	**2**	0.68	**-2**	-0.79	**-3**	-0.86	6*	6*		Distinguishing F1
3	The complexity of policies and rules around AFS in Germany makes is a major constraint to adoption of AFS.	**1**	0.48	**1**	0.54	**-1**	-0.52		***	***	Distinguishing F3
4	It is not the responsibility of farmers to switch to AFS on their own, policies should incentivise changes	**-1**	-0.45	**0**	-0.08	**0**	-0.21				Consensus
5	The communication between the different stakeholder groups about AFS needs to be improved.	**0**	-0.04	**0**	0.13	**0**	0.02				Consensus
6	Silvopastural as well as Silvoarable AFS need to be subsidised by policies.	**3**	1.39	**0**	0.11	**3**	1.1	***		**	Distinguishing F2
7	The lack of long-term legal certainty with respect to keeping land-use rights in Germany is a major barrier for farmers to adopt agroforestry practices.	**4**	1.43	**-3**	-1.35	**5**	2.49	6*	***	6*	Distinguishing all
8	Current German policy regulations lack funding support for AFS.	**3**	1.39	**2**	0.68	**3**	1.06	*			Broad Consensus
9	The investments needed for the transformation to AFS need to be covered by public funds (i.e., the CAP) or private initiatives, not the farmer.	**0**	0.21	**-2**	-1.01	**1**	0.49	***		***	Distinguishing F2
10	AFS should only be subsidised if done through organic means.	**-3**	-1.42	**-4**	-1.75	**-5**	-2.06		*		Broad Consensus
11	The public is unaware of AFS and its diverse benefits.	**0**	0.15	**2**	0.83	**1**	0.23	*			Broad Consensus
12	Consumers are not willing to pay a price premium for AFS products	**-3**	-1.35	**-2**	-0.72	**0**	-0.04	*	6*	*	Distinguishing all
13	Most farmers' identity is at odds with the purpose of AFS.	**-2**	-0.69	**-3**	-1.57	**-1**	-0.43	**		***	Distinguishing F2
14	Farmers lack awareness about the diverse potential of AFS.	**2**	0.81	**0**	0.33	**-2**	-0.64		6*	**	Distinguishing F3
15	Farmers are reluctant to take risks related to implementing AFS.	**-1**	-0.43	**0**	-0.04	**4**	1.63		6*	6*	Distinguishing F3
16	The mainstreaming of AFS in Germany is very unlikely.	**-4**	-1.7	**-2**	-0.63	**1**	0.24	***	6*	**	Distinguishing all

17	Adopting AF practices requires a high degree of motivation and engagement from the farmer’s side.	**1**	0.26	**1**	0.46	**1**	0.55				Consensus
18	Farmers are sceptical about AFS, as the system needs years to deliver financial returns.	**-2**	-0.76	**3**	1.18	**4**	1.61	6*	6*		Distinguishing F1
19	Findings about appropriate AFS farming practices are very individual and hard to transfer to other regions, which hinders large scale adoptions.	**-2**	-0.79	**2**	1.06	**1**	0.23	6*	***	**	Distinguishing all
20	Farmers are subject to a tight schedule, which makes the integration of AFS stressful.	**-2**	-1.07	**-3**	-1.19	**1**	0.26		6*	***	Distinguishing F3
21	The lack of appropriate technologies to increase efficiency within AFS is a barrier to its adoption.	**-1**	-0.57	**-1**	-0.23	**1**	0.65		***	**	Distinguishing F3
22	Lack of social acceptance by neighbours may constraint the adoption of AFS.	**-2**	-0.73	**-1**	-0.44	**-3**	-1.01				Consensus
23	The lack of popular best practice examples for AFS in Germany hinders its mainstreaming from the bottom up.	**0**	-0.07	**-1**	-0.21	**2**	0.91		***	***	Distinguishing F3
24	Trees hinder the overall efficiency of farms.	**-4**	-1.94	**-2**	-1.18	**0**	0.05	*	6*	***	Distinguishing all
25	AFS are unattractive, as the competition between trees and crops for soil nutrients and sunlight are lowering yields.	**-5**	-2.25	**-4**	-1.82	**-3**	-1.94				Consensus
26	Ecological knowledge necessary for implementing and managing AFS is complex and difficult to obtain.	**-1**	-0.19	**-1**	-0.27	**3**	0.98		***	***	Distinguishing F3
27	AFS are very good land-use system to long-term sequester carbon in deeper soil layers, whilst producing food and timber.	**3**	1.38	**4**	1.42	**-2**	-0.62		6*	6*	Distinguishing F3
28	AFS are more appropriate systems for lower yielding soils, higher yielding soils should not be farmed with AFS.	**-3**	-1.64	**-5**	-2.77	**0**	0.11	***	6*	6*	Distinguishing all
29	AFS generate higher quality food due to healthier and more diversified soils.	**0**	0.15	**5**	1.58	**-3**	-1.23	***	6*	6*	Distinguishing all
30	AFS enable the agricultural sector to unleash the potential as an important leverage point to mitigate climate change.	**1**	0.51	**3**	1.14	**-1**	-0.59	*	***	6*	Distinguishing all
31	AFS holds great potential to restore the share of degraded soils in Germany.	**2**	1.14	**3**	1.4	**-1**	-0.33		6*	6*	Distinguishing F3
32	AFS increases the resilience of farms against more extreme weather events in Germany such as droughts and floods.	**2**	0.94	**4**	1.58	**-1**	-0.24	*	***	6*	Distinguishing all
33	AFS represent shelter belts for domesticated as well as wild animals from weather (sunlight, rain etc.).	**1**	0.37	**1**	0.46	**2**	0.94		*		Broad Consensus

34	Livestock and other farm animals integrated into AFS have the potential to close the nutrition cycle.	**-1**	-0.16	**3**	1.27	**-1**	-0.36	***		6*	Distinguishing F2
35	AFS create a better microclimate, which is beneficial for animals as well as crops.	**3**	1.19	**2**	0.76	**2**	0.72				Consensus
36	Existing AFS (meadow orchards/ hedgerows) should be prioritised in terms of subsidies to ensure their preservation and maintenance.	**-2**	-0.69	**1**	0.38	**2**	0.78	***	6*		Distinguishing F1
37	AFS provide multiple benefits including biodiversity and water quality improvements.	**5**	1.62	**0**	0.29	**2**	0.82	***	**		Distinguishing F1
38	Agroforestry enables people to reconnect to nature.	**0**	0.19	**1**	0.47	**-1**	-0.24			*	Broad Consensus
39	AFS have the potential to help leave a better world for future generations.	**4**	1.53	**0**	0.34	**-2**	-0.79	***	6*	***	Distinguishing all
40	AFS entail the potential to improve the public perception of farming in Germany.	**1**	0.5	**-1**	-0.12	**0**	0.23	*			Broad Consensus
41	The effort to implement AFS enables people to take part in the combat against climate change.	**-1**	-0.24	**2**	0.98	**0**	-0.07	***		***	Distinguishing F2
42	The adoption of AFS equals the adoption of a new vision for farmers.	**2**	1.03	**-3**	-1.35	**-2**	-0.74	6*	6*		Distinguishing F1
43	AFS can create a sense of community and motivation to implement it among farmers.	**1**	0.32	**-1**	-0.47	**-2**	-0.65	**	***		Distinguishing F1
44	AFS are more profitable in the long-term than land-use systems not applying AFS.	**2**	0.99	**1**	0.38	**-4**	-2.03	*	6*	6*	Distinguishing all
45	Having a more diverse supply makes farms more resilient to market price movements.	**1**	0.38	**1**	0.44	**-4**	-2.03		6*	6*	Distinguishing F3
46	AFS landscapes are part of the German Cultural Heritage.	**0**	-0.02	**-1**	-0.12	**2**	0.78		**	**	Distinguishing F3
47	Traditional farming knowledge about hedgerows and small-scale fields should be considered in AFS planning and development	**-1**	-0.44	**2**	0.67	**3**	1.5	***	6*	**	Distinguishing all

[3] The complete absence of a * symbol in one row indicates consensus across all factors regarding the relevant statement, i.e., no differentiation between the strength of opinion is possible (p-value > 0.05). Broad consensus is indicated if very weak distinguishment is possible between the factors regarding the relevant statement, which is however neglectable. * Expresses a p-value < 0.05, whereas ** expresses a p-value <0.01; *** <0.001; and 6* < 0.00001

4.2 Qualitative Results: Three social perspectives around AFS in Germany

The analysis of the qualitative comments of stakeholders contained in each factor were used to develop the social perspectives. Those were given the following titles to best capture their perspective on AFS in Germany: (1) Optimists, (2) Systemic Transformists, and (3) Sceptics.

4.2.1 Social perspective I: Optimists

This social perspective (SPI), named Optimists, consists of eight significantly loading Q-Sorts, explaining 26.5 % of the studies' variance. Stakeholders are regenerative farmers, politicians, academics, farmer associations and private initiatives supporting farms in transitioning to regenerative practices or using AFS products. Regarding the most extreme positions in the IQS shown in Table 3, Optimists are aligned by their strong belief into the mainstreaming success of AFS (Q16–4) and the general capabilities of AFS to deliver diverse benefits for current and future societies and the environment (Q37+4, Q39+5), thereby acknowledging its bequest value. *'AFS can bring the way we farm closer to nature'* [Stakeholder09]. They believe that the '*creation of a viable future for next generations is only possible if ways to deal with global warming are found. AFS entail immense potential to do so'* [Stakeholder06]. They are convinced that *'the trend we currently see with AFS will turn into a change'* [Stakeholder09]. However, Optimists understand that milestones such as achieving long-term security of land-use rights for farmers and reducing false ecological assumptions are vital to accomplish this transformation and help farmers to *'decide quicker'* [Stakeholder01] (Q7+4, Q24–4, Q25–5).

Optimists differ from the other viewpoints through their stronger belief that the missing market for AFS products is not restricting its adoption (Q1–3), convinced that getting *'creative as a farmer opens many options [...], especially as consumers are nowadays actively looking for ways to get better food'* [Stakeholder13]. Opposite to SPII and SPIII, they agree that the concept of monetary compensations for provided ES could increase the adoption rate of AFS (Q2+2), while old AFS should not be prioritised through policy incentives (Q36–2). Optimists stand out through their disbelief into farmers' general scepticism towards AFS due to its delay in financial returns (Q18–2), framing this '*the dead-beat argument used repeatedly in conventional agriculture, which must be rejected so the incentive is not destroyed from the start'* [Stakeholder06]. They are the only perspective convinced that the introduction of AFS changes farmers' vision (Q42+2), especially as *'we must do something different, [and] AFS give us the opportunity to restore many [ecological] functions that we have already lost'* [Stakeholder13]. Opposite to the other SPs, Optimists believe that AFS can create a sense of community among farmers motivating them to take risks associated with implementing AFS (Q43+1).

4.2.2 Social perspective II: Systemic Transformists

This social perspective (SPII) is defined by four Q-Sorts, explaining 15.1% of the study variance. Stakeholders were either academics or employees of private businesses. Considering the aspects Systemic Transformists feel most strongly about (see Table 3), their affection towards the precautionary principle becomes evident. They see immense potential in the *'preservation of soils from the beginning. AFS is […] a precaution measure for soils, which makes sense on every soil, no matter how productive.'* (*Q28*–5) [Stakeholder17]. For them, *'AFS can also generate economic added value on highly productive soils, but here people often do not think far enough, making this seem absurd'* [Stakeholder16]. They emphasise the necessity to be more creative when prioritising sustainability and investing in longer-term thinking regarding financial, technical, and ecological aspects of AFS, which explains their position towards Q7 as only temporarily restrictive (–3). Educating and getting farmers used to *'slow-growing things like trees'* [Stakeholder16] is important to them and they emphasise that *'communicating and enlightening farmers about the potential of AFS is an important step, which includes improving the external communication of politicians'* [Stakeholder04]. Systemic Transformists acknowledge the diverse socio-ecological benefits of AFS (Q27+4, Q25–4, Q32+4, Q29+5, Q34+3), which is vital to achieve a successful systemic transition in agriculture. They are convinced that we have to *'collectively and globally learn'* [Stakeholder16], as *'we have been pushing […] intensification in agriculture and managed to extremely degrade our soils over the last century, which are no longer able to secure us long-term harvests'* [Stakeholder17]. Contrary to SPI and SPIII, Systemic Transformists reject the argument that farmers are not responsible for engaging in financial investments required for the transition to AFS, opposing the assumption of this being solely covered by public funds or private initiatives (Q9–2). This is especially noticeable as they also deny the assumption that most farmers' identity contradicts the initial purpose of AFS (Q13–3). In their perspective '*every farmer is intrinsically interested in generating a stable yield, protected against weather extremes through resilient soils'* [Stakeholder20]. Systemic Transformists attribute importance to the potential of AFS in enabling people to take part in the collective efforts to combat climate change (Q41+2), thereby asserting importance to the '*intrinsic, ethical and incommensurable values entailed in AFS'* [Stakeholder16]. In their perspective, AFS have the potential to consider sociological aspects, aside from monetary concerns, more than conventional approaches. Overall, Transformists approach the issue very systemic whilst acknowledging its diverse potential.

4.2.3 Social perspective III: Sceptics

This third social perspective (SPIII), named Sceptics, is explanatory for 13.7% of the study variance and consists of six stakeholders engaged in academia, farmers associations, and conventional/ organic agriculture. Their scepticism is largely shaped by financial and cognitive arguments (see Table 3).

Regarding the economic sphere of their understanding, Sceptics are neither convinced by the potential of AFS to make farm economics more resilient (Q45–4), nor to be more profitable in the long-term (Q44–4). Overall, they strongly believe that farmers are unwilling to take on the risks associated with AFS (Q15+4, Q18+4). In their understanding *'farmers are already scraping the limit. Their willingness to take on additional risks for the benefit of society is low. They are the ones bearing the risks, whilst everyone enjoys the benefits, but no one wants to participate in the efforts.'* [Stakeholder05]. They believe that *'AFS will always be a subordinate small income branch that takes a long time to pay for itself'* [Stakeholder12]. Stakeholder15 argues that *'a forestry mindset is nowadays scarce in agriculture, which leads to the upfront investments connected to AFS implementation be perceived even more risky'*. Cognitively, they strongly believe that the insecurity of future land-use rights is a major hurdle for farmers (Q7+5). Further, Sceptics emphasise the importance of popular best-practice examples in mainstreaming efforts more than SPI and SPII (Q23+2). This adds to their agreement with the complexity and unavailability of ecological knowledge hindering AFS uptake (Q26+3), in contrast to the other two perspectives. Sceptics don't consider lacking awareness about AFS potential on the farmers side as restrictive (Q14–2). Opposite to SPI and SPII, Sceptics believe that the tight schedule of farmers (Q20+1), combined with the lack of appropriate technology to support efficient AFS management, (Q21+1) makes their management difficult. They are further sceptical about the potential of AFS to sequester carbon into the soils (Q27–2) as well as its potential to restore degraded soils (Q31–1). However, Sceptics do believe that traditional AFS landscapes entail cultural heritage (Q46+2).

4.3 Areas of polarisation and consensus

4.3.1 Consensus across stakeholders

The analysis flagged six true and six broad[5] points of consensus across perspectives, which were matched with the qualitative data. Stakeholders collectively agreed that the communication between involved parties to facilitate large scale change needs to be improved (Q5). They further disagreed with the competition for nutrients and sunlight between trees and crops (Q25), saying that *'this only happens if AFS are incorrectly implemented'* [Stakeholder09], thereby emphasising the necessity of appropriate communication and education. The correct design and implementation of AFS creates a system, where '*components are in symbiosis with each other'* [Stakeholder17]. It is, however, *'difficult to convince farmers of this'* [Stakeholder01] and depends on sufficient knowledge and appropriate consulting. Stakeholders did not assess the lacking social acceptance of peers as restrictive for farmers to adopt AFS (Q22). The improved microclimate in AFS is collectively seen as beneficial (Q35). All SPs were convinced that *'it must also be the responsibility of the farmer to*

[5] Less significantly relevant than true points of consensus but still important points of consensus among participants.

understand the potential of AFS for his individual situation' [Stakeholder10], supported by policy incentives (Q4). Stakeholders agreed that farmers need to be highly motivated to engage with risks (Q17), thereby requiring effective incentives, as *'the system currently rewards not those who want the right thing, but those who are the most persistent'* [Stakeholder01].

Broad points of consensus revealed the importance to stakeholders to *'promote AFS on all farms'* [Stakeholder16]. In their perspective, a subsidisation of only organically operating farms *'shouldn't be encouraged, as this would reinforce an already existing gap'* [Stakeholder13]. On the contrary, *'AFS offer potential to unify conventional and organic farmers, thereby enabling large-scale changes'* [Stakeholder03[6]], and *'increasing the rate of acceptance for AFS'* [Stakeholder07]. '*Moreover, the share of organic farming in Germany is very low*[7]. *Disregarding the land not farmed organically would be fatal. We cannot afford to target only organic farms but must achieve a broad impact quickly'* [Stakeholder15], especially as *'farmers will move automatically to more extensive practices with AFS* [Stakeholder07] (Q10). Stakeholders agreed that current agricultural policies could reach larger uptake with appropriate subsidisation, convinced that *'there have been serious omissions in German politics in the past'* [Stakeholder18], where *'too little incentive was created, and too little education and information work has been done'* [Stakeholder04] (Q8). Stakeholders further perceived the public as unaware of AFS and its diverse benefits (Q11). Considering the diverse socio-ecological benefits of AFS, stakeholders agreed that they facilitate important shelter from weather extremes (Q33), improve the human-nature relationship (Q38), as well as the public perception of farming in Germany (Q40).

4.3.2 Polarisation across stakeholders

Twelve distinguishing statements were elicited across perspectives, as shown in Table 3. Statements distinctly distinguishing single factors are included in the description of the corresponding perspective.

For eight of those statements, extreme positions were chosen. These statements resulted in greater polarisation between stakeholders and could present a larger obstacle to efforts aligning stakeholders. AFS potential to increase the degree of nutrients in food caused extreme polarisation between Systemic Transformists (+5) and Sceptics (–3) (Q29). Opinions further polarised all SPs regarding the long-term land-use right security limiting AFS uptake (Q7), aligning SPI (+4) and SPIII (+5) in their support contrary to SPII (–3). Sceptics (0) are more convinced that AFS are better on lower yielding soils, contrary to Optimists (–3), and Systemic Transformists (–5) (Q28). The increased

[6] This stakeholder did not load significantly into any factor, however, agreed with the point made, which is why the quote emphasising this was included at this point.
[7] Approximately 88 % of German farmers are pursuing conventional farming practices, leaving 12% practicing organic agriculture (German Farmers' Association, 2020)

weather resilience results in a similar polarisation, leaving Sceptics slightly disagree (–1), whilst Optimists (+2) and Systemic Transformists (+4) agree (Q32). Optimists strongly reject (–4) the pessimistic prognosis of AFS future opposite to Sceptics (+1) (Q16). Additionally, Q39 also strongly polarised Optimists, who believed in the creation of a viable future for coming generations through AFS (+4), opposite Sceptics (–2). The perception of trees on arable fields as restricting efficiency (Q24) left Optimists (–4) as well as Systemic Transformists (–2) disagree, if implemented correctly. However, Sceptics perceived this statement as true (0). Regarding the long-term profitability of AFS, viewpoints differed between Optimists (+2) and Sceptics (–4) (Q44). Regarding the remaining four distinguishing statements, no extreme position was chosen (Q12, Q19, Q30 and Q47). This indicates a weaker polarisation across the different viewpoints, offering potential for easier stakeholder alignment.

5 DISCUSSION

This dissertation investigated the social perspectives, points of polarisation and consensus among German stakeholders regarding AFS. Q-Methodology revealed three perspectives differing in their understanding, support, and prognosis of the field's future. They were given the following titles: (1) Optimists, (2) Systemic Transformists and (3) Sceptics. Overall, results showed that all social perspectives understood the diverse potential of AFS as well as the necessity of a paradigm change in agriculture, thus generally supported the approach (Q35, Q33). This goes in line with findings from the literature reviewed for this thesis (Kay *et al.*, 2019; Otter and Langenberg, 2020). The various barriers related to the implementation and management of AFS were however perceived differently. On the one hand, they were understood as strongly restricting AFS uptake by Sceptics. On the other hand, they were understood as merely temporary obstacles, solvable through setting appropriate priorities by Optimists and Systemic Transformists. Several points of consensus and polarisation among the perspectives were elicited, of which the most important are discussed below.

Social Acceptance. The first notable finding of this study addresses the collective rejection of stakeholders towards the influence of peers on farmers decision-making regarding AFS uptake (Q22). This contradicts the results from Isaac *et al.* (2007), Sereke *et al.* (2016) and Beer and Theusen (2018). However, this finding might be individual to the present P-Set. The mentioned studies explicitly focused on farmers, whereas in this study, about 2/3 of participants were not involved in agriculture (see Table 2). These participants thus understood farmers' perceptions on this matter differently than farmers themselves. This misconception could be an explanation for the gap in AFS uptake. The present results further confirm previous findings from Langenberg *et al.* (2018) and Otter and Langenberg (2020), suggesting that uptake of AFS is motivated by the need to improve the image of

German farming, thereby confirming AFS potential to increase social acceptance of farming practices by the public (Q40).

Communication and cognition. Regarding the aspects of communication and collective learning processes, results indicate that transparent communication efforts to raise awareness among farmers and society (Q5) are crucial to increase AFS acceptance. Society was collectively assessed as unaware (Q11), which is supported by results from Borremans *et al.* (2016). Open communication and the adaptation of scientific findings to the targeted audience in practice could therefore possibly reduce the number of misunderstandings leading to the polarisation points identified in this study (Q29, Q28 and Q32), thereby further aligning stakeholders. Additionally, following Isaac *et al.* (2007), the promotion of peer-to-peer learning opportunities such as best-practice examples via demonstration farms could facilitate hands-on learning opportunities for farmers. The next point of consensus adds to this aspect. Stakeholders collectively did not perceive trees and crops as competing (Q25) and emphasised the need for clear communication addressing this misconception. This goes in line with the suggestions of Isaac *et al.* (2007) and Louah *et al.* (2017) on the cognitive barriers related to AFS in Europe and the potential of interactive and participatory learning experiences to inspire farmers to adopt new land-use systems. Reeg (2011) adds to this stating that farmers often only start to change their way of farming when under social, financial, or ecological pressure. This aligns with the RESET (Regulation, Education, Social Pressure, Economic Incentives and Tools) framework proposed by Borremans *et al.* (2016), building on a study from Van Woerkum *et al*. (1999), where potential leverage points to tackle extrinsic barriers restricting AFS uptake are offered. Following this, social pressure through peers, the public and politics can contribute to inducing behavioural change in agriculture (Borremans *et al.*, 2016). Optimists align with this literature by believing into the sense of community created among farmers through AFS practices, thereby potentially motivating others to adopt AFS (Q43). However, Sceptics are distinct in their perception that lacking awareness about AFS potential on the farmers side is not restricting its uptake (Q14–2), thereby indicating a conscious decision of farmers not to implement AFS despite its potential. This outcome reinforces the existing limitations of awareness-raising, communication and educational campaigns to unite stakeholders, making it depend on the overall existing motivation to commit to the issue (Meadows, 2008; Murshed-e-Jahan *et al.*, 2014).

Cultural heritage protection. Sceptics were the most convinced of traditional AFS belonging to German cultural heritage (Q46). As traditional AFS, such as woody pastures, hedgerows or meadow orchards used to be frequent in European and Germany, they belong to their cultural identity (Marshall and Moonen, 2002; Bergmeier *et al.*, 2010). Implementing AFS into landscapes that used to be characterised by small-scale structural diversity can potentially revive and conserve this cultural heritage and traditional value diversity (Marshall and Moonen, 2002; Bergmeier *et al.*, 2010). As German landscapes are strongly characterised by its agricultural practices, AFS thus entail potential to influence their future perceptions (Commission on the Future of Agriculture, 2021; Hübner, 2021).

Monetary compensation of ES. Payments for Ecosystem Services (PES) are an instrument enabling financial compensation of ES provisioners, i.e., farmers practicing AFS, through ES beneficiaries, i.e., societies or private businesses (Wunder, 2005). Kay *et al.* (2019) found that in theory, the financial compensation of ES would make AFS more profitable compared to conventional land-use approaches. However, regarding the potential of PES to govern farmers behaviour, Sereke *et al.* (2016) found that its potential to change farmers behaviour regarding AFS adoption is limited, which was confirmed by the findings of Louah *et al.* (2017). Furthermore, general risks connected to the implementation of financial incentives, such as crowding-out effects on farmers' intrinsic motivations for nature conservation need to be considered (Rode *et al.*, 2015). In highly developed countries like Germany, where the human-nature-relationship is alienated and already governed through economic instruments to influence behaviour, the risks of generating new crowding-out effects or initiating the commodification of nature through PES can be considered low (Bourdeau, 2004; van Hecken and Bastiaensen, 2010; Ezzine-de-Blas *et al.*, 2018; Drechsler, 2021). However, risks and undesirable consequences may still arise if policies only incentivise the provision of a single ES, assuming the validity of the homo oeconomicus, i.e., full rationality and utility maximisation (Kosoy and Corbera, 2010; Drechsler, 2021). The mere promotion of increased carbon sequestration through AFS could for example lead to this ES being particularly promoted by farmers through merely planting fast growing trees to maximise farmer's short-term benefits (Kosoy and Corbera, 2010). Thereby, the original objective of AFS to generate diverse ES is missed (Nerlich *et al.*, 2013). Considering the results of this study, the lack of monetary compensaion for provided ES (Q2) was only perceived as limiting towards AFS uptake by Optimists, while Systemic Transformists and Sceptics did not support this. This polarisation is also mirrored in the literature, where PES is assessed as an ineffective policy incentive to change farmers' behaviour (Sereke *et al.*, 2016; Louah *et al.*, 2017), but simultaneously seen as having potential to make AFS more profitable (Kay *et al.*, 2019). This perceived inefficiency might be explainable with the potential invalidity of the homo oeconomicus model, as human behaviour towards nature is not only influenced by rationality and utility maximisation, but also by altruism, value pluralism and intrinsic motivations (McCauley, 2006; van Hecken and Bastiaensen, 2010).

Subsidisation. Several points of consensus addressed AFS subsidisation. Stakeholders collectively emphasised the necessity to subsidise agricultural transitions to AFS through all means, i.e., organic, and conventional (Q10), as a mere limitation on organic farms was perceived as restricting larger changes in German agriculture. Stakeholders were further aligned in their belief that German politics is responsible for inducing land-use changes through incentives and is currently not fulfilling its subsidisation potential for AFS (Q4, Q8). Additionally, policies should subsidise Silvoarable as well as Silvopastoral AFS, which aligned Optimists and Sceptics, whilst Systemic Transformists did not attach great importance to it (Q6). This point of polarisation might be explainable with the recently approved motion of the German Bundestag to subsidise both AFS types, which reinforces the character of Systemic Transformists seeing such barriers as short-term restrictive (DeFAF, 2021b, 2021a; Parliament of Lower Saxony, 2021).

Land tenure complexity. Results of this study showed strong polarisation regarding the barrier of long-term land-use security, where SPI and SPIII agreed that this is restricting AFS uptake, whereas SPII, characterised by their transformative and systemic way of thinking, did not see it as a long-term limitation (Q7). Borremans *et al.* (2016) align with this point suggesting that land tenure complexity and insecurity is one of the most pressing barriers for the targeted group.

Limitations of the present study. As the objective of this study was to investigate the overall perceptions towards AFS, stakeholders had to engage with a broad range of topics, which may have caused exhaustion on their side as well as unexperienced answers with some of the addressed topics. Further, and due to time limitations, this study could not integrate interviews with AFS experts into the development of the Q-Set. Thereby, potential to directly mirror voices of participants has been missed and exposure to researchers interference with the Q-Set was increased (Webler *et al.*, 2009). Additionally, neither the final Q-Set, nor the results could be adjusted according to feedback from the P-Set. Thereby, perspective characterisations could not profit from feedback of participants. The risk of researchers' bias has been reflected on during the studies' design and conduction, thereby minimising interference.

Recommendations. Following the implications of this dissertation research several recommendations can be made regarding future efforts targeting AFS uptake in Germany. These go in addition to the general urgency to clarify the land tenure complexity and land-use insecurity in Germany connected to long-term projects such as AFS with the forthcoming CAP:

(1) In line with Mosquera-Losada *et al.* (2012), Graves *et al.* (2009) and Louah *et al.* (2017), the need for transparent communication and educational campaigns is emphasised, particularly targeting stakeholders characterised by scepticism. Explicit awareness raising regarding the necessity of system change in agriculture and AFS leverage potential needs to be initiated. This should be done through hands-on experiences for farmers such as demonstration farms, as recommended by Isaac *et al.* (2007). Simultaneously and following results from this study, long-

term forestry thinking needs to be reintroduced in agriculture. Considering the general limits to educational and communication campaigns, those approaches should, however, not be seen as sufficient to successfully change behaviours, but rather as part of a larger solution (Meadows, 2008; Meyer, 2015).

(2) Educational campaigns targeting the public and communicating the potential of AFS and corresponding products to increase social pressure (in line with RESET) on political decision-making regarding the redesign of the CAP as well as farmers to increase their openness towards the uptake of more sustainable land-use systems, such as AFS (Borremans *et al.*, 2016).

(3) Whilst designing future policy incentives, interdisciplinary and participatory dialogues between involved stakeholders should be envisioned to ensure the consideration of value pluralism and the multitude of different social perspectives around AFS as well as potential risks emerging with the use of economic incentives, thus engaging with the principles of post-normal science (Funtowicz and Ravetz, 1994; Swedeen, 2006; Kosoy and Corbera, 2010). This could be achieved through deliberative and non-monetary valuation processes (Raymond *et al.*, 2014).

(4) Despite the above-described risks and assessed low effectivity of PES as a policy incentive, this instrument could still be effective when privately subsidising AFS uptake in Germany (Kay *et al.*, 2019). Complex subsidy frameworks such as the CAP can be circumvented through PES, which encourages more efficient private solutions between farmers and businesses (Borremans *et al.*, 2016; Kay *et al.*, 2019). Thus, PES should not be prioritised as a policy incentive to increase AFS uptake, reinforced by the currently lacking framwork to consistently quantify ES provision (Fagerholm *et al.*, 2016; Göbel, 2016). However, private PES solutions between farmers and private companies could entail potential to increase AFS uptake.

Paths forward. Further studies are required to arrive at a holistic understanding of the controversial issue around AFS uptake in Germany. This is crucial to identify leverage points in the agricultural system supporting the design and implementation of agricultural policies aimed at increasing the sustainability of the agricultural sector. The following paragraphs will suggest several paths forward:

(1) *The RESET framework applied to AFS in Germany.* This framework could offer an holistic approach to changing farmers behaviour towards an increased uptake for the unique case of AFS in Germany (Van Woerkum *et al.*, 1999; Borremans *et al.*, 2016). Studying the distinct potential of AFS through RESET could elicit important points for future work for private initiatives, farmers as well as political stakeholders to facilitate higher AFS uptake.

(2) *Investigating subsidy preferences of German farmers to adopt AFS using a Choice Experiment and Q-Methodology.* Regarding the large share of conventionally farmed land in Germany (88%) (German Farmers' Association, 2020), combined with the results of this study recommending the consideration of all agricultural practices for AFS subsidies to induce large-scale changes, it is crucial to integrate the distinct preferences of conventional farmers for AFS incentivisation in the design of new policies. As the literature review showed, the German society is already willing to pay more taxes to see AFS practices implemented in Germany, whereas farmers perceive the associated risks to be restrictive towards AFS uptake (Sereke *et al.*, 2016; Beer and Theusen, 2018; Otter and Langenberg, 2020). A Choice Experiment aiming at eliciting the willingness-to-accept (WTA) a transition to AFS of conventional farmers could facilitate this (see Hanley *et al.*, 1998). Simultaneously, a Q-Study could deliver information about their exact preferences regarding the form of incentivisation. By combining those findings and communicating them to decision-makers, leverage points to align stakeholders in the efforts to transform the agricultural sector could be identified.

(3) *Assessing the awareness of German farmers regarding the existence and potential of AFS.* An updated investigation into the awareness and understanding of German farmers regarding AFS would be an appropriate baseline to design future communication and educational campaigns about AFS targeting farmers. The consensus of all stakeholders regarding the required improvement and transparency of communication between all actors involved (Q5) showed that enabling a proactive and interdisciplinary dialogue between farmers, policy makers and private initiatives is essential to achieving a transformation of the agricultural sector in Germany.

(4) *Investigating the WTP of private initiatives to support transitions to AFS on farms.* To investigate the above-described potential of privately funded transitions to AFS through PES, it is crucial to elicit the WTP of private businesses for ES provided through a transition to AFS and corresponding products (Wunder, 2005; Kay *et al.*, 2019). This could be done through a choice experiment (see Hanley *et al.*, 1998). Implementing PES could enable private businesses to improve their sustainability image as well as increase the profitability of farms, thereby potentially increasing the attractivity of AFS.

(5) *Human-Nature-Relationship improvements through AFS.* Investigations of this potential is barely existent in the literature (Takeuchi, 2010). It is, however, evident that especially urbanised societies are alienated from nature, not understanding that their food security depends on healthy ecosystems (Bourdeau, 2004; Commission on the Future of Agriculture, 2021). This problem could be addressed through AFS, as this holistic approach has a potentially educational side to it,

closely imitating natures processes whilst securing food provision (Rigueiro-Rodríguez *et al.*, 2009; Takeuchi, 2010). Considering the results of this dissertation, the potential of AFS to reconnect humans and nature is indicated by the broad consensus of all stakeholders towards Q38. Further research into this distinct potential of AFS could support the communication of its diverse potential to alienated societies and thereby deliver a reconnection between humans and nature.

6 CONCLUSION

Multidimensional sustainability issues around land-use systems and potential approaches to tackle those are frequently discussed topics (Louah *et al.*, 2017; Lankoski and Thiem, 2020; Otter and Langenberg, 2020). The forthcoming update of the CAP framework and its potential to increase the sustainability of the agricultural sector through, amongst other approaches, AFS, is currently debated in European and German politics, the private sector and agricultural practice (DeFAF, 2021b; Hübner, 2021). Understanding what drives social behaviour is vital to effectively increase its sustainability (Hyland *et al.*, 2016). This dissertation used Q-Methodology to identify the social perspectives existent among the stakeholders involved in AFS in Germany. Twenty participants from agriculture, farmer associations, research, and politics were included. Results revealed three social perspectives: (1) Optimists, characterised by their strong belief in the possible mainstreaming success of AFS in Germany, (2) Systemic Transformists, understanding the hurdles connected to its implementation, however, seeing them as mainly short-term restrictive whilst emphasising the diverse potential entailed in a holistic transformation of agriculture to generating socioecological and socioeconomic benefits for societies. Lastly, (3) Sceptics, who were aligned in their belief that the diverse risks connected to AFS implementation were too high and thus restricting farmers to its wide-scale adoption. Overall, stakeholders generally believed in the potential of AFS to transform the agricultural sector in Germany as well as understood the urgency for a system change. This suggests existing support for the approach and thus potential to increase its future uptake through appropriate measures. However, this study also found that the conception of farmers is different than their self-conception, thereby presenting a misconception between different stakeholders. Following the implications of this study, the following recommendations were made: (1) Communication campaigns to align stakeholders, targeting farmers characterised by scepticism combined with awareness-raising campaigns addressing the urgency for system change to increase commitment of farmers towards the issue and promote long-term visions; (2) awareness-raising campaigns aimed at the public to increase social pressure on politics and farmers to facilitate increased AFS uptake; (3) acknowledgement of interdisciplinarity, value pluralism and diversity of social perspectives whilst designing new policies addressing AFS; (4) promotion of PES not as a policy subsidy but as private solutions between farmers and businesses.

Several areas of future research were identified, emphasising the need for diverse investigations of the dynamic field of AFS to effectively increase the sustainability of land-use systems in Germany. Those were: (1) Applying the RESET framework to AFS in Germany to identify leverage points; (2) investigating subsidy preferences of farmers to increase social acceptance of policies addressing AFS uptake; (3) assessing the general awareness of farmers for AFS to generate a baseline for future communication, educational and awareness-raising campaigns; (4) eliciting the WTP of initiatives and businesses to privately support a transition to AFS on German farms; and (5) investigating the potential of AFS to improve the human-nature-relationship in Germany.

To conclude, considering the urgency to change the paradigm of agriculture in order to avoid environmental collapse, which was recently reemphasised by the IPCC (2021), the potential of AFS to contribute to this should not be underestimated. Although not a panacea, efficient communication addressing AFS obstacles should be initiated by research, politics, and private businesses in Germany to realise its potential to decouple food production from environmental degradation. Thereby, ecosystem service provision for societies could be secured and societies held within planetary boundaries. It can only be emphasised what the Commission on the Future of Agriculture (2021) said recently, that we need all parts of society to align in the commitment regarding this transformation in order to secure a viable future for current as well as coming generations.

REFERENCE LIST PART II

Barry, J. and Proops, J. (1999) 'Seeking sustainability discourses with Q methodology', *Ecological Economics,* 28, pp. 337–345.

Beer, L. and Theusen, L. (2018) 'Determinanten der Entscheidung für die Anlage von streifenförmig integriertem Agrarholz als ökologische Vorrangfläche', 27, pp. 121–127. doi: 10.15203/OEGA.

Bergmeier, E., Petermann, J. and Schröder, E. (2010) 'Geobotanical survey of wood-pasture habitats in Europe: Diversity, threats and conservation', *Biodiversity and Conservation*, 19(11), pp. 2995–3014. doi: 10.1007/s10531-010-9872-3.

Billeter, R., Liira, J., Bailey, D., Bugter, R., Arens, P., Augenstein, I., Aviron, S., Baudry, J., Bukacek, R., Burel, F., Cerny, M., De Blust, G., De Cock, R., Diekötter, T., Dietz, H., Dirksen, J., Dormann, C., Durka, W., Frenzel, M., Hamersky, R., Hendrickx, F., Herzog, F., Klotz, S., Koolstra, B., Lausch, A., Le Coeur, D., Maelfait, J. P., Opdam, P., Roubalova, M., Schermann, A., Schermann, N., Schmidt, T., Schweiger, O., Smulders, M. J. M., Speelmans, M., Simova, P., Verboom, J., Van Wingerden, W. K. R. E., Zobel, M. and Edwards, P. J. (2008) 'Indicators for biodiversity in agricultural landscapes: A pan-European study', *Journal of Applied Ecology*, 45(1), pp. 141–150. doi: 10.1111/j.1365-2664.2007.01393.x.

Bishaw, B. and Abdelkadir, A. (2003) 'Agroforestry and Community Forestry for Rehabilitation of Degraded Watersheds on the Ethiopian Highlands', *Combating Famine in Ethiopia,* (October), pp. 1–22.

Borremans, L., Reubens, B., Van Gils, B., Baeyens, D., Vandevelde, C. and Wauters, E. (2016) 'A sociopsychological analysis of agroforestry adoption in Flanders: understanding the discrepancy between conceptual opportunities and actual implementation', *Agroecology and Sustainable Food Systems,* 40(9), pp. 1008–1036. doi: 10.1080/21683565.2016.1204643.

Boulding, K. (1967) 'The Economics of the Coming Spaceship Earth', *Technology and Culture,* 8(4), p. 523. doi: 10.2307/3102137.

Bourdeau, P. (2004) 'The man-nature relationship and environmental ethics', *Journal of Environmental Radioactivity*, 72(1–2), pp. 9–15. doi: 10.1016/S0265-931X(03)00180-2.

Briggs, J. (2009) 'Green revolution', *International Encyclopedia of Human Geographie*, 3(1), pp.

634–638. doi: 10.1186/gb-spotlight-20020419-01.

Brown, S. E., Miller, D. C., Ordonez, P. J. and Baylis, K. (2018) ‘Evidence for the impacts of agroforestry on agricultural productivity, ecosystem services, and human well-being in high-income countries: A systematic map protocol’, *Environmental Evidence*, 7(1), pp. 1–16. doi: 10.1186/s13750-018-0136-0.

Brown, S. R. (1993) ‘A Primer on Q Methodology’, *Operant Subjectivity*, 16(3/4), pp. 91–138.

Brown, S. R. (1996) ‘Q Methodology and Qualitative Research’, *Qualitative Health Research*, 6(4), pp. 561–567. doi: 10.1177/104973239600600408.

Commission on the Future of Agriculture (2021) *Zukunft Landwirtschaft. Eine gesamtgesellschaftliche Aufgabe - Empfehlungen der Zukunftskommission Landwirtschaft*. Rangsdorf.

DeFAF (2021a) ‘Stellungnahme zum Entschließungsantrag „Agroforstsysteme und Kombinationshaltung unterstützen und fördern“ (Drucksache 18/9077) der Fraktionen CDU und SPD des niedersächsischen Landtages’, pp. 1–7.

DeFAF (2021b) ‘Stellungnahme zum Entwurf eines Gesetzes über die Durchführung der im Rahmen der Gemeinsamen Agrarpolitik finanzierten Direktzahlungen (GAP-Direktzahlungen-Gesetz – GAPDZG)’, pp. 2–3.

Deutsch, M. and Otter, V. (2021) ‘Nachhaltigkeit und Förderung ? Akzeptanzfaktoren im Entscheidungsprozess deutscher Landwirte zur Anlage von Agroforstsystemen’, *Berichte über Landwirtschaft: Zeitschrift für Agrarpolitik und Landwirtschaft*.

Drechsler, M. (2021) ‘Impacts of human behaviour in agri-environmental policies: How adequate is homo oeconomicus in the design of market-based conservation instruments?’, *Ecological Economics*, 184(July 2020), p. 107002. doi: 10.1016/j.ecolecon.2021.107002.

Duke, G. (2020) ‘Demystifying tipping points and other points of aprupt ecosystem change’, *Valuing Nature Paper VNP04*, (September).

Elbakidze, M., Surová, D., Muñoz-Rojas, J., Persson, J.-O., Dawson, L., Plieninger, T. and Pinto-Correia, T. (2021) 'Perceived benefits from agroforestry landscapes across North-Eastern Europe: What matters and for whom?', *Landscape and Urban Planning*, 209, p. 104044. doi: 10.1016/j.landurbplan.2021.104044.

Elevitch, C. R., Mazaroli, N. D. and Ragone, D. (2018) 'Agroforestry standards for regenerative agriculture', *Sustainability (Switzerland)*, 10(9), pp. 1–21. doi: 10.3390/su10093337.

Esser, B. (2020) 'Unter uns: So können wir den Boden retten', *National Geographic*, 2 December. Available at: https://www.nationalgeographic.de/umwelt/2020/11/unter-uns-so-koennen-wir-den-boden-retten.

Etienne, M. and Rapey, H. (1999) 'Simulation integration of agroforestry into livestocl farmer's projects in France', in *Agroforestry for Sustainable Land-use*. Springer-Science + Business Media, B.V., pp. 257–272.

Ezzine-de-Blas, D., Corbera, E. and Lapeyre, R. (2018) 'Payments for Environmental Services and Motivation Crowding: Towards a Conceptual Framework', *Ecological Economics*, 156, pp. 434–443. doi: 10.1016/j.ecolecon.2018.07.026.

Fagerholm, N., Oteros-Rozas, E., Raymond, C. M., Torralba, M., Moreno, G. and Plieninger, T. (2016) 'Assessing linkages between ecosystem services, land-use and well-being in an agroforestry landscape using public participation GIS', *Applied Geography*, 74, pp. 30–46. doi: 10.1016/j.apgeog.2016.06.007.

Fisher, B., Turner, R. K. and Morling, P. (2009) 'Defining and classifying ecosystem services for decision making', *Ecological Economics*, 68(3), pp. 643–653. doi: 10.1016/j.ecolecon.2008.09.014.

Funtowicz, S. and Ravetz, J. R. (1994) 'The worth of a songbird : ecological economics as a post-normal science', 8009(93).

German Farmers' Association (2020) *Situationsbericht 2020/21 - Trends und Fakten zur Landwirtschaft*. Berlin.

Göbel, A. (2016) *Ecosystem services in agroforestry systems of Europe - A systematic map*. Albert-

Ludwigs-University Freiburg. Available at: https://www.biom.uni-freiburg.de/lehre/PastThese/amelie-ende.pdf.

Gomez-Baggethun, E. and De Groot, R. (2010) 'Natural capital and ecosystem services: The ecological foundation of human society', *Issues in Environmental Science and Technology*, 30, pp. 105–121.

Le Gouis, J., Oury, F. X. and Charmet, G. (2020) 'How changes in climate and agricultural practices influenced wheat production in Western Europe', *Journal of Cereal Science*, 93(November 2019), p. 102960. doi: 10.1016/j.jcs.2020.102960.

Graves, A. R., Burgess, P. J., Liagre, F., Pisanelli, A., Paris, P., Moreno, G., Bellido, M., Mayus, M., Postma, M., Schindler, B., Mantzanas, K., Papanastasis, V. P. and Dupraz, C. (2009) 'Farmer Perceptions of Silvoarable Systems in Seven European Countries', in Rigueiro-Rodríguez, A., McAdam, J., and Mosquera-Losada, M. R. (eds) *Agroforestry in Europe*. Dordrecht: Springer Netherlands, pp. 67–86. doi: 10.1007/978-1-4020-8272-6_4.

Grünewald, H. and Reeg, T. (2009) 'Überblick über den Stand der Forschung zu Agroforstsystemen in Deutschland', *Anbau und Nutzung von Bäumen auf Landwirtschaftlichen Flächen*, pp. 231–239. doi: 10.1002/9783527627462.ch21.

Hanley, N., Wright., R. E. and Adamowicz, V. (1998) 'Contingent valuation versus choice experiments: Design Issues, Current Experience and Future Prospects', *Journal of Agricultural Economics*, 49(1), pp. 1–15.

van Hecken, G. and Bastiaensen, J. (2010) 'Payments for Ecosystem Services in Nicaragua: Do Market-based Approaches Work?', *Development and Change*, 41(3), pp. 421–444. doi: 10.1111/j.1467-7660.2010.01644.x.

Holland, J. M., Douma, J. C., Crowley, L., James, L., Kor, L., Stevenson, D. R. W. and Smith, B. M. (2017) 'Semi-natural habitats support biological control, pollination and soil conservation in Europe. A review', *Agronomy for Sustainable Development*, 37(4). doi: 10.1007/s13593-017-0434-x.

Hübner, R. (2021) *Den Wald aufs Feld holen, Der kritische Agrarbericht*.

Hyland, J. J., Jones, D. L., Parkhill, K. A., Barnes, A. P. and Williams, A. P. (2016) 'Farmers' perceptions of climate change: identifying types', *Agriculture and Human Values*, 33(2), pp. 323–339. doi: 10.1007/s10460-015-9608-9.

IPBES (2018) *Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Europe and Central Asia of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.* Edited by M. Fischer, M. Rounsevell, A. Torre-Marin Rando, A. Mader, A. Church, M. Elbakidze, V. Elias, T. Hahn, P. A. Harrison, J. Hauck, B. Martín- López, I. Ring, C. Sandström, I. Sousa Pinto, P. Visconti, N. E. Zimmermann, and M. Christie. IPBES secretariat, Bonn, Germany.

IPCC (2021) *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Edited by V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou. Cambridge University Press. doi: 10.1080/03736245.2010.480842.

Isaac, M. E., Erickson, B. H., Quashie-Sam, S. J. and Timmer, V. R. (2007) 'Transfer of knowledge on agroforestry management practices: The structure of farmer advice networks', *Ecology and Society*, 12(2). doi: 10.5751/ES-02196-120232.

Jackson, K. and Bazeley, P. (2019) *Qualitative Data Analysis with NVivo*. 3rd Editio, *Information Theory*. 3rd Editio. Edited by J. Seaman. SAGE Publications Ltd. doi: 10.4135/9781412984485.n1.

Jennifer O'Connor (2020) *Barriers For Farmers & Ranchers To Adopt Regenerative Ag Practices In The US*. Available at: https://forainitiative.org/wp-content/uploads/Barriers-to-Adopt-Regnerative-Agriculture-Interactive.pdf.

Junge, X., Lindemann-Matthies, P., Hunziker, M. and Schüpbach, B. (2011) 'Aesthetic preferences of non-farmers and farmers for different land-use types and proportions of ecological compensation areas in the Swiss lowlands', *Biological Conservation*, 144(5), pp. 1430–1440. doi: 10.1016/j.biocon.2011.01.012.

Kay, S., Graves, A., Palma, J. H. N., Moreno, G., Roces-Díaz, J. V., Aviron, S., Chouvardas, D., Crous-Duran, J., Ferreiro-Domínguez, N., García de Jalón, S., Măcicăşan, V., Mosquera-Losada, M. R., Pantera, A., Santiago-Freijanes, J. J., Szerencsits, E., Torralba, M., Burgess, P. J. and Herzog, F. (2019) 'Agroforestry is paying off – Economic evaluation of ecosystem services in European landscapes with and without agroforestry systems', *Ecosystem Services*, 36(January). doi: 10.1016/j.ecoser.2019.100896.

Klages, S., Heidecke, C. and Osterburg, B. (2020) 'The impact of agricultural production and policy on water quality during the dry year 2018, a case study from Germany', *Water (Switzerland)*, 12(6), pp. 1–20. doi: 10.3390/W12061519.

Klement, L., Bach, M., Breuer, L. and Häußermann, U. (2017) 'Groundwater nitrate pollution: High-resolution approach of calculating the nitrogen balance surplus for Germany', *Eguga*, 19, p. 326000. Available at: https://ui.adsabs.harvard.edu/abs/2017EGUGA..1915032K/abstract.

Kosoy, N. and Corbera, E. (2010) 'Payments for ecosystem services as commodity fetishism', *Ecological Economics*, 69(6), pp. 1228–1236. doi: 10.1016/j.ecolecon.2009.11.002.

Langenberg, J., Rauert, M. and Theuvsen, L. (2018) 'EInstellungen landwirtschaftlicher Betriebsleiter und weiterer Stakeholder zu silvoarablen Alley-Cropping-Agroforstsystemen in Deutschland: Eine empirische Analyse anhand von Experteninterviews', *Berichte über Landwirtschaft: Zeitschrift für Agrarpolitik und Landwirtschaft*, 92(1), p. 33. Available at: http://buel.bmel.de.

Lankoski, J. and Thiem, A. (2020) 'Linkages between agricultural policies, productivity and environmental sustainability', *Ecological Economics*, 178(October 2019), p. 106809. doi: 10.1016/j.ecolecon.2020.106809.

Lin, H. C. and Hülsbergen, K. J. (2017) 'A new method for analyzing agricultural land-use efficiency, and its application in organic and conventional farming systems in southern Germany', *European Journal of Agronomy*, 83, pp. 15–27. doi: 10.1016/j.eja.2016.11.003.

Lindemann-Matthies, P., Junge, X. and Matthies, D. (2010) 'The influence of plant diversity on people's perception and aesthetic appreciation of grassland vegetation', *Biological Conservation*, 143(1), pp. 195–202. doi: 10.1016/j.biocon.2009.10.003.

Louah, L., Visser, M., Blaimont, A. and de Cannière, C. (2017) ‘Barriers to the development of temperate agroforestry as an example of agroecological innovation: Mainly a matter of cognitive lock-in?’, *Land Use Policy*, 67(May), pp. 86–97. doi: 10.1016/j.landusepol.2017.05.001.

Lutfallah, S. and Buchanan, L. (2019) ‘Quantifying subjective data using online Q-methodology software’, *The Mental Lexicon*, 14(3), pp. 415–423. doi: https://doi.org/10.1075/ml.20002.lut.

Marshall, E. J. P. and Moonen, A. C. (2002) ‘Field margins in northern Europe: Their functions and interactions with agriculture’, *Agriculture, Ecosystems and Environment*, 89(1–2), pp. 5–21. doi: 10.1016/S0167-8809(01)00315-2.

McCauley, D. J. (2006) ‘Selling out on nature’, *Nature*, 443(7107), pp. 27–28. doi: 10.1038/443027a.

Meadows, D. H. (2008) *Thinking in Systems: A Primer*. White River Junction.

Meyer, A. (2015) ‘Does education increase pro-environmental behavior? Evidence from Europe’, *Ecological Economics*, 116, pp. 108–121. doi: 10.1016/j.ecolecon.2015.04.018.

Millenium Ecosystem Assessment (2005) *Ecosystems and human well-being: synthesis.* Washington, DC: Island Press.

Moser, D. J. and Baulcomb, C. (2020) ‘Social perspectives on climate change adaptation, sustainable development, and artificial snow production: A Swiss case study using Q methodology’, *Environmental Science and Policy*, 104(October 2019), pp. 98–106. doi: 10.1016/j.envsci.2019.10.001.

Mosquera-Losada, M. R., Moreno, G., Pardini, A., McAdam, J. H., Papanastasis, V., Burgess, P. J., Lamersdorf, N., Castro, M., Liagre, F. and Rigueiro-Rodríguez, A. (2012) ‘Past, Present and Future of Agroforestry Systems in Europe’, in Ramachandran Nair, P. K. and Garrity, D. (eds) *Agroforestry - The Future of Global Land Use*. Springer Science + Business Media Dordrecht, pp. 285–312. doi: 10.5860/choice.50-6172.

Mosquera-Losada, M. R., Santiago-Freijanes, J. J., Pisanelli, A., Rois-Díaz, M., Smith, J., den Herder, M., Moreno, G., Ferreiro-Domínguez, N., Malignier, N., Lamersdorf, N., Balaguer, F., Pantera, A., Rigueiro-Rodríguez, A., Aldrey, J. A., González-Hernández, M. P., Fernández-Lorenzo, J. L., Romero-Franco, R. and Burgess, P. J. (2018) ‘Agroforestry in the European common agricultural policy’, *Agroforestry Systems*, 92(4), pp. 1117–1127. doi: 10.1007/s10457-018-0251-5.

Murshed-e-Jahan, K., Belton, B. and Viswanathan, K. K. (2014) ‘Communication strategies for managing coastal fisheries conflicts in Bangladesh’, *Ocean and Coastal Management*, 92, pp. 65–73. doi: 10.1016/j.ocecoaman.2014.01.003.

Nair, P. K. R. (2007) ‘The coming of age of agroforestry’, *Journal of the science of food and agriculture*, 87, pp. 1613–1619. doi: 10.1002/jsfa.

Nair, P. K. R. (2011) ‘Agroforestry Systems and Environmental Quality: Introduction’, *Journal of Environmental Quality*, 40(3), pp. 784–790. doi: 10.2134/jeq2011.0076.

Nair, P. K. R., Kumar, B. M. and Nair, V. D. (2009) ‘Agroforestry as a strategy for carbon sequestration’, *Journal of Plant Nutrition and Soil Science*, 172(1), pp. 10–23. doi: 10.1002/jpln.200800030.

Nair, P. K. R., Nair, V. D., Mohan Kumar, B. and Showalter, J. M. (2010) ‘Carbon sequestration in agroforestry systems’, *Advances in Agronomy*, 108(C), pp. 237–307. doi: 10.1016/S0065-2113(10)08005-3.

Nerlich, K., Graeff-Hönninger, S. and Claupein, W. (2013) ‘Agroforestry in Europe: a review of the disappearance of traditional systems and development of modern agroforestry practices, with emphasis on experiences in Germany’, *Agroforestry Systems*, 87(2), pp. 475–492. doi: 10.1007/s10457-012-9560-2.

Niederist, A. and Helmle, S. (2011) ‘Landwirte und Klimaschutz - Ein Vergleich der Meinungen von Betriebsleitern konventioneller und ökologischer Betriebe in Bayern’, pp. 9–12.

Otter, V. and Langenberg, J. (2020) ‘Willingness to pay for environmental effects of agroforestry systems: a PLS-model of the contingent evaluation from German taxpayers’ perspective’, *Agroforestry Systems*, 94(3), pp. 811–829. doi: 10.1007/s10457-019-00449-6.

Palma, J., Graves, A. R., Burgess, P. J., van der Werf, W. and Herzog, F. (2007) ‘Integrating environmental and economic performance to assess modern silvoarable agroforestry in Europe’, *Ecological Economics*, 63(4), pp. 759–767. doi: 10.1016/j.ecolecon.2007.01.011.

Parliament of Lower Saxony (2021) 'Agroforstsysteme und Kombinationshaltung unterstützen und fördern', pp. 1–3.

Porro, R., Miller, R. P., Tito, M. R., Donovan, J. A., Vivan, J. L., Trancoso, R., Van Kanten, R. F., Grijalva, J. E., Ramirez, B. L. and Gonçalves, A. L. (2012) *Agroforestry in the Amazon Region: A Pathway for Balancing Conservation and Development*. doi: 10.1007/978-94-007-4676-3_20.

Ramlo, S. (2016) 'Mixed Method Lessons Learned From 80 Years of Q Methodology', *Journal of Mixed Methods Research*, 10(1), pp. 28–45. doi: 10.1177/1558689815610998.

Raworth, K. (2017) *Doughnut economics: 7 ways to think like a 21st century economist*. London: Penguin Random House.

Raymond, C. M., Kenter, J. O., Plieninger, T., Turner, N. J. and Alexander, K. A. (2014) 'Comparing instrumental and deliberative paradigms underpinning the assessment of social values for cultural ecosystem services', *Ecological Economics*, 107, pp. 145–156. doi: 10.1016/j.ecolecon.2014.07.033.

Reeg, T. (2011) 'Agroforestry systems as land use alternatives in Germany? A comparison with approaches taken in other countries', *Outlook on Agriculture*, 40(1), pp. 45–50. doi: 10.5367/oa.2011.0032.

Rigueiro-Rodríguez, A., McAdam, J. and Mosquera-Losada, M. R. (2009) *Agroforestry in Europe: Current Status and Future Prospects*. Edited by J. McAdam, M. R. Mosquera-Losada, and A. Rigueiro-Rodríguez. Springer Science + Business Media B.V. Available at: http://www.springerlink.com/index/10.1007/978-1-4020-8272-6.

Rigueiro-Rodríguez, Fernández-Núñez, E., González-Hernández, P., McAdam, J. H. and Mosquera-Losada, M. R. (2009) 'Agroforestry Systems in Europe: Productive, Ecological and Social Perspectives', *Agroforestry in Europe: Current Status and Future Prospects*, pp. 43–65. doi: 10.1007/978-1-4020-8272-6_3.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., De Wit, C. A., Hughes, T., Van Der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R. W., Fabry, V. J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. and Foley, J. A. (2009) 'A safe operating space for humanity', *Nature*, 461(7263), pp. 472–475. doi: 10.1038/461472a.

Rode, J., Gómez-Baggethun, E. and Krause, T. (2015) 'Motivation crowding by economic incentives in conservation policy: A review of the empirical evidence', *Ecological Economics*, 117, pp. 270–282. doi: 10.1016/j.ecolecon.2014.11.019.

RStudioTeam (2021) 'RStudio: Integrated Development Environment for R'. Boston, MA: RStudio, PBC. Available at: http://www.rstudio.com/.

Schmidt, C. (2011) *Zur ökonomischen Bewertung von Agroforstsystemen*. Justus-Liebig-Universität Gießen.

Sereke, F., Dobricki, M., Wilkes, J., Kaeser, A., Graves, A. R., Szerencsits, E. and Herzog, F. (2016) 'Swiss farmers don't adopt agroforestry because they fear for their reputation', *Agroforestry Systems*, 90(3), pp. 385–394. doi: 10.1007/s10457-015-9861-3.

Soliman, J. and Kan, M. (2002) 'Grounded Theory and NVivo : Wars and Wins', *International Conference on Qualitative Research in IT & IT in Qualitative Research*, pp. 24–26.

Spiller, A., Gauly, M., Balmann, A., Bauhus, J., Birner, R., Bokelmann, W., Christen, O., Entenmann, S., Grethe, H., Knierim, U., Latacz-Lohmann, U., Matinez, J., Nieberg, Hiltrud, Qaim, M., Taube, F., Tenhagen, B.-A. and Weingarten, P. (2015) 'Wege zu einer gesellschaftlich akzeptierten Nutztierhaltung', *Agrarwissenschaft Forschung Praxis - Zeitschrift für Agrarpolitik und Landwirtschaft*, p. 172. Available at: http://m.interculture-journal.com/index.php/buel/article/view/82/Nutztiergutachten - Sonderheft 221 - B?L-pdf.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., De Vries, W., De Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B. and Sörlin, S. (2015) 'Planetary boundaries: Guiding human development on a changing planet', *Science*, 347(6223). doi: 10.1126/science.1259855.

Swedeen, P. (2006) 'Post-normal science in practice: A Q study of the potential for sustainable forestry in Washington State, USA', *Ecological Economics*, 57(2), pp. 190–208. doi: 10.1016/j.ecolecon.2005.04.003.

Takeuchi, K. (2010) 'Rebuilding the relationship between people and nature: The Satoyama Initiative', *Ecological Research*, 25(5), pp. 891–897. doi: 10.1007/s11284-010-0745-8.

Torquebiau, E. F. (2000) 'A renewed perspective on agroforestry concepts', *Elsevier*, 323, pp. 1009–1017.

Tubenchlak, F., Badari, C. G., de Freitas Strauch, G. and de Moraes, L. F. D. (2021) 'Changing the Agriculture Paradigm in the Brazilian Atlantic Forest: The Importance of Agroforestry', *The Atlantic Forest*, pp. 369–388. doi: 10.1007/978-3-030-55322-7_17.

Vogel, E. and Meyer, R. (2018) 'Climate change, climate extremes, and global food production-Adaptation in the agricultural sector', in *Resilience: The Science of Adaptation to Climate Change*. Elsevier Inc., pp. 31–49. doi: 10.1016/B978-0-12-811891-7.00003-7.

Watts, S. and Stenner, P. (2012) *Doing Q Methodological Research - Theory, Method and Interpretation*. London: SAGE Publications Ltd.

Webler, T., Danielson, S. and Tuler, S. (2009) 'Using Q Method to Reveal Social Perspectives in Environmental Research', *Social and Environmental Research*, 01301(November), pp. 1–54. Available at: http://www.seri-us.org/pubs/Qprimer.pdf.

Van Woerkum, C. M. J., Aarts, M. N. C. and van der Poel, M. M. (1999) 'Communication in policy processes: reflections from the Netherlands', *European Spatial Research and policy*, 6(1), pp. 75–87.

Wunder, S. (2005) 'Payments for Environmental Services: Some nuts and bolts'. Available at: https://vtechworks.lib.vt.edu/handle/10919/66932.

Zabala, A., Pascual, U. and Garcia-Barrios, L. (2017) 'Payments for Pioneers? Revisiting the Role of External Rewards for Sustainable Innovation under Heterogeneous Motivations', *ECOLOGICAL ECONOMICS*, 135, pp. 234–245. doi: 10.1016/j.ecolecon.2017.01.011.

Zoom Video Communications Inc. (2016) 'Security guide. Zoom Video Communications Inc.', *https://d24cgw3uvb9a9h.cloudfront.net/static/81625/doc/Zoom-Security-White-Paper.pdf*, (July 2016), p. 81625.

APPENDIX A – CODE USED TO ANALYSE QUANTITATIVE DATA IN THE R SOFTWARE

Installing and requiring necessary packages

```
install.packages("qmethod")
install.packages("openxlsx")
install.packages("psych")
install.packages("factoextra")

require(qmethod)
require(openxlsx)
require(psych)
require(factoextra)
```

Setting the working directory

```
setwd("~/Desktop/Uni/MSc.Edinburgh/MSc Ecological Economics/Dissertation/03_Analsyis/RStudio")
```

Data import

```
qData <- openxlsx::read.xlsx("./QData/QdataAFS.xlsx", sheet=1, colNames =T)
```

Removal of ID columns in data

```
qData <- qData[-c(1:2)]
```

Scree plot of unrotated factors

```
fviz_eig(
   prcomp(qData),
   ncp    = nOFTE,
   choice = screeType,
   xlim   = c(0,nOFTE),
   main   = "Scree plot of unrotated factors"
)
```

Automated Q-Methodology analysis for Spearman correlation type

```
source("factorHunt().R") #loading factorHunt function

factorHunt(
```

```
  qdata              = qData,
  nstatements        = nrow(qData),
  max_factors        = 3,
  correlation_method = "spearman",
  gridRows           = dim(qDistribution)[1],
  gridColumns        = dim(qDistribution)[2],
  gridColumnLabels   = c("-5", "-4", "-3", "-2", "-1", "0", "+1", "+2", "+3", "+4", "+5"),
  extremeDisagree    = -5,
  extremeAgree       = 5,
  distributionRef    = qDistribution
)
```

Appendix B – Full output report generated by the R-software

Q-method analysis.

Finished on:	Sat Jun 26 12:00:41 2021
'qmethod' package version:	1.8
Original data:	47 statements, 20 Q-sorts
Forced distribution:	TRUE
Number of factors:	3
Extraction:	PCA
Rotation:	varimax
Flagging:	automatic
Correlation coefficient:	spearman

Tests

Reference Values	f1: Actual Values	f1: Passes Test?	f2: Actual Values	f2: Passes Test?	f3: Actual Values	f3: Passes Test?
Eigenvalue ≥ 1 (Kaiser Guttmann Criterion)	5.3008	Yes	3.0124	Yes	2.7423	Yes
Sign. loading Q-Sorts ≥ 2	8	Yes	4	Yes	6	Yes
Humphreys Rule ≥ 0.2917	0.6264	Yes	0.4499	Yes	0.4202	Yes
% Variance explained	26.5039	--	15.0618	--	13.7113	--
Σ % Variance explained ≥ 35	55.277	Yes				

Factor loadings and flagged Q-Sorts (*)

QSorts	fg1	f1	fg2	f2	fg3	f3
Stakeholder01	*	0.65		0.04		0.20
Stakeholder02		0.35		0.47		0.31
Stakeholder03		0.52		0.56		0.24
Stakeholder04		0.35	*	0.65		0.15
Stakeholder05		0.14		0.09	*	0.65
Stakeholder06	*	0.62		0.22		-0.31
Stakeholder07		0.00		0.30	*	0.60
Stakeholder08	*	0.77		0.34		0.01
Stakeholder09	*	0.79		0.29		0.13
Stakeholder10		-0.12		-0.45	*	0.58
Stakeholder11	*	0.66		0.39		-0.08
Stakeholder12		-0.21		0.02	*	0.63
Stakeholder13	*	0.79		0.03		-0.06
Stakeholder14		0.12		-0.18	*	0.65
Stakeholder15		0.27		0.28	*	0.60
Stakeholder16		-0.40	*	0.53		0.18
Stakeholder17		0.20	*	0.67		-0.17
Stakeholder18	*	0.79		0.22		0.02
Stakeholder19	*	0.76		0.09		0.20
Stakeholder20		0.36	*	0.67		0.01

flag_f1	flag_f2	flag_f3
TRUE	FALSE	FALSE
FALSE	FALSE	FALSE
FALSE	FALSE	FALSE
FALSE	TRUE	FALSE
FALSE	FALSE	TRUE
TRUE	FALSE	FALSE
FALSE	FALSE	TRUE
TRUE	FALSE	FALSE
TRUE	FALSE	FALSE
FALSE	FALSE	TRUE
TRUE	FALSE	FALSE
FALSE	FALSE	TRUE
TRUE	FALSE	FALSE
FALSE	FALSE	TRUE
FALSE	FALSE	TRUE
FALSE	TRUE	FALSE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	FALSE	FALSE
FALSE	TRUE	FALSE

IQSP (fsc) and z-Scores (zsc)

#	zsc_f1	fsc_f1	zsc_f2	fsc_f2	zsc_f3	fsc_f3
1	-1.42	-3	-0.78	-2	-0.77	-2
2	0.68	2	-0.79	-2	-0.86	-3
3	0.48	1	0.54	1	-0.52	-1
4	-0.45	-1	-0.08	0	-0.21	0
5	-0.04	0	0.13	0	0.02	0
6	1.39	3	0.11	0	1.1	3
7	1.43	4	-1.35	-3	2.49	5
8	1.39	3	0.68	2	1.06	3
9	0.21	0	-1.01	-2	0.49	1
10	-1.42	-3	-1.75	-4	-2.06	-5
11	0.15	0	0.83	2	0.23	1
12	-1.35	-3	-0.72	-2	-0.04	0
13	-0.69	-2	-1.57	-3	-0.43	-1
14	0.81	2	0.33	0	-0.64	-2
15	-0.43	-1	-0.04	0	1.63	4
16	-1.7	-4	-0.63	-2	0.24	1
17	0.26	1	0.46	1	0.55	1
18	-0.76	-2	1.18	3	1.61	4
19	-0.79	-2	1.06	2	0.23	1
20	-1.07	-2	-1.19	-3	0.26	1
21	-0.57	-1	-0.23	-1	0.65	1
22	-0.73	-2	-0.44	-1	-1.01	-3
23	-0.07	0	-0.21	-1	0.91	2
24	-1.94	-4	-1.18	-2	0.05	0
25	-2.25	-5	-1.82	-4	-1.94	-3
26	-0.19	-1	-0.27	-1	0.98	3
27	1.38	3	1.42	4	-0.62	-2
28	-1.64	-3	-2.77	-5	0.11	0
29	0.15	0	1.58	5	-1.23	-3
30	0.51	1	1.14	3	-0.59	-1
31	1.14	2	1.4	3	-0.33	-1
32	0.94	2	1.58	4	-0.24	-1
33	0.37	1	0.46	1	0.94	2
34	-0.16	-1	1.27	3	-0.36	-1
35	1.19	3	0.76	2	0.72	2
36	-0.69	-2	0.38	1	0.78	2
37	1.62	5	0.29	0	0.82	2
38	0.19	0	0.47	1	-0.24	-1
39	1.53	4	0.34	0	-0.79	-2
40	0.5	1	-0.12	-1	0.23	0
41	-0.24	-1	0.98	2	-0.07	0
42	1.03	2	-1.35	-3	-0.74	-2
43	0.32	1	-0.47	-1	-0.65	-2
44	0.99	2	0.38	1	-2.03	-4
45	0.38	1	0.44	1	-2.03	-4
46	-0.02	0	-0.12	-1	0.78	2

47	-0.44	-1	0.67	2	1.5	3
	Data Check Totals					
		0		0		0

Consensus and distinguishing statements

dist.and.cons	f1_f2	sig_f1_f2	f1_f3	sig_f1_f3	f2_f3	sig_f2_f3
Distinguishes f1 only	-0.6379622	*	-0.6454127	*	-0.0074505	
Distinguishes f1 only	1.46833537	6*	1.53529903	6*	0.06696366	
Distinguishes f3 only	-0.0546962		1.00049097	***	1.05518712	***
Consensus	-0.3709231		-0.2372677		0.1336554	
Consensus	-0.1629604		-0.0578046		0.10515571	
Distinguishes f2 only	1.27610404	***	0.29010282		-0.9860012	**
Distinguishes all	2.77221077	6*	-1.0595513	***	-3.831762	6*
	0.71674371	*	0.33683331		-0.3799104	
Distinguishes f2 only	1.22360463	***	-0.2809661		-1.5045707	***
	0.33042519		0.63795592	*	0.30753072	
	-0.6724382	*	-0.0803987		0.59203952	
Distinguishes all	-0.6326936	*	-1.3154931	6*	-0.6827995	*
Distinguishes f2 only	0.88382737	**	-0.2607829		-1.1446103	***
Distinguishes f3 only	0.47922724		1.4532058	6*	0.97397856	**
Distinguishes f3 only	-0.3943884		-2.0579974	6*	-1.663609	6*
Distinguishes all	-1.0691415	***	-1.935854	6*	-0.8667125	**
Consensus	-0.1956817		-0.2928039		-0.0971223	
Distinguishes f1 only	-1.9444061	6*	-2.3735951	6*	-0.429189	
Distinguishes all	-1.8430745	6*	-1.0155366	***	0.82753793	**
Distinguishes f3 only	0.11751744		-1.3301722	6*	-1.4476896	***
Distinguishes f3 only	-0.3375229		-1.2177502	***	-0.8802273	**
Consensus	-0.2871944		0.28845933		0.57565372	
Distinguishes f3 only	0.13777488		-0.9863202	***	-1.1240951	***
Distinguishes all	-0.757693	*	-1.9925617	6*	-1.2348686	***
Consensus	-0.4391434		-0.319028		0.12011546	
Distinguishes f3 only	0.0764674		-1.1702183	***	-1.2466857	***
Distinguishes f3 only	-0.037739		2.00424694	6*	2.04198592	6*
Distinguishes all	1.12730968	***	-1.7509302	6*	-2.8782399	6*
Distinguishes all	-1.4297659	***	1.38063509	6*	2.81040101	6*
Distinguishes all	-0.6301614	*	1.09889199	***	1.72905338	6*
Distinguishes f3 only	-0.2619057		1.47496419	6*	1.73686993	6*
Distinguishes all	-0.6363352	*	1.17416235	***	1.81049751	6*
	-0.0888179		-0.5706625	*	-0.4818447	
Distinguishes f2 only	-1.4298099	***	0.20384321		1.63365309	6*
Consensus	0.43077095		0.46702421		0.03625327	
Distinguishes f1 only	-1.0734061	***	-1.4715341	6*	-0.398128	
Distinguishes f1 only	1.32471075	***	0.79926604	**	-0.5254447	
	-0.2794466		0.42771873		0.70716529	*
Distinguishes all	1.19317892	***	2.32123987	6*	1.12806095	***
	0.61540454	*	0.27141604		-0.3439885	

Distinguishes f2 only	-1.2130428	***	-0.1665504		1.04649244	***
Distinguishes f1 only	2.37938185	6*	1.76552712	6*	-0.6138547	
Distinguishes f1 only	0.78575305	**	0.97021748	***	0.18446443	
Distinguishes all	0.61516132	*	3.02079959	6*	2.40563828	6*
Distinguishes f3 only	-0.0575028		2.40857889	6*	2.46608173	6*
Distinguishes f3 only	0.09737749		-0.7974218	**	-0.8947992	**
Distinguishes all	-1.1134336	***	-1.9442652	6*	-0.8308316	**

Idealised Q-Sorts

X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
f1										
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
25	16	1	13	4	5	3	2	6	7	37
	24	10	18	15	9	17	14	8	39	
		12	19	21	11	30	31	27		
		28	20	26	23	33	32	35		
			22	34	29	40	42			
			36	41	38	43	44			
				47	46	45				
f2										
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
28	10	7	1	21	4	3	8	18	27	29
	25	13	2	22	5	17	11	30	32	
		20	9	23	6	33	19	31		
		42	12	26	14	36	35	34		
			16	40	15	38	41			
			24	43	37	44	47			
				47	40	45				
f3										
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
10	44	2	1	3	4	9	23	6	15	7
	45	22	14	13	5	11	33	8	18	
		25	27	30	12	16	35	26		
		29	39	31	24	17	36	47		
			42	32	28	19	37			
			43	34	40	20	46			
				38	41	21				