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agromix

Policy scenarios in the EU, including Central-Eastern EU member states and five national states

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Deliverable 6.2

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Deliverable 6.2	**Policy scenarios in the EU, Central-Eastern EU member states and five national states**
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1 Executive summary

Background:
The way we farm and manage our land is fundamental to the health of people and planet. Decisions made now have the potential to chart a course of increased sustainability and resilience. On the other hand, inaction may result in worsening climate impacts, food shortages and global conflicts. Agroecology (including agroforestry and mixed farming) have been championed as a positive 'force for change' within the food system, with various reports demonstrating the multitude of benefits that an agroecological future may bring: reduced emissions; reducing diet-related ill health; reducing inequality; improving food sustainability and nutrition; and; making space for nature. We use the five levels of agroecological food and farming system transformation proposed by Gliessman (2015) as a lens to co-develop policy scenarios for two agroecological approaches, agroforestry and mixed farming (AF/MF), at each level from increased efficiency (level 1), to input substitution (2), redesign (3), and food network transformation (4 and 5). This builds on previous work in the project, specifically D5.1 and the conceptual framework with the five level of transformation used there.

Purpose of this report:
This report takes two agroecological approaches to land management, agroforestry and mixed farming (or a combination of both), and builds on the policy inventory of these methods (Deliverable D6.1 of AGROMIX) to provide policy scenarios in the EU, Central-Eastern EU member states, England, France, Germany, Hungary and Switzerland. Based on the insights from D6.1, this report documents several **policy scenarios** for each region and suggests accompanying policy. We have added Hungary as an additional detailed case study to study EU Central-Eastern Europe further. For Hungary we have expert knowledge within the consortium and Hungary will also feature in the workshops in D6.3. In the United Kingdom (UK), the former EU agricultural policy is now devolved further to the four nations or devolved states: England, Northern Ireland, Scotland and Wales. There is no UK agricultural policy anymore (besides a framework for what is devolved from the EU and UK level). Having the UK as case study would not make sense, as it is four nations, therefore we decided to focus on the largest nation. When writing 'UK' in the Grant Agreement in 2019 it was not clear that the UK would devolve all EU agricultural policy straight to the four nations ('Double Brexit'). This improvement in focus will give us more meaningful results and the case of England makes a comparison with other federal/devolved states in Germany more scientifically interesting.
Key policy scenario findings are also extracted into seven **Policy briefs** for different case studies, and they are added in the Annex of this document. They will also be used in the workshops, and on the website as stand-alone documents as stakeholders are less inclined to read long deliverables or scientific papers. These policy scenarios will also be used within the policy workshops for D6.3 to be further discussed, refined and given the scrutiny of stakeholders.
In addition, besides the in-depth policy scenarios for the various case studies, we deliver two further complementary **computer modelling approaches**: (i) one in Brandenburg, based on adaption of the farm economics model MODAM with novel agroforestry data inputs and, (ii) one in England on novel AF/MF-ABM (Agent-Based-Modelling) for policies. Both novel additional modelling approaches are presented with the methodological background and preliminary results. Both models, especially the Agent-based model require

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interaction with the agents in the workshops forthcoming in Task 6.3 and 6.4 in the year 2023 and 2024 as planned in the Grant Agreement. The AF/MF-ABM is first developed for England, but is kept generic so it can later also be used on the EU level in Task 6.4 in the year 2024. The MODAM model is used and calibrated in detail in one federal state of Germany (Brandenburg). This gives an in-depth insight into one case study state, which is not possible with the FADN data used in Work Package 5, and hence complementary to the research done elsewhere in the project. This deliverable, as outlined in the Grant Agreement, will be updated at the end of the project (month 48) with feedback from Task 6.3 and 6.4 into Task 6.2 and how this has improved and shaped the policy scenarios, and the policy computer model. The main body of the report runs to page 82, after which the supporting evidence is provided.

Summary of key findings of this report:

The five levels of agroecological food and farming system transformation provide a good lens to analyse and co-design policies for agroforestry and mixed farming. Change can be both incremental and transformational, and this report shows that on each level meaningful proposals have been made. For the success of policies each level is equally important and must demonstrate coherence within and beyond food policy for a sustainable transition to agroecology. In detailed policy fact sheets we make proposals to improve policy at the smallest level e.g. instead of defining wood strips from 3-15 m width using 1-20 m as to increase the coverage for different forms of tree fodder (see Rhineland-Palatinate, Germany Factsheet) and analysing different payments with CAP and eco-schemes, single double and tripled (see Brandenburg, Germany Factsheet). Other case studies (France, EU and Central-Eastern EU) take in further levels of food and farming system transformation and so does the work in Switzerland and England, where legislation is more direct and influenced only by one higher level.

We also recognise that the policy co-design process can be ‘patchy and messy’. Policies like ELMs (environmental land management) in England, widely considered as innovative, and including various agroforestry and mixed farming option of silvo-horticulture and silvo-arable, can be removed on short notice by a new government (September 2022) listening to powerful lobby groups. Also in Switzerland, steps forward and backwards are reported.

However, there are also strong **unifying results** coming through from all cases which provide key learnings and policy inspiration. For example more and targeted policy support for agroforestry and mixed farming is required, and a better understanding of the technical details for agricultural policy making is needed. Further unifying results are more the need for improved training and more regionalised policy making with central governments, setting long-term reliable frameworks, within which regions have more options available to them. **Financial support** is also coming up in each case, however it has to be targeted and easy to administer for farmers and should mainly remove uncertainty and risk e.g. during the establishment of agroforestry or the transition from conventional to organic/agroecological management. The agent-based model approach used helps us to understand ‘messiness’ better as it includes contrasting behaviour of agents. The detailed financial farm level model does the same for the other main barriers identified.

Although this author team has found agroecology a useful lens to study policy co-design, and NGO’s like ‘Agroecology Europe’ have a certain positionality, we are aware that this positionality or vision for an agroecological future is not shared by everyone. However, there is a ‘minimum consensus’ in the consortium and wider public, that mixing more trees and free-range livestock into most agricultural landscapes of Europe is generally a good and necessary concept and that this will transform our landscapes. At first, incrementally but later with further adoption, to a considerable degree. For this ‘minimum consensus’ sharing the vision

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Agroecology Europe has developed is not necessary, and plurality in visions of the future is a high value in itself in a democratic policy process.

Conclusions and key recommendations:

This report has detailed policy scenarios and pathways at the EU wide level and five national or federal policies. Recommendations are given for the individual cases and for an agroecological future in the EU. We have Identified strategies for policy improvement for AF and MF development and with this ongoing task, contribute to improving policy design and implementation options at national and EU level. This deliverable builds a solid basis for the next phase of the policy co-development: the workshops and the EU summit planned for 2023 and 2024. The task T6.2 does not end with this deliverable, feedback from the workshops will be received and the scenarios and two models further developed. In addition, work in WP2 & WP4 'pilots' & 'mix-app', WP3 'monitoring and bio-physical modelling' and WP5 'economics' and supply chains will feed into further refinement of policy development.

Policy suggestions as a result of this report which can be applied at both the European Union level or national/federal state level are:

1. Clear definitions of AF (and in particular MF) are needed. These definitions should be agroecological in nature; incorporating spatial and temporal mixing, resource recycling and participation. The success of 'certified organic food and farming systems' with its clear minimum level definition in European law has helped and this can be adopted for AF and MF
2. Funding opportunities, grants and subsidies should be prioritised to help with tree establishment and cash-flow on farm adopting AF and MF for the first time
3. Reduced profitability or loss of yield must be incorporated into economic models and any financial loss to the farmer covered by EU, member state or other state budgets. The carbon markets for sequestration can help but are not a substitute for lacking government support. The establishment of new systems needs nurturing like a tree nursery, once mature sector is developed this is no longer needed and transformed landscapes can return also increased environmental benefits and higher taxes from multiple diverse land uses
4. Existing trees within the farmed landscape should not be forgotten; management options for existing woodland on farms must be incorporated into EU member state objectives with greater collaboration between foresters and farm advisors
5. As new policies are developed at the EU, national level and non-EU level, a greater integration of available tools and frameworks such as Gliessman's 5 levels, the HLPE 13 principles of agroecology and the Global Alliance for the Future of Food are needed to ensure policy coherence to support a just transition to sustainable food systems.

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2 Expected impact and pathways to policy impact

2.1 General impact

The project:
The Horizon 2020 AGROMIX project (1 November 2020 – 31 October 2024), is a € 7 million research and innovation action (RIA) funded by the European Commission and Associate Countries to Horizon 2020. AGROMIX focuses on the transition towards resilient farming, efficient land use, and sustainable agricultural value chains across Europe. AGROMIX aims to deliver participatory research specifically on agroforestry (AF) and mixed farming (MF) systems as practical agroecological solutions for farm and landscape management, together with the related value chains.

This deliverable within the WP6 and the wider project:
This delivery report D6.2 presents the findings of AGROMIX's work package on Policy Co-Development (WP6) Task 6.2 after 24 months. Work in the task itself continues until month 48, but the deliverable is needed now to feed into the next steps of WP6 Task 6.3 and 6.4. Tasks 6.3 and 6.4 are iterative, in that they feed back into each other and also into an updated version of this deliverable D6.2, with additional computer modelling, also considering the forthcoming bio-physical modelling and biodiversity data collection results in work package 3 and the economic result from work package 5.

Contribution to impact of this deliverable:
Deliverable 6.2 is an in-depth analysis of policy scenarios and sector mechanisms within the EU (including a special focus on Central-Eastern European states) and 5 national and federal/devolved states (Hungary, France, Germany (Brandenburg (Germany-East), Rhineland-Palatinate (Germany-West)), Switzerland and England (United Kingdom). For Central-Eastern EU member states (CEEU states) in addition an in-depth example of Hungary is used as the diversity is large across the different Central-Eastern EU member states. Because of the nested case-study approach taken with expect impact in the different EU and non-EU national and federal states. We also expect a better understanding of AF/MF policy development on the EU level, comparing and contrasting the national approach taking in member states, including specifics in Central-Eastern EU member states. There is an additional level of comparison with the non-EU states of Switzerland and England shedding extra light on non-common agricultural policy making for agroecology, agroforestry and mixed farming.

Expected policy insights and understanding can lead to better policy making with greater or more targeted impact, and with less unintended consequences. The following specific insights at different levels can produce this impact:

1. In-depth understanding of agroecological transition policy at the EU level using the example of AF/MF policies.
2. Understanding of the options of devolution of agricultural policy (using the example of AF/MF policies) to national states or federal states within the EU.
3. Deeper insights and understanding into the specifics of Central-Eastern EU member states on agricultural policy for AF/MF within the EU.

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4. Comparison between EU and non-EU policy making in countries like Switzerland and England (using the example of AF/MF policies).
5. Understanding of the effect of leaving EU common agricultural policy making and devolution to a federal state level (double Brexit).

The above insights lead to recommendation based on AF/MF policies, sharing best practise, understanding and learning from interventions on different levels.

Pathways to impact of the policy recommendations:

The main policy recommendations can also be presented in **a 'policy-maker-friendly' format on the following pages**. We are **linking policy recommendation with pathways to impact per country and region**. This has been undertaken for 3 countries (Germany, England and Switzerland) and 1 region (Central and Eastern Europe) as proposed impact pathways. These pathways rank the relative priority of the recommendation, the prime decision-making body and the other stakeholders involved in development and implementation of the policy, as well as the higher level project impacts that each recommendation addresses. The high level project impact pathways are: 1. Deliver effective solutions for ensuring the highest level of implementation in heterogeneous landscapes; 2. Unlock and improve viability and replicability and propose different transition scenarios; 3. Reduce the environmental impact of agriculture and contribute toward mitigation and adaptation to climate change; 4. Provide ecosystem services through integrated and small scale land management; and 5. Foster synergies between agricultural production, climate change mitigation and adaptation.
In addition to show the holistic definition of agroecology in our work we have indicted which policy recommendation predominantly for the field, farm and landscape level (Gliessman levels 1-3), and which is more for supply chain and food system levels (Gliessman levels 4-5). Further detail (Gliessman, 2015) is also found in the AGROECOLOGY PARTNERSHIP SRIA page 15ff (SRIA is the Strategic Research and Innovation Agenda of a PARTNERSHIP (https://scar-europe.org/home-scar/news-display/221-agroecology-partnership-s-sria). Levels adapted from Gliessman (2015) and added with a special scale used are:

- G1 Increase efficiency of inputs on field and farm with bio-physical agroecological approach
- G2 Substitute with alternative practices on field and farm with bio-physical agroecological approach
- G3 Redesign the whole agroecosystem at field, farm and landscape level with bio-physical agroecological approach
- G4 Connection between growers and eaters in food networks at regional and territorial levels with bio-physical and ecological economic agroecological approach
- G5 Transformation of global food system with equity and sustainability at national, European union and international level with bio-physical, ecological economic and political ecology agroecological approach.

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2.2 Specific policy impact – Linking policy recommendations with pathways to impact.

Policy change recommendation (as identified in D6.2)	Priority (High, Medium, Low)	Prime decision making body	Other stakeholders	Gliessman levels (G1-G5)* and Potential impact areas**
Germany				
Increase Eco-Scheme Payments to 850€/ha wooded area	M	BMEL (Government department)	DeFAF e.V.	**G1-G2** 1, 4, 5
Provide investment aid that covers 100% of establishment costs of agroforestry systems	H	Agricultural ministries of federal states	Service Providers for planting and managing agroforestry systems	**G1-G2** 1, 4, 5
Provide funding for extension services	H	Agricultural ministries of federal states	Agricultural extension agencies and providers, DeFAF e.V.	**G3** 1

***Gliessman levels G1-G5** as outlined on the page before

****Impact areas** (as stated in the project document):

1. Deliver effective solutions for ensuring the highest level of implementation in heterogeneous landscapes
2. Unlock and improve viability and replicability and propose different transition scenarios
3. Reduce the environmental impact of agriculture and contribute toward mitigation and adaptation to climate change
4. Provide ecosystem services through integrated and small scale land management
5. Foster synergies between agricultural production, climate change mitigation and adaptation

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Policy change recommendation (as identified in D6.2)	Priority (High, Medium, Low)	Prime decision making body	Other stakeholders	Gliessman levels (G1-G5)* and Potential impact areas**
Central and Eastern Europe region countries				
Clear definitions on regulation level of agroecology, and agroecological practices	H	Governments of the CEE region	Farmers, forestry industry, foresters	**G1-G5** 1, 2
Clearly differentiate from other land-use types on definition, regulation, land-use registration, subsidies, evaluation	H	Governments of the CEE region	Farmers	**G4** 1, 2
Defining cost and benefits of agriculture contribution to degradation/regeneration to ecosystem	H	Governments of the CEE region	Farmers, foresters, nature conservation organisations	**G4-G5** 3, 4, 5
Incorporate EU regulations and strategies into national level administration	H	Governments of the CEE region	-	**G4** 1, 2
Provide national/local best practice collection and especially testing results on economic cost-benefit bases to provide an effective guidance to farmers and reduce risk on agroecological transition	M	Governments of the CEE region	Farmers	**G4** 1, 3, 4
Provide financial support to agroecological transition	H	Governments of the CEE region	Farmers, foresters	**G4** 1, 2
Focus on local needs and possibilities	M	Governments of the CEE region	Farmers	**G3** 3, 4, 5
Ease the bureaucratic burden of funding the agricultural transition	H	Governments of the CEE region	Farmers	**G4** 1, 2
Support knowledge transfer not only nationally, but also transboundary	M	Governments of the CEE region	Farmers, education institutes, colleges, universities	**G4-G5** 1, 2
Support the free data providing system to make precision agriculture available to more farmers	M	Governments of the CEE region	Farmers, education institutes, colleges, universities	**G1-G4** 1, 2
Support cooperative solutions in order to accelerate landscape level regeneration, provide techniques accessible for more farmers and decrease costs	M	Governments of the CEE region	Farmers	**G3** 3, 4, 5

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Policy change recommendation (as identified in D6.2)	Priority	Prime decision making body	Other stakeholders	Gliessman levels (G1-G5)* and Potential impact areas**
England (a devolved nation of the United Kingdom)				
All eggs should be woodland eggs: Legislate ban on all caged eggs and offer financial support and training for converting to woodland eggs	M	DEFRA (Government department)	British Free Range Egg Association, British Egg Industry Council, National Farmers Union, British Retail Consortium	**G1-G4** 1, 3, 4, 5 Costs £2,000/ha to plant, payback achieved in six months (Lakes Free Range Egg Company)
Mandate management of no- *farm* trees and woodland: retro fit existing farm woodland (commonly un-managed) into farm enterprises through implementation of AF/MF systems	M	DEFRA	Forestry Commission, Woodland Trust, NFU, CLA	**G1-G4** 1, 3, 4, 5 75% of agroforestry and farm woodland is classified as woodland (i.e. not AF)
Clear funding available for planning, establishing and maintaining trees and agroforestry systems within the farmed landscape: including shelter belts, riparian buffers, hedgerow and food production systems	H	DEFRA	-	**G1-G4** 1, 2, 3, 4, 5
Adjust quota of permitted imported wood products by 40% over a 60-year period	M	BEIS,	Forestry Commission, DEFRA,	**G4-G5** 1, 2, 5
Independent agroforestry or 'trees on farms' training and advisory body to be established and funded by increasing land tax on major landowning institutions	H	DEFRA	Forestry Commission, Woodland Trust,	**G4** 1, 2, 3, 4
Phase-out all intensive livestock production: Legislate ban on all domestic intensive livestock production and increase import tax and standards on livestock products	H	DIT	DEFRA, BEIC	**G4-G5** 2, 3, 4, 5
Limit imported feed for livestock: Legislate imported livestock feed to make up maximum 50% of diet. All livestock feed to come from certified regenerative systems.	H	DIT	DEFRA, BEIC, EC	**G4-G5** 2, 3, 5
Farm metric to change from yield per hectare to human nutrition per hectare	M	DEFRA	-	**G5** 2, 3, 5
Mandate all public land, parks, allotments etc to increase tree cover to 15%	L	DEFRA	CCC	**G4** 1, 4

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Policy change recommendation (as identified in D6.2)	Priority (High, Medium, Low)	Prime decision making body	Other stakeholders	Gliessman levels (G1-G5)* and Potential impact areas** with further details given
Switzerland				
Accounting of agroforestry as biodiversity promotion areas (BFF) in arable land for the 3.5% minimum share of BFF in arable farming.	H	Federal Office for Agriculture (=BLW, Bundesamt für Landwirtschaft)	-	**G1-G3** 3, 4 The 3.5% arable BFF obligation will apply from 2025 for farms with more than 3 hectares of open arable land in the valley and hill zone. In 2022 Switzerland had around 400.000 ha arable land.
Annual maintenance support for agroforestry systems for climate and resource protection.	M	BLW, Bundesamt für Landwirtschaft	-	**G1-G3** 1, 3, 4, 5 Only fruit and nut trees are currently supported with CHF 13.5 (quality I) and CHF 31.5 (quality II) per tree and year. Other tree species should receive similar support for their contribution to climate and resource protection.
Free choice of tree species, fodder hedges.	H	-	-	**G2** 1, 3, 5 Fruit trees are currently supported with CHF 13.5 (quality I) and CHF 31.5 (quality II) per tree and year. Other tree species should receive similar support for their contribution to climate and resource protection. Swiss farmers are very interested in planting fodder hedges, but legislation (nature conservation) restricts the use (direct grazing) and a potential removal of hedges after planting. 60% of Swiss farmland are grasslands.
One-off start-up funding/financing for agroforestry systems.	M	BLW, Bundesamt für Landwirtschaft	FOEN (Federal Office for the Environment, in German: BAFU, Bundesamt für Umwelt)	**G1-G4** 1, 3, 4, 5 The introduction of new agroforestry systems would be supported by start-up funding (e.g. CHF100 per tree). We see (in private programs) that these start-up grants greatly increase farmers' motivation to plant woody plants.
Agroforestry consulting for each farm to take account of site-specific features (e.g. soil and water protection, biodiversity).	M	BLW, Bundesamt für Landwirtschaft	FOEN (Federal Office for the Environment, in German: BAFU, Bundesamt für Umwelt)	**G1-G3** 1, 2, 3, 5 Aware of the variety of possibilities as well as potential mistakes, we advocate mandatory consultation with experts on the farms. A system adapted to the site and farm increases the chances of success of the system, the longevity of the trees/shrubs and the satisfaction of the farmers.

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3 Introduction to policy modelling

3.1 Context

As detailed in AGROMIX's D1.2 and D6.1, agriculture and farming can play an integral role in solving our global interconnected crises, whilst also addressing the United Nation's Sustainable Development Goals (SDGs). As outlined there and in the Grant Agreement, Agroecology with its 5 levels according to Gliessman (2015), can be a re-imagining of our food systems that can reduce agriculture's impact on the land, produce enough food, while reducing greenhouse gas emissions and helping to restore biodiversity as well as addressing power imbalances and issues of social justice.

Within WP6 of AGROMIX, which focuses on two agroecological approaches, agroforestry (AF) and mixed farming (MF) policy is analysed in general as a tool for change, and specific policies are analysed to see the extent to which certain outcomes may be realised. D6.1 detailed out a policy inventory relating to AF and MF, contrasting detailed European national and EU wide policies, with six non-EU countries and cross-border initiatives. This analysis highlights that Agroforestry is an exciting multifunctional land-use option that addresses issues such as soil health, biodiversity and carbon sequestration but there is a distinct lack of financing, policy up-take and farmer up-take for this cropping system. While MF was on the whole, not yet recognised in direct policy support, other than indirect e.g., the EU's Nitrates Directive or the Organic Farming Regulation. Another salient point from this research was the lack of joined-up or coherent policies that took a food systems approach, i.e., very little coordination between food, health, biodiversity and education for example.

Mapping from D6.1 reveals a strong lack of public financing for AF and MF practices. Only Belgium, France, Hungary, Ireland, Italy (some regions), Portugal, Spain (some regions), and Switzerland have activated CAP measures for AF. The potential for AF is seen in respect to carbon sequestering ecosystem service providers but not as major food system change driver. MF is namely not recognised within policy as having the potential to meet sustainability or food security goals, though several eco-schemes are concluding to mixed production systems.

Moving forward from D6.1's policy inventory, this report seeks to analyse policy options for land use decisions within the EU (including Central-Eastern EU countries) and five national states (Hungary, France, Germany, Switzerland, England (UK) to better understand the desired scenarios and outcomes in order to develop policy recommendations. As consensus builds that the current policies affecting land use and agriculture need improvement, different, better policy models are needed to co-develop and convince all policymakers that some deep structural changes that are needed. It is important to analyse and understand which policies will best incentivise the required changes, both within the CAP and at national level.

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3.2 Policy modelling

There are many ways in which policy modelling is carried out, to varying degrees of success. Within the agricultural sector in particular, this modelling is particularly challenging, in part because it combines economic modelling with public policy, natural capital and highly complex speculative commodity markets, where empirical data may not be available. There are two key approaches for quantitative assessments of agricultural policy reforms: partial equilibrium (PE) and general equilibrium (GE) programming models. GE models take into account the interaction between the agricultural and non-agricultural sectors whereas PE do not, and instead incorporate more information on production and policy instruments than GE models (Salvatici *et al.,* 2001). More and more, agricultural policy modelling is also being called to include climate change mitigation policy frameworks, for example in Nationally Determined Contributions (Fellmann et al., 2018), which adds further complexity. Legislative frameworks with regards to climate change must be considered alongside agricultural policy analysis and models given agriculture's overall contribution to climate change (Benton and Harwatt, 2022).

It is important for policymakers and agricultural economists to have different modelling approaches so that tailor-made, specific analyses can be run. However, it is essential to note that for the most part, negative externalities of the agricultural sector are not included in current mainstream policy models. The current failures in our food system can (in part) be seen as a failure to reach a consensus on the 'best' way to produce food, whether we prioritise yield over nutrition or soil biodiversity over calorie production for example.

The European Commission (EC) currently uses a suite of model-based scenario modelling in impact assessments and analysis of policy options. For a number of key policies such as the European Green Deal, the EU Climate Target and the EU Long-Term Strategy, the EC provides a link to all the models used. The key model used in support of decision making related to the Common Agricultural Policy (CAP) and therefore the European Green Deal, is the CAPRI model, detailed below.

3.2.1 CAPRI model

The Common Agricultural Policy Regional Impact Analysis (CAPRI) modelling system is a large-scale economic comparative, multi-commodity agricultural model, developed by European Commission research funds. CAPRI has been in use for almost a decade, and it is used to support decisions around the CAP. It focuses on the EU but includes bilateral trade (outside of the EU) for major agricultural commodities. The primary objective of the model is to evaluate *ex-ante* impacts of the CAP and other trade policies on markets, income, the environment and production from the global to the regional scale (CAPRI-Model, 2022). The model is a partial comparative static equilibrium model, consisting of two 'modules': the supply module (which covers about 280 regional models covering the EU, Norway and Western Balkans at the NUTS2 level) and the market module, a global multi-commodity model. As a partial equilibrium model, CAPRI only consider effects within the agricultural sector, while ignoring other interactions with other sectors (Britz and Witzke, 2014).

In 2021, the Joint Research Centre's Technical Report 'Modelling environmental and climate ambition in the agricultural sector with the CAPRI model: Exploring the potential effects of selected Farm to Fork and Biodiversity strategies targets in the framework of the 2030 Climate targets and the post 2020 Common Agricultural Policy' was published (Barreiro-Hurle et al., 2021). This report uses the CAPRI model to run

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modelled scenarios based on CAP reform proposals and provides some insights into the potential impacts of the targets for the agricultural sector. In their summary they note the major limitations of this work being that *"not all policies that affect the transition are captured by this model"* and *"the report also highlights that the current modelling tools need improvements to help us prepare future impact assessments".* They highlight that *"while agro-economic models will be an integral part of the tools for such an evaluation, the present exercise has identified areas where additional efforts are needed, especially in the need to capture the environment not only as a restriction for agricultural production but also as an input. The current modelling approach focuses on the trade-offs between environmental protection and agricultural production based on past experience, failing to capture the positive synergies that a better environment brings*" (Barreiro-Hurle et al., 2021 page 6).

Polices are one factor that influence famers and landowners over how they farm, economics and demand being another key factor (see Figure 1). Other key motivators are time, environmental concern, financial costs and societal pressure. These are, by large, excluded from standard policy models. It is important to note that policy development can only go as far as governing politicians allow, who are also subject to other influential factors such as economic or political success. Other modelling approaches including behaviour and social interactions have been proposed and we discuss them briefly in the following sections, before detailing the two modelling approaches, we have developed for two case studies.

3.2.2 IFM-CAP (Individual Farm Model for Common Agricultural Policy Analysis)

Recently the EU has developed a different modelling approach to simulate policy impacts. The EU-wide Individual Farm Model for Common Agricultural Policy Analysis (IFM-CAP) is an individual level model that can further details the farmers responses to EU agricultural and environmental policies. Kremmydas et al. (2022) argue that the CAP 2013 requires a different modelling approach than CAPRI as an additional conditional layer on specific farm obligation was added.

3.3 Agent-based modelling for agricultural policy evaluation

Agent-based modelling (ABM) approaches have become increasingly popular for the evaluation of agricultural policies because they offer as a key advantage the ability to model the heterogenous behaviour and decision making of individual actors as well as their interactions with their social and physical environment (Nolan et al. 2009).

Reviews of ABM models in the European context have been provided by Kremmydas et al. (2018) and Huber et al. (2018). Kremmydas et al. (2018) focus specifically on ABM approaches for agricultural policy evaluation reviewing 32 studies based on data-driven models reproducing real world situations validated by data, while they exclude ABM studies simulating an actual farming system to explore policies theoretically.
One of the earlier examples of a data driven ABMs is the **AgriPolis model** (Happe et al., 2006), which has been applied to analyse the impact of the CAP reform in 2003 in the Hohenlohe region of Germany using the **rental value of land** as response variable. Apart from policy change, the AgriPolis model uses four other factors impacting on this response variable including investments in technological change, managerial abilities of farmers, interest on borrowed capital and interest on equity (Happe et al., 2006). When applied

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to the Hohenlohe region, the model results showed that the policy shift from payments for production (Agenda, 2000) to single area payments increased rental land values (partly because grasslands became eligible for the payments) while little structural change occurred, and farmers' incomes slightly declined (Happe et al., 2006). While AgriPoliS (in this example) is based upon the basic structure of an agricultural system from an economic point of view, it does not integrate outcomes for the environment or livelihood of communities.

The review by Huber et al. (2018) focuses on 20 ABMs developed in the European context and also includes non-data-driven simulation models with a special focus on farmers' decision-making. They focus on Europe because the highly regulated environment in which agriculture takes place is a main factor in farmers' decision-making. The 20 models were reviewed in collaboration with the model developers using existing frameworks to classify how the decision-making process is integrated into the individual models. They found that in most models the interaction between farmers was represented by the **land market** with few using social interactions, such as imitation of neighbours or social networks (Huber et al. 2018). Most models also used farmer typologies to consider different goals and values in the farmers' decision-making depending on e.g., farm ownership, farm succession, beliefs and values, and management. They conclude that ABMs are a suitable tool for policy assessments and can be improved by more integration of social science to better represent farmers' decision making (Huber et al. 2018).

An on-going European Commission project, **BESTMAP** (funded under Horizon 2020 research and innovation programme under grant agreement No 817501) is currently working to develop behavioural, ecological and socio-economic tools for modelling agricultural policy. BESTMAP tries to address the behaviour and decision-making complexities made by farmers. The consortium argues that *"existing impact assessment models do not appropriately address the complexity of decisions made by farmers and ignore the wider impacts of policy on natural, social and cultural assets in rural areas".* BESTMAP therefore aims to design and develop a new Policy Impact Assessment Model (PIAM) framework, using socio-economic, behavioural and biophysical approaches that incorporates environmental, social and economic variability on farms and EU regions. Work-Package 4 within the BESTMAP project will set up Agent-Based Models for each case study region, with the aim to capture the decision-making process of farmers. This work is upcoming (due December 2022), but is not specific for agroforestry or mixed farming. Once work is released AGROMIX will approach BESTMAP for cooperation in the further development of are agroforestry/mixed farming agent-based model approach.

3.3.1 Agent-based models for agroforestry or mixed farming systems

Looking more specifically at the application of ABMs to AF or MF systems, we found few examples, mainly from outside Europe. A case study in **Indonesia** uses an ABM to simulate the **interdependencies of agroforestry systems** and local livelihoods, income, land use, biodiversity, and carbon sequestration (Nöldeke et al. 2021). The model is used to explore the introduction of an agroforestry system in comparison to a 'business-as-usual' scenario concluding that adoption of agroforestry diversified livelihood of farmers, increased their income and increased biodiversity at the landscape level. Authors also run the model in climate change scenario (+ 1.5ºC) finding a higher adoption rate of agroforestry with farmers compensating for losses in rice production, however, overall food production is predicted to decline as is biodiversity, albeit to a lesser extent than in the business-as-usual scenario (Nöldeke et al. 2021). Given the crucial role of

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farmers' behaviour in the decision process of agroforestry adoption, Nöldeke et al. (2022) also used role playing games with smallholder farmers in Rwanda to validate several decision-making modelling options as part of their ABM. They found that the **'Theory of Planned Behaviour'** was best describing farmers decisions in the game compared to the other approaches tested in the model which had predicted either higher (in the case of rational choice theory, econometric approach) or lower (bounded rationality approach) adoption rates (Nöldeke et al. 2022). In Europe, an ABM was used to model the future development of the existing Montado silvo-pastoral systems in the Alentejo region of Portugal (Acosta et al. 2014). Based on interviews, farmers in the region were grouped according to socio-economic attributes (e.g. education, age) in four types (innovative, active, absentee, and retiree) who manage the land differently in response to changing socio-economic and climate conditions and depending on the characteristics of their land. In their scenario analysis they used the A1fi storyline of the Intergovernmental Panel on climate change (IPCC), which represents a globalised, market-orientated world that has a fossil fuel intensive energy mix. Under this scenario, their model found that by 2050 the Montado land use declined and unmanaged forests and shrublands increased (Acosta et al. 2014). However, the A1fi storyline assumes also decreasing policy interventions as well as decreasing fertiliser and pesticide costs whereas labour costs increase. Not all of these assumptions seem now as realistic as at the time the paper was published in 2014, and further research could explore different policy intervention aiming specifically to maintain existing agroforestry systems as well as the creation of new ones.

Given the potential of ABM within agricultural decision and policymaking outlined above, this deliverable develops this approach for AF and MF. The ABM is developed for England, however it is generic enough so it could be used in other European countries and specifically on the EU level for Task 6.4. Later in the methodology section, the model method, preliminary results and further development are discussed.

3.3.2 Agent-based model approach taken in AGROMIX

The detailed methodology for the ABM is outlined in the next chapter. Here we reflect on our approach and the work which has started from scratch with several internal expert meetings to discuss the needs of the modelling for the AF/MF policy interventions we wanted to test. As these interventions, unlike the plot, field and farm specific modelling of MODAM, are on a food system and societal level (Gliessman levels 4 and 5) the model approach has to start broad and generic. As we are interested in the "big-picture" potential agroecological transition scenarios with various land use changes, we have included a timeline to 2050 and 2100, being able to look in the future and test scenarios longer term.

In our ABM approach we are specifically interested in the dynamics of farming land use change with various forestry, agroforestry, mixed farming and mono-land use options. We also include 'fallow' or 're-wilding' as this an option currently in the political discussion mentioned debated a lot. In addition, we also have solar (solar photovoltaic systems and 'dynamic agrovoltaism' considered as part of the modelling, as written in the Grant Agreement. At this stage, however, we do not yet include solar (neither mono-solar land use nor AF/MF mixed solar land use ('dynamic agrovoltaism') as not to overlay the AF/MF research with too much complexity.

Our ABM approach is to capture the driving forces for land use change, its resiliencies and its sensitivities including barriers to change. Of specific interest and linking to the bio-physical modelling in WP3 are the

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dynamics that are influenced by external factors, climate events, pest and disease management and socio-economic dynamics (WP5). The approach delivers an analysis of **how policy options and scenarios affect AF/MF or mono land use choice by the agents.** The approach is also able to consider external disruptions (e.g. storms, droughts, pandemics, wars).

Comparing this to the few agroforestry ABM models we have found in the literature our approach is more generic, on a large scale of a country (England) and later to be used for the whole EU. However, like Nöldeke et al. 2021, simulating agroforestry adoption in rural Indonesia, we also simulate the "interdependencies of agroforestry systems and local livelihoods, income, land use, biodiversity, and carbon sequestration." We add MF and mono-land use options, and the agents are much more diverse: from Crown estates, landed gentry, co-operate businesses, charity landlords to family farmers, tenants and peasant agroecology. As Nöldeke et al. (2021, 2022), we contrast development paths with and without agroforestry (BAU - business as usual scenario). Alternatively, we can use the current 1.61% agroforestry land use found in LUCAS data for England as a current business as usual. We also aim to support policymakers to assess the potential of AF/MF over larger temporal and spatial scales. In addition, we use policy co-development which uses farmers landowners as citizen agents in the process of co-development, policy is not exclusively delegated to policymakers it is an active process of agents. We use Python as programming language and not Net Logo as published for Nöldeke et al. (2021).

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3.4 Aims and objectives of this deliverable

This report builds on the knowledge and research presented in D6.1 with a view to developing policy recommendations at the EU level, national and federal state levels. By using different policy modelling tools (such as ABM) and scenario building, it is possible to include various desirable outcomes that not only focus on ecological outcomes, but social and political also. It is also possible to test policy 'extremes' (e.g. 100% vegan, 100% free range, 100% organic) and show, discuss the effect they might have. This should then improve policy makers ability in a democratic process to create more coherent policies that join up to other sectors and long-term goals. It is a fact that despite many efforts made over the years to reduce the environmental impact of agriculture, there has been limited improvement, with results considerably behind EU ambitions and sometimes legislative requirements (Barreiro-Hurle et al. 2021). As such, the aims of this report are as follows:

- Identify key success factors for EU agricultural policy
- Develop scenarios for the transition to agroecological principles and the integration of AF/MF in the EU and selected European national policies
- Provide in-depth insight into potential successes, failures and bottlenecks in the transition to resilient AF/MF land use options with better computer models using agents and in-depth agroforestry knowledge
- Provide policy recommendations at federal, national and EU level for increased AF/MF land-use

And the objectives are the following:

- Provide policy scenarios and pathways for an AF/MF increase within an agroecological transition of the EU
- Identify strategies for policy improvement for AF/MF development at federal, national and EU level
- Contribute to improving policy design by using co-development and agent-based model approaches

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4 Methodology used for scenarios and modelling

4.1 Policy scenario development

This report focusses on specific agroecological scenarios with AF/MF systems and what policies might be needed to achieve these outcomes. AF/MF includes agroforestry (AF) and mixed farming (MF) with trees (e.g. silvopastoral, woody landscape features). In other words, all systems discussed in this report include at least some form of tree component. As it was evident from D6.1, there is a lack of clear policy and definitions for MF and there are indirect policy effect on both AF and MF like the NVZ regulation, the organic regulation and other policies.

Given the diverse regions included in the report, two separate approaches have been used and these are discussed in their relevant section. For the EU, France, Hungary, Switzerland and Germany partners developed scenarios for an agroecological transition considering AF as a vital component. These scenarios have then been developed and the relevant policies needed considered and included. This was done with literature review, expanding on D6.1, and expert knowledge. For this tables and spreadsheets are produced and shown but not computer modelling.

For England and Germany in addition two computer models are used and developed further. In Germany (Brandenburg), a more focussed economic policy model has been employed (MODAM), and for England, an agent-based model has been developed. Both of which are described below in the next two sub-chapter in more detail. The scenarios, possible policy outcomes and models will be further discussed and developed in T6.3 and T6.4 whereby e.g. a 'policy menu' is discussed with experts and practitioners.

4.2 Deterministic economic modelling (AFR and MODAM)

4.2.1 AgroForstRechner (AFR)

The AFR provides a dynamic modelling framework to compare the economic performance of both arable and woody crops in different spatial settings over the entire rotation of the woody crop. The economic indicators used for the final comparison of the systems are net present value (NPV) and annual equivalent value (AEV) at a per hectare scale. To explain terms, **NPV** is the difference between the present value of cash inflows and the present value of cash outflows over a period of time, **AEV** is the equivalent value of an original amount at any particular time or annual as in AEV. The AFR is specific for the German federal state of Brandenburg in the way that the integrated database uses values specific to this region. The AFR was originally developed as an Excel based spreadsheet model and due to data limitations only includes poplar, willow, and black locust in either short or medium rotations as tree components. The AFR makes use of an integrated database, but the user can also input individual values for the calculations.

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Due to technical and usability considerations the Excel based model was transferred to a Python based script and databases in order to allow the continued improvement of the model as well as the integration of additional tree species in the future. The backend of the model calculates NPV and AEV for the arable and wooded area on a per hectare scale and uses an integrated database or data input from the user. Currently there is no frontend in the form of a graphical user interface (GUI) available and the source code is not public. This is planned for the near future. Meanwhile, the AFR in the Excel version is available on the DeFAF e.V. website (**https://agroforst-info.de/agroforstrechner/**). The AFR in its Excel as well as Python version does not account for **interactions** between the arable and tree components. The user can input the share of wooded area on the total agricultural plot (e.g., a plot with 90% of the area used for arable production and 10% used for trees) in the GUI of the Excel spreadsheet model and the same is planned for the Python based GUI. The AFR is not a spatially explicit model and does not depict the configuration of the individual wood strips. Results from the AFR will show how AF with different shares of wooded area on the total agricultural area perform compared to pure arable farming at a per hectare level with different subsidy schemes.

Our scenario modelling will compare pure arable farming to the cultivation of **poplar** in short and medium rotations in silvoarable AF. The short rotations are 4 years and medium rotations 8 years, both with their final rotation at year 24. The performance of these systems is calculated for different growing conditions detailed along the German soil quality index. The performances of the agroforestry systems are calculated by adding up the economic performance of the arable and the wooded shares under various policy scenarios. The different shares of wooded areas are used to approximate different agroforestry configurations in terms of the alley width. Higher wood shares therefore approximate narrower alley and lower wood shares wider alley. Both arable crops and the wood chips (the only product generated from the poplar trees) are assumed to be sold and not used on-farm. Input data is specific to the federal state of Brandenburg and collected by the state in the “Datensammlung” which is published every four years (Hanff and Lau 2021) or are taken from the original database of the Excel based AFR. Wherever data was missing gaps were filled by consulting existing literature or databases. This was mostly relevant for prices, especially silage corn and wood chip prices. They were taken from the Landwirtschaftskammer Niedersachsen (2022) and C.A.R.M.E.N. e.V., who publishes wood chip prices every quarter. This results from the AFR modelling are used as an input in the modelling framework MODAM.

4.2.2 MODAM

The development and implementation of MODAM is still ongoing and will be finalised after development of the AFR is completed, since the AFR will provide the technical and economic coefficients for MODAM. The data for MODAM as well as for the AFR are specific to the Federal State of Brandenburg.

The objective of MODAM is to develop policy recommendations for a successful transition towards agroforestry and mixed farming. This includes the identification of strategies for policy improvement and well as new and improved policy design and implementation options. For this we conduct policy scenario modelling to answer questions such as: “*May AF be competitive with agricultural land use?”.* The Federal State of Brandenburg in the East of Germany (the state surrounding the city state of Berlin) is used as a case study for in-depth modelling. The level of detail is complex and aims to capture site specific production options and ecological impacts, farm specific costs and restrictions and ecological and economic impacts of

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policies at regional level. MODAM uses a comparative static and/or dynamic, farm level mathematical programming approach of typical farms with regional 'weights' or 'regional farms' or a 'fully synthetic farm population' with typical fields or concrete INVEKOS fields. Here the framing is flexible and can be tailored to research questions and/or data availability. MODAM will use typical site-specific data for crop production with and without agroforestry strips. Several options of tree species and spatial arrangement on the field can be considered. This allows for an analysis of the economic performance of different AF options on different typical sites. In addition, it considers mixed farming (MF) and policy scenarios with concrete policy instruments and market conditions, which are further defined and reflected on in the two participatory stakeholder workshops of task 6.3. The economic and ecological indicators used for measuring the impact of these policies and production systems are based on previous deliverables of WP1. As task 6.2 is ongoing, we will integrate feedback from all partner workshops (not only those in Brandenburg).

4.3 Agent-based modelling (AF/MF-ABM)

4.3.1 Introduction

A novel agent-based model, i.e. the **AF/MF-ABM** for Agroforestry (AF) and Mixed Farming (MF), was and is being developed first with the view to be used and improved with stakeholder feedback in England and in the policy-workshops planned there in 2023. However, the model is generic enough to also be used in other European countries and on the EU level informing task 6.4. The purpose of AF/MF-ABM is to explore the dynamics of farming land use allocation (i.e. its driving forces, its resiliencies and its sensitivities), and how these dynamics are influenced by external factors (e.g. policy frameworks or climate events). Within this broad aim, two distinct applications of the model are envisaged:

1) analysis of **how different policy options or policy scenarios affect land use** allocation (or land use change from the current baseline in the area modelled), particularly with regards to identifying optimal policies for encouraging agroforestry and mixed farming land uses; and

2) analysis of **regional land use performance and resilience to external disruptions**, such as climate-driven weather events (e.g. storms, droughts) and socio-economic stressors (e.g. pandemics, wars).

It is important to note, that the **AF/MF-ABM** model is not a predictive model of policy change. The modelling is done to better understand the effect of current and future policies on decisions farmers and landowners make on land use options, which can be various, extreme and random. The modelling covers a wide set of dynamics including, among others, land use change, farmer behaviour and climate change. It is therefore an explorative type of model for policy making, providing policy decision support. The model is, however, not able to 'make policy', which within democratic states range from co-creating basic-democratic (i.e. Switzerland) to complex levels of policy decision making in the EU i.e., the 'Trilogues' between the EU-Parliament, the EU-Council and the EU-Commission. Other potential users for the policy decision support the model can offer are NGOs promoting policies on agroforestry, mixed farming or AF/MF combined. For all those users the AF/MF-ABM model can be equally useful.

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Here we present the methodological approach of the AF/MF-ABM model, including some preliminary modelling results. The model and any resulting insights are further refined following presentation at the workshops and discussion with expert colleagues at our first physical project meeting in Pisa in November 2022 and with the stakeholder feedback collected during the series of workshops in T6.3 and the T6.4 activities on an EU level. Constant iterative stakeholder feedback (i.e. co-design) is an important part of the further policy model development.

4.3.2 Model structure

AF/MF-ABM is a computer model, built around five key components: agents, land uses, commodities, events, and performance indicators. These five components and their interactions are detailed below, but in summary: agents decide land use allocations, land uses yield commodities, events affect yields, land use allocations and commodity yields govern performance indicators, performance indicators affect agent choices for the next iteration (Figure 1). Each iteration represents a period of time, commonly one year. A sixth component, policies, can be superimposed on a simulation to affect the five core components or their interactions. Livestock is modelled a part of different land use types (land use types 'mono livestock', 'mixed farming' and 'silvopastoral'. The land use type 'fallow' is 'rewilding' and not domesticated livestock.

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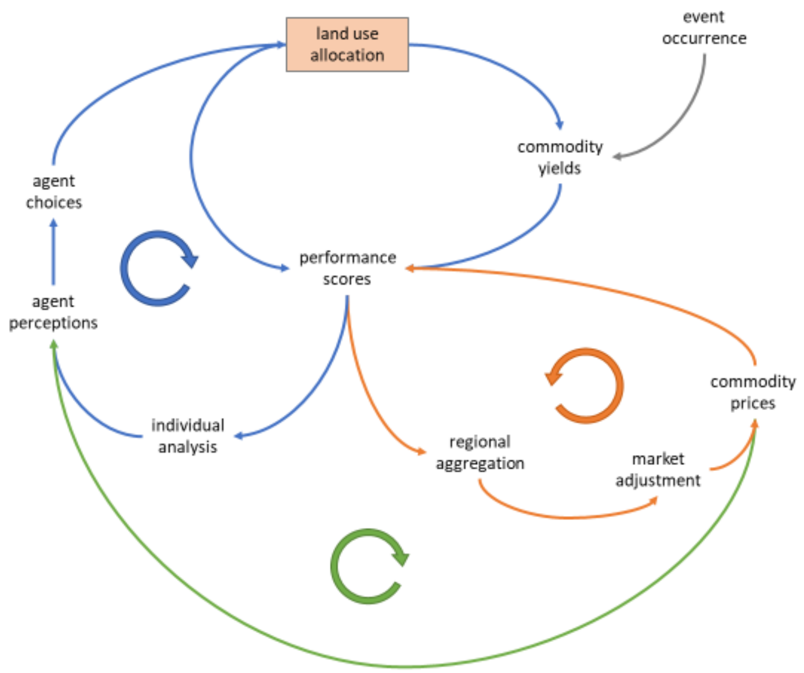

Figure 1: Conceptual structure of the AF/MF-ABM model. The key model components (agents, land use, commodity, events, and performance scores) are explained in the main text. The three colours and corresponding circular arrows indicate feedback loops within the model.

The model represents a virtual region (e.g., country, province, county, …). Regions are not explicitly defined but are implicitly defined through their available land use types and the local properties of these land use types. Regions comprise a number of virtual farms. This number is user-defined and is reflected through the number of farming "agents".

Agents are virtual farm managers (e.g., farmers, landowners, land managers, land trusts, …) that have the power to decide which land use, or which combination of land uses, will be implemented on their virtual farm, and how much land will be allocated to each of these land uses. Agents themselves are defined through a number of properties that define their personalities, most notably priorities and informedness. Agent priorities define the relative preferences of four different personal goals: financial gain (maximal profit), environmental karma (maximal environmental benefits), social karma (maximal social benefits), and work-life balance (minimal time and effort). These priorities are quantified with a value between 0 and 1, with the constraint that the sum of the four priorities must equal 1. Different agent personalities can be created by adjusting the agent priorities (Table 1). Agent informedness defines how well the agent is aware of the

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environment they operate in. It takes a value between 0 (completely clueless) and 1 (perfectly informed). A default value of 0.9 is used.

Agents have a perception of financial, environmental, social and effort values of land uses and commodities. This perception is based on the true value of these properties but is distorted by the agent's individual level of informedness (the amount of distortion is inversely proportional to informedness). Based on these perceptions, farmers decide their land use by attempting to optimise toward their own priorities (i.e., financial gain, environmental karma, social karma, work-life balance). This can be updated with agent personality form observing actors in the forthcoming WP5 survey in Task 5.3. With a PCA (Principle Component Analysis) a clustering using survey questions on statements it can be used to create groups based on different personalities and observed data (Table 1).

Table 1: Sample agent personalities, as defined by their four priorities of profit, environment (enviro), social and work/life, with values ranging from 0 to 1.

	profit	enviro	social	work/life
'capitalist'	1.00	0.00	0.00	0.00
'treehugger'	0.00	1.00	0.00	0.00
'social worker'	0.00	0.00	1.00	0.00
'loafer'	0.00	0.00	0.00	1.00
'standard'	0.60	0.20	0.10	0.10
'enviro-aware'	0.30	0.50	0.10	0.10
'enviro-social'	0.20	0.40	0.40	0.00

Note: The first four agent personalities are defined as "extremists" who only have one priority and do not care about anything else. Although these caricature agent types are unlikely to reflect real mentalities, they can be useful for analysis purposes. The latter three agent types are more subtle and have a more complex balance of priorities. These may be more reflective of reality. Additional agent types can be defined by the user or can be added following stakeholder feedback.

Land use is at the heart of the simulation. Dedicated land use input files contain all information for all land use types available in a simulation. The land use input file is user-defined, allowing users to tailor the land uses for their region of interest or for their specific simulation needs. Each land use is defined through a number of properties, most notably the land use name and the commodities generated through the land use. For each commodity available within the land use, the input file specifies the default unit yield of the commodity, as well as the modification thereof by events (also see Events below). Incorporating this information in the land use input file allows for the same commodities to have different yields and different

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responsiveness to events within different land uses. In addition to the commodity specifications, each land use type also has an environment rating, a social rating, and an effort rating. These ratings are used by agents, in conjunction with commodity yield and commodity prices, to align their land use allocation to their individual priorities. The three ratings, however, are subjective assessments of the relative environmental benefits, relative social benefits and relative cultivation efforts of the land use. As all other land use properties, these ratings are user defined. For our initial seven land use types, values for these three ratings are arbitrarily set; however, improved values will be obtained from expert surveys to be conducted during the project meeting in Pisa in November 2022.

In the first instance we use seven generic land use types: monoculture arable, monoculture livestock, monoculture woodland, integrated arable-livestock (mixed farming), integrated arable-woodland (silvoarable), integrated livestock-woodland (silvopastoral), and fallow (Table 2). These seven land use types are broad, but are sufficient to illustrate and assess the working of the model. However, other land uses can easily be envisaged in later developments of the model we expect to broaden the range of land uses, including for example specific arable crops, different types of livestock, different types of woodland, orchards, rewilding and even solar panelling.

Table 2: Sample generic land use types, as used in the testing of the model (Note: the profit rating is dynamically calculated and not fixed to any given land use, and hence not in this table).

land use type	commodity	enviro rating	social rating	work/life rating
mono arable	crop	0.30	0.30	0.20
mono livestock	livestock	0.00	0.10	0.10
mono woodland	wood	0.70	0.40	0.40
mixed farming	crop + livestock	0.20	0.10	0.00
silvoarable	crop + wood	0.50	0.35	0.20
silvopastoral	livestock + wood	0.30	0.25	0.05
fallow	none	0.20	0.00	1.00

Land uses yield **commodities**. Aspects of commodities that are specific to the land use (e.g. unit yield, sensitivity to events) are defined as part of the land use type. However, universal commodity properties, notably unit price and demand, are user-defined in a separate input file. In the initial version of the model, with seven generic land use types, there are just three commodities: crop, livestock and wood. However, as additional land use types are added, more commodities can be added as well (e.g. fruit, grain, vegetable, solar energy).

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Events occur probabilistically and affect commodity yields. Events can affect a single commodity or can affect all commodities. Probability of event occurrence is user-specified through an events input file. The extent to which a commodity yield is affected depends on the land use generating the commodity (i.e. different land uses respond differently to events, even for the same commodity). Hence, event impacts for each commodity are included in the land use input file. Initially, four different event types are included (Table 3), but users can modify these or can add other event types as desired. Concurrent or compound events (e.g. drought and pest attack combined) are currently not in the model but can be added later stage, if feedback during the workshop phase recommends this.

Table 3: Overview of default event types, their probability, the commodities affected and the impact on modelled yield.

event type	probability	commodity affected	yield impact
storm/flood	0.05	all	decrease
drought	0.05	all	decrease
pest/disease	0.02	single	decrease
clement weather	0.05	all	increase

Performance indicators evaluate the financial, environmental, social, and work/life balance ratings of the virtual farms. Four performance indicators are employed: net profit, environmental benefits score, social benefits score, work/life score. The first of these is derived from commodity yields, whilst the other three are derived from the agents' chosen land uses on their virtual farms. Since commodity yields also result from land use, land use allocation is the prime control of the simulation performance indicators, although the net profit indicator is also affected by events and commodity pricing (Figure 1).

The performance indicators are analysed both individually for each agent and aggregated over the whole region (Figure 1). Individually, performance indicators are used to update the agent's perceptions. Thus, agents can "learn" from their experiences to adjust their decision making in subsequent iterations. Performance indicators also are aggregated for all agents to derive indicators for the whole region. Particularly, overproduction or shortages of individual commodities will result in a market adjustment whereby commodity prices increase or decrease for the next iteration. These two feedback loops (individual and regional) currently are not implemented in the model, but this is planned for the next phase of model development.

User-defined **policies** can be imposed from the start of a simulation or can be introduced during a simulation. Policies mainly affect other model components or component interactions (Figure 2). Possible policies include: 1) subsidising or taxing land uses or commodities; 2) prohibiting, restricting, or mandating specific land uses; and 3) education and awareness campaigns. Additional policy options will be considered in consultation with project partners and expert colleagues during the project meeting in Pisa in November

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2022. Currently, policy options are configured by manually editing the input files or the model code. However, definition and implementation of policies via a dedicated easily editable user-defined policy input file is planned for the next phase of model development.

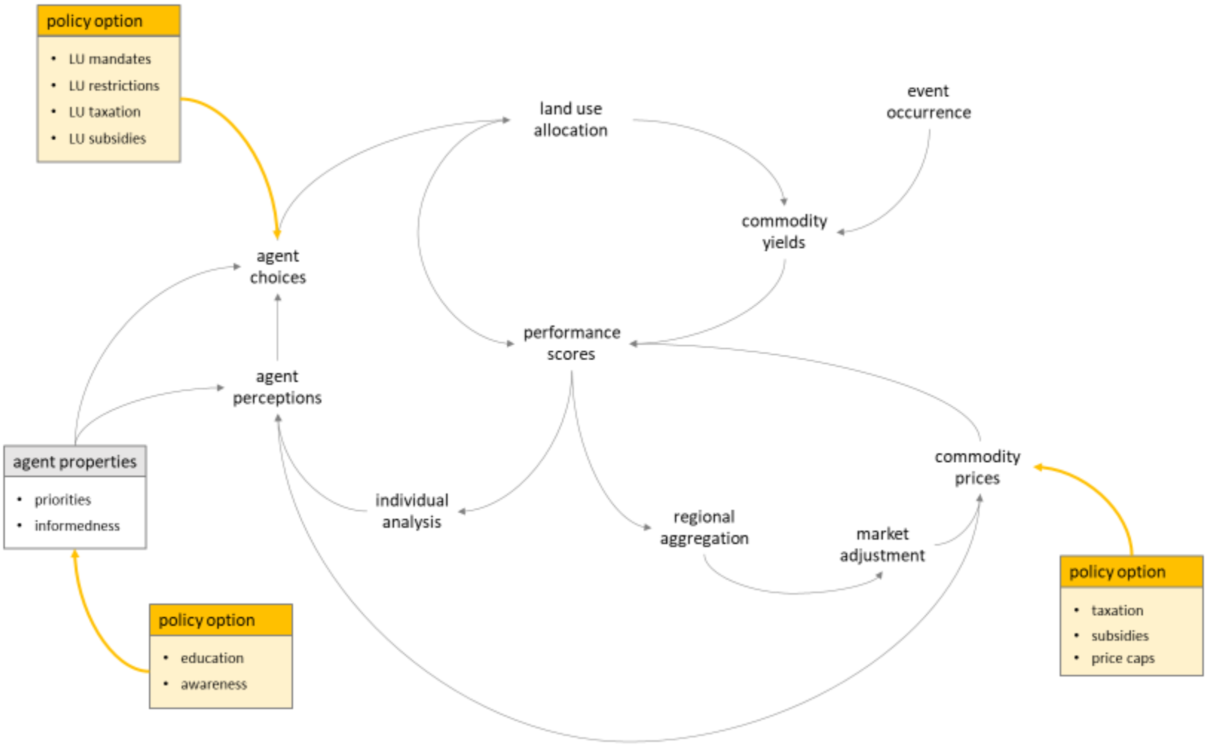

Figure 2: Possible policy options and their points of impact within the conceptual model structure.

The model runs through a sequence of user-defined iterations. Each iteration represents a period of time, commonly one year. Common simulation times are 30 years, 75 years, 100 years and 300 years. The 30-year simulations, with the year 2050 as a time horizon, are a common time frame for many perennial tree crops like apple orchards. For agroforestry, like forestry, besides a shorter 30-year time frame, a 100- and even 300-year time horizon is equally appropriate to mirror the changes in forestry over longer-term cycles. The 75-year simulations, with the year 2100 as a time horizon, correspond to common climate scenarios used elsewhere in AGROMIX (WP3). Once they are further devolved, we plan to link the climate modelling with the policy modelling.

The AF/MF-ABM model is programmed in Python and is designed to be flexible and versatile. All of the key model components are user-defined and can be modified or extended to suit the user's need. The model also is flexible enough to add more details on many of the computational aspects – actually on all. However, such

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increased complexity may hinder understandability and tractability of the model outputs and may also limit both the understandability for stakeholders and prediction and decision support advice for policy making.

4.3.3 Preliminary results

4.3.3.1 Impact of agent properties

Agent type affects choice of land uses and resulting commodity yields. The exact land use choices are dependent on the land-use and yield properties, as perceived by the not fully informed agents. In the simulations presented here the land use properties and commodity properties are set to indicative but arbitrary values. The resulting quantitative values are, therefore, rather meaningless in an absolute sense. What is important, however, is that the different agent-types make different choices, resulting in very distinct land use allocations and commodity yields (Figures 3 and 4).

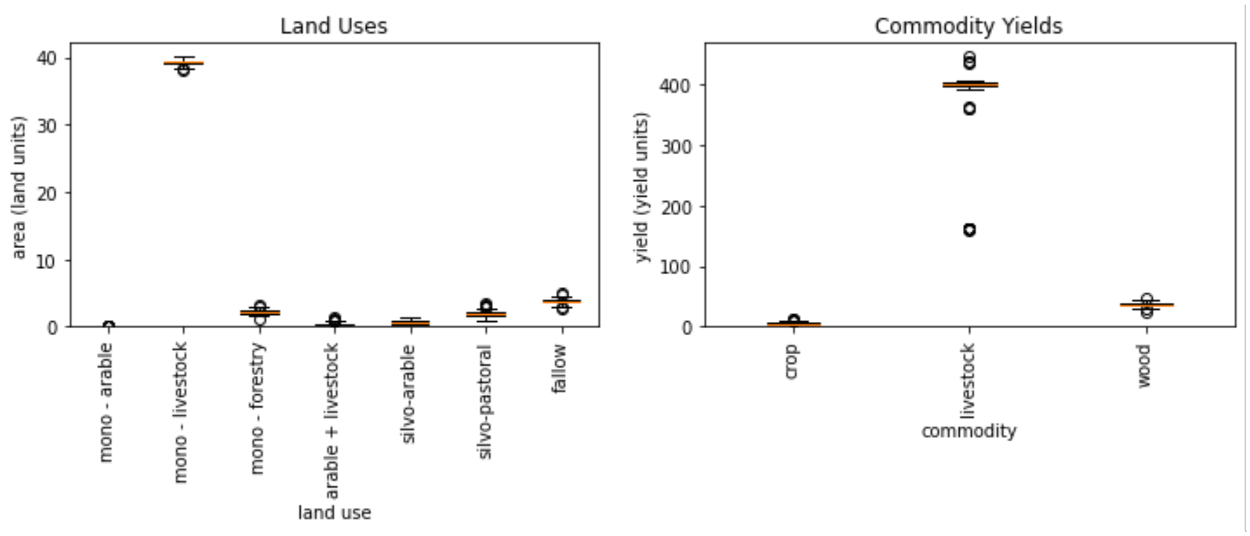

Figure 3: Distributions of land uses (left) and commodity yields (right) over 100 iterations, using 100 "standard" agents (see Table 1). Orange lines indicate median values, the box comprises 25th to 75th percentiles, whiskers indicate 5th and 95th percentiles, and circles indicate outliers.

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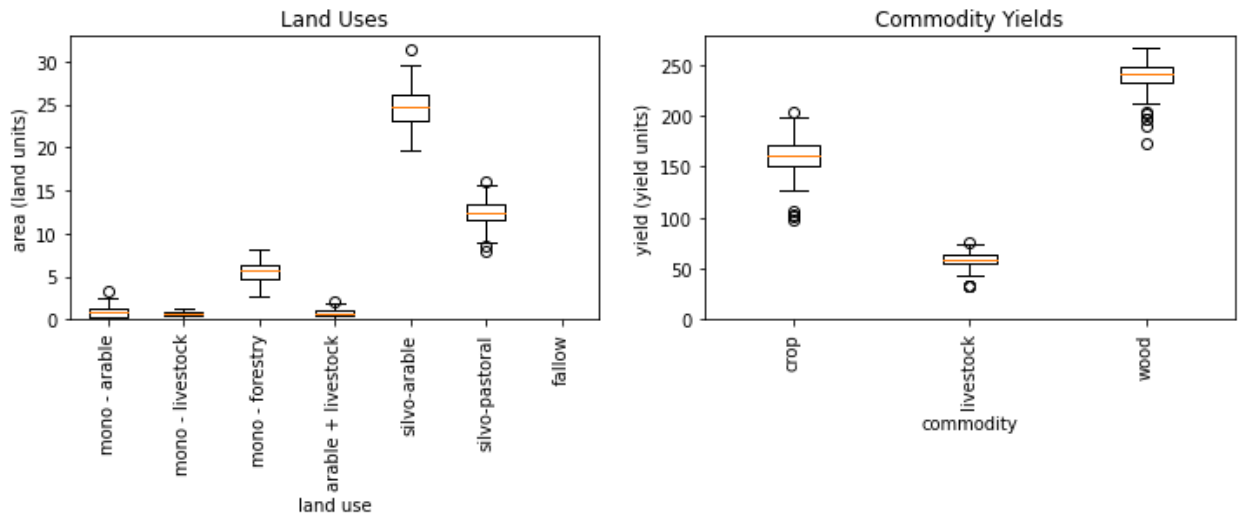

Figure 4: Distributions of land uses (left) and commodity yields (right) over 100 iterations, using 100 "envirosocial" agents (see Table 1). Orange lines indicate median values, the box comprises 25th to 75th percentiles, whiskers indicate 5th and 95th percentiles, and circles indicate outliers.

Each simulation comprises 100 agents. These agents choose their preferred land uses, based on their own priorities and their perceptions of land-use and yield properties, which contains a stochastic component. The results are, therefore, be different between one iteration of agent choices and another iteration of agent choices, even if the agents themselves have the same properties (i.e. same priorities). Hence, rather than presenting the result of one iteration, the results of a range of iterations (n = 100) is presented here. The spread of distributions is due to agent imperfect informedness (set to 0.9 in these simulations) and, for commodity yields, also due to the impact of events.

The remaining differences between the distributions are due to differences in agent priorities. The 100 "standard" agents have a strong preference for monoculture livestock farming (under the arbitrary land use properties used in these simulations), with an associated dominance of livestock commodity yield (Figure 3). In contrast, "envirosocial" agents have a distinct preference for mixed farming, particularly silvo-arable and silvo-pastoral, with more wood and crop commodities produced (Figure 4).

Similarly, agent informedness also affects land use allocation and commodity yields. Fully uninformed agents (informedness = 0.0) essentially make random land uses choices, with a near equal distribution of land uses and commodity yields (Figure 5). However, highly informed agents (e.g. informedness = 0.9) make more targeted land use allocations to match their priorities, resulting in distinct preferences for specific land uses (Figure 4).

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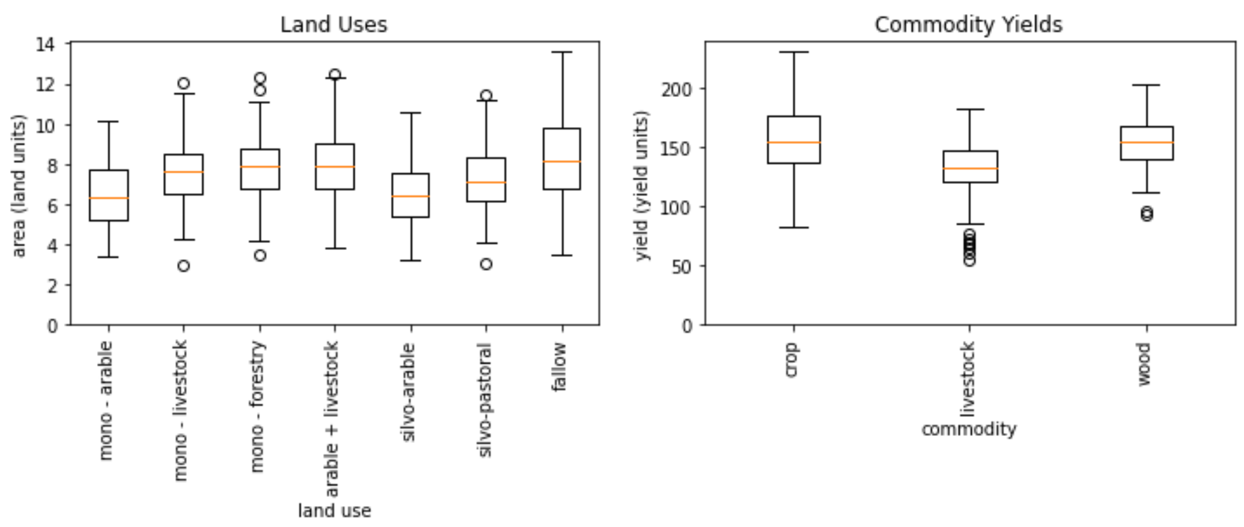

Figure 5: Distribution of land uses (left) and commodity yields (right) over 100 iterations, using 100 "envirosocial" agents (see Table 1), with informedness = 0.00. Orange lines indicate median values, the box comprises 25th to 75th percentiles, whiskers indicate 5th and 95th percentiles, and circles indicate outliers.

4.3.3.2 Impact of extreme policies – Three scenarios explained

We present results from three hypothetical "extreme" policy scenarios. These preliminary results are subject to the same caveat as above, i.e. the land use properties and commodity properties used in these simulations are set to indicative but arbitrary values. The resulting quantitative values are, therefore, not meaningful in an absolute sense. But the relative differences between simulations illustrate how the AF/MF-ABM model can be used to analyse the impacts of policy scenarios.

The three policy scenarios are "100% free-range", "100% organic" and "100% vegan", which represent different restrictions on livestock land use.

These scenarios, although we called them "extreme" in the Grant Agreement, are nevertheless seriously discussed in policy pressure groups. Radical vegans are indeed out to 'liberate all domestic animals from misuse and suffering through farming' and making animal husbandry, excluding companion animals, illegal. An option if realised over the next 100 years could change the landscape of Europe. How and why and are there unintended consequences – this is what our policy modelling tries to shed some light on. We are not taking the position that these policies should have any preference, we just study the effects on AF/MF and report them back into the discussion.

The same is the case with the other two extremes: "**100% free-range**" means making indoor animal farming illegal in the EU, i.e. systems labelled as 2 barn and 3 cage in laying hens are not possible and monoculture livestock land use would not be possible.

In the "100% organic scenario" it is assumed making every farm following the legal definition and certification of the EU on organic and in addition making agroforestry mandatory in organic. Currently only organic farming practices are legally defined, while the addition of 100% mandatory agroforestry into organic (or turning all mixed farming into mixed farming with trees = agroforestry) is not. This is however proposed and

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a recent aim of a large organic certification body in the UK, the Soil Association, is working towards 50% agroforestry on their membership farms. The ABM model can elegantly deal with this by phasing out all tree livestock options mono-livestock, mixed farming and silvo-pastoral for 100% vegan. It confirms that this is the most extreme of the extreme options as all three livestock types are excluded.

1. In the "100% **free-range**" scenario, the **one livestock land use** 'monoculture livestock' is phased out, i.e. the only animal land uses are integrated arable-livestock (mixed farming) and integrated livestock-woodland (silvo-pastoral).
2. In the "100% **organic**" scenario, **two livestock land uses** 'monoculture livestock' and 'integrated arable-livestock are phased out, i.e. only silvo-pastoral remains for any livestock rearing. This is done to distinguish the organic from the free-range, which assumes agroforestry is not mandatory and mixed farming arable-livestock without trees is still possible. For 100% organic agroforestry is assumed mandatory, with every farm having it.
3. Finally, in the "100% **vegan**" scenario, **all three livestock land uses** are phased out.

These three scenarios are contrasted to a baseline scenario where all land uses are allowed (Figure 3).
The term phase-out means this choice is not allowed in the model, as if this land use would be illegal. The model currently treats this choice as sudden and not gradually over 100 years, therefore the phase-out is modelled instantly and not gradual.

4.3.3.3 Impact of extreme policies – Results from three scenarios with "standard' agents

In a first set of simulations, the four scenarios (baseline + three policy scenarios) are compared using 100 "**standard**" agents (Table 1). In the baseline scenario, monoculture livestock land use dominates (Figure 3 left), with a corresponding high livestock yield of about 400 yield units (Figure 3, right).

However, this land use is not permitted in the "**free-range**" policy scenario. The agents, therefore, need to choose different land uses, and predominantly opt for integrated arable-livestock (Figure 6, left). Yields are more diversified, with about 330 yield units of crop, about 200 yield units of livestock and limited wood yield (Figure 6, right).

In the "**organic**" scenario, integrated arable-livestock also is not available. The dominant land use is silvo-pastoral as the agents opt for the only remaining animal land use (Figure 7, left). Consequently, the main commodity yields are about 180 yield units of livestock and about 300 yield units of wood (Figure 7, right).
The "free-range" and "organic" scenarios thus **result in a shift to mixed farming and agro-forestry**, both with an element of integrated livestock farming. Although overall livestock yields are lower than in the baseline scenario, this is compensated for by significant increases in crop yield and wood yield respectively.
Finally, in the "**vegan**" scenario, the agents predominantly opt for monoculture arable land use (Figure 8, left), resulting crop yield of about 450 yield units without any livestock or wood yields (Figure 8, right). In relation to the baseline scenario, the "vegan" scenario thus **shifts land use from one monoculture land use (monoculture livestock) to another (monoculture arable),** without encouraging diversification into silvo-arable land use.

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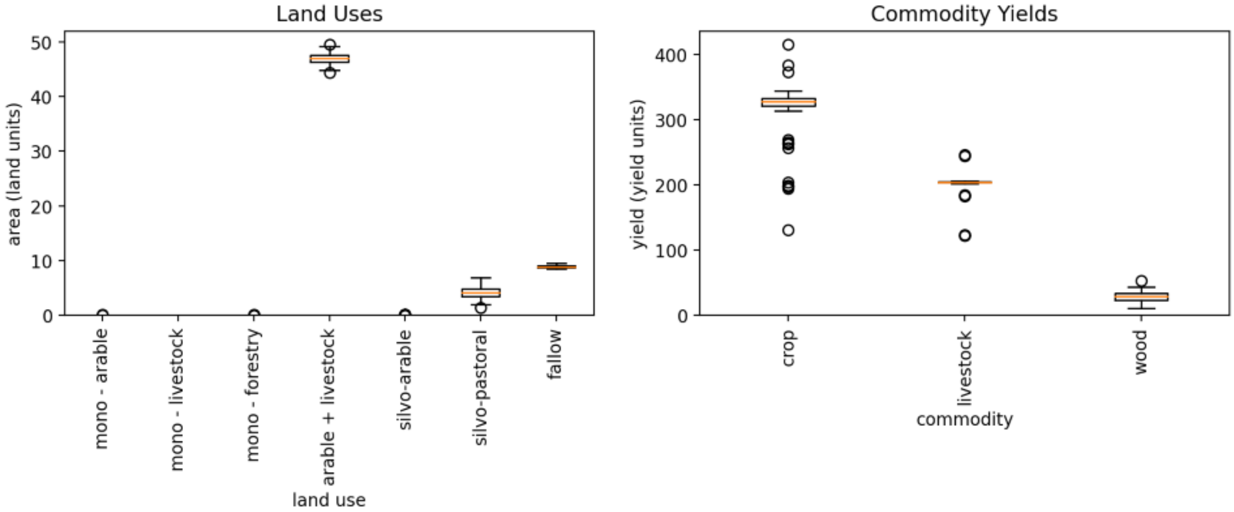

Figure 6: Distribution of land uses (left) and commodity yields (right) over 100 iterations, using 100 "standard" agents (see Table 1), for the "free range" policy scenario. Orange lines indicate median values, the box comprises 25th to 75th percentiles, whiskers indicate 5th and 95th percentiles, and circles indicate outliers.

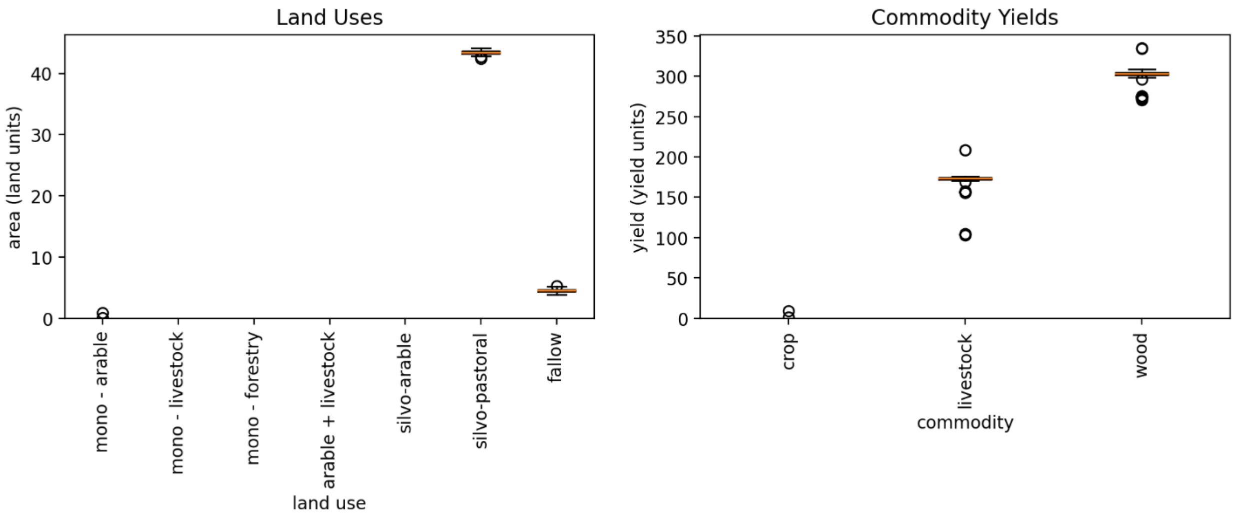

Figure 7: Distribution of land uses (left) and commodity yields (right) over 100 iterations, using 100 "standard" agents (see Table 1), for the "organic" policy scenario. Orange lines indicate median values, the box comprises 25th to 75th percentiles, whiskers indicate 5th and 95th percentiles, and circles indicate outliers.

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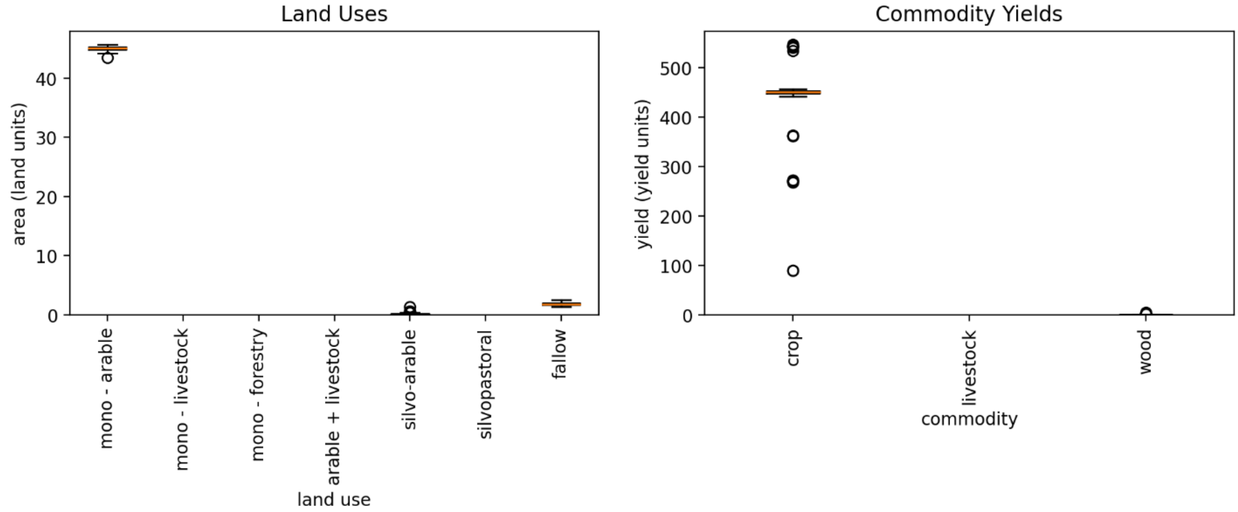

Figure 8: Distribution of land uses (left) and commodity yields (right) over 100 iterations, using 100 "standard" agents (see Table 1), for the "vegan" policy scenario. Orange lines indicate median values, the box comprises 25th to 75th percentiles, whiskers indicate 5th and 95th percentiles, and circles indicate outliers.

4.3.3.4 Impact of extreme policies – Results from three scenarios with 50% "enviro-social" and 50% "standard' agents

The above results, however, are obtained with one particular assumption, where all virtual agents belong to one agent type, i.e. all are "**standard**" agents. To analyse how different agent types affects analysis of policy scenarios, the same analysis comprising a baseline scenario and three extreme scenarios is repeated using a more diversified set of agents, i.e. 50 "standard" agents and 50 "**enviro-social**" agents (Table 1). The baseline scenario in this case no longer shows a single dominant land use, but instead sees three prevalent land uses (Figure 9, left). There still is a majority monoculture livestock land use, selected by the "standard" agents, but there also is a notable presence of silvo-arable, silvo-pastoral, and monoculture woodland land use, selected by the "enviro-social" agents. Correspondingly, all three commodities are produced in the region, with circa 80 yield units of crop, 230 yield units of livestock, and 140 yield units of wood (Figure 9, right).

In the "**free-range**" scenario, there is an increase in integrated arable-livestock land use as the "standard" agents shift away from the phased-out monoculture livestock (Figure 10, left).

In the "**organic**" scenario there is a subsequent shift to silvo-pastoral land use as integrated arable-livestock land use is also phased (Figure 11, left). However, the "free range" and "organic" policies do not affect the "enviro-social" agents, who still can opt for their preferred land uses (i.e. silvo-arable, silvo-pastoral, and monoculture woodland). In both these policy scenarios all three commodities are still produced (Figures 10 and 11, right), albeit with lower yield of livestock and increased yields of crop and wood relative to the baseline scenario.

The "**vegan**" scenario affects both sets of agents. However, whereas the "standard" agents shift to monoculture arable land use, the "enviro-social" agents replace their silvo-pastoral lands use to silvo-arable

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and monoculture forestry land uses (Figure 12, left). The region thus retains a diversified land use, and produces two commodities in abundant yields, with approximately 300 yield units of crop and 190 yield units of wood (Figure 12, right). Hence, the "vegan" scenario induces a different policy response in this analysis than in the preceding analysis as the different agent types seek different alterative land uses.

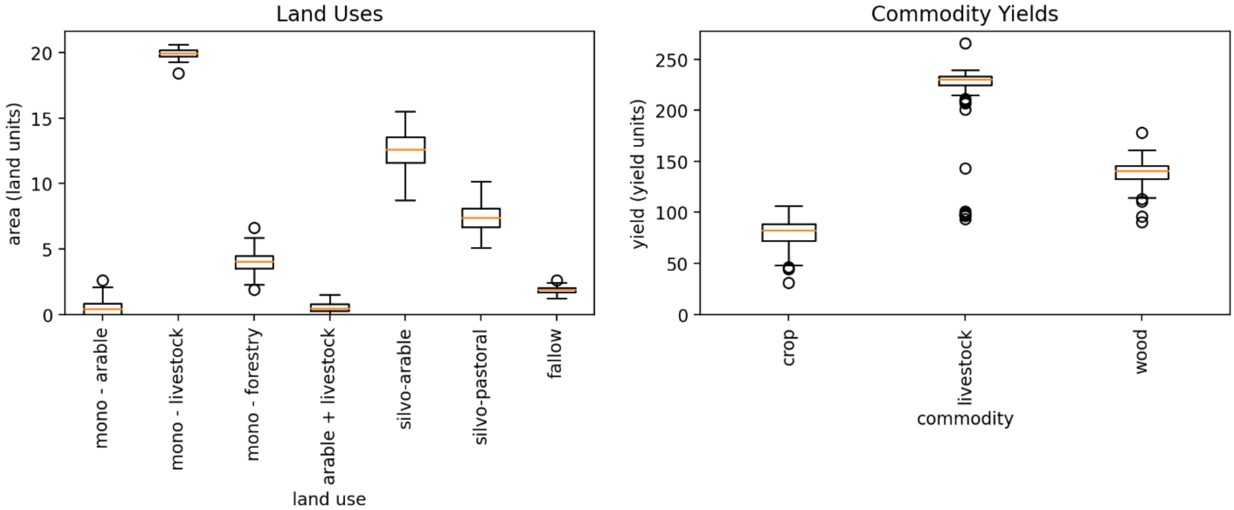

Figure 9: Distribution of land uses (left) and commodity yields (right) over 100 iterations, using 50 "standard" agents and 50 "enviro-social" agents (see Table 1), for the baseline scenario. Orange lines indicate median values, the box comprises 25th to 75th percentiles, whiskers indicate 5th and 95th percentiles, and circles indicate outliers.

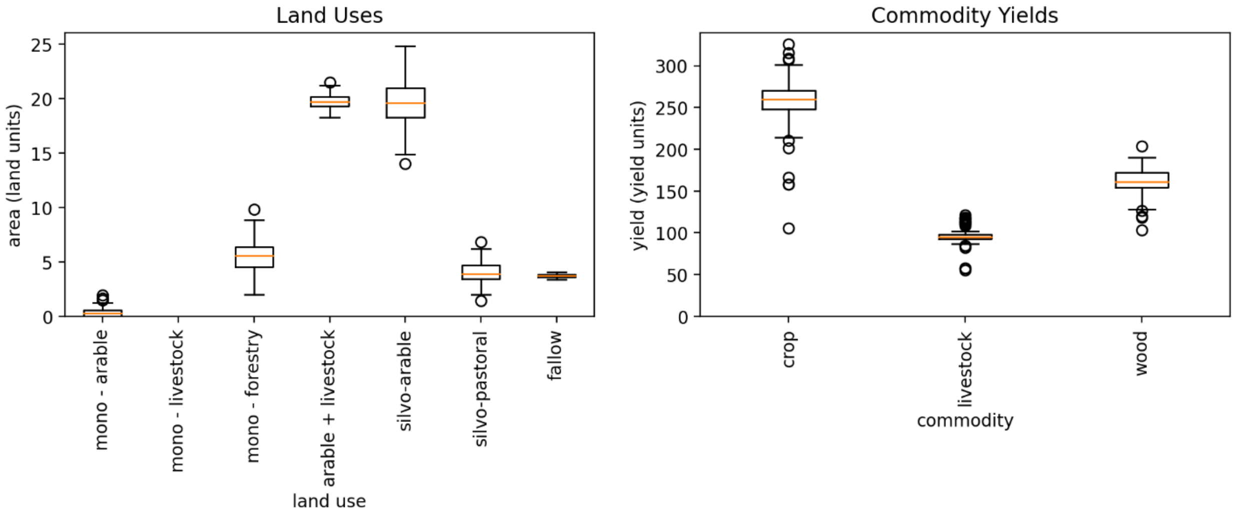

Figure 10: Distribution of land uses (left) and commodity yields (right) over 100 iterations, using 50 "standard" agents and 50 "enviro-social" agents (see Table 1), for the "free range" scenario. Orange lines indicate median values, the box comprises 25th to 75th percentiles, whiskers indicate 5th and 95th percentiles, and circles indicate outliers

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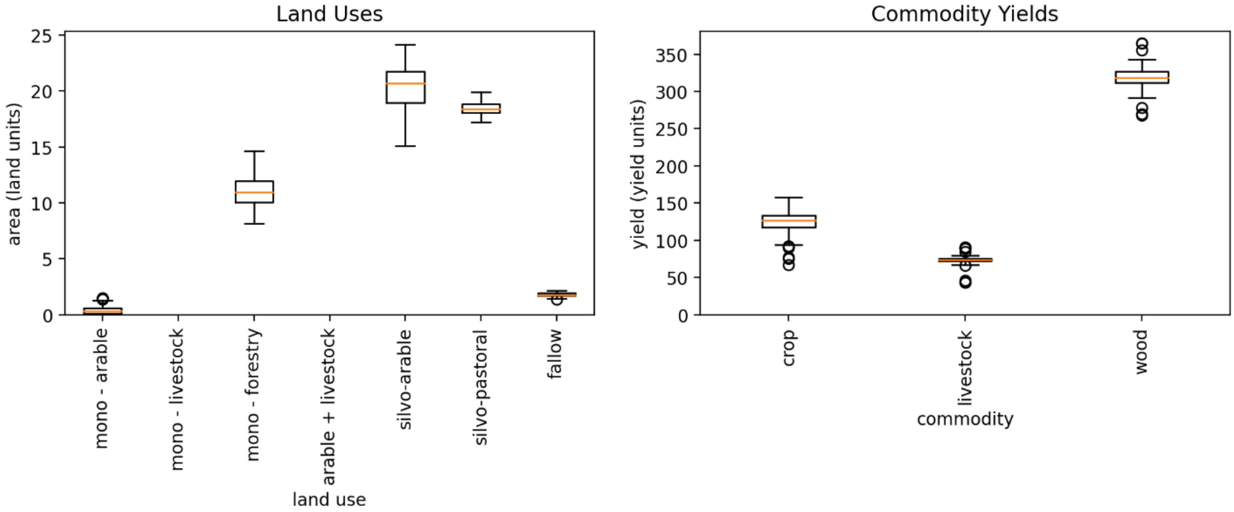

Figure 11: Distribution of land uses (left) and commodity yields (right) over 100 iterations, using 50 "standard" agents and 50 "enviro-social" agents (see Table 1), for the "organic" scenario. Orange lines indicate median values, the box comprises 25th to 75th percentiles, whiskers indicate 5th and 95th percentiles, and circles indicate outliers.

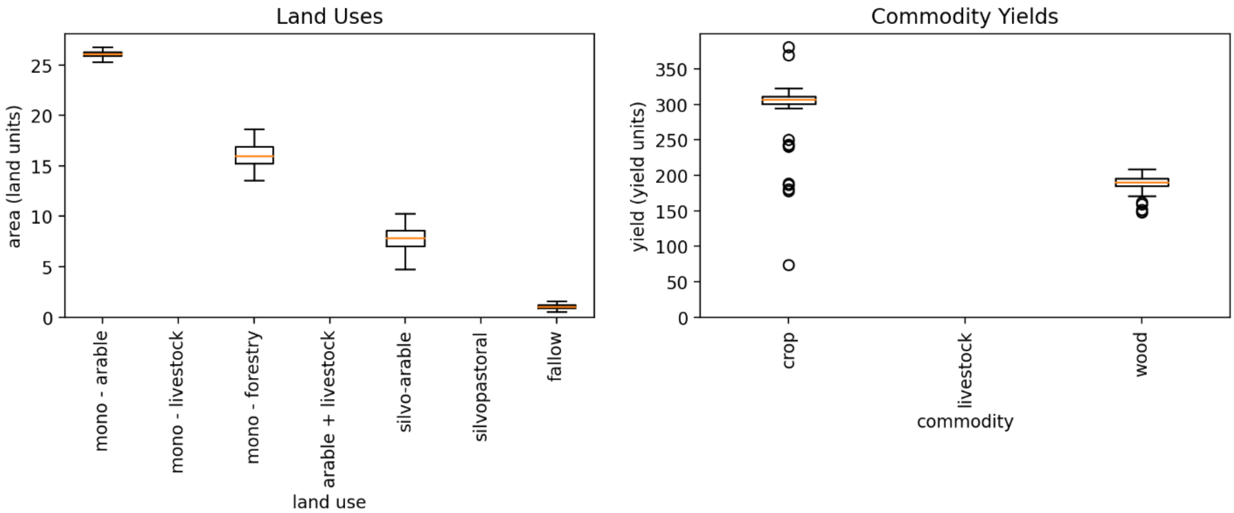

Figure 12: Distribution of land uses (left) and commodity yields (right) over 100 iterations, using 50 "standard" agents and 50 "enviro-social" agents (see Table 1), for the "vegan" scenario. Orange lines indicate median values, the box comprises 25th to 75th percentiles, whiskers indicate 5th and 95th percentiles, and circles indicate outliers.

These two preliminary analyses show how the AF/MF-ABM model can give insights as to how policy decision can impact in the land use allocations in a given region. Importantly, however, these analyses indicate that policy impacts depend on agent types, and that care must be taken in representing agents. Ideally, policy analyses are repeated for multiple configurations of agent types to assess robustness of anticipated policy impacts.

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4.3.4 Summary

A novel agent-based model, i.e. the **AF/MF-ABM model**, is being developed to explore the dynamics of farming land use allocation. The model integrates agents, land uses, commodities, events, and performance indicators to determine regional land use allocations. The model can be used to evaluate how different policy scenarios may affect land use allocation, and how resilient land uses are to external disruptions.

Preliminary results illustrate that the model predicts different regional land use allocations in response to agent configuration and policy scenarios. The model and any resulting insights are further refined following discussion with expert colleagues at our first in-person project meeting in Pisa in November 2022 and with the stakeholder feedback collected during the series of workshops in T6.3 and the T6.4 activities.

The model results suggest that beside incentives mechanism, farmer attitudes play a prominent role in explaining the uptake of sustainable faming system. This calls for a strong farmer led support, based on education and technical assistance to put sustainable transformation in place. Preliminary results therefore suggest a better understanding of the coherences among the different policy and education instruments.

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5 Policy scenarios for an agroecological transition – England

5.1 Overview of current policy

As detailed within D6.1, there is significant scope for change within the food and farming sector in the United Kingdom and equally in England. Leaving the EU has created a necessity and opportunity to rethink and reform how food is grown and distributed. The amount of literature on the subject continues to grow (Lang 2020; National Food Strategy 2021; Sustainable Food Trust 2022), yet actual change and progress is slow, due in part to lengthy bureaucratic processes and the uncertainties of devolution especially in the different nations of the UK.

Russia's invasion of Ukraine in February 2022 compounded some of the effects of the Covid-19 pandemic and there appears to be a renewed sense of urgency around food security in the UK and England, as well as questioning the normalisation of the 'just in time', globalised food system. Within this policy context, the current UK government has also committed to 'net zero' by 2050, which is extremely unlikely to be achieved without big changes in land use, including afforestation and agroforestry targets and reducing the amount of land being farmed (Committee on Climate Change 2020).

The UK government is responding to these changes, challenges and opportunities with new policies, namely, the Agricultural Bill (2020), which is planned to replace the CAP alongside a suite of **Environmental Land Management** schemes (**ELMs**) and the Environment Act (2021), with ambitious targets to reform agriculture and land use, restore biodiversity, sequester carbon and pay farmers 'public money for public goods'. The UK government however only set a framework, the agricultural policy in the UK is not common and devolved to the four nations: England, Northern Ireland, Scotland and Wales. Northern Ireland is however a special case as it is de facto in the EU common market to guarantee a borderless trade within the island of Ireland in a more unified policy environment.

Within the rest of the UK the **Basic Payment Scheme** (BPS), equivalent of the EU Pillar 1 payments, are being annually reduced and gradually replaced by ELMs. However, when writing (September 2022) **ELMs has been put on hold** and basic area payments are back on the table. This is in part due to the most recent shift in the UK government and the situation going forward is very much unclear. An additional factor is the **independence movement in Scotland** which, if successful would de facto end the UK and the union of the two kingdoms of Scotland and England. It is also likely Scotland will re-join the EU, having voted with nearly a 2/3 majority for remain in the EU. For these reasons we have used England as case study region in AGROMIX, as not being distracted by the unpredictable fate of the UK.

ELMs, if it is introduced, is planned to come in three tiers. The three tiers are: the Sustainable Farming Incentive (SFI); Local Nature Recovery (LNR); and Landscape Recovery (LR). Farmers will be paid to take more sustainable farming actions, provide more public engagement, or make large land use changes for nature and climate. However, there is limited to no detail on what these schemes will pay for and what the overall

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objectives these schemes are trying to achieve actually are (e.g., achieving net zero). But AF/MF provisions are mentioned within these documents. The recent Agricultural Transition Plan: June 2021 progress update (DEFRA, 2021), stipulates that ELMs will be fully introduced and open for applications by 2024.

Three recent reports by the National Audit Office, DEFRA Select Committee and Public Accounts Committee (PAC) state that progress of ELMs is too slow and fundamental elements are omitted. The Public Accounts Committee describes the situation as *"blind optimism"*, highlighting key gaps in DEFRA's approach: *"the Department has not established the metrics that it will need… We are not convinced the Department sufficiently understands how its environmental and productivity ambitions will impact the food and farming sector… the Department is not doing enough to support farmers through the transition to the new schemes…"* (House of Commons Committee on Public Accounts 2022, pg. 5 and pg.7).

There is also a lack of coherent policy for AF, detailed in D6.1. Prior to Brexit, the CAP Pillar II, Article 23 of the Rural Development Regulation 1305/2013 (Establishment of agroforestry systems), Sub-measure 8.2 provided for AF. However, this was left as an individual member state (MS) issue, which the UK declined to adopt. The England Woodland Creation Offer Grant (Forestry Commission EWCO Grant Manual 2022) offers support for the creation of new woodland via planting, payments and ten years of maintenance costs, but a minimum of 400 trees per hectare is required, which is too dense for most forms of AF. Funding can also be applied for under Measure 10 Agri-Environment Climate if the trees are being planted around sources of ammonia or as riparian buffers or on floodplains. The Countryside Stewardship schemes offers some AF related options such as pasture creation and single trees on farmland, despite AF not being explicitly mentioned. Given the lack of clear definition and policy for MF, the below section focusses on AF.

5.1.1 Advocates for agroforestry

Within this context, there is an ever-growing group of advocates for agroforestry (AF). Made up of civil society, farmers, academics and to an extent, the wider public, given the popularity of public tree planting initiatives. Yet, AF continues to be a little practiced form of agriculture and only makes up 3.3% of the UK's land use and **in England this is just 1.61%** (AGROMIX calculations based on LUCAS dataset from 2015). This lack of AF in the landscape is due to a range of different factors, which according to farmers are primarily a lack of conceptual understanding and knowledge, a lack of funding opportunities and grants and a lack of a whole farm economic assessment of AF practices (Organic Research Centre, 2021).

To develop and refine elements of the ELMs process, the Department for Food, Farming and Rural Affairs (DEFRA), has commissioned a range of **'Test and Trial'** programs to assess what the ELM scheme will include and how it will be implemented. Initially, AF was not included as a unique programme within ELMs but this has recently changed, with the implementation of a **specific ELMs Agroforestry test group** being coordinated by a consortium that consists of: The Organic Research Centre, The Soil Association, The Woodland Trust and Abacus Agriculture. This consortium has been tasked with providing information to DEFRA on preferred farmer payment mechanisms and guidance for increasing AF uptake post-Brexit. The new ELMs all have aspects of AF and woodland creation within them, but the lack of clarity of how these schemes will work on a practical basis means many farmers are likely to decide to hold off planting new trees (or other 'nature friendly' interventions) until the schemes and related funding is confirmed. The questioning of the recent new of ELMs in general, does add to the general uncertainty. On the positive side, all this means, that there

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is significant scope to affect the ways in which policy for AF is currently being developed in England. It is no understatement to say that the planned AGROMIX workshops in England in 2023 will come in one of the most turbulent and unpredictable times for the UK, and to a lesser degree also for England.

5.1.2 Existing models and policy recommendations for AF support

There is a growing evidence base and accompanying policy recommendations from AF advocates who are trying to embed AF within standard agricultural practices. Below we list the most pertinent and give a brief summary of their key outputs. Positions from these reports are incorporated into this reports' recommendations for England and experts are consulted and included in the up-coming policy workshop task, D6.3.

5.1.2.1 Soil Association and Woodland Trust

'Agroforestry in England: Benefits, Barriers and Opportunities' (2018) - a report summarising the multiple benefits for production, resilience and environment, along with four case studies, key barriers to uptake and subsequent policy recommendations. To a large extent, all barriers and policy recommendations remain relevant today, four years later, highlighting the slow pace of change in policy.

5.1.2.2 Organic Research Centre (2021)

'Incentives and disincentives to the adoption of agroforestry by UK farmers: a semi-quantitative evidence review' (Tosh & Westaway 2021) - an evidence review confirming that the ELM Test focuses on payment and advice and guidance for farmers considering AF systems. The report analysed 10 source documents: 4 quantitative surveys of UK farmer opinion, 1 quantitative survey of European farmers with UK-specific data, 1 interview study of European farmers with UK-specific data, and 4 non-quantitative expert reviews of published work on UK farmer opinion and attitudes to agroforestry. Potential incentives and disincentives were coded and organised, and the report confirms that economic/financial constraints and farmer knowledge base are the top factors for farmers.

5.1.2.3 The Landworkers' Alliance (2021)

'The promise of agroforestry: lessons from the field' (2021) - a broad report detailing 8 case studies of AF farms, key lessons for farmers and land managers and a concluding section on policy recommendations. Critically the report gives insight from farmer experiences, highlighting *"of all farmers surveyed here, no one regretted it, and everyone said they could see positive benefits. Everyone was planning or considering expanding (AF) onto further areas"*. The report suggests a two-to-three-year launch pad to develop the "where and when" to plant, to increase tree alleys up to 60-70% on agricultural land over the next 5 years.

5.1.2.4 Soil Association (2022)

'*Trees and woodland in the farmed landscape: a farmer-led approach towards a diverse, resilient and vibrant agroforestry and farm woodland economy for England'* (2022) - a briefing outlining the key findings from a collaboration between the Soil Association and Cumulus Consultants to understand the economic case for AF and farm woodland in England. An economic model was developed using partial budgets for five farm types (poultry, cereals, dairy, lowland grazing and less favoured area grazing) to estimate the change in net income if a percentage of the area of each farm type is changed to an AF or farm woodland system. A hypothetical scenario was developed (see Figure 13 below), whereby 355,000 hectares would be delivered through a farmer-led approach. The change in net income is modelled at an annual cost of £90 million. The authors note that this *"is a small fraction of the annual £1.6 billion currently spent on farm support"* (page 5). The briefing concludes with a set of policy recommendations to increase trees and woodland on farm with a focus on whole system planning and confidence building.

Farm Type	Total Farm type area (ha.) in England	Area of agroforestry or farm woodland based on %age allocation by farm type					Total farm type allocation (ha.)	Total change in farm type net annual income (£)
		Orchards	Silvoarable/ Silvopasture	Silvopasture (shelter only)	Shelterbelts	Mixed Farm Woodland		
Poultry – free range	11,314			@ 50% = 5657ha.			5,657ha.	+£16,971
Cereals	2,629,637	@1% = 26,296ha.	@1% = 26,296ha.		@1% = 26,296ha.		78,888ha.	-£9,782,112
Dairy	983,542		@5% = 49,177ha.	@10% =98,354ha.	@1% = 9,835ha.		157,366ha.	+£16,434,905
LFA grazing	1,190,402			@5%= 59,520ha.	@1%= 11,904ha.	@10%= 119,040ha.	190,464ha.	-£53,139,456
Lowland grazing	1,208,771		@5%= 60,438ha.	@5%= 60,438ha.	@1%= 12,087ha.	5%= 60,438ha.	193,401ha.	-£43,853,805
Total	6,023,666 ha.						625,776 ha.	£90,323,497
Overall woodland and canopy cover area		Total in-field agroforestry canopy area[2] = 115,851ha.			Total farm woodland area[3] = 239,600ha.			

2. Agroforestry systems assumed 30% canopy cover at maturity 3. Farm woodland systems assumed 100% canopy cover

Figure 13: Results from Soil Association's model, hypothetical scenario whereby 355,000 hectares of agroforestry are delivered at an annual cost of £90 million

5.1.2.5 Friends of the Earth (2022)

'Why we need more trees in the UK' (2022) - a recent report in response to the government's tree planting targets and environmental targets consultation, highlighting the role farming can play in integrating more trees into the UK's landscape. The report focuses on the role of the UK in global deforestation and the need to reduce timber imports (and increase domestic supply); trees for nature restoration, sequestration, health, timber and; the role of AF. It highlights the need for a land strategy in England and other nations, to ensure land is strategically used, balancing multiple needs and objectives.

5.1.2.6 Woodland Trust (2022) - upcoming

AGROMIX is in conversation with the Woodland Trust and, though not released yet, are aware of an upcoming report with regards to AF, along with an accompanying policy launch in November 2022.
As AGROMIX develops, the policy working group in England is staying connected to these organisations to facilitate knowledge sharing and movement building. We aim to include representatives from the above organisations in the subsequent task, 6.3, whereby the policy priorities discussed below will be taken forward. All of the policy recommendations from the above reports have been taken into consideration and where appropriate, included in this report.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

5.2 Scenarios for an agroecological transition and the role of agroforestry and mixed farming

The scenarios listed below in Table 4 are drawn from expert knowledge, current literature and the on-going development of the agroecology movement in the UK (see Section 5.1.2). The potential role of AF/MF is given, along with an assessment of which HLPE 13 principles for agroecology the scenario addresses, as well as which of the 5 levels of food system change the scenario matches up to on the so called "Gliessman levels" (2007). The first three levels describe the steps farmers can take on their farms for converting from industrial or conventional agroecosystems. Two additional levels go beyond the farm to the broader food system and the societies in which they are embedded such as social governance and the circular economy. See Figure 14 below which matches the FAO 10 Principles for agroecology with Gliessman 5 levels.

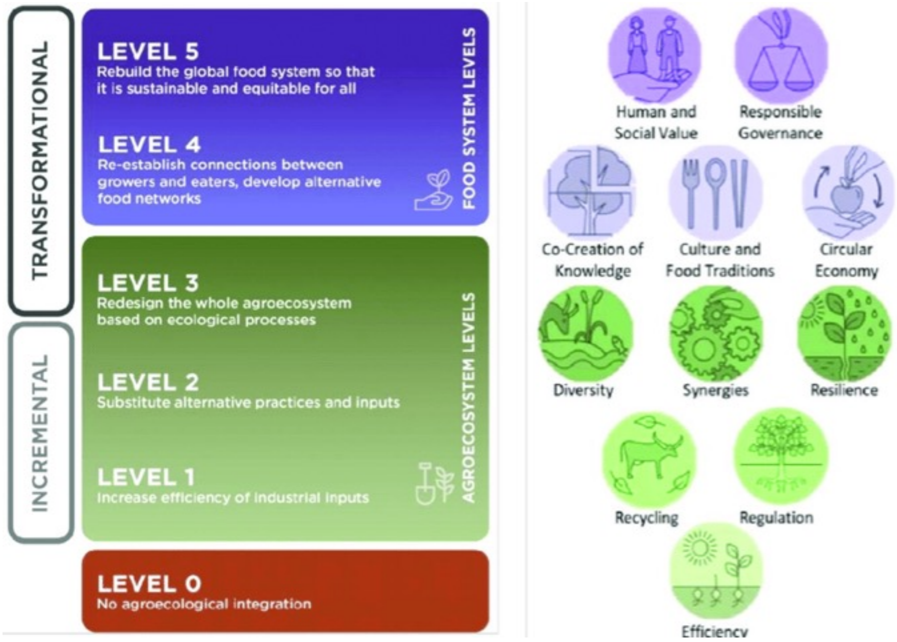

Figure 14: Conceptual framework of the 5 levels of food system transformation (Gliessman 2015) and the 10 elements of agroecology (FAO)

Both the HLPE 13 principles for agroecology and Gliessman 5 levels of transformation are also outlined by the European Partnership for Agroecology Living Labs and Research Infrastructures and hence provide a useful categorisation of AF/MF scenarios. These could be called a 'wish-list' of agroecological scenarios and highlights the role AF/MF plays in that. These scenarios will be further built on in the policy-workshops in T6.3. Some of these scenarios, listed in Table 4, can also be modelled in the ABM, which we discuss below as well as the recent Soil Association's model, details below.

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Table 4: Scenarios for an agroecological transition and the role of AF/MF

Scenario	Role of AF/MF within scenario	HLPE principle(s)	Gleissman levels 1-5
1. Phasing out all fossil fuel inputs	Effective design of AF/MF systems can be used for biomass (fuel), nitrogen fixing (fertilising) and habitat provision for beneficial biodiversity (pest control). Not enough evidence to suggest could replace all fossil fuel inputs, but blended with other inputs and systems	Input reduction Recycling Soil health Animal health Biodiversity Synergy Economic diversification	Levels 1, 2, 3 and 4
2. All landowners require 10% AF on their land	Incorporation of AF for all landowners	Soil health Synergy Land and natural resource governance	Level 2, 3
3. Re-establish common land for grazing	Improved access to common land would encourage MF, particularly for localised and regional food supply chains	Co-creation of knowledge Social values and diets Fairness Connectivity Land and natural resource governance	Level 4
4. All eggs to be woodland eggs	Legislate ban on all caged eggs and offer financial support and training for converting to woodland eggs	Input reduction Biodiversity Animal health	Level 3
5. Elimination of all intensive livestock production	Replace intensive production with MF/AF systems	Soil health Animal health Synergy	Level 3, 4
6. Community supported agriculture hubs around all urban areas, providing 10% of all food for cities from agroecological green belts	AF systems offer low input, diversified multi-strata growing conditions ideally suited to CSA type sites, inclusion of MF to diversify nutrition base, recycle nutrients and	Recycling Biodiversity Co-creation of knowledge Social values and diets Fairness Connectivity Participation	Level 4
7. Farm metric to change from yield per hectare to nutrition per hectare	AF/MF systems can increase both yield per hectare and nutrition per hectare by allowing the farmer to stack enterprises, as well as utilising more strata within farmed area. Trees can provide nutrition for both livestock and human consumption.	Fairness Land and natural resource governance Participation	Level 3, 4
8. 25% of farmed land organic	Both AF and MF systems provide beneficial environmental interactions which can work towards replacing in-organic inputs	Recycling Input reduction Soil health Animal health Biodiversity Synergy	Level 1,2,3
9. Increase tree cover and AF on common land, allotments, parks and public spaces	Growing opportunities for communities to manage woodlands and or AF systems in local areas for fuel and food provision, increased appetite for tree planting in urban areas for cooling effect	Soil health Animal health Biodiversity Social values and diets Fairness Connectivity	Level 3, 4

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		Land and natural resource governance Participation	
10. Focus on feeding the soil through regenerative practices, using cover/catch crops	The re-mixing of livestock and arable systems enables nutrients to be re-cycled back into the soil, improving soil quality	Recycling Input reduction Soil health Animal health Biodiversity Synergy Economic diversification	Level 1, 2
11. Re-establish trees in the farmed landscape, improving biodiversity, working towards net zero and improving water quality of UK rivers	Shelter belts, riparian buffers, hedgerows and other AF systems improve biodiversity, water quality and carbon sequestration rates at the landscape scale	Input reduction Soil health Animal health Biodiversity Synergy Land and natural resource governance	Level 3
12. Increase genetic diversity in crops and livestock	Re-mixing of systems encourages re-mixing of genetics; local breeds and varieties to be prioritised which is often central to MF/AF designs	Biodiversity Synergy	Level 2
13. Reduce wood imports by 40%	Potential for AF systems to incorporate high value timber products; comes with increased management costs	Biodiversity Economic diversification Fairness Connectivity Land and natural resource governance	Level 2
14. Improve current on farm tree management	73% of agroforestry and farm woodland in the UK is classified as woodland (i.e. not AF), commonly un-managed. Substantive potential to incorporate existing trees into farm enterprises through AF/MF systems	Soil health Biodiversity Economic diversification Land and natural resource governance Participation	Level 3
15. Dietary shift towards fewer and better animal products, more fruit, legumes and nuts with a focus on regional and seasonal production	Both AF/MF systems can provide regional and seasonal produce at scale, including greater supply of nuts, legumes and fruit as dietary changes become more necessary for net-zero	Economic diversification Social values and diets Connectivity Participation	Level 3, 4, 5
16. Improved animal welfare	Livestock benefit from being in proximity to trees for shade, shelter, browse and medicinal purposes	Input reduction Soil health Animal health Biodiversity Synergy	Level 3

5.2.1 Scenario modelling with agent-based modelling

For England, agent-based model (**AF/MF-ABM** as outlined in the previous chapter) is used, and this can also be based on land ownership. Land ownership data from 'Who Owns England' (Shubsole, 2019) is used, and

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this will represent our agents, based on type and land owned. Landowners are (hectare in brackets): Crown (184,732 ha), Church (70,820 ha), Public sector (1,098,060 ha), Conservation charities (257,345 ha), Companies in Great Britain and overseas (2,329,644 ha), Aristocracy and Gentry (3,884,986), "New Money" (new investors) (2,201,492 ha), and Homeowners with domestic homes and gardens (707,973 ha). To arrive at the total, the working assumption is that land that is unaccounted for is most likely represented by private farmers (2,214,442 ha).

In fact, the detailed study of this ownership data (a table is shown in the factsheet mentioned below and in the England Factsheet in the Annex) has let us develop an ABM model to contrast the approach taken in Brandenburg which does not include agents. By including ownership, and people employed, we attempt an agroecological food system approach to the question who, and where should agroforestry and mixed farming increase. We also include insight from the work by ORC on the ELMs Environmental Land Management scheme which is envisaged to replace the EU-CAP system by 2027 in England (this is not funded by AGROMIX but still useful for the model approach).

5.2.2 Scenario modelling with the Soil Association's model

Based on the scenario shown in Figure 13 we have developed a scenario with further increases in tree cover, increasing specifically some of the options:

- **Free-range poultry** can increase tree cover from 51% to 91% as poultry are woodland species and this can be realised with 10% orchards, 20% Silvoarable/Silvopasture. Silvopasture shelter remains as before but shelterbelts (as in others) and mixed farm woodland also increase.

- **Cereals** are too conservative they can be increased to 2% (even 3%) as this level of tree-cover is unlikely to limit the yield of crops, given the micro-climate and deep rootzone nutrient supply benefits.

- For **Dairy**, trees are already commercially beneficial and orchards (cider and perry but also peach, nuts and olives in the south of England) can be considered. Use of mixed farm woodland it set to at least 1%, this is too low as young stock can use wood pasture more easily, up to 5% is possible**.**

- **LFA grazing** (Less Favourable Areas = mountainous uplands) and **Lowland grazing** can also be increased with fruit and nuts, local varieties adapted to the climate and altitude.

The above scenario results in 429,924 hectare (ha) being available which is already above the target for 2050, which triggers the question: is the target too low? This shows that the model developed by Soil Association is flexible and can be used in the stakeholder workshops in addition to agent-based modelling, as it gives an easy-to-understand spreadsheet model and has all the main land use types in the UK covered.

Additional detail would be gained by adding **free-range pigs** and also **horticultural annual crops** (vegetables, herbs). Even perennial horticultural crops like mono-culture **vineyards**, **hops** and existing intensive **apple and soft-fruit (blackcurrant, raspberry, blueberry) orchards** could benefit from further agroforestry and mixed farming. As this land use types are small area in comparison to field crops, they are currently amalgamated

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with cereals or cropping in general. Adding further detail also from the ELMs test trial sites on horticulture would be useful in the policy workshops.

Farm type	ha	Orchards		Silvoarable/ Silvopasture		Silvopasture shelter only		Shelterbelts		Mixed Farm Woodland		Total (ha)	Total change in net annual	Change per ha net annual income (£)	Total
Poultry -free range	11,314			1%		50%	5,657					5,657	16,971	3	51%
Cereals	2,629,637	1%	26,296	1%	26,296			1%	26,296			78,889	-9,782,112	-124	3%
Dairy	983,542			5%	49,177	10%	98,354	1%	9,835			157,367	16,434,905	104	16%
LFA grazing	1,190,402					5%	59,520	1%	11,904	10%	119,040	190,464	-53,139,456	-279	16%
Lowland grazing	1,208,771			5%	60,439	5%	60,439	1%	12,088	5%	60,439	193,403	-43,853,805	-227	16%
Total	6,023,666		26,296		135,912		223,970		60,124		179,479	625,781	-90,323,497	-144	
Overall woodland and canopy co		In-field 30% over					115,853	Farm woodland 100% co			239,602		Total	355,456	ha

Farm type	ha	Orchards (fruit & nuts)		Silvoarable/ Silvopasture		Silvopasture shelter only		Shelterbelts		Mixed Farm Woodland		Total (ha)	Total change in net annual	Change per ha net annual income (£)	Total
Poultry -free range	11,314	10%	1,131	20%	2,263	50%	5,657	1%	113	10%	1,131	10,296	16,971	2	91%
Cereals	2,629,637	2%	52,593	2%	52,593		0	1%	26,296	1%	26,296	157,778	-9,782,112	-62	6%
Dairy	983,542	2%	19,671	5%	49,177	10%	98,354	1%	9,835	1%	9,835	186,873	16,434,905	88	19%
LFA grazing	1,190,402	1%	11,904	1%	11,904	5%	59,520	1%	11,904	10%	119,040	214,272	-53,139,456	-248	18%
Lowland grazing	1,208,771	2%	24,175	5%	60,439	5%	60,439	1%	12,088	5%	60,439	217,579	-43,853,805	-202	18%
Total	6,023,666		109,474		176,375		223,970		60,237		216,742	786,798	-90,323,497	-115	
Overall woodland and canopy co		In-field 30% over					152,946	Farm woodland 100% co			276,979		Total	429,924	ha

Table 5: Scenarios based on Soil Association's model shown in Figure 13

Further information on agents and land ownership in England is already formatted as EIP-style factsheet called "Agroforestry: an agroecological transformation of England's landscapes - Policy scenario co-design" and this is be used in workshops and is attached in the annex as:

FACTSHEET Agroforestry: an agroecological transformation of England's landscapes - Policy scenario co-design

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6 Policy scenarios & modelling for an agroecological transition – Germany

6.1 Overview of current policy

In recent years no policy support or legislative framework existed for agroforestry in Germany. With the upcoming programming period however, this is going to change. Germany has included the maintenance of agroforestry systems as one of their eco-schemes with a payment of 60€/ha of wooded area (BMEL, 2022). Additionally, Germany is planning to offer investment aid through the framework for improving agricultural structures and coastal protection. Some federal states have also announced to provide funding for implementing agroforestry, for example Brandenburg. How these funding option will be coordinated between the federal government and the federal states is not yet clear (Albrecht, 2022), neither are their financial details. Germany is also implementing a legally binding definition for agroforestry (BMEL, 2022).

6.2 Scenarios for an agroecological transition and the role of agroforestry and mixed farming

The policy scenarios for Germany consist of different funding schemes described in Table 6. Since there has been critique that the eco-scheme payments for agroforestry are too low (Günzel 2021; Tsitos and Compagnon 2021) scenarios are included where the eco-scheme payments are doubled and tripled. The AUKM1 and AUKM2 scenarios are based on a proposal from the project SIGNAL, where for the first 7 years of establishment the farmer would receive 1,546€/ha wooded area, and for the years 8 to 14 a total of 787€/ha wooded area (Böhm et al., 2020). Whether this will be the investment aid available in the upcoming programming period is unclear. It's function here is to contrast the relatively low eco-scheme payments and to see if high initial financial support will be sufficient to make agroforestry an economically attractive land use option for farmers. While economic viability is not the only motivation for farmers to consider adopting AF, it is especially important in regions where farmers are already operating on very slim profit margins as it is the case in Brandenburg. This is due to the relatively poor soil quality in the state combined with low precipitation during the vegetation period which makes Brandenburg a relatively dry region, a fact that has been exacerbated in recent years through severe summer droughts.

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Table 6: Policy Scenarios for Germany

Scenario	Description
Baseline	No grants
CAP23	Direct payments (156€/ha) + eco-scheme (60€/ha wooded area)
Eco_double	Direct payments (156€/ha) + eco-scheme*2 (120€/ha wooded area)
Eco_tripple	Direct payments (156€/ha) + eco-scheme*3 (180€/ha wooded area)
AUKM1	Year 1-7: Direct payments (156€/ha) + investment aid (1,546€/ha wooded area) Year 8-24: Direct payments (156€/ha) + eco-scheme*1.5 (60€/ha wooded area)
AUKM2	Year 1-7: Direct payments (156€/ha) + investment aid (1,546€/ha wooded area) Year 8-14: Direct payments (156€/ha) + investment aid (787€/ha wooded area) Year 15-24: Direct payments (156€/ha) + eco-scheme (60€/ha wooded area)

Policy modelling for agroecological scenarios (Results from the AgroForstRechner)

The work on expanding the AFR in its Python script is still ongoing, especially the extension for policy modelling as well as updating input data. There are however some initial modelling results that can be shared here which were produced using the AFR Excel version with input data from 2016. Here, the percentage AEVs (annual equivalent value see detail in method section) for poplar short rotation alley cropping were compared to those of pure arable farming without tree components in the five agricultural zones in Brandenburg and over four different alley width (which correspond here to a specific area share since the AFR is not spatially explicit). The five agricultural zones in Brandenburg represent different soil qualities, with zone 1 containing the most and zone 5 containing the least fertile and therefore productive soils. Table 7 depicts these results. The final rotation occurs after 24 years and trees are harvested every 4 years. The tree density in the wood strips is 8000 trees/ha and alley width are set at 24 m, 48 m, 72 m and 96 m. They are based on the maximum operating width of plant protection sprayers and have found application on experimental plots in the region (Emmann et al. 2012; Böhm et al. 2014; Kanzler et al. 2019). The pure arable production is set as the basis for comparison (100%) and the performance of the AFS are measured against this.

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Table 7: Modelling results for baseline calculations using the AFR Excel version, with different alley widths (AW) and showing the AEV (annual equivalent value) as proxy for profitability in five different agricultural zones (I-V with I best soils and V least fertile) over a 24-year rotation. The AEV is a percentage of 'pure' or mono-cropping arable farming

AEV (%)	**Agricultural Zones**	**Average over all AW**	**24m AW**	**48m AW**	**72m AW**	**96m AW**
AEV in percentage (%) of 'pure' arable farming over a 24-year rotation.	**Average**	**85.05%**	**78.58%**	**84.96%**	**87.83%**	**88.83%**
	I	88.31%	83.80%	89.27%	89.66%	90.51%
	II	86.96%	80.54%	87.30%	89.57%	91.42%
	III	84.99%	81.58%	82.44%	87.44%	88.48%
	IV	79.02%	66.91%	78.67%	84.60%	85.89%
	V	63.26%	44.56%	62.64%	71.79%	74.03%

Table 7 shows that in all agricultural zones and for all alley widths the profitability of AF is below that of pure arable farming. The lower the area share of trees (i.e., the larger the alley width), the closer in economic performance are AFS to arable farming. In agricultural zone 5 (V) which includes the least fertile soils AF has the largest discrepancy to arable farming because of the low yield potential for poplars. If the yield potential for poplars is higher, like in agricultural zones one and two, the profitability is also modelled to be closer to that of pure arable farming. The highest AEV (91.4% as highlighted in table 7) is modelled for agricultural zone 2 (II), and not zone 1 (I) as might be expected. This is for an alley width of 96 m and with higher wood prices this scenario could become quickly the first to become more profitable then mono-cropping arable.

However, these results are based on price and yield data from 2016 and with the ongoing work in task 6.2 the goal is to provide further updated calculations as well as a **sensitivity analysis** with different wood chip prices. Given the current energy crisis in Germany prices for wood chips have increased sharply, as demand has risen, which will likely have a positive effect on the profitability of AF with energy wood in the future, providing an incentive for farmers to adopt this land use system. This sensitivity analysis will also be done for the policy scenarios detailed in Table 6 and the stakeholder feedback in task 6.3. Results for this policy modelling are still forthcoming and will be part of upcoming academic publications.

6.3 Policy priorities

For modelling purposes, the policy scenarios in Germany will focus on different financial incentives for farmers. While other policies like the nitrate directive will undoubtedly also impact land use and the relative attractiveness of agroforestry systems, these impacts are indirect and hard to predict or measure. Therefore, only policies that directly impact on the financial viability of agroforestry are considered. This includes payment schemes that already exist or are programmed in the new CAP, but also payment through a

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potential commodification of ecosystem services or carbon sequestration. A sensitivity analysis will be conducted to understand the impact of different variables like the discount rate, prices for agricultural and tree products and input prices like nitrogen or fuel. By varying these costs and prices it is possible to approximate (indirect) effects of other polices. This can be done by for example setting prohibitive prices for external farm inputs to simulate a phasing-out of e.g., N fertiliser or pesticides.

Further information is already formatted as EIP-style factsheet called "Agroforestry for Germany: adaptation and mitigation of climate change and environmental externalities" and this is be used in workshops and is attached in the annex as:

6.3.1.1 FACTSHEET Agroforestry for Germany: adaptation and mitigation of climate change and environmental externalities.

An additional seventh EIP-style factsheet is available for Germany with details from the federal state of Rhineland-Palatinate. This is called "Agroforestry: Benefits, costs and options for political support in Rhineland-Palatinate, Germany - policy scheme co-design" and this is be used in workshops and is attached in the annex as:

6.3.1.2 FACTSHEET Agroforestry: Benefits, costs and options for political support in Rhineland-Palatinate, Germany - policy scheme co-design.

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7 Policy scenarios for an agroecological transition – France

In this section we discuss opportunities and policy needs to enhance Agroforestry in France

7.1 Methodology

This part was written using literature resources (see reference links at the end of this chapter) and after conducting 8 expert interviews with a diversity of actors, most belonging to the French Agroforestry network:

1. Advisor from the Drome Chamber of Agriculture, conducting training sessions on agroforestry systems in free range poultry production in the South East of France
2. Engineer of the French Technical Poultry Institute (ITAVI), conducting research projects on Agroforestry systems in poultry farming in the South West of France
3. Engineer of the French Technical Ruminant Institute (IDELE), conducting research projects on Agroforestry systems in the ruminant sector in the North West of France
4. Manager of Agroof, a firm of Agroforestry consulting (all productions)
5. Project manager at the Permanent Assembly of the Chambers of Agriculture (APCA), specialised in Agroforestry
6. Three researchers of INRAE (French National Research Institute for Agriculture, Food and Environment): Two from the Eco-development unit, conducting research on all types of Agroforestry systems and one from the Diversified Agrobiosystems unit, conducting research on silvopastoralism, ruminant and poultry.

7.2 Diversity of AF systems

Starting with the AGFORWARD project' s definition of Agroforestry and including the ones from the FAO and AFTA, the French Agroforestry Rural Network proposed a definition which was clarified to classify different kinds of Agroforestry systems:

- Field-orchards/vineyard
- Hedges
- Groves
- Intra-plot Agroforestry
- Wooded meadow
- Pastured forest

These systems can be applied either to silvopastoralism or silvoarable systems (except for pastured forest which only concerns silvopastoralism systems).

Silvoarable agroforestry was commonly used in the past but was slowly abandoned for mechanisation and parcel size purposes. However, it is slowly reimplemented to increase productivity and to adapt agriculture to climate change in multiple sectors: cereal, vegetables or aromatic plants.

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In Provence-Alpes-Côte d'Azur region, silvoarable field orchards systems are getting popular in the new generation of farmers with the implementation of fruit trees in vegetable growing plots, allowing an income diversification for direct sales. These systems are extensive and represent only a small part of vegetable growing agriculture (surface wise) but the dynamic is strong.

Silvopastoralism is quite developed in France. In the **ruminant sector**, hedges are often present on the outline of pastures, even though withering and/or uprooting is commonly observed. Pasture in wooded areas more or less dense also occur at a regular basis. Intra-plot agroforestry however is quite recent in the sector. With climate change, the interest is rising to bring shelter to animals from the heat. Also, research is currently studying the use of foliage as fodder even though at the moment, the low productivity of trees limits the use of this practice.

In **free-range poultry production**, agroforestry development started twenty years ago to encourage animal exploration of the outdoor run, animal welfare and the image of free-range production. Although individual actions were taken by some farmers, agroforestry development was mainly driven by specific production companies (one in Britany/Pays de la Loire and one in the Auvergne region). Other actors included agroforestry in their PGI (Protected Geographical Indication) specifications but at a low level (20 trees/ha) as it is not seen as essential. As a result, the development of agroforestry in poultry production has been uneven in France. Currently, the fattening duck inter-branch organisation CIFOG stated in its sector's objective plan to have agroforestry in 100% of the outdoor run by 2025, but failing to detail what level of agroforestry is expected by farm (number of trees or linear meter of hedges). Also, agroforestry is being developed more commonly in the whole French territory to counter heat waves which have high consequences on animal welfare. Moreover, while up till now agroforestry was implemented in free range poultry production, the opposite is also appearing. Introducing poultry in orchards to help managing grass growth, add fertiliser and help with pest management. If this development of agroforestry systems is encouraging in poultry production, the sanitary situation (Avian Influenza) is a major drawback: agroforestry isn't the priority, animals have been kept inside from November to March these last couple of years and mixing fruit trees and poultry complicates heavily the respect of biosecurity measures.

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Figure 15: (L) Nut trees implemented in poultry outdoor run to bring shelter from heat and add economic value. (R) Free range laying hens introduced in an apple orchard to increase biodiversity, manage grass and add fertiliser. Copyright ITAVI

In **pork production**, agroforestry is mandatory in certain specific free-range productions (*porc noir de Bigorre, cul noir du Limousin, baron des Cevennes*) but it represents less than 1% of the national pork production. Outside those specific productions, agroforestry in free range pork production is quite rare and is just beginning to appear.

Figure 16: Newly implemented agroforestry system in organic free range pork production to bring shelter and feed. Copyright ITAB

The most common silvopastoralism systems are applied on farms where the animals and wooded land both belonging to the farmer. Other less commonly used agroforestry models are growing but still represent a small fraction of agroforestry practices and receive few political supports. **Eco-pastoralism** is a mixed farming cooperation of two farmers: a shepherd sending his animals grazing on a fruit-grower's 'orchard' or vineyard. This allows more grazing surface for the animals and helps with grass growth and pest management in the orchard. A contract is made between the two farmers but practicalities issues limit the development of this practice: e.g. last minute request for pasture, damages to fruit trees. Finally, **eco-pasturage** consists of a

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shepherd sending his animals grazing in non-agricultural areas (like rural forests or urban hospital/museum parcs). These are a new emerging farming models which have yet to be developed further. Indeed, there is limited literature on the subject and tools (online platform for example) lack for linking farmers to cooperate on the subject.

7.3 Overview of current policy

Agroforestry systems have been encouraged by European, national or regional policies. Direct funding of agroforestry development has occurred mainly at a regional level. For example, in Auvergne-Rhône-Alpes region, through the poultry sector plan, seedling, plantation and protection equipment and advice for implementation was funded at 40% since 2018 for implementing trees in poultry outdoor runs. In the Nouvelle Aquitaine region, through the competitiveness plan, a rate of 16 € per seedling with protection was offered for the development of agroforestry on pastures (any type of animal production). Also, a national program occurred in 2021/22 "Let's plant hedges" which, through the regions, funded the plantation of hedges and provided advice (rules of financing depending on the region where it was deployed). These regional subsidies are currently being revised and are going to be more oriented on climate change (mitigation or adaptation), giving an opportunity for agroforestry systems to expand. For example, in Auvergne-Rhône-Alpes, a new program (EAFRD and regional funds) will be launched in 2023: "Cooperation for the development of Agroforestry, hedges and rural trees". This program will fund collective agroforestry multiyear projects: seedling, plantation and protection equipment (as the previous funding plan) but also management advice after implementation insuring sustainability of those systems. Moreover, the funding will provide 80% of expenses (40% in the last plan). This new agroforestry plan shows the political will to develop agroforestry systems in the Auvergne-Rhône-Alpes region but similar programs in other regions are yet to be developed.

At a national level, free-range 'Label Rouge', Protected Designation of Origin (PDO) or Protected Geographical Indication (PGI) poultry productions are obligated to have a certain amount/surface of trees in the outdoor run. Other policies do not fund directly implementation of agroforestry systems but intervene indirectly throughout more global environmental measures:

- Under the CAP, aids are conditioned throughout green payment occurs if farmers maintain or establish areas of ecological interest (including trees and shrubs) on the equivalent of 5% of its surface in arable land (green payment), or the maintenance of hedges (good agricultural and environmental conditions)
- Rural development regulation, agro-environmental and climatic measure: plantation of intra parcel trees, hedges
- Group of farmers recognised by the State who commit to a multi-year project to modify or consolidate their practices: agroforestry is eligible
- Low carbon label: agroforestry can contribute to a carbon credit action plan
- Funding for *Trame Verte et Bleue*: network made up of terrestrial and aquatic ecological continuities identified by regional schemes of ecological coherence

Other organisations are beginning to fund agroforestry systems: water agencies, national company of the Rhône, etc. In the research sector, funding (European, national or regional) is being more and more oriented

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towards climate change including agroforestry systems. For example, in Auvergne-Rhône-Alpes region, 50% of agricultural research funding is oriented towards climate change.

7.4 Scenarios for an agroecological transition and the role of agroforestry and mixed farming

TYFA (Ten Years for Agroecology) is an agroecological scenario for Europe in 2050 conducted by Iddri, a French institute, with an emphasis on climate challenges, that gives some clue for policy makers on the potential consequences on farming, food, environment via a modelling exercise. The hypotheses are fertility management at territory level, abandonment of pesticides, extensification of vegetal production and livestock production (organic agriculture as a reference), redeploying of natural grasslands, adoption of food regimes more balanced on a healthy point of view. In this scenario, re-diversification of production systems and landscapes (including agroforestry and crop-livestock systems) are a cornerstone, but in combination with other agroecological practices.

In France, a plan for agroforestry was conducted during the period 2015-2020 to develop these practices. The different measures proposed are still relevant to be extended and will be source of inspiration for the further recommendations.

7.5 Agroforestry in France - Strength and Weaknesses

7.5.1 Strength and benefits of AF

Hedges and trees have many functions, economic and ecological. For the farmer, it leads to an economic diversification, providing a larger range of products (production of wood, fodder, berries/fruits, energy, materials…). Trees also represent a capital that can be transmitted to the following generations. Trees and hedges can provide several agro-ecological benefits when considering the interactions with the crops, or with the animal production. For the crops, it can improve soil fertility (by the roots and leaf-litter) and water and nutriments supply (thanks to the deep roots), leading to better productivity, moreover the auxiliaries hosted can provide biological pest control and consequently reduce phytosanitary treatments. For animal production, it can improve the animal welfare (by the shade provided and the wind reduction generated) and also the animal performances (the leaves can provide additional feed). For eco-pastoralism and eco-pasturage, these practices provide the shepherd with extra pastureland and in eco-pastoralism it helps the fruit/wine grower to control sodding in the orchard or contribute to landscape/green areas maintenance. From an environmental point of view, both systems can contribute to higher biodiversity (it creates a semi natural habitat that can provide a shelter for various species), climate change resilience (adaptation and mitigation), carbon storage, microclimatic regulation (wind breaker, cooler environment), water regulation (run off protection and floods control by soil conservation measures) and soil erosion control (by the soil cover). It can also contribute to forest fire prevention (less flammable material on the forest floor). For the society, it contributes to societal services as maintenance of the rural landscape, aestheticism, and it can create related jobs.

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7.5.2 Weaknesses of AF

We can distinguish weaknesses and barriers for the development of AF at the farmer level and at the environment level (AKIS, politico-regulatory and funding mechanisms).

7.5.2.1 At the farmer level

- Economic: cost of planting, long return on investment (outside of a logic of patrimonial investment), economic viability not clear but often low (apart from fruit trees where the selling of fruits can bring an economic return) but farmers don't want to change practices if not economically viable,
- Social: workload of maintenance of trees and hedges (difficult for livestock keepers not available in winter period), administrative burden-work for funding access, time spent on/devoted to AF considered as unproductive time,
- Operational: mechanisation difficulties for intra-parcel AF and hedges,
- Psychological -cultural: in their mental representation/perception, trees are pretty but seen as "useless" and complicated to handle. During decades (after the 2nd WW), farmers were used to have and gave priority to large parcels without trees/hedges that were considered unproductive. There is also a social pressure between farmers not to bother anymore with trees. And we can note also a bias/belief that trees attract wildlife animals,
- Cognitive: lack of knowledge and awareness on the local adapted practices and benefits of AF (loss of know-how within one generation),
- Technic: lack of available figures/references on the benefits of AF, apart from the general advantages put in emphasis, lack of elements on predation, lack of elements on pests (trees could be the habitat for crop pests also, not only for beneficial species)

7.5.2.2 At the environment level

AKIS: In AKIS organisms (as for farmers), they faced also a lack of interest on AF and consequently a loss of knowledge, after the 2nd WW and the "productivist period", but there is a recent new interest on these systems that are considered as agroecological practices and systems; At the knowledge level, there is a lack of research on adapted crops, lack of knowledge and local references on adapted systems (large diversity of forms of AF) and their performances (indicators of viability calculated generally on a single production and not systemically/globally), lack of available figures/references on the benefits of AF (for examples, the consequences on the performances of livestock, compared to a reference without trees with more heat), apart from the general advantages put in emphasis, to catch the attention and convince farmers, lack of concrete experiences and feedbacks, gap between research and reality, lack of pragmatic guidelines for poultry keepers when designing their buildings and wooded outdoor runs (in their shift to ban cages), taking into account landscape aspect also ; the pioneer demonstrator AF farmers are generally very atypical (and often activist) so it is difficult for them to be inspiring (and leader) for other medium farmers. At the organisational level, lack of extension services on AF, AKIS including extension and training organised in silo on animal production or on arable crops or on perennial crops, but recently rise of specialists in AF in advisory services either in chambers of agriculture and private extensionists but they faced a quick turnover of their advisors that leads to a lack of expertise and know-how.

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Policy funding: complex (diverse instruments, complex calculation mode of wooded eligible surfaces depending on number, density, width of trees…) and heterogeneous access to funding (depending on the regions, all the measures are not activated) not really indicative, and constraining (eco-conditionality aids restricted to certain species - for example fruit trees are considered in CAP as productive crops but not timber trees -, aids restricted for certain forms of AF - hedges, intra-parcel AF-, agroecological infrastructures aids are very strict on the maintenance conditions and the tree cover : no freedom for farmers to change, move it or and adapt it, so fear of sanctuarisation of the existing hedges that can discourage farmers), moreover even if the plantation/AF installation can be supported in some cases, the maintenance of AF and support/advice is rarely subsidised. The complexity of the setting up of the application forms for CAP aids is also an administrative barrier (too important compared to the low gain). The potential loss of ICHN aids is a barrier for livestock keepers settled in mountain areas (considered as less-favoured areas) that have cooperation with a fruit-tree grower in a plain region when they leave their zones to go and pasture their parcels.

Regulatory: complexity of the framework (multi-layers), soil tenure, tree status and rights, securitisation of the relationships between owners and renters/leasers, fiscal measures, fruit trees are considered in CAP as productive crops but not timber trees, vineyards management is very complex because they have to be in conformity with different regulations about customs (export), INAO (office for quality labels), FAM (funding agency): for example there is a risk of loss of aid if vines are uprooted and replaced by trees.
Sectoral: lack of outlets/markets (for tree pruning products, mainly in rural remoted areas, farmers gave it free, they don't know what to do with this huge quantity), lack of economic valorisation of tree products; low value of timber wood or wood energy (very different compared to agrovoltaism).
Conjunctural, during a sanitary crisis: difficult to project on poultry outdoors run (as poultry have to be confined in buildings), not the priority during influenza sanitary crisis (biosecurity respect);
Animal health: free-range pigs need extra double-fencing to protect from wild boar, if present in the territory.

In case of eco-pastoralism, cooperation between two farmers with very different production is complex to implement: bringing complementary people together, formalising an agreement between the two farmers, timeframe organisation, potential fruit tree damage by animals. And it is difficult to identify the good structure that can play the role of intermediary between two complementary farmers, that can help on organisational, technic (for example a suitable pesticide) and regulatory aspects (legal insurance…) and on the equity of the exchange (sometimes the benefits are not balanced, so it is important to help determine a fair price for the service considering the costs implemented by each part and the resource saving). The actual CAP measures have to be adapted to this new collective arrangement that emerges.

7.6 Recommendations for policy measures to develop agroforestry

The leverages actions and recommendations are mainly at the environment level:

1. Actionable knowledge production and dissemination (making it visible, accessible): R&I on shade varieties selection, elements on predation, elements on C sequestration, local techno-economic references on adapted practices and validated benefits/interests (factsheets) but also tools, as decision support tools, serious games to design and assess different scenarios with stakeholders, demonstration

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and promotion of good practices via reference parcels and pioneer farmers implementing AF in concrete real conditions (farmers trust other farmers, better to have as a demonstrator a medium farmer not too much atypical in whom another farmers can be inspired from), network of references farms to collect and analyse data on specific aspects where there is a lack of references: e.g. potential Carbon stock, economic viability.

2. Education and training on AF: training on observation capacity and local adaptation of AF practices, a special attention is needed on this aspect to change the mentality and consider trees and hedges as productive crops, so a means is to restore the culture of the tree, which was somewhat lost in the previous generation, in the agricultural high schools.
3. Extension / technical support: training of advisors on technical and regulatory aspects specific to AF, adaptation of the arguments to the different profile of farmers (to convince of the interests of AF), viability indicators of mixed systems based on the interactions between the components of the systems, focus on collective advice, incitation to collective action (pooling human resources for maintenance of AF/hedges). On the organisational side advisory services have to pay better their AF advisors to keep them longer.
4. Coordination between AKIS (Agricultural Knowledge Innovation System) actors on AF: national network.
5. Equipment: facilitate the provision of equipment as shredder, or the delegation of certain arduous tasks as hedge maintenance by using CUMA (cooperative for the common use of agricultural equipment).
6. Political-regulatory-funding: accessible and simple, coherent between different policies, ambitious with a real vision at long term. Some aspects have to be consolidated for the eligibility of CAP aids linked to production (production rights): the eligibility of tree parcels needs to be reinforced (simplification of the calculation mode for wooded eligible surfaces, flexible in time in the eco conditionality, IGN-OFB have now a spatialised inventory/observatory of all hedges in France on which to build), and a global and unique support for plantation for any form of AF (hedges and intra parcel AF) is required (not different aids on different forms of AF and conditions), the national program “let’s plant hedges” has recently inventoried (and harmonised?) all existing various instruments (public and private, on hedges and on intra parcel trees, in all regions, some targeted on biodiversity…) on planting aids. For example, an incentive measure is currently lobbied at AuRA (Auvergne-Rhone-Alpes) region level for EU’s CAP (Common Agricultural Policy) 2nd pillar that proposes an aid for the investment in planting AF-hedges at 80%-funding and the technical support organised in a collective format (less than 20% on the subvention total) to a group of AF farmers. There is also a need for maintenance of AF already in place during the first years. Eco-schemes for sustainable management plan of hedges and intra parcel trees (that are accessible for farmers with a hedge label or certification low C in the hedge method) are considered by advisor as a good lever if the amount is revised up. Another point of attention is to have more adequate issues between regulation for appellations (origin labels) and vineyard (and fruit trees) payment rights. And also, more flexibility for leasers in the rural code.
7. Innovation support: another idea is to set up a research tax credit applicable to demonstration farmers would make it possible for these pioneer farmers to ensure risks over a given period (in case of losses).
8. Sector development support: economic valorisation of AF products (for hardwood, which is not at all well valorised, for example in wood chips, for timber also), perhaps a collective organisation between AF farmers to gather their wood products could be a way to have more power in front of wood buyers; new sustainable local supply chains (label, brands, consumer understanding of the benefits of AF, etc.), there is a need for sharing experiences and feedbacks on these local initiatives on the structuration of actors

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and the valorisation (production costs, potential gains) and marketing of products; as the energy crisis is rising, we can imagine an incentive for local authorities to encourage wood heating for schools and retirement homes. e.g. collective heating, contracts with farmers (to better valorise the hedges), creation of local wood energy micro-factories.

9. Labelling (equivalent to PEFC for well managed forest products): concerning organic farming, the obligation to plant trees will become compulsory for climate change but also for food autonomy (especially for pigs) with soaring costs. The balance between gains and costs needs to be analysed carefully. There is a reflexion on a label that indicates products of an AF farm, but some people consider there are already too many labels, and it could be difficult for the consumers to distinguish and understand; some regional parks have implemented a label.
10. Carbon credit is also a promising way to valorise C sequestration. The stake of adaptation and mitigation of climate change is an important growing concern. Conjunctural, the climate change urgency (and the regular summer heat peaks) can be a lever to change the minds of farmers, advisors and policy makers.
11. Payment for environmental services: some water agencies have put in place some experimentation in some pilot territories in water catchments areas.
12. Territory concertation: a coherent strategy at territory level co-designed and concerted in a multi actor setting, consolidated climate energy territory plan (AF considered as a carbon measure), sustainable management plan, the next AF plan in France is expected to be regionalised to adapt to each specific contexts, stakes, priorities and propose suitable systems to encourage, a platform that match offer and demand for cooperation between farmers (for grazing fruit trees or vineyards parcels or even forests areas.

Additional text is already formatted as 2- page EIP-style factsheet called ”Opportunities and policy needs to enhance agroforestry in France - The multiple agroforestry systems present in France” and this is be used in workshops and is attached in the annex as:

FACTSHEET Opportunities and policy needs to enhance agroforestry in France - The multiple agroforestry systems present in France

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8 Policy scenarios for an agroecological transition – Central-Eastern EU member states

8.1 Overview of current policy

Central-**E**astern **E**uropean countries (CEE) have several inter-governmental supporting bodies with different territorial and focus interests, such as the Carpathian Convention, the European Strategy for Danube Region (EUSDR), Visegrad 4 initiatives, many of them have some progression on collaboration fostering agricultural approach, such as climate initiatives, agroecological transition, sustainable agriculture actions. These regional approaches are meant to support a coherent and synergised rural development and natural asset protection. These international agreements usually rather showcasing the frame to agroecology acceptance then providing exact methods and practices. Nevertheless, these are the traces of international cooperation stepping over national boundaries.

Below (Table 8) are shown and described: The (1) Carpathian Convention Protocol on Sustainable Agriculture and Rural Development, the (2) EUSDR Priority Area 6: Biodiversity, Landscapes and Air & Soil Quality respective target 5 to improve and/or maintain the soil quality in the Danube Region, and (3) the Visegrad 4 initiatives 2014 agreement to actively contribute to a strong Europe and promote and implement projects aimed at fostering cohesion and enhancing competitiveness of the V4 and EU in a global context. The latter is to overcome the impacts of the global financial and economic crisis. In negotiations on the next multiannual financial framework, of which well targeted cohesion policy and reformed Common Agricultural Policy must remain an integral part, the V4 countries will advocate respect for the principles which strengthen the internal convergence and external competitiveness of the EU.

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Table 8: Summary of key inter-governmental initiatives, main targets and relevant agroecology principles within the CEE region

International Initiative	Main targets	Enabled relevant agroecology principles
Carpathian Convention: Protocol on Sustainable Agriculture and Rural Development	- site-specific rural development strategies,	Land and natural resource governance
	- the protection and management of traditional cultural landscapes,	Land and natural resource governance Social values and diets
	-integrated land resource management,	Land and natural resource governance Synergy.
	-promotion of extensive farming and organic production, traditional knowledge and practices,	Social values and diets Fairness
	-marketing of typical agricultural and rural products and services,	Social values and diets. Fairness
	-promotion of agritourism and diversification,	Economic diversification. Social values and diets
	-prevention of adverse impacts on air, water, soil, landscape and biological diversity.	Soil heath Biodiversity
EUSDR Priority Area 6: Biodiversity, Landscapes and Air & Soil Quality respective target 5	To improve and/or maintain the soil quality in the Danube Region.	Soil heath
Visegrad 4 Group: 2011 Declaration:	To actively contribute to a strong Europe and promote and implement projects aimed at fostering cohesion and enhancing competitiveness of the V4 and EU in a global context, so as to overcome the impacts of the global financial and economic crisis. In negotiations on the next multiannual financial framework, of which well targeted cohesion policy and reformed Common Agricultural Policy must remain an integral part, the V4 countries will advocate respect for the principles which strengthen the internal convergence and external competitiveness of the EU.	Land and natural resource governance

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The analysis above shows that most of the intern-governmental initiatives are targeting the social assets related to Agroecological Principles such as 9. Social values and diets and 12. Land and natural resource governance.

8.2 Traditional forms of agroforestry and mixed farming in the CEE region

In the CEE region AF and MF have many centuries long tradition, though not defined as agroforestry and/or mixed farming in most of the countries. The most important traditional land-use types, fits to agro-forestry or mixed farming are detailed below:

Pasture forest and “un-manged” wooded pasture was created through a slow forest harvesting use. Both are quite rare nowadays, except in Romania, but deserve attention in light of climate change and the market trends of extensive cattle farming expectation, providing a traditional silvo-pastural system.

Figure 17: “Un-managed” wooded pasture forest in Somogy County, Hungary (Nagy, 2014)

A commonly still used form of agroforestry is forest-bounds/hedges close to the edges of fields, or between parcels as separating them. The original aim of this planation or left-behind (un-manged) natural areas is to protect the soil and the plantations against wind, or water against dust pollution. This kind of use was and still remains the main field protection system in the plane areas of the countries, and this bounds provides the basic ecological corridor system for example to the Great Plain connecting natural habitats and protected areas to a rich habitat system.

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Figure 18: Close to-natural hedges in Békés County, Hungary (Nagy, 2014)

A unique land-use type is when grape or other fruit species are planted together with vegetables, and/or fruit bushes providing a mixed use; where usually grape or the fruit tree is the main plantation, within the rows there are random fruit trees, such as apple, walnut, chestnut, cherries, and/or there are vegetables between the row, or under the trees canopy, such as bean, peas, pumpkin, carrot or forage plants. This kind of land use is run mostly by smaller farmers nowadays, while in the last century it was still wildly popular.

Figure 19: Grape plantation with Fabacea forage plantation in Győr-Moson- Sopron County, Hungary (Nagy, 2012)

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8.3 Central-Eastern EU country examples

8.3.1 Example of the Czech Republic

As most of the CEE EU countries the Czech Republic is securing long traditions in agroforestry and mixed farming, but the mainstream of agricultural production is based on intensified, monocultural practices. Therefore, the new policy support in establishing the promotion and development agroecological transition mainly specified in organic farming initiatives, is answering the agroecology principles.

In 2021 the Czech Republic established an **Action Plan for Development of Organic Farming for the 2021-2027 timeframe**, with the following main development areas:

- Stabilise economic viability of organic farms
- Enhancement of the market for organic products
- Support of organic products consumption
- Define benefits of organic farming for the environment and animal welfare
- Increase awareness raising

The plan provided some **quantifiable goals to be reached:**

- Reaching 22 % of organic agriculture land by 2027
- Reaching 30 % of arable land in organic use
- Increase perennial culture by 10 %
- Reaching 4 % consumption of organic products on the overall consumption of food and beverages
- Directing 5 % of organic products into public catering
- Increase share of budget on organic research

The new national CAP will mean a great challenge for farmers and institutional requirements for the country, as the government is committed to full-fill the new EU strategies and in the meantime establish a strong innovation development of precision agriculture.

8.3.2 Example of Hungary

Hungary has a long tradition recognised nowadays as agroforestry and mixed farming, though the definition and legal identification and its embedding to policy levels are unstable. Meanwhile agroforestry has direct subsidies in the national CAPs since 2004, and mixed faming management has a strong support within 'family farm' initiatives, the definition of agroforestry has not been embedded to legislation, so the implementation of the CAP targeted subsidies are weak, and mixed farming in legislation is non-existing.
Traditional agroforestry systems are hedges, shrub and alley system is a basic landscape character element of the country, originally meant to provide the protection against erosion and deflation, nowadays besides the previous functions it is recognised as ecosystem services provider for ecological corridors, biodiversity reservoirs and climate mitigation measure. Meanwhile silvo-pastural systems are rather tolerated than supported, in the sense of the only way of extensive grazing system, where animals stay outdoor almost all along the year, therefore sheltering is crucial especially over summer heat.

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8.3.2.1 The recent actions of the CAP 2022 Strategic plan

Agroecological non-productive investment:

Agroforestry: hectare-based subsidy for the "good practices" such as agroforestry, focus on soil, water and biodiversity protection, plantation/crop and meadow establishment (meadows are in a semi-natural biological status in Hu due to the non-pesticides using practice and the extensive cow-grazing practice).

Management diversification in agricultural farms and around recognised as mixed farming support. The main aim of the measure to support production of more than 1 product per farm, and in the meantime support the transition to agroecological practices. The basis of the measure is the EU regulation No. 1305/2013/EU, article 28. (3) paragraph.

As part of agroecological transition non-productive actions are supported, such as tree/shrub plantations/perennial plantations, new hedges, new meadows plantation, erosion prevention planation, water protection planation, wetlands creation, foresting the edges of water bodies, agroforestry systems, silvo-pastural systems.

Also, diversified farm management is supported by investments into food processing, especially by small investments. The measure also aims to enhance energy efficiency, as the currently used food processing practices are usually gas or oil based, and now less fuel consumed and more digitalised machinery is preferred. Besides the utilisation of solar, thermal or innovative energy production methods , development of packaging and storing capacities are also supported as side investments.

Supporting farm industry:

Short supply chains are supported by developing food industrial investment within farm management and/or cooperatives, farm clusters, common entrepreneurs. The aim of the measure is to bring up the quality and quantity of small producers' products to the market , to support innovation in this level (rather use innovation, than provide innovation) and digitalisation.

Special support of small-scale farms (meant to support family farms and mixed farming management) - this measure is aiming to benefit the classic family farm types, mostly half-agricultural and half-manufactural farms to become more energy- and capacity effective, more digitalised while also stabilising the quality of the products.

8.3.2.2 Climate change scenarios threatening the Great Hungarian Plain

According to the climate change scenarios irradiation and therefore mean temperature will greatly increase in Hungary in summer especially on the Great-plain area. Evapotranspiration will also increase, and therefore irrigation needs will grow, natural water-level in the soil will decrease, and this process may run to an environmental catastrophe. So far, most horticulture land use is irrigated in Hungary, many fruit orchards need cover to protect from sunburn and some cereals now need irrigation, too (e.g. maize) (Figure 3-5).

Agroforestry can help with shading and decreasing irrigation needs, and also cereal fields should be considered as mixed use with agroforestry.

Most of the plantation forests are situated in the Great-plain area (Figure 20), where the most outstanding heatwaves are predicted to occur in the climate change scenarios. In this area there are also many cereal fields but also vegetable and fruit orchards (Figure 20). These land-uses must change to mitigate climate

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change, either by different cultivation or by different land-use with agroforestry element. In total the affected area is about the half of Hungary (Figure 21).

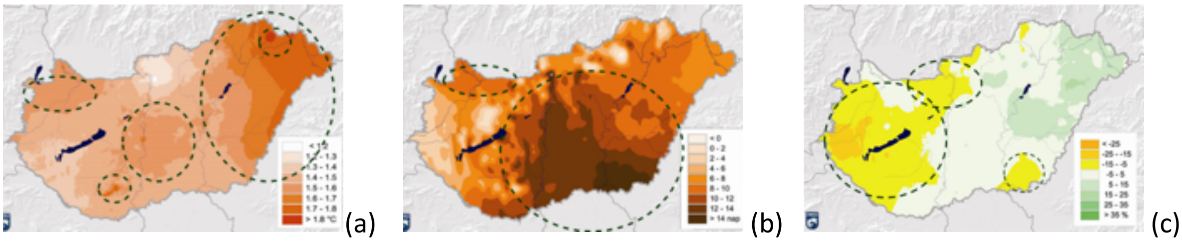

Figure 20 Annual mean-temperature change (a), Heat wave days increasement (b) and changing rainfall pattern in Hungary (c) (Nagy, 2017, based on OMSZ, Szentimrey and Bihari, 2015)

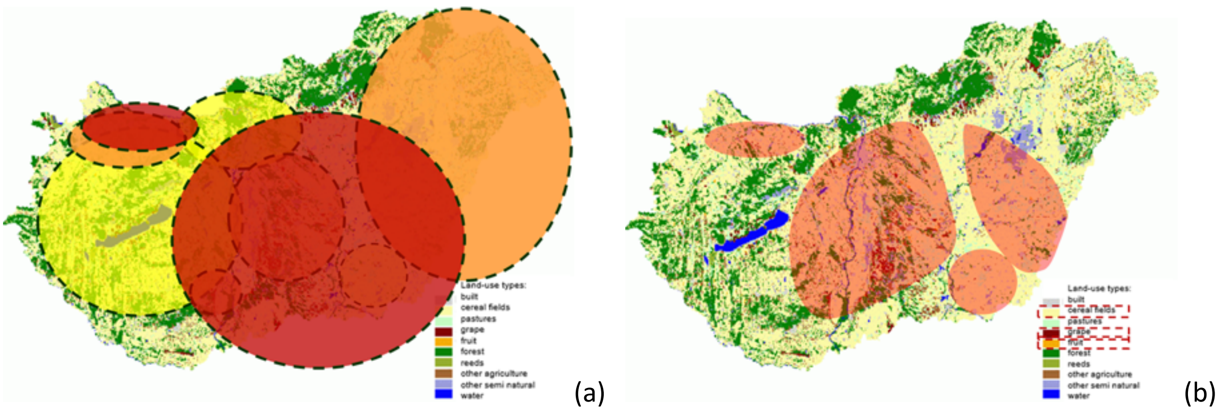

Figure 21 Hot-spots of climatic change (a) and climatic changes problems-map in Hungary (b) (Nagy, 2017, based on OMSZ, Szentimrey and Bihari, 2015)

8.3.3 Example of Poland

In Poland one of the main barrier of agroforestry becoming a common a practice is that it is not recognised as a traditional agricultural practice and therefore lacks a clear definition and regulation.

Borek and EIP-AGRI Focus Group Agroforestry (2017) identified the following barriers, also mentioned in Gyuricza et al. (2022):

- communication and awareness: farmers are not aware of agroforestry.
- lack of financial support, especially subsidy system in CAP
- lack of legal background.
- commercialisation: Local producers do not use agroforestry systems and therefore there would be no market for the products that could be sold from them, as they are not familiar with the agroforestry sector.

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At the same time, basic elements of agroforestry, though not identified as agroforestry, were funded in the 2002-2004 and 2007-2014 programming period such as:

- shrubs and hedges, afforestation agricultural fields, the program was not favoured as the general parcel structure of Poland is quite small scale and fragmented, more space for buffer measures could not be feasible, therefore since 2022 a mid-field tree plantation is also subsidised (Gyuricza et al., 2022)
- protective buffer stripes along water bodies, to protect water from nutrient pollution and against erosion was a favoured subsidy.

For the future plans, within the 5th meeting of the Working Group on SUSTAINABLE AGRICULTURE AND RURAL DEVELOPMENT (WG SARD) of the Carpathian Convention, Magdalena Nowicka representative of Department for Direct Payments Ministry of Agriculture and Rural Development, Poland presented the state of the art of the implementation of the SARD Protocol related to the new CAP in Poland.

Priorities for the SARD Protocol - Poland:

- strengthening the local agricultural economy, sustainable development of the region and preservation of the natural values and cultural heritage of the Carpathians;
- implementation of the provisions of the Protocol, so as to create favourable conditions for the development and growth of agricultural production, including in particular production carried out using organic methods,
- increasing the level and quality of life of the inhabitants of the Carpathians;
- strengthening the competitiveness and attractiveness of the Carpathian region based on the internal development potential while maintaining cultural and environmental values;
- promoting activities and programs that use the potential of agriculture and rural areas to improve the quality of life and enable the increase and diversification of the income of the rural population in the Carpathian region;
- ensuring international cooperation throughout the region, especially cross-border cooperation, ensuring greater effectiveness in achieving ecological cohesion and the implementation of the objectives of the protocol.

The tools of CAP to support the targets above are:

- Direct payments and
- Environmental activities under the Rural Development Programme (RDP)
- Foreseen RDA payments relevant to the SARD protocol:
- Payments to areas facing natural or other specific constraints (LFA) - Support is provided to compensate for the effects of the existing difficulties in agricultural production in areas including mountainous and sub-montane.
- Agri-environment-climate measure - Promotes practices contributing to sustainable land management and the preservation of biodiversity by protection of:
- Valuable natural habitats and endangered bird species
- Endangered genetic resources of cultivated plants and farm animals
- Organic farming measure - Promotes sustainable plant and animal production, as well as application of biological and mineral substances, which were not technologically processed

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- Afforestation measure - It contributes to: prevent erosion, prevent the fragmentation of forest complexes, create new plantings adapted to habitat conditions. Payment rates are higher in unfavourable conditions (slope).
- Creation of mid-field forestation - New in Polish RDP i.e.: (1) rows or strips of trees and shrubs and (2) clusters up to 0.5 ha. This change will contribute to preventing water erosion of soil, increasing water retention and improving water quality. It will have positive impact on biodiversity (melliferous tree and shrub species will be preferred) and landscape quality in rural areas. Payment rates are higher in unfavourable conditions (slope).

Original presentation on the webpage of the Carpathian Convention:
www.carpathianconvention.org/tl_files/carpathiancon/Downloads/03MeetingsandEvents/WorkingGroups/SustainableAgriculture,RuralDevelopmentandForestry/5thmeeting/Meetingpresentations/4PL-NationalupdatesandprioritiesfortheSARD.pdf

8.3.4 Example of Romania

The most important form of agroforestry in Romania is silvo-pastural system. Forestry law of Romania strictly differentiate between forested area and agro-forestry, for forestry livestock grazing is strictly prohibited, but identified grassland with sparse trees as agroforestry (Lucreţia, 2018), therefore Romania has the 3rd greatest legally recognised agroforestry area of Europe after Spain and France (Gyuricza et al., 2022).
Besides this identified agroforestry system no fund or supporting measure existed by the 2021 programming period, but the form of sparse tree grazing considered as a traditional form of agriculture, consciously used to protect livestock from summer heat, especially favoured in the southern part of Transylvania (Vityi, 2017). For future support, within the 5th meeting of the Working Group on ‘SUSTAINABLE AGRICULTURE AND RURAL DEVELOPMENT’ (WG SARD) of the Carpathian Convention Mr. Eduard Lazarescu and Mr, Sabin Farcas, from the National Mountain Area Agency, Romania presented a report on "Best practices models: Short food supply chains", aiming to provide topics for cooperation under the WG SARD.

Presenters provided a short explanation on the potential mechanisation of agricultural labour in the mountain area in the light of opportunities and limitations:

- Mechanisation of agricultural labour in the mountain area is limited by several factors: steep gradients, soil structure, typology of agricultural practices and various commitments to preserve biodiversity and highly nature value areas.
- There are also mechanised agricultural activities that are not presented with limitations, such as: mechanical milking, grassland and pasture labour with light equipment, drainage works, ant nests and molehill distraction, shrubbery and wooden vegetation removal for agroforestry arrangements, agricultural land fertilising works.

Original presentation on the webpage of the Carpathian Convention:
www.carpathianconvention.org/tl_files/carpathiancon/Downloads/03MeetingsandEvents/WorkingGroups/SustainableAgriculture,RuralDevelopmentandForestry/5thmeeting/Meetingpresentations/2PresentationTopicCarpathianConventionSARDProtocol_Romania.pdf

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8.3.5 Example of Slovakia

Agroforestry is not traditionally recognised in Slovakia, and a quite new concept for legacy and policy levels Špulerová et al. (2011), as in most of the region's countries laws strictly separate forested area from all other agricultural use, and doesn't support mixed management practices generally.
Meanwhile in Slovakia still exists on rather small scales the traditional practice of growing together or in a fragmented mosaic of the landscape vineyards, grasslands, high-trunk orchards of obsolete varieties and landraces of wild fruit tree species, grazed by cattle or sheep or intercropped with arable crops (cereals, vegetable), and traditional forest pastures (Gyuricza et al, 2022).
Recently, tree energy plantations become favoured to produce biomass as energy plant, also acceptable by law to be planted with other cultivars.

8.4 Drivers of agroecological transition in the CEE region

The space taken by agriculture provides the largest potential for transformative change to a nature-based production system, but in the meantime, agriculture seems to need to be required to go through the most fundamental transformation over the upcoming decade by the international agreements, but most importantly due to climate change.
There are many theories on how to transform agriculture of the region to become a more resilient sector, all of them agree that it must be based on the ecosystem's natural circles. As of the concept of ecosystem services, agriculture should provide not only food, forage, bioenergy and pharmaceuticals, but all the processes that are supporting the creation of these production, such as pollination, biological pest control, maintenance of soil structure and fertility, nutrient cycling, carbon sequestration and hydrological services (Power, 2010.). In order to use the potential of agriculture it must provide first of all space to nature, and natural processes, even ecological corridors. All the above-mentioned ecosystem services are attached, so cannot be handled, or even mended in separated small portions, the connection of them is essential.
The concept of agroecology is based on the holistic approach which considering all the identified and potential ecosystem services as a whole inseparable system, which requires most importantly a nature-based transformation from agriculture - accepting all the processes lead to sustainable natural resource management - with the understanding of the ancient needs on food quality and quantity and the new demands such as energy production and carbon sequestration.
The implementation of such an agriculture requires first of all a sustainable land-use system, where the natural functions are close to the production-oriented functions, therefore a land-use change is necessary which can be implemented through the tradition based, but modernised methods of agroforestry system, such as:

- agri-silvicultural systems, which are a combination of forestry (tree plantation) and the target cultivation of crops, such as alley cropping, hedge system or even as a classical solution of home gardens, providing wood and food production in the same space.
- silvo-pastoral systems, which combine forestry and grazing on pastures, rangelands or on-farm, where ecology provides the necessary shading and water management services for animals, while animals providing the necessary nutrition for the soil, in the meantime a frequent rotation system required from management in the actual land-use, to save the soil structure and use the fertility, accordingly.

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- agri-silvicultural and silvo-pastoral systems might be integrated into agro-sylvo-pastoral systems and are illustrated by mixed farms providing all production needed by a local market and running a sustainable nutrition cycle, but it requires a diverse knowledge from farmers with a frequent training support to keep up with the climate change caused new challenges.
- new agro-technologies which are more energy effective , regenerative and support nutrition cycles and prevent from nutrition, pesticide and herbicide overuse, such as
- no till, min till supporting soil formation and structure, soil fertility, nutrient cycling, reducing green-house gas emissions, reduce irrigation needed water use,
- diverse crop system/hedge system/temperate perennial orchards/strip crops/push-pull pest control providing protection against erosion and deflation; providing habitat to pollinators and pest control support species by being habited by natural predators; providing habitat to vertebrates providing a balanced predation cycle to control small mammals and herbivores, in the meantime providing the basis of wildlife management as a potential benefit to farmers; providing genetic diversity for future agricultural use, purify water and regulate its flow into agricultural systems, providing green manures, natural fertilisers and nitrogen fixation; provides natural shading system to sun-sensitive species, protect against sun-burst
- precision agricultural techniques provide less input use (energy, pesticide, herbicide, nutrition, water, seed, forage, human resource involvement etc.), due to more targeted and optimised management systems on all levels of farm management.

All these agro-ecological and agro-technical solutions provide service to neighbouring land-use such as supporting the biodiversity protection of protected areas, providing habitat, supporting natural regeneration of the overall ecosystem and providing a non-fragmented, well-connected habitat system to migrating species.
Besides the above mentioned “technical” transition a social transition is also needed to become feasible as the climate change and natural resource loss crises demand. As not only agriculture or ecosystem services are in crises nowadays but the whole society seems to suffer from general unbalance, obviously deepened and highlighted by the aforementioned factors. According to the FAO 5 main criteria must be considered to reach a sustainable food system:

- protects ecosystem biodiversity; which the main focus of this paper, but also a must for a successful transition is
- is accessible and culturally acceptable;
- is economically fair and affordable;
- is safe, nutritionally adequate, and healthy; and
- optimises natural and human resource use. (FAO, 2012 in Magrini M.-B. et al., 2019))

As the whole region is suffering from the lack of experts on agronomy, especially the young generations seems to be unwilling to run farms, a new carrier concept should be provided to involve the society again to agriculture and arise not only awareness but active interest in some smaller scales of own needs satisfying production.

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8.4.1 Actors of transition in the CEE region

The main actors of the agricultural transition are first and foremost the farmers themselves as the production side of agriculture. As they are the greatest services providers for this transition and bearing the greatest risk of changing - the badly but working - management system to a system which is extremely promising, but can't be well tested on other conditions, only on the actual farm level, so reserves a great risk on every farm economic balance and requiring the transition from farmers in the meantime becoming financiers and risk bearers, not only exploiters of the ecosystem.

The other most important stakeholder group of this transition is all consumers, meant every person, as they are the most important benefiters. Most certainly it means a mind and behaviour transition from every single human and from the society, to support the agriculture as a sector, to share their economic burdens of the change. Within both the production and consumption circles the whole society's contribution is needed, such as from a farmer, food processing, consumer and governance viewpoints:

- Farmers need to understand the theory and practice of the potential solutions; therefore a massive knowledge transfer is required not only from a science-to-farmer as knowledge users, but also a farmer-to-farmer information flow is necessary. Therefore, more cooperation is needed within the farmer associations such as the national chambers of agriculture, farm clusters and resource sharing associations. The member states of the region all accepted the AKIS initiative of the European Commission, therefore a robust institutional bases of knowledge transfer to be provided over the next couple of years.
- Food industry and food marketing system should accept new standards embedding the investment of farmers into the protection of natural resources and support the shortening of supply chains for a less energy consumption and less waste-providing distribution system.
- Individuals consumers by demands for the more sustainable and healthier food, in the meantime by acceptance of the sharing the risks and costs of the transition.
- National governments - redefining the subsidy system of food production, sharing the costs among the other production systems. promoting the importance of the transition and its burden on the whole society.
- International governmental bodies: providing support to national governments on knowledge transfer and new financial schemes.
- Global governmental bodies: calling on action and accelerating the transition, highlighting the global crisis can be solved only locally.

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8.4.2 Policy scenarios of agroecological transition:

The identified main two ways of transitions to a more nature-oriented agriculture for the CEE region follows the agroecological principles and the technological transition. In many aspects both seems to be win-win transition and on the other hand both threatens with un-foreseen challenges, unrecognised hazards and might conclude to further risks, most likely to become a hybrid form to be the best to be chosen.
For the sake of analysis we separated these two main ways of transformation in scenario 1 and scenario 2:

		1. scenario: following (waiting for) technological transition	**2. scenario: following "EU new strategies" - agroecological transition**
Main features (Policy and technical background and requirements)	Main drivers of the transition	Market: Great lobby background from food/agricultural industry	Policy: Great lobby from environmental sector
	Main problem	Precision agricultural technics to be provided to each farm or farm cluster – who pays for it?	Not properly tested technics and solutions – high risk
	Policy support	There isn't strong policy support; potentially not even needed	There is strong policy support and even further needed
Impacts:	Human input needs	Significantly less	Potentially more, but there isn't! any potential in this respect
	Pesticide/herbicide use	Proven lower pesticide/herbicide use	Potentially lower, not properly tested
	Accuracy	More exact processing	Not properly tested
	Economic balance	huge investment in management, expensive yearly services, form all other aspects less input, more output on yearly management bases	Not properly tested
	Tested processes	Well tested, there are professional solutions and providences	Not properly tested, which means a high risk (risk management needed)
	Policy transition needs	Yes, but it is not required change on authorities' level	Yes, a new regulation set is needed
	Funding needs	High funding needed, Finance technological transition	Not properly tested, a financial risk management needed
	New skills requirement/ farmers knowledge	new skills required (not all farmers ready to change machinery)	new skills required (not certain if farmers ready to change management practices)
	Prices	Expensive on start the processing and on maintenance, not appropriate stocks exist on farm level in Hungary	Cheap on starting process, potentially expensive maintenance, finance losses due to lack of experience
	Data needs	Yes, above farm level data reach, farm level data providing services	Yes, on farm level – species /varieties combination, ecological relations
	Further costs	- Data providing services (Accessible satellite)	- potentially more input, less output - results less exact processing,

		- Technical expertise providing services farmers mainly can't pay it. - Higher educated farmers (less likely to remain in agriculture)	- might cause economical loss and further social crisis.
	Societal transition needs	Yes; To decrease costs of individual farms, clustering transition might need (social opposition might occur)	Yes; Society acceptation on potentially lower quality / smaller quantity production, food price increasing

8.4.3 Identified recommendations to policy making supporting the agricultural transition for the CEE region:

- Clear definitions on regulation level of agroecology, agroecological practices
- Clearly differentiate from other land-use types on definition, regulation, land-use registration, subsidies, evaluation
- Defining cost and benefits of agriculture contribution to degradation/regeneration to ecosystem
- Incorporate EU regulations and strategies into national level administration
- Provide national/local best practice collection and especially testing results on economic cost-benefit bases to provide an effective guidance to farmers and reduce risk on agroecological transition
- Provide financial support to agroecological transition
- Focus on local needs and possibilities
- Ease the bureaucratic burden of funding the agricultural transition
- Support knowledge transfer not only nationally, but also transboundary
- Support the free data providing system to make precision agriculture available to more farmers
- Support cooperative solutions in order to accelerate landscape level regeneration, provide techniques accessible for more farmers and decrease costs.

A condensed version of the text above is also formatted as 2- page EIP-style factsheet called 'Sustainable transition drivers of agriculture in the Central-Eastern European Region' and this is be used in workshops and is attached in the annex as:

FACTSHEET 'Sustainable transition drivers of agriculture in the Central-Eastern European Region'

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9 Policy scenarios for an agroecological transition – EU wide

9.1 Overview of current policies

Currently, agroforestry represents about 20 million hectares of land in Europe, 90% of which is dedicated to silvopastoral practices (LUCAS). The majority of silvopasture is found in Southern Europe, while 7.67 million hectares of silvopasture in woodlands is primarily found in Northern and Southern countries, with a much lower percentage in Central Europe. Silvoarable practices, on the other hand, occupy only around 360,000 hectares, which is under 1% of those 20 million hectares (LUCAS).

Europe has pledged its support of agroforestry through policy and financing. These can be found both in state policies and through the European Union (EU), for example through each country's CAP strategic plan. Below are some examples of commitments made to support the expansion of agroforestry throughout the EU.

As we can see (Table 9), wide policy support does exist in Europe, yet the expansion of land devoted to agroforestry has been slow and incremental. Further, the ecosystem services derived from such systems have been inconsistent since agroforestry can be practiced in an industrial manner. It is important for agroforestry to be part of a food system transformation, where capacity building and effective monitoring is prioritised, along with an agroecological agriculture that focuses on the cultural and environmental realities of each landscape. Such a food systems approach must focus on 13 Agroecological Principles by HLPE on Food Security and Food Sovereignty, along with frameworks such as the one created by the Global Alliance for the Future of Food's to provide a deeper systemic understanding of policy making, with a multi-level approach both to the mission of transformation and how to achieve it in an inclusive and cohesive way (Global Alliance for the Future of Food, 2022).

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Table 9: CAP Pillars I and II and other EU policies with commitments made to support the expansion of agroforestry throughout the EU

CAP (EU Common Agricultural Policy)	**Pillar I**	Direct payments per hectare are given through greening and cross compliance (SMR's and GAEC's in the 2007-2013, 2014-2020 and 2023-2027 periods). Direct payments through the agroforestry Eco-schemes (2023-2027): • Establishment and maintenance of landscape features above conditionality • Management and cutting plan of landscape features • Establishment and maintenance of high-biodiversity silvo-pastoral systems
	Pillar II	Rural Development support for the Establishment (2007-2013), Maintenance (2014-2020), Regeneration and Renovation (Omibus Expansion, 2018) of agroforestry. In some countries there is also the possibility to support agroforestry in the 2023-2027 period through Pillar II.
European Green Deal	**Farm to Fork** **Biodiversity Strategy**	Agroforestry maintains support as a tool to increase biodiversity, climate health, forest growth, as well its ability to create resilient jobs. Landscape features are also mentioned a handful of times within the documents, which are part of agroforestry.
EU Forestry Strategy	Complements the measures set out in the European Green Deal and recognises the role agroforestry can play in achieving the 3 billion trees by 2030 target.	
Nature Restoration Law	Asserts the need for sustainable, resilient and biodiverse agricultures and supports agroforestry to achieve such resilient agricultural ecosystems. It also declares the need to increase and maintain pesticide and fertiliser free high-diversity landscape features on agricultural land including buffer strips, rotational or non-rotational fallow land, hedgerows, individual or groups of trees, tree rows, field margins, patches, ditches, streams, small wetlands, terraces, cairns, stonewalls, small ponds and cultural features – all relevant to agroforestry – to provide ecosystem services for humans, wildlife, soil, water and climate.	

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9.2 Scenarios for an agroecological transition and the role of agroforestry and mixed farming

Scenario: An agroecological transition by 2050:

1. Plant protein feed products are not to be imported
2. Phase out of synthetic pesticides (insecticides, herbicides, fungicides) and fertilisers, replacing with symbiotic fixation from leguminous crops, nitrogen transfers from livestock, long and diverse crop rotations, intercropping, and constant soil cover and catch crops, including between trees and other permanent crops
3. Mixed crop-livestock systems to be present in every region (including through regional cooperation amongst neighbouring farms)
4. Extensively managed livestock are to be prioritised, with a primary focus on animal welfare
5. Permanent grasslands (which include agroecological infrastructures) are to be enlarged and restored as much as possible
6. Trees are to be returned to agricultural landscapes and agroforestry is a practice that should exist in every region
7. Farms should prioritise a diverse number and types of crops grown on them
8. Heritage breeds are to be prioritised with continued research on enhancing and preserving the genetic diversity of livestock
9. Farmers and landowners will increase the diversity of habitats (including high-diversity landscape features)
10. All stakeholders in food and farming sector focus on healthier diets for all, with fewer animal products and sugars, and more fruits, vegetables, legumes and nuts
11. The synergy and interactions between different elements of the agroecosystem increase, improving soil conditions significantly (organic matter and biological activity)
12. Agroecology should be taken on a regional level, or 'territorialised' in order to become 'fit for purpose' and take into consideration local realities (making it a practical body beyond the academic)

Within these scenarios, both ecology and human health are being prioritised. Agroforestry is instrumental in the modelled transition to agroecology because it provides an agricultural system where many of these realities can be implemented. For example, in order to extensively manage animals, it is important for both grasslands and trees to be present to provide shelter from a variety of climates. Further, many of the common industrial breeds can be removed for heartier robust breeds (some of them heritage breeds) that are more adjusted to living outdoors. This, in turn, leads to a lowered need for plant proteins, and therefore importation from outside of Europe can cease.

Finally, this lowers the pressure on many of the realities that make it seem impossible to maintain an agriculture free of pesticides. All of these scenarios are building blocks that should be seen as individual parts that make up a single whole, as one or a handful of these changes will not create the balance needed for transition. Similarly, the policy priorities described in the next section should also be seen as a synergetic whole and not as a menu of options.

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9.3 Policy priorities

In order to achieve the previous scenarios, the following policies need to be prioritised as a roadmap on how to get there:

1. Review all current and planned legislations to amend them towards a common food systems approach (creating complementing strategies in agriculture, rural development, fisheries, food safety, international trade, transport, energy, environment, health and humanitarian assistance, instead of different departments focusing on single issues individually, with fragmented objectives and varied perspectives which often contradict one another)
2. Cease the importation of plant protein feed products
3. All policies should be created with the focus to transition agricultural systems to achieve optimum yields, rather than maximum yields
4. Phase-out synthetic pesticides through integrated pest management practices
5. Increase all agroecological practices at the farm level through making them requirements to receiving EU funding (including diversifying types/number of crops grown on a single farm; leguminous crops; nitrogen transfers from livestock; long and diverse crop rotations; intercropping; constant soil cover and catch crops, including between trees and other permanent crops; genetic diversity in livestock; diversify habitats, including high-diversity landscape features; organic farming; organic matter in soil)
6. Create incentives to extensively manage livestock through agroforestry and mixed farming systems
7. Develop regional supply chains for agroforestry and agroecological products, including creating affordable access to such products in order for all members of society to be able to choose a healthy diet with more fruits, vegetables, legumes and nuts
8. Restore and enlarge permanent grasslands (including agroecological infrastructure)
9. Increase the adoption of organic farming
10. Increase research on best practices at the local and regional scale for all aspects of the food system including for climate, soil, land management, and crop and animal diversity
11. Promote participatory and multi-stakeholder approaches in knowledge generation (including gender equity, cultural representation and racial justice)
12. Legislate for agroecological green belts - 15% of all food for cities from agroecological green belt
13. Transition to agroecology and a ‘bio-circular economy’ on a food and farming system level
14. Address tenancy to incentivise long-term agreements for multi-use agreements with the potential to support new entrants, open access to land with land reform and transparency of land ownership
15. Increase training (train advisors), financing and practical support for farmers and landowners wishing to implement agroforestry systems, as well as peer to peer mentoring
16. Develop policies that see food as a common good, rather than a consumer good

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This policy scenario is based on previous policy papers including AE4EU (2022), IDDRI (2018) and the Global Alliance for the Future of Food (2022).

Further information is included in the EIP-style Factsheet "Agroforestry for the Transition to an Agroecological European Union (EU)". This is be used in workshops and for the AGROMIX summit planned in Task 6.4 in 2024 and is attached in the annex as:

FACTSHEET Agroforestry for the Transition to an Agroecological European Union

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

10 Policy scenarios for an agroecological transition – Switzerland

The overview of current policies, scenarios for an agroecological transition and the role of agroforestry and mixed farming and policy priorities have been included in the EIP-style Factsheet “Agroforestry: Strengthening Resilience and Ecosystem Services of Swiss Land Use Systems - Policy scenario co-design”. This is be used in workshops and is attached in the annex as:

FACTSHEET Agroforestry: Strengthening Resilience and Ecosystem Services of Swiss Land Use Systems - Policy scenario co-design

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement 862993.

11 Conclusions & Recommendations

This section brings together conclusions and policy recommendations based on the modelling and scenario building as discussed above. They are preliminary, in that these recommendations will be discussed in policy workshops as part of T6.3.

11.1 Reflections on our aims for the deliverable

The research has given a deeper insight into key success factors for EU agricultural policy. It developed several scenarios for the transition to agroecological principles and the integration of AF and MF systems in the EU. We have discussed potential successes, failures and bottlenecks in the transition to resilient AF/MF systems and this will provide the basis for further work in the workshops. Preliminary policy recommendations at national and EU level for increased AF/MF land-use have been provided, which now also need stakeholder feedback. Novel policy modelling is being developed and presented in the deliverable to show how the economics of agroforestry can be modelled on a plot, field and farm scale. In addition, agent-based modelling was developed to study the effects of policy extremes and better understand the role of agent and their perceptions in successful policy making. We have also provided policy scenarios and pathways for an agroecological future in the EU.

Using an agroecological framework has helped categorise and understand AF/MF in a wider transition concept. However, we also have learned that the agroecology concept is perceived as complicated and overloading by some stakeholders. Some preliminary want to plant more trees and discuss, where and which trees without the wider agroecology transition debate. We have also identified strategies for policy improvement for AF and MF development, mainly by using policy co-development, however the work was also hampered by not being able to meet in person and discuss issues in detail. Email communication is just a very inferior, prone to various misunderstandings, form of communication and even "zoomed-out" meetings are not the equivalent of in-person policy debate. Both are much more inefficient and performance reducing. Nevertheless, we have made contributions to improving policy design and implementation options at national and EU level, attending conferences like EURAF online and in Sardinia and other international and national science and policy events.

11.2 Policy priority recommendations

Agroforestry and mixed farming hold great potential for an agroecological transition, both at the EU and individual MS level. Specific policy priorities for each region included in this report have been discussed in their respective sections. Here we give general policy priorities that need to be considered at both the EU and individual MS level. These priorities are considered relevant to policy makers, farmers, land managers and farm advisors, academics and civil society.

1. Clear definitions of AF (and in particular MF) are needed. These definitions should be agroecological in nature; incorporating spatial and temporal mixing, resource recycling and participation. The success of

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'certified organic food and farming systems' with its clear minimum level definition in European law has helped and this can be adopted for AF and MF

2. Funding opportunities, grants and subsidies should be prioritised to help with tree establishment and cash-flow on farm adopting AF and MF for the first time
3. Reduced profitability or loss of yield must be incorporated into economic models and any financial loss to the farmer covered by EU, member state or other state budgets. The carbon markets for sequestration can help but are not a substitute for lacking government support. The establishment of new systems needs nurturing like a tree nursery, once mature sector is developed this is no longer needed and transformed landscapes can return also increased environmental benefits and higher taxes from multiple diverse land uses
4. Existing trees within the farmed landscape should not be forgotten; management options for existing woodland on farms must be incorporated into EU member state objectives with greater collaboration between foresters and farm advisors
5. Existing mixed farming and small-scale "Peasant Agroecology" farm structures especially in Central and Eastern Europe deserve support, protection and the diversity and mixed nature of farming preserved if not increased e.g. with further agroforestry additions
6. Farm advisors, consultants and land managers should be robustly upskilled to engage with farmers and support the implementation and maintenance of AF and MF systems
7. The implementation of regional farmer networks should be prioritised, with training days and participative governance to allocate an at least 10% increase in tree cover in all regions
8. National AF and MF associations must be supported and encouraged through individual EU member state funding sources, prioritising farmer networks and access to case studies and demonstration farms. This is equally applicable for non-EU countries and federal states which could integrate agroforestry more with eco-tourism and promotion of the territory as clean and pleasant holiday destination
9. Legal landowners, where possible, should mandate an increase in tree cover by 10%. They should cover part of the cost as part of their social responsibility as property owner. Non-compliance and keeping land only as tax avoidance or needs to be legislated against
10. Never extract more than the ecosystem can regenerate. Regenerative farming has included mixed farming as a principle; however, the reality is often behind aspirations with large, minimum tillage fields increase pesticide use and no additional trees. The approach lacks certification and rigor like organic but still is promising and could adopt agroforestry and as a principle or mandatory on each farm self-defining as regenerative
11. Never waste or pollute ecosystems. Zero pollution and zero carbon (one type of pollution) are becoming more popular and consumers understand the necessity of it demanding pollution free products. This can only be good for agroforestry and mixed farming as both remove or minimise the need for any harmful inputs like pesticides or antibiotic in livestock
12. As new policies are developed at the EU, national level and non-EU level, a greater integration of available tools and frameworks such as Gliessman's 5 levels, the HLPE 13 principles of agroecology and the Global Alliance for the Future of Food (e.g. Galli et al., 2020, Kugelberg et al. 2021) are needed to ensure a just

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transition to sustainable food systems. EU countries can learn from non-EU approaches e.g. in Switzerland and England – and vice versa.

11.3 Conclusion and next steps

This report has detailed policy scenarios and mechanisms at the EU wide level and five national policies. Recommendations have been given based on these findings, detailed above and also further in the specific sections. As described before, this deliverable builds a solid basis for the next phase of the policy co-development the workshops and the EU summit planned for 2023 and 2024.

The task T6.2 does not end with this deliverable, feedback from the workshops will be received and the scenarios and two models further developed. In addition, work in WP2 & WP4 'pilots' & 'mix-app', WP3 'monitoring and bio-physical modelling' and WP5 'economics' and supply chains will feed into further refinement of policy development.

These interconnections have already informed this deliverable but with the first physical meetings happening soon, this can only improve. WP3 with bio-physical modelling and WP5 with economic modelling is of particular interest to link into the AF/MF-ABM model and MODAM model, respectively, but for these further results from WP3 and WP5 are required. The cooperation with STARGATE and especially MIXED is ongoing and further projects like BESTMAP, as already detailed in the ABM section, are being included in the WP6 policy co-development research. The Grant Agreement promises an update of this deliverable at the end of the project (month 48), and this will also reference to publications being written up or planned within the next 2 years.

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13 Annex 'EIP style factsheets'

13.1 EU and member state countries

13.1.1 FACTSHEET Agroforestry for the Transition to an Agroecological **European Union**

13.1.2 FACTSHEET Opportunities and policy needs to enhance agroforestry in France - The multiple agroforestry systems present in **France**

13.1.3 FACTSHEET Sustainable transition drivers of agriculture in the Central European Region

13.1.4 FACTSHEET Agroforestry for **Germany**: adaptation and mitigation of climate change and environmental externalities

13.1.5 FACTSHEET Agroforestry: Benefits, costs and options for political support in **Rhineland-Palatinate, Germany** - policy scheme co-design.

13.2 Non-EU countries

13.2.1 FACTSHEET Agroforestry: Strengthening Resilience and Ecosystem Services of **Swiss** Land Use Systems - Policy scenario co-design

13.2.2 FACTSHEET Agroforestry: an agroecological transformation of **England's** landscapes - Policy scenario co-design

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Policy co-design, the background

Europe has a deep heritage of traditional agroforestry, therefore the practice represents a great opportunity for the future of European sustainable farming, with biodiversity and soil health at its core. Agroforestry is understood as the integration of woody vegetation with either crops and/or livestock in the same parcel of land but it can also be represented by windbreaks, hedgerows and riparian buffers. It can be practiced by introducing trees to agricultural land or through the introduction of agriculture through woodland.

Currently, agroforestry represents about 20 million hectares of land in Europe, 90% of which is dedicated to silvopastoral practices (LUCAS). The majority of silvopasture is found in Southern Europe, while 7.67 million hectares of silvopasture in woodlands is primarily found in Northern and Southern countries, with a much lower percentage in Central Europe. Silvoarable practices, on the other hand, occupy only around 360,000 hectares, which is under 1% of those 20 million hectares (LUCAS).

Europe has pledged its support of agroforestry through policy and financing. These can be found both in state and European Union (EU) policies, for example through each country's CAP strategic plan. Below are some examples of the commitments made to support the expansion of agroforestry throughout the EU:

CAP	Pillar I	Direct payments per hectare are given through greening and cross compliance measures (SMR's and GAEC's in the 2007-2013, 2014-2020 and 2023-2027 periods). Direct payments are available through the agroforestry Eco-schemes (2023-2027): Establishment and maintenance of landscape features above conditionality Management and cutting plan of landscape features Establishment and maintenance of high-biodiversity silvo-pastoral systems
	Pillar II	Rural Development support is found for the Establishment (2007-2013), Maintenance (2014-2020), Regeneration and Renovation (Omibus Expansion, 2018) of agroforestry.
European Green Deal	Farm to Fork Biodiversity Strategy	Agroforestry maintains support as a tool to increase biodiversity, climate health, forest growth, as well its ability to create resilient jobs. Landscape features are also mentioned a handful of times within the documents, which are part of agroforestry.
EU Forestry Strategy		Complements the measures set out in the European Green Deal and recognises the role agroforestry can play in achieving the 3 billion trees by 2030 target.
Nature Restoration Law		Asserts the need for sustainable, resilient and biodiverse, agricultures and supports agroforestry to achieve such resilient agricultural ecosystems. It also declares the need to increase and maintain pesticide and fertiliser free high-diversity landscape features on agricultural land including buffer strips, rotational or non-rotational fallow land, hedgerows, individual or groups of trees, tree rows, field margins, patches, ditches, streams, small wetlands, terraces, cairns, stonewalls, small ponds and cultural features – all relevant to agroforestry – to provide ecosystem services for humans, wildlife, soil, water and climate.

Source: Rural Development support is found for the Establishment (2007-2013), Maintenance (2014-2020), Regeneration and Renovation (Omibus Expansion, 2018) of agroforestry.

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The importance of an agroecological framework

As shown, wide policy support does exist in Europe, yet the expansion of land devoted to agroforestry has been slow and incremental. Further, the ecosystem services derived from such systems have been inconsistent since agroforestry can be practiced in an industrial manner. It is important for agroforestry to be part of a food system transformation, where capacity building and effective monitoring is prioritised, along with an agroecological agriculture that focuses on the cultural and environmental realities of each landscape. Such a food systems approach must focus on 13 Agroecological Principles by HLPE on Food Security (The High Level Panel of Experts, 2019), along with frameworks such as the one created by the 'Global Alliance for the Future of Food' to provide a deeper systemic understanding of policy making, with a multi-level approach both to the mission of transformation and how to achieve it in an inclusive and cohesive way (Global Alliance for the Future of Food, 2022).

Policy priorities and recommendations

Rural Development support is found for the Establishment (2007-2013), Maintenance (2014-2020), Regeneration and Renovation (Omibus Expansion, 2018) of agroforestry.

1. Review all current and planned legislations to amend them towards a common food systems approach (creating complementing strategies in agriculture, rural development, fisheries, food safety, international trade, transport, energy, environment, health and humanitarian assistance, instead of different departments focusing on single issues individually, with fragmented objectives and varied perspectives which often contradict one another)
2. Cease the importation of plant protein feed products
3. Strengthen the synergy and interactions between different elements of agroecosystems
4. Aim for optimum yields rather than maximum yields
5. Phase-out synthetic pesticides (insecticides, herbicides, fungicides) and fertilisers (through symbiotic fixation from leguminous crops, nitrogen transfers from livestock, long and diverse crop rotations, intercropping, and constant soil cover and catch crops, including between trees and other permanent crops)
6. Increase mixed crop-livestock systems (including regional cooperation amongst farms)
7. Enhance animal welfare and extensively manage livestock
8. Restore and enlarge permanent grasslands (including agroecological infrastructure)
9. Return trees to agricultural landscapes
10. Diversify the types and number of crops grown on a single farm
11. Enhance and preserve the genetic diversity of livestock
12. Increase diversity of habitats (including high-diversity landscape features)
13. Increase the adoption of organic farming
14. Increase research on best practices at the local and regional scale for all aspects of the food system including for climate, soil, land management, and crop and animal diversity
15. Promote participatory and multi-stakeholder approaches in knowledge generation (including gender equity, cultural representation and racial justice)
16. Improve soil condition (organic matter and biological activity)
17. Transition to healthy diets for all (fewer animal products and sugar, more fruits, vegetables, legumes and nuts)
18. Re-establish common land for grazing
19. Establish more community supported agroforestry systems in urban and peri-urban areas (e.g., allotments, parks, micro forests, public spaces with fruit trees)
20. Legislate for agroecological green belts (e.g., 15% of all food for cities coming from agroecological green belts)
21. Transition to agroecology and a 'bio-circular economy' on a food and farming system level
22. Address tenancy to incentivise long-term agreements for multi-use agreements with the potential to support new entrants, open access to land with land reform and transparency of land ownership
23. Increase training (train advisors), financing and practical support for farmers and landowners wishing to implement agroforestry systems, as well as peer to peer mentoring
24. Develop regional supply chains for agroforestry products
25. Develop policies that see food as a common good, rather than a consumer good

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Free-range laying hens in a desert apple orchard increases biodiversity, help managing grass growth, and add fertiliser. (Copyright ITAVI)

The many different agroforestry systems present in France

In France (European territories), we can observe two predominant agroforestry models: silvoarable (intercropping trees with field crops) and silvopastoralism (pastoralism in a partially wooded environment). Silvoarable agroforestry was commonly used in the past but was slowly abandoned for mechanisation and parcel size purposes. However, it is slowly reimplemented to increase productivity and to adapt agriculture to climate change. Silvopastoralism is commonly observed in poultry production to encourage animal exploration of the outdoor run to improve animal welfare and the image of free-range production. In other animal production (cattle, pork), agroforestry was less used. But like silvoarable agroforestry, silvopastoralism is currently being implemented more and more frequently to counter heat waves and their impact on animal welfare in a global warming context. Other less commonly used agroforestry models are growing but still represent a small fraction of agroforestry practises and received few political supports. Eco-pastoralism is a mixed farming cooperation of two farmers: a shepherd sending his animals grazing on a fruit-grower 'orchard' or vineyard. Finally, eco-pasturage consists of a shepherd sending his animals grazing in non-agricultural areas (rural like forests or urban like hospital/museum parcs). These are a new emerging farming models which have yet to be developed further.

Policies contributing to agroforestry systems maintenance and development

Agroforestry systems have been encouraged by European, national and regional policies. Direct funding of agroforestry development has occurred mainly at a regional level. For example, in Rhône-Alpes region, through the poultry sector plan, seedling, plantation and protection equipment and advice was funded at 40% for implementing trees in poultry outdoor run. In the Nouvelle Aquitaine region, through the competitiveness plan, a rate of 16 € per seedling with protection was offered for the development of agroforestry on pastures (any type of animal production). At a national level, free-range 'Label Rouge' poultry production are obligated to have a certain amount/surface of trees in the outdoor run. Other policies do not fund directly implementation of agroforestry systems but intervene indirectly throughout more global environmental measures: aids conditioned throughout maintenance of areas of ecological interest (including trees and shrubs), carbon credits or ecological continuities in environmental management plans which can include implementing agroforestry systems. In the research sector, funding (European, national or regional) is being more and more oriented towards climate change including agroforestry systems. For example, in Auvergne-Rhône-Alpes region, 50% of research funding is oriented towards climate change.

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Agroecological scenarios

TYFA (Ten Years for Agroecology) is an agroecological scenario for Europe in 2050 conducted by Iddri, a French institute, with an emphasis on climate challenges, that gives some clue for policy makers on the potential consequences on farming, food, environment via a modelling exercise. The hypothesis are fertility management at territory level, abandonment of pesticides, extensification of vegetal production and livestock production (organic agriculture as a reference), redeploying of natural grasslands, adoption of food regimes more balanced on a healthy point of view. In this scenario, re-diversification of production systems and landscapes (including agroforestry and crop-livestock systems) are a cornerstone, but in combination with other agroecological practices.

In France, a plan for agroforestry was conducted during the period 2015-2020 to develop these practices. The different measures proposed are still relevant to be extended and will be a source of inspiration for the further recommendations.

Benefits and challenges of agroforestry systems

Benefits

Hedges and trees have many functions, economic and ecological. For the farmer, it leads to an economic diversification, providing a larger range of products. Trees and hedges can provide several agroecological benefits when considering the interactions with the crops or livestock. For the crops, it can improve soil fertility (by the roots and leaf-litter) and water and nutrients supply (thanks to the deep roots), leading to better productivity, moreover the auxiliaries hosted can provide biological pest control and consequently reduce phytosanitary treatments. For animal production, it can improve the animal welfare (by the shade provided and the wind reduction generated) and also the animal performances (the leaves can provide additional feed). For eco-pastoralism and eco-pasturage, these practises provide the shepherd with extra pasture land and in eco-pastoralism it helps the fruit/wine grower to control sodding in the orchard or contribute to landscape/green areas maintenance.

From an environmental point of view both systems can contribute to higher biodiversity (it creates a semi natural habitat that can provide a shelter for various species), climate change resilience (adaptation and mitigation), carbon storage, microclimatic regulation (wind breaker, cooler environment) water regulation (run off protection and floods control by soil conservation measures) and soil erosion control (by the soil cover). It can also contribute to forest fire prevention (less flammable material on the forest floor). For society, it contributes to societal services as maintenance of the rural landscape, aestheticism, and it can create related jobs.

Challenges

At the farmer level,

- Economic: cost of planting, long return on investment, economic viability not clear,
- Social: workload of maintenance of trees and hedges, administrative burden-work for funding access,
- Operational: mechanisation difficulties for intra-parcel AF and hedges,
- Psychological: in their mental representation/perception, trees are pretty but seen as unnecessary and complicated to handle,
- Cognitive: lack of knowledge and awareness on the local adapted practices and benefits of AF,

At the environment level

- Agricultural Knowledge Innovation System (AKIS): lack of research on adapted crops, lack of knowledge and local references on adapted systems (large diversity of forms of AF) and their performances (indicators of viability calculated generally on a single production and not systemically/globally), lack of extension services on AF, AKIS including extension and training organized in silo on animal production or on arable crops or on perennial crops,
- Policy funding: complex and heterogeneous access to funding (depending on the regions, all the measures are not activated),

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- Regulatory: complexity of the framework (multi-layers), soil tenure, tree status and rights, securitisation of the relationships between owners and renters/leasers, fiscal measures,
- Conjunctural, during a sanitary crisis: difficult to project on poultry outdoors run, not the priority during influenza sanitary crisis;
- Animal health: free-range pigs need extra double-fencing to protect from wild boar, if present in the territory.

Recommendations for policy measures to develop agroforestry

The following recommendations are in part taken from the 'Plan de Developpment de l'agroforesterie 2015-2020', mainly at the environment level:

1. actionable knowledge production and dissemination (making it visible): R&I on shade varieties selection, local technico-economic references on adapted practices and validated benefits (factsheets), demonstration and promotion of good practices via pioneer farmers implementing AF in concrete real conditions,
2. education and training: training on observation capacity and local adaptation of AF practices,
3. extension / technical support: adaptation of the arguments to the different profile of farmers, viability indicators of mixed systems based on the interactions between the components of the systems, focus on collective advice, incitation to collective action (pooling human resources for maintenance of AF/ hedges),
4. coordination between AKIS (Agricultural Knowledge Innovation System) actors on AF: national network,
5. political-regulatory-funding: accessible and simple, coherent between different policies, for example an incentive measure is currently lobbied at AuRA (Auvergne-Rhone-Alpes) region level for EU's CAP (Common Agricultural Policy) 2nd pillar that proposes an aid for the investment in planting AF-hedges at 80%-funding and the technical support organised in a collective format (less than 20% on the subvention total) to a group of AF farmers,
6. sector development support: economic valorisation of AF products, new sustainable local supply chains (label, brands, consumer understanding of the benefits of AF, etc.)
7. territory concertation: coherent strategy at territory level co-designed and concerted in a multi actor setting, consolidated climate energy territory plan (AF considered as a carbon measure), sustainable management plan,

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Traditional agroecology practices in the CEE region

Agroforestry as a land-use option has been included within the Common Agricultural Policy (CAP) of the European Union (EU) for many decades. Agroforestry as a land-use is often supported at the policy level as it can be more environmentally friendly than other land-uses or farming systems. As a system, agroforestry often: requires less herbicides and pesticides; creates more habitat for flora and fauna as well as having a high species diversity; and creates relations between different kind of greenfield elements – which are usually cut from each other. In addition, agroforestry systems can be more accessible to society than mono-cultures and creates a diverse landscape.

In the Central-Eastern European region, agroforestry has many centuries of tradition. Silvopasture, silvoarable and many types of mixed production practices, such as pasture forest, left wooded pasture, forest-bounds/hedges close to the edges of fields, grape-fruit-vegetable mixed use.

Need for transition

According to the climate change scenarios for the Central-Eastern European region the irradiation and therefore mean temperature will increase in summer time, meaning evapotranspiration will also increase, leading to increased irrigation needs. The natural water-levels are already decreasing in the soil. Already it is common in the region, that many horti- and fruticulture systems are irrigated, fruit plantations need cover to protect from sunburn and even some common cereals need irrigation (eg. corn).

The role of agroforestry

Agroforestry as a system could be important to the region given its multifunctional benefits. For example, shading from trees can decrease the need for irrigation and protect crops from high radiance levels. Even cereal fields could be considered as mixed-use agroforests in the future. These land-uses must change either by different cultivation or by different land-use. Agroforestry as climate change mitigation tool can also increase water stocks more evenly used, soil protection and provide alternatives to artificial shading systems.

Policy recommendations

- Clear definitions on regulation level of agro-forestry and mixed farming
- Clearly differentiate from other land-use types on definition, regulation, land-use registration, subsidies, evaluation
- Incorporate EU regulations and strategies into national level administration

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- Provide national/local best practice collection and especially testing results on economic cost-benefit bases to provide an effective guidance to farmers and reduce risk on agro-ecological transition
- Provide financial support to agro-ecological transition
- Focus on local needs and possibilities
- Ease the bureaucratic burden of funding of implementation of AF systems

		Scenario 1: Waiting for the 'technological transition'	Scenario 2: An 'agroecological transition' with "EU new strategies"
Main features (policy and technical background and requirements)	Main drivers of the transition	Market: Great lobby background from food/ agricultural industry	Policy: Great lobby from environmental sector
	Main problem	Precision agricultural technicians to be provided to each farm or farm cluster – who pays for it?	Not properly tested technicians and solutions – high risk
	Policy support	There isn't strong policy support; potentially not even needed	There is strong policy support and even further needed
Impacts	Human input needs	Significantly less	Potentially more, but there isn't any potential in this respect
	Pesticide/herbicide use	Proven lower pesticide/herbicide use	Potentially lower, not properly tested
	Accuracy	More exact processing	Not properly tested
	Economic balance	huge investment in management, expensive yearly services, form all other aspects less input, more output on yearly management bases	Not properly tested
	Tested processes	Well tested, there are professional solutions and providences	Not properly tested, which means a high risk (risk management needed)
	Policy transition needs	Yes, but it is not required change on authorities level	Yes, a new regulation set is needed
	Funding needs	High funding needed, Finance technological transition	Not properly tested, a financial risk management needed
	New skills requirement/ farmers knowledge	new skills required (not all farmers ready to change machinery)	new skills required (not certain if farmers ready to change management practices)
	Prices	Expensive on start the processing and on maintenance, not appropriate stocks exist on farm level in Hungary	Cheap on starting process, potentially expensive maintenance, finance losses due to lack of experience
	Data needs	Yes, above farm level data reach, farm level data providing services	Yes, on farm level – species /varieties combination, ecological relations
	Further costs	• Data providing services (Accessible satellite) • Technical expertise providing services farmers mainly can't pay it. • Higher educated farmers (less likely to remain in agriculture)	• potentially more input, less output • results less exact processing , • might cause economical loss and further social crisis.
	Societal transition needs	Yes; To decrease costs of individual farms, clustering transition might needed (social opposition might occur)	Yes; Society acceptation on potentially lower quality / smaller quantity production, food price increasing

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Agroforestry for Germany: adaptation and mitigation of climate change and environmental externalities

Policy co-design, the background

Germany's agriculture is facing multiple challenges simultaneously: the climate crisis, energy crisis, and biodiversity crisis, all while food security remains an important issue. Due to the urgency of these concerns, agriculture and land use in general need to address them at the same time. One land use system that has been shown to combine many of these goals is agroforestry. It can sequester carbon, improve soil health and water quality as well as increase biodiversity, while producing higher biomass outputs than tree- or agriculture-only systems. Despite these documented benefits, very little land in Germany is currently used for agroforestry systems.

Farmer perceptions

One of the reasons for limited adoption is farmer perceptions of these systems. German farmers mostly reject planting agroforestry, even if they were to become profitable through subsidies. Positive predictors for willingness to plant agroforestry systems were farmers with low quality soil, a high level of training, and if they had a generally positive attitude towards agricultural wood (Beer and Theuvsen 2020). Non-agroforestry farmers often perceive agroforestry to be less productive and profitable, even though many do recognise the positive environmental aspects of these systems. One major barrier is also seen in policy and legislation, which discourages the implementation of agroforestry (Tsonkova et al. 2018). While economic performance is not the only factor that influences adoption decision it seems to be an important element for many conventional farmers, especially as a first step to even consider these systems as a potential land use option.

Policy Option	Description
Baseline	No grants
CAP23	Direct payments (156 €/ha) + eco-scheme (60 €/ha wooded area)
Eco_double	Direct payments (156 €/ha) + eco-scheme*2 (120 €/ha wooded area)
Eco_tripple	Direct payments (156 €/ha) + eco-scheme*3 (180 €/ha wooded area)
AUKM1	Year 1-7: Direct payments (156 €/ha) + investment aid (1,546 €/ha wooded area) Year 8-24: Direct payments (156 €/ha) + eco-scheme*1.5 (60 €/ha wooded area)
AUKM2	Year 1-7: Direct payments (156 €/ha) + investment aid (1,546 €/ha wooded area) Year 8-14: Direct payments (156 €/ha) + investment aid (787 €/ha wooded area) Year 15-24: Direct payments (156 €/ha) + eco-scheme (60 €/ha wooded area)

Table 1: Policy Scenarios for Germany

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Policy landscape

In recent years no policy support or legislative framework existed for agroforestry in Germany. With the upcoming programming period of the Common Agricultural Policy (CAP) however, this is going to change. Germany has included the maintenance of agroforestry systems as an eco-scheme with a payment of 60€/ha of wooded area (BMEL 2022). Wooded area here means the area where trees are planted. Additionally, Germany is planning to offer investment aid through the "Joint Task for the Improvement of Agricultural Structure and Coastal Protection (GAK)". Some Federal States in Germany (e.g. Brandenburg) have also announced that funding will become available for establishing agroforestry. How these funding options will be coordinated between the federal states and the federal government is not yet clear (Albrecht 2022). Germany is also implementing a legally binding definition for agroforestry (BMEL 2022).

Policy scenarios

The policy scenarios for Germany consist of different financial support schemes described in Table 1. The coming programming period for the European CAP starts in 2023 and Germany has incorporated agroforestry as an eco-scheme in its strategic plan. The programmed 60€ are paid per hectare of wooded area, i.e. the area where trees ae planted on the agricultural plot. This area is declared by the farmer. Germany has not yet specified how the measurement of the wooded areas will be legislated. This wooded area, or area with trees, is then broken down into a share of the total agricultural plot e.g., if on a 20ha plot tree rows are planted that sum up to a total of 2ha, the share of wooded area on this plot would be 10% and a farmer would receive a total of 6€/ha on top of the direct payments. Direct payments are paid per hectare to each farmer independent of how the land is used. Since there has been critique that the eco-scheme payments for agroforestry are too low, two scenarios are included where the eco-scheme payments are doubled and tripled from their original value. The AUKM1 and AUKM2 scenarios are based on a proposal from the project SIGNAL, where for the first 7 years of establishment the farmer would receive 1,546 €/ha wooded area, and for the years 8 to 14 a total of 787 €/ha wooded area (Böhm et al. 2020). Whether this will be the investment aid available in the upcoming programming period is uncertain. It is used here to contrast the relatively low eco-scheme payments. All scenarios are forward looking assuming certain financial incentives. If time and resources allow for more scenarios to be run, other policies may be incorporated as well, e.g. reduced nitrogen fertilization or additional payments for carbon sequestration or other ecosystem services.

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Agroforestry: Benefits, costs and options for political support in Rhineland-Palatinate, Germany

Jörg Böhmer, Zaira Ambu, Frank Wagener, Felix Gräven & Peter Heck

Background

According to the German Insurance Association (GDV[1]), the **centennial flood event** in Germany and its neighbouring countries in 2021 has so far left a total of more than 8 billion euros in damage (€2 billion of this in the Ahr Valley alone). This means that the devastation caused within one single day exceeds the damage caused by the floods in the area under the influence of the Elbe and Danube rivers in 2002.

Agroforestry as a solution & current framework conditions

If one assumes – generously calculated – an investment requirement for agroforestry (AF) systems of €8,000 per hectare (ha) of net woodland area (or €800 per ha if only 10% agroforestry on and arable field), then 1-10 million hectares of agroforestry systems (depending on planting density) could have been financed with the damage amount of this single day alone. With around 16 million hectares of agricultural land in Germany, that would mean more or less comprehensive agroforestry in Germany, depending on the proportion of trees and shrubs. Under this premise, the restructuring of the landscape not only improves flood protection, but also improves numerous other landscape functions. The promotion of agroforestry is therefore an economically long-term highly sensible approach.

The Common Agricultural Policy in the EU

In the following, suggestions are formulated that relate to practical land management and are not covered by the existing legislation. Practical references are made that relate to real agroforestry systems and newly developed farming concepts as multi-use concepts or multi-profit strategies:

1. Implementation of the ˋEG WRRL´ in the riparian strips with agroforestry (´WERTvoll´)
2. Cultivation of different agroforestry cultures on one area, e.g. fodder hedges, standard tree traditional orchards, energy wood and high valuable timber wood (ˋMUNTER´, ˋEvA´)
3. Installation of agroforestry cultures on narrow parcels of land, e.g. in valleys in the upland mountain ranges of Germany ˋMittelgebirgeˋ (ˋMUNTER´

[1] https://www.gdv.de/de/medien/aktuell/nordrhein-westfalen-und-rheinland-pfalz-mit-hoechsten-unwetter-schaeden-84702

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Legal basis and suggestion to change

Bundesrecht GAPDZV 24. January 2022 BGB (national state law of Germany)

The concept of an agroforestry culture (type) in the draft bill (01.10.2021) § 4 Agricultural area and Annexes 1 and 5:

3 § 4,2 GAPDZV: An agroforestry system on arable land, in a permanent crop or on permanent grassland exists if the area with the primary aim of raw material extraction or food production according to a positive assessment by the competent state authority or by an institution recognised by the state, is assessed as valid woody plants (that are not listed in Annex 1) Specifically: 1. In at least two strips covering no more than 35 percent of the respective agricultural area, or 2. Scattered over the area in a number of at least 50 and at most 200 such woody plants/ha.

Practical problems: With a distance of 20 m (metre) and two strips, the plot width must be at least 69 m. References: some valleys are too narrow, mixed cultivation systems are excluded, only one strip on the water body also on both water body edge strips (different parcels/plots) are not an agroforestry system but rather coppice in short-rotation coppice. Proposal: Abolition of the minimum distances between the strips, approval of a pure percentage coverage of up to 50% of the respective agricultural area, no limitation on the number of woody plants, minimum distance to the upper edge of the embankment of a water body 1m.

Annex 1 The following woody plants are prohibited in agroforestry systems: Scientific name *Latin* (German name): *Acer negundo* (Eschen-Ahorn), *Buddleja davidii* (Schmetterlingsstrauch), *Fraxinus pennsylvanica* (Rot-Esche), *Prunus serotina* (Späte Traubenkirsche), *Rhus hirta* (Essigbaum), *Rosa rugosa* (Kartoffel-Rose), *Symphoricarpos albus* (Gewöhnliche Schneebeere).

CAP strategy plan, CCI 2023DE06AFSP001, page 296 ff., there is a subsidy of €60/ha for wooded area.

CAP strategy plan, CCI 2023DE06AFSP001, page 296 ff., there is a subsidy of €60/ha for wooded area.

3. In § 20.1.3 GAP Direct Payments Act

3.1. If an agroforestry management method is retained on arable land or permanent grassland, the area of the wooded strips on an eligible area of arable land or permanent grassland that meets the requirements under numbers 3.2. and 3.3 can receive subsidies.

3.2. The wooded strips must meet the following requirements:

3.2.1. The proportion of wooded areas in eligible arable land or permanent grassland is between 2 and 35 percent.

Suggestion: up to 50% (e.g. modern extensive forests for animal welfare (shading).

3.2.2. The strips of trees must be covered with trees as far as possible.

Suggestion: Cultivated areas such as stock-pile areas for agricultural wood can be uncovered (10 - 40 m).

3.2.3. The minimum number of strips of wood is two. (Intervention SMEKUL and advice from WERTvoll was unsuccessful, however a revision is planned in the federal state of Saxony)

Suggestion: The minimum number of wood strips is one. Various agroforestry cultures can be combined in the area: then up to 50% of the area is planted with trees and shrubs.

3.2.4. The width of the individual strips of wood is between 3 and 15 meters.

Suggestion: reduce to 1 to 20 m (fodder hedges, EG-WFD)

3.2.5. The greatest distance between two strips of wood and between a strip of wood and the edge of the area is 100 meters. Suggestion: delete

3.2.6. The smallest distance between two strips of wood and between a strip of wood and the edge of the area is 20 meters. Proposal: Abolition of the minimum distances between the strips

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3.3. Irrespective of nature conservation regulations, timber harvesting measures in the application year are only permitted in the months of January, February and December. Proposal: no change

Important for watercourses according to the GAP strategy plan: If a strip of woodland is planted alongside or near a watercourse, the distance to the edge of the area specified there may be less (intervention SMEKUL & advice WERTvoll)

Promising policy schemes solutions for Rhineland-Palatinate

1. **State level (national and federal state):**
   - Agroforestry support as 2nd pillar environmental scheme
   - Agroforestry support within agricultural investment subsidies (income diversification)
   - Financial support for planning & concepts (for farmers and/or municipalities) – including additional funding from the federal state (not the national Germany level)
   - Integration of agroforestry as a measure in the `Aktion blau plus' programme
   - Uptake of agroforestry as a possible compensation measure within the state compensation regulations
2. **Political framework conditions / regulations:**
   - Extension of the regulations for the recognition of agroforestry in the context of the area application at federal and national state level
3. **Municipal level:**
   - prioritised acquisition of wood chips from agroforestry for local district heating system

For more information about 'Agroforestry: Benefits, costs and options for political support in Rhineland-Palatinate' and the AGROMIX project, please contact

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Policy scenario co-design

In Switzerland, there is still a large proportion (7.9% of usable agricultural area, in total about 79.000 ha) in traditional agroforestry systems, like traditional orchards or forest pastures. Modern agroforestry practices only account for a small proportion (500 ha) of land use. Modern agroforestry systems are eligible for funding under the biodiversity promotion scheme. Although the financial incentives are high, up to 2250.- Swiss francs/year and ha, the conversion to modern silvoarable and silvopastoral systems is progressing only slowly. However, especially in the last three years, interest on the part of political decision-makers has increased.

Swiss Agroforestry in Practice

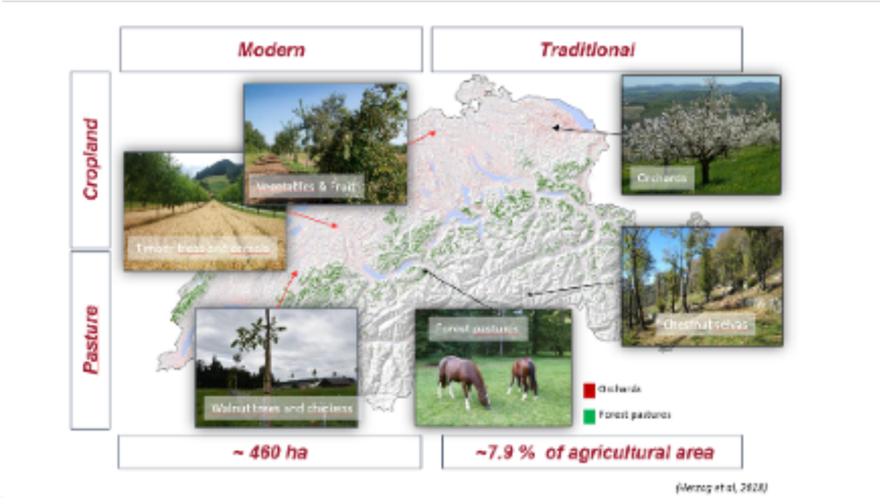

Figure 1: Overview - traditional and modern agroforestry in practice.

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For example, in its Sustainable Development Strategy 2030 (SDS 2030), the Federal Council indicates the priorities to be set for the implementation of the 2030 Agenda for Sustainable Development over the next ten years:

"sustainable consumption and production", "climate, energy and biodiversity" and "equal opportunities and social cohesion".

Among other things, concrete measures were defined for the period 2021 - 2023 within the framework of an action plan in order to achieve targets within the above-mentioned priority themes.

Measure 7 directly targets agroforestry measures. Specifically, it states: "*This measure generally aims to evaluate the potential of coordinated promotion of trees in the form of urban forestry and agroforestry in rural areas. A cross-sectoral and spatially differentiated approach to the use of trees as a natural resource is proposed. The assessment of the promotion potential is based on the question of the extent to which this can contribute to addressing global challenges such as CO_2 sequestration, biodiversity loss and adaptation to climate change.*"

The specific objectives of Measure 7 are:

1. Development of a cross-sectoral, coordinated partnership
2. Dialogue and knowledge transfer for the further development of urban forestry and agroforestry
3. Development of guidelines and recommendations
4. Exploration of innovative approaches and perspective analysis

A concept will be developed for the promotion of trees and for reflections on forest and agriculture policies of the future, as well as on their relationship to ecological infrastructure in the context of the biodiversity strategy.

In three stakeholder meetings in the first half of 2022, the Federal Offices for Agriculture and the Environment discussed various measures to promote agroforestry in Switzerland, defined possible research priorities and discussed current problems with practitioners. The current Swiss Climate Strategy for Agriculture, which will be adopted this autumn, also includes various measures to promote agroforestry systems from a climate perspective.

Overall, the current situation of agroforestry in Switzerland can be summarised as follows:

Two steps ahead – one step back

- Growing interest from farmers
- Support from farmer organisations, e.g. IP-Suisse (~20,000 members) created a climate label with agroforestry amongst the proposed measures
- **Agro4esterie:** a pilot project funded by Ag. Ministry with funding for 100 agroforestry farmers and for scientific monitoring (2021-2027)
- **The Coop Agroforestry Support Programme** is the first climate project in Switzerland to be financed by the private sector in the voluntary CO2 market. Between 2018 and 2022, 60 farms participated. The carbon yield in woody biomass in the agroforestry system was financed.
- Ag. and Env. Ministries organise three **networking / information days** on agroforestry related to the revision of the «Swiss CAP» and the Sustainability Agenda for administration + stakeholders + research (as explained before)
- Revision of the «Swiss CAP» contained an agroforestry measure. It was stopped by parliament in 2020 (there was a general disagreement about subsidy levels and «how green should it be»). The government's new proposition has no agroforestry measure, however this is back to parliament in autumn 2022

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The most important policy scenario co-design options for Switzerland are:

Overall, the following broad directions are currently being discussed in Switzerland:

1. Agricultural policy as a whole will become more agroecological and promote production systems that meet these objectives.
2. Intensive livestock and fodder production for ruminants in the valley areas is being shifted to the hill and mountain areas in favour of site-adapted, grassland-based animal husbandry. The area for fodder production in the valley areas is increasingly used for arable farming and the products flow directly into human nutrition.
3. The intensive keeping and feeding of non-ruminants (pigs, poultry) is coming under increasing pressure in Switzerland. In September, the Swiss population will vote on the factory farming initiative. Even if the initiative is rejected, it shows the increasing sensitivity of consumers to the issues of animal welfare and "feed no food". In the long term, the husbandry regulations for non-ruminants will continue to adapt to the existing rules of organic farming.
4. The degree of self-sufficiency in cereals, oil crops and grain legumes to be increased.
5. In a mosaic-like and diverse cultural landscape, mountain agriculture will increasingly use land for arable farming.
6. Negative environmental impacts from agriculture are reduced to a minimum.

IG Agroforst recommend the following policy options:

These are the result of the policy workshops described above and were also communicated to the Federal Office for Agriculture in a letter at the beginning of 2022:

- Anchoring agroforestry in agricultural policy as an independent production system.
- Agroforestry should be recognised measure as a biodiversity-promoting area in arable farming.
- Today, the topics of agroecology (including agroforestry) are very much underrepresented in agricultural education. There is also rarely an advisory structure on these topics, so that interested farmers hardly have a place to turn to. The federal government must make efforts to increase capacities in this area.
- Implementation of the Climate Strategy for Agriculture and strengthening of agroforestry measures within it.
- Promotion of direct partnerships between cities and municipalities and local agriculture within the framework of climate protection projects.

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IG Agroforst

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Agroforestry: an agroecological transformation of England's landscapes

Policy co-design, the background

Governments in the UK and England are committed to significant land use changes in order to meet ambitious but necessary climate, biodiversity and landscape restoration targets. To meet net-zero emissions by 2050, we need to drastically reduce our greenhouse gas emissions, whilst simultaneously increasing our carbon sinks, such as woodlands and peat soils. At the same time, we need to transform our **food systems** to reduce their environmental impact and also address growing health related concerns and issues of food justice and food poverty. Leaving the European Union and the constraints of the current EU-Common Agricultural Policy means we have an opportunity to make **significant changes** to the way we produce, consume and distribute food and agricultural products.

Given the need for afforestation and reforestation in the UK, **agroforestry**, implemented in an agroecological way, offers many `**co-benefits**' across the nature and human health objectives. These include: carbon sequestration; habitat creation; improved biodiversity; climate mitigation; improved diets; regionalised food supplies; improved rural livelihoods and more. Despite the acknowledged benefits of these systems, **farmer and landowner uptake is currently low**. This is because of a lack of financing, knowledge, advice, supporting schemes, and a missing supply chain infrastructure.

Currently, agroforestry makes up only 3.3% of the UK's land-use. In England, this is only 1.61% (our data based on LUCAS 2015). To make any significant changes in land use, we need to engage with who **owns England** and can make the changes we so desperately need. Land ownership in England is **highly concentrated**, meaning a few key decisions from a few key stakeholders could make a **big change**.

Land owners	Area in acres	Area in hectares	As a % of England
Crown	456,482	184,732	1.4%
Church	175,00	70,820	0.5%
Public sector	2,713,3663	1,098,060	8.5%
Conservation charities	635,914	257,435	2.0%
Public sector total	**3,980,759**	**1,610,957**	
Limited Companies & Limited Liability Partnerships	5,756,670	2,329,644	18%
'Old money' - aristocracy & gentry	9,600,000	3,884,986	30%
'New money' - wealthy individuals	5,440,000	2,201,492	17%
Homeowners (domestic homesand gardens)	1,749,439	707,973	5.5%
Unaccounted	5,472,000	2,214,442	17.1%
Private sector total	**28,018,109**	**11,338,537**	
Total	**31,998,868**	**12,949,494**	**100%**

Source: 'Who Owns England?' Guy Shrubsole (2019), data additions by authors.

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Our 'menu of 20' policy scenario options for England:

To make agroforestry an agroecological transition pathway, we have discussed the following scenario options and policy priorities. They are in recognition of previous policy papers related to agroforestry in England by Smith (2010), Soil Association (2018), Shrubsole (2019) and Tosh (2021).

1. Change to healthy diets for all (fewer animal products and sugar, more fruit, legumes and nuts)
2. Remove all imported feed products (soy and other grains)
3. Conversion of all intensive livestock systems to mixed farming and free range
4. Re-establishing shelter belts, riparian buffers, trees in the farmed landscape
5. Re-establishing natural grasslands with hedges, single trees and agroforestry
6. Using cover and catch crops in crop rotations and under trees
7. Focus on feeding the soil (4 per 1000 initiative) and regenerative agriculture and forestry
8. Increase food-diversity in varieties, crops and livestock
9. Re-establish common land for grazing and appropriate tree cover increase agroforestry to 5%
10. Within ELMs (Environmental Land Management scheme) further eco-schemes (public goods, carbon credits) directed and funded appropriately to increase agroforestry and mixed farming
11. Phase-out all fossil-fuel derived synthetic fertilisers
12. Phase-out all fossil-fuel derived synthetic pesticides
13. 25% certified organic land by 2030 (to match EU policy) or 30% certified organic land by 2030 (to match Germany, Bavaria, Austria policy)
14. Make 10% agroforestry mandatory on all certified organic farms
15. Urban Agroforestry: establish more community supported agroforestry systems in urban and peri-urban areas: allotments, parks, micro forest and enhance public spaces with fruit trees
16. Legislate for agroecological green belts; 15% of all food for cities from agroecological green belt
17. Transition to agroecology and a 'bio-circular economy' on a food and farming system level
18. Address tenancy to incentivise long-term agreements for multi-use agreements with the potential to support new entrants, open access to land with land reform and transparency of land ownership
19. Address non-compliance with banded land tax (equivalent to council tax) and new land ethic
20. Ensure a 'fair share, fair play and fair say' approach to farming and the food industry; with mandated labelling to enable consumers to make choice based on ethical, political and environmental values through consumption

Policy Priorities

- Increase training (train advisors), financing and practical support for farmers and landowners wishing to implement agroforestry systems
- Develop regional supply chains for agroforestry products
- Support access to research, practical guidance, and peer to peer mentoring
- Support agroforestry to work towards the 2030 Action Target 10 of the UN Post-2020 Global Biodiversity Framework in the UK: for agroecosystems that are both resilient and productive
- Include agroforestry into wider policy areas: e.g. Path to Net Zero, National Food Strategy, Delivering for Nature

For more information about 'Agroforestry: An agroecological transformation of England's landscapes' and the AGROMIX project, please contact the authors:

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