D8.6 Transferability analysis of project results

agricore

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Executive Summary

The agricultural sector is crucial for global food security, economic stability, and environmental sustainability. The AGRICORE project was initiated to address the evolving challenges in agriculture by integrating cutting-edge technologies and data-driven solutions. This deliverable explores how the developments within AGRICORE can assist policymakers in shaping and implementing sustainable agricultural policies that enhance productivity and ensure food security.

AGRICORE aims to revolutionise agriculture through advanced technologies and data-driven approaches. The project leverages key components such as data sources, synthetic population generation, agent-based modelling, and policy impact assessment based on various KPIs. These capabilities enable policymakers to make informed and effective decisions.

The structure of this deliverable begins with a summary of the main contributions from the AGRICORE project and their potential uptake strategies, as well as a description of how such advances contributed to the achievement of the project goals. This is then followed by a brief description of state-of-the-art (SoA) in agricultural policy modelling, highlighting the innovations introduced by AGRICORE. In this regard, this section delves on how AGRICORE provides significant advancements over traditional non-agent-based business models and more developed agent-based approaches. It also details how the project has addressed the limitations of existing models, such as the need for extensive user input and interaction with the broader economy. It then enters into detail on the exploitable elements developed within the project, delving into the possibilities to use, reuse and further improve the project results for diverse actions. In this area, five main elements are analysed, including the overall AGRICORE solution and the associated policy making support services and the individual results: the ARDIT platform; the Synthetic Population Generation approach and modules; the infrastructure for ABM simulations and the rest of the AGRICORE modules.

Overall, this deliverable highlights the most important features of each of the project outputs and describes the actual potential of such individual results.

In conclusion, this deliverable reinforces the fact that the AGRICORE project offers valuable resources and tools for policymakers to address the challenges and opportunities in agriculture, and for researchers to further explore and develop the innovative approaches presented in the project. Such innovative approach and advanced capabilities provide a comprehensive framework for enhancing agricultural productivity, sustainability, and food security.

Abbreviations

Abbreviation	Full name
CGE	Computable General Equilibrium
DAG	Direct Acyclic Graph
DEM	Data Extraction Module
DFM	Data Fusion Module
DWH	Data Warehouse
ETL	Extra-Load-Transform
FADN	Farm Accountancy Data Network
FES	Financial Economic Simulation
IAM	Impact Assessment Module
ICT	Information and Communication Technologies
KER	Key Exploitable Result
MP-MAS	Mathematical Programming-based Multi-Agent Systems
PMP	Positive mathematical programming
SPG	Synthetic Population Generation
SR	Synthetic Reconstruction

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1 Introduction

The agricultural sector plays a pivotal role in global food security, economic stability, and environmental sustainability. To address the evolving challenges faced by agriculture, the AGRICORE project was initiated, aiming to integrate cutting-edge technologies and data-driven solutions into the agricultural domain. The purpose of this manuscript is to investigate how the developments within the AGRICORE project can serve as valuable resources for policymakers in shaping and implementing policies that promote sustainable agriculture, enhance productivity, and ensure food security. More specifically, this deliverable explores the potential of the AGRICORE project and its various developments in providing valuable insights and tools to support policymakers in the field of agriculture. The AGRICORE project aims to revolutionise agriculture by integrating advanced technologies and data-driven approaches. In this paper, we investigate the different aspects of the project and how they can be harnessed to inform and enhance policy decisions in the agriculture sector. We examine the key components of AGRICORE, such as data source, synthetic population generation, leverage of agent-based modelling and policy impact assessment according to different types of KPIs. By leveraging the capabilities of AGRICORE, policymakers can make more informed and effective decisions to address the challenges and opportunities in agriculture.

The sections on this deliverable are dedicated to detail, with different approaches, how the AGRICORE project results have gone over the current State of the Art related to modelling in the agricultural policy sector. It also covers the exploitation potential of the project developments, either through consulting services (support to policy making), by reusing the project technologies, or by fostering further research linked to agricultural policy modelling, synthetic populations or ABM simulations. All these elements have the potential to provide (either directly or indirectly) valuable support for policymakers operating in the agricultural sector.

2 Summary of main contributions from the AGRICORE project and their potential uptake strategies

This section synthesises the outputs of the AGRICORE project that contribute to going beyond the state of the art of agricultural modelling tools and enable further improvements and developments. This applies to the whole AGRICORE suite and, thanks to its high modularity, the parts that comprise the suite that can potentially be extrapolated to similar applications.

As described in Section 3, the AGRICORE suite entails a sound step beyond the state of the art because it enhances several aspects of the current farming modelling approaches. The ABM approach of the AGRICORE tools includes the benefits of traditional mathematical programming but incorporates better representativeness and heterogeneity of populations at different geographical levels. Additionally, it overcomes the limitations of econometric approaches, enabling the connection of external modules and the integration of multiple data sources. ABM also allows for positive and normative analysis through the execution of multiple scenarios simulation. Overall, the AGRICORE tool improves other state-of-the-art ABM-based tools thanks to the reduction of calibration and parametrisation efforts, its open sourcing and the incorporation of advanced ICT technologies.

All those benefits are included in the overall project result, the AGRICORE suite, which presents multiple exploitation paths. It is important to remark that the suite represents a step beyond the current technologies in the area but yet should be subject to further research and improvements in order to maximise the benefits it can provide to the corresponding stakeholders. This is aligned with the two main paths that are considered, consulting and scientific exploitations, which put the suite at the service of policymakers and organisations in the sector and lay the foundations for future research in this field, respectively. This also highlights something as important as the suite, the knowledge gained during its development, which will facilitate tackling common problems such as finding reliable data sources and processing farms' data, as well as assisting entities at different levels to extract valuable information regarding the impact of agricultural policies.

Thanks to the modularity of the tool, this is also reflected in the four main individual outputs described in the subsequent corresponding sections. These are functional parts of the suite that comprise other developments and that are easily replicable and reused in other approaches or fields, or that are suited for further research. These are illustrated in Figure 1, together with their transferability potential.

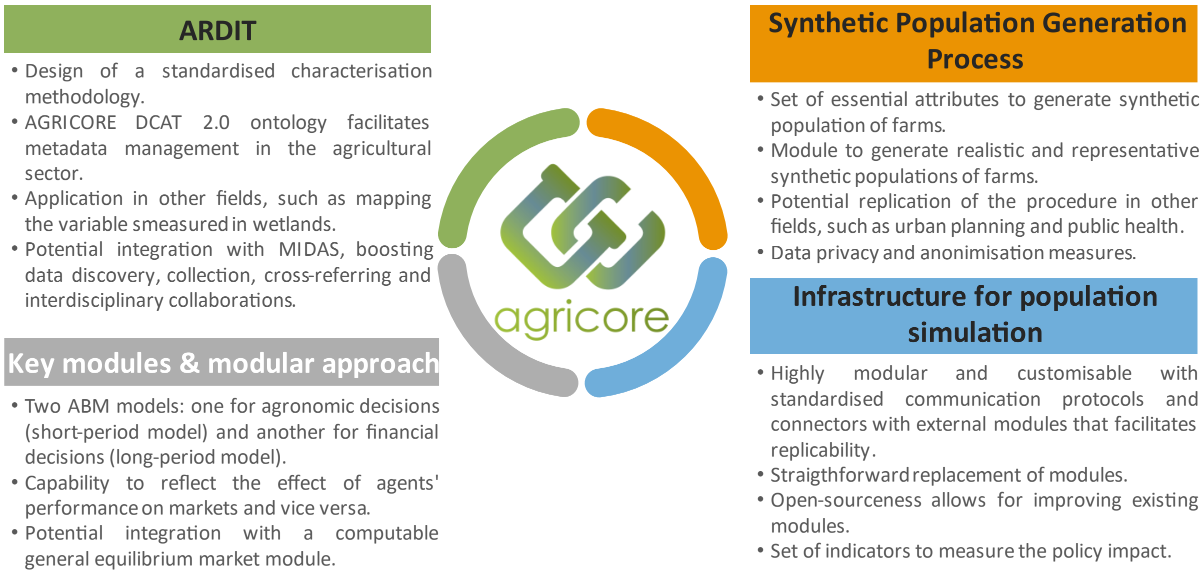

Figure 1. Summary of main individual contributions from the AGRICORE project and their potential uptake strategies

Although the main outputs (both, the overall Agricore suite and associated services and the individual outputs) are further described in Section 4, they are briefly presented next.

- **(Global result) AGRICORE suite and associated research services:** the overall result of the AGRICORE project, this is, the AGRICORE suite, represents a step beyond on ABM simulation at farm level towards policy modelling. Although the platform status at the end of the project still requires further development and connection to external systems (e.g. CGE models for product prices evolution) to provide meaningful and complete policy impact assessments, the current version allows for the proper simulation of populations in a given policy scenario, which can be used to provide insights into the impact of agricultural policies, especially in the short term (1-2 year of simulation) and therefore support policy impact assessment. Moreover, the knowledge acquired by the AGRICORE members, the overall tools and its parts will be combined with the previous knowledge of different entities (UNIPR, AUTH, UTP, IAPAS) to provide new and improved research services to different local and EU-level agencies in the impact analysis of agricultural policies.
- **(Individual result) ARDIT**: The Agricultural Research Dataset Index Tool (ARDIT) is a web application that aims to foster and facilitate access to agricultural data sources which are useful for agricultural research, especially in the field of policy impact assessment and in the initialization of ABM models. This application will remain active after project completion with IDENER in charge of its maintenance. New dataset characterisations can be included by third parties and therefore made accessible to the research community. On top of that, the proposed standardised characterisation methodology (published as AGRICORE DCAT-AP extension) allows for describing data sources (and the information contained on them) in a much higher level of detail than current alternatives. Overall, the the standardized characterization and its usage in the ARDIT tool under a common ontology saves time in searching for data sources for policymakers and researchers, while fostering information sharing and interdisciplinary collaboration. Additionally, the tool and the ontology can be easily translated to other research areas, fostering its potential exploitation and reuse after the project.
- **(Individual result) Synthetic Population Generation Process**. The developed semi-automatic tool (Synthetic Population Generator) includes a set of algorithms to combine data from different sources to support the generation of anonymised and representative

synthetic populations of farms at different geographical scales. The implemented approach uses a reduced set of variables called attributes of interest and generates agents grouped by a feature of interest, in this case, crops. The tool does not require extensive expert knowledge, and agricultural researchers and policymakers can use it to generate other populations (e.g., changing the representative groups of crops, using other data sources). This tool represents a step ahead specially towards ABM simulations, presenting obvious advantages over other approaches (i.e. sample-based simulations, farm-type simulations) as it allows to extract valuable information regarding incipient behaviours and specific geographic based evolutions, while exploiting all the information available without compromising private / sensible information. Despite its potential reuse by further research projects or activities (including but not exclusively policy impact assessments), the developed elements can be further reused and adapted to other research areas, especially for those where ABM is applicable and presents advantages over current approaches.

- **(Individual result) Infrastructure for population simulation**. The set of modules that comprise the AGRICORE suite have been developed to achieve a high degree of modularity and customisation and are released (as all project software results) as open source. This derives into several benefits that increase the impact of the project, especially regarding their adoption and reuse by other research and development teams. The overall infrastructure, the proposed cycle (Data identification -> synthetic population generation -> ABM simulation -> result analysis) and technologies (ORM, optimized simulation engine, data architecture, …) can be adapted towards the support of other research and analysis in other fields, including those related to policy impact in other areas but also in non-policy-related analyses and in non-agricultural environments.
- **(Individual results) Key modules and modular approach**. Most (if not all) of the AGRICORE modules can be reused or readapted to other fields. The AGRICORE suite allows for simulating the evolution of (agricultural) populations, mimicking the farmers agronomic and financial decisions under different environments. This includes, obviously, the farm ABM models for short-term and long-term decision-making replication. These models can be easily adapted to other simulation strategies (not necessarily embracing the same approaches as AGRICORE) to embrace the advantages of the 2-stages (short/long term) decision making modelling approach. Nonetheless, the AGRICORE suite includes several elements (e.g. multi-market modules, KPI implementations, interfaces) that can also be easily integrated in other solutions, or further developed to build complex or alternative solutions for policy impact assessments or completely different goals.

All these outputs significantly contributed to the achievement of the overall project objectives. The contributions of each one of the individual results are presented in the table below while the overall global result (the AGRICORE suite) contributes to all project objectives.

AGRICORE outputs	Project objective	Main contributions
ARDIT	O1. To develop a European data-sources index tool	Development of the ARDIT tool to facilitate access to data sources, including ontologies and characterisaiton methodology,
Synthetic population generation process	O2. To minimise the time and user efforts currently required for the parameterisation and calibration of ABM models	The SPG process allow non-expert end-users to generate SPs based on FADN data which is then used to initialise ABMs.
Infrastructure for population simulation	O5. To develop a flexible and integrated simulation suite	The AGRICORE architecture integrates all developed modules and connectors for external ones.

	O10. To develop a highly modular and customisable tool to allow further improvements as needs arise	The AGRICORE architecture is based on standard communication protocols to boost the tool's modularity and customisation.
Key modules and modular approach	O3. To develop an evolved agent-based model with improved capacity to model policies dealing with agriculture	The ABM simulation module and the Multi-Markets approach leads to realistic simulations in which the evolution of the population can be easily observed.
	O4. To produce a behavioural model of farmers mimicking their decision-making rationale	The short-period and long-period models deal with the agronomic and economic decisions of the farmers, complementing different aspects of their decision-making process.
	O6. To compile, analyse and show the produced information in an optimal way	The visualisation layer implemented in the AGRICORE interface shows customised charts that provide easy access to key information about the evolution of the populations and the impact of the selected policies.
	O7. To provide social, economic and environmental impact assessments of agricultural policies at farm, sector and global levels	The selected KPIs (including socio-economic, and environmental ones) are calculated and graphically shown in the interface of the AGRICORE tool on real time, and are adapted dynamically to the selected geographic scope.

3 State of the art of modelling in the agricultural policy sector and AGRICORE's innovations in the field

This section describes the state-of-the-art modelling approach applied **to the agricultural policy sector and the linked AGRICORE's innovations**.

Since the Common Agricultural Policy (CAP) has shifted its focus more towards assessing farmers' behaviours, there has been a growing interest in farm-level models. The primary decision-making unit in these models is the farm, the starting point for agro-economic innovations. Furthermore, agricultural and agro-environmental policies determine changes in land use, production, and externalities.

Within this framework, the literature review identifies five main approaches to farm-level modelling [1]: 1) Mathematical programming, 2) Econometric approach, 3) Econometric mathematical programming, 4) Simulation approach, and 5) Agent-based model (ABM). AGRICORE falls under the ABM and mathematical programming categories. The AGRICORE suite presents advancements compared to the other categories. The innovations in question are listed below:

3.1 - Progress of AGRICORE compared to the state-of-the-art in mathematical programming: The most advanced and used farm-level models applied in the ex-ante impact assessment of EU agriculture are based on mathematical programming at the farm-type level, such as FARMIS [2], FSSIM [3], AGRISP [4], CAPRI-FT [5], FAMOS [6] e AROPAj [7]. In these models, an optimisation problem is solved regarding input and land-use decisions, subject to a set of constraints representing production technology and policy restrictions. In this context, farm type refers to given typologies of farms that are considered representative.

Several advantages explain the widespread use of mathematical programming at the farm type level: (i) It allows for the explicit modelling of how decisions input factors and farmers' decisions influence productions; (ii) it can incorporate complex policy, economic, environmental, and production constraints; (iii) it enables modelling of potentially complex policy schemes due to flexibility in designing the objective function and model constraints; (iv) it can be used for both ex-ante and ex-post policy analysis; and (v) it enables various impact analyses, including financial, technical, socio-economic, and environmental impacts.

As mentioned above, the structure of the AGRICORE agent-based model is based on a mathematical programming approach. Therefore, the model inherits all the related advantages discussed above. As a main improvement, AGRICORE considers farms as individual decision-making units related to each other. This feature adds significant advantages to AGRICORE compared to mathematical programming at the farm type level for the following reasons: (i) it better accounts for heterogeneity among farms in terms of representation and policy impacts; (ii) it allows modelling at various geographical scales, from farm to regional and global scales; and (iii) it reduces aggregation bias when considering the average of multiple farms in response to policy, market signals, and other exogenous variables.

3.2 - Progress of AGRICORE compared to the state-of-the-art in econometrically estimated farm models: In general, farm-level econometric models are built for representative (average) farms as evolutions of the standard short-term profit maximisation model developed by Chambers [8]. Within these models, the behavioural function is empirical, providing theoretically coherent simulations and testing parameters' relevance given an adequate dataset. However, econometric models present some significant drawbacks that limit their use: (i) they require very comprehensive datasets to deduce the behavioural function empirically; (ii) additional constraints cannot be easily incorporated; (iii) they are limited to evaluating policies for which past observations are available (ex-post analysis) and therefore are poorly suited to analysing the impact of new policy instruments (ex-ante analysis); (iv) they generally focus only on financial impact analysis; and (v) they cannot easily connect to biophysical models. These listed constitute gaps that the model developed by AGRICORE aims to fill.

In this regard, AGRICORE offers clear advantages over econometrically estimated farm models: (i) it is designed to accommodate fragmented and disparate databases to deduce model characteristics through an advanced population process; (ii) it can easily incorporate as many restrictions as necessary; (iii) it can be used for both ex-ante and ex-post analysis (note: the current version of AGRICORE support ex-post analyses but would benefit from further R&D to further facilitate this task and reduce user intervention for this purpose); (iv) it takes into account a comprehensive set of impact assessment modules, including environmental and climatic impacts, socio-economic factors, and ecosystem services; (v) it can be connected to biophysical models and can be easily expanded to incorporate additional linkages provided by other research teams and institutions.

3.3 - Progress of AGRICORE compared to the state-of-the-art in econometrically programmed farm models: Econometric programming involves first estimating the parameters of the mathematical programming model using a Bayesian approach to existing datasets and subsequently employing the estimated parameters in the programming model to perform simulation scenarios. Introduced by Heckelei and Wolff [9], this hybrid approach has been presented as an alternative to mathematical programming (specifically positive mathematical programming). Its main advantage is that the parameters defining the objective function are estimated more consistently compared to "standard" mathematical programming models. However, this approach has yet to be applied to policy analysis, mainly due to the (limited) availability of data and numerical resolution issues. In this parameterising, AGRICORE aims to provide advancements over "standard" econometric programming models in parameterising the objective function, which is directly linked to faithfully reproducing farmers' behaviour.

To overcome the limitations of econometric programming related to data availability and numerical resolution issues, AGRICORE enhances farmer behaviour modelling by (i) leveraging stakeholder knowledge to refine the objective function structure through participatory research and the use of previous existing data and (ii) presenting a new farmer decision-making algorithm derived from artificial intelligence algorithms to replicate their behaviours.

3.4 - AGRICORE's progress compared to the state of the art in business simulation models: Economic simulation models consist of statistical relationships estimated from historical data and accounting identities to simulate the behaviour of a real system. Well-known simulation models, such as FLIPSIM, exist in the literature [10]. The FES model was developed at Wageningen University. FES is a financial-economic microsimulation model. Based on the Business Information Network it calculates the effects of policy measures which demand investments from agricultural companies, and specifically the effects of these investments on the financial position and income of agricultural businesses.

As a notable characteristic, one type of these models (specifically, stochastic models) incorporates risk by assessing the probability distribution of specific exogenous and endogenous variables. However, business simulation modelling (i) is a purely positive approach that can only be used to simulate the real system as faithfully as possible; (ii) does not allow for structural changes in different policy scenarios (e.g., no changes in land allocation); and (iii) validation and verification phases are generally very costly and time-consuming, as business simulation models do not provide a single solution but rather several alternative options.

To address these issues, AGRICORE incorporates, among others, the temporal dimension (short and long-term).Moreover, AGRICORE incorporates risk similarly to business simulation models, although it does not inherit the modelling limitations. Specifically, the agent-based AGRICORE model is designed to have access to probability distributions (mean, variance, and skewness) of the probabilistic estimates of future framework conditions (market processes, crop yields, etc.), which leads to practical consideration of risk and uncertainty in the rational behavioural function. Unlike business simulation models, AGRICORE: (i) can be used for both positive and normative purposes (i.e., to simulate a given policy or to compare optimality of policy choices towards a defined objective); (ii) explicitly allows for structural change (e.g., transfer of production factors such as land); and (iii) provides individual simulation outputs, thus facilitating validation and verification of results.

3.5 - Innovation potential of AGRICORE: In addition to the advancement provided by AGRICORE compared to the state of the art in non-agent-based business models (as discussed earlier), the project also offers relevant innovations compared to more developed and widely used agent-based approaches. A brief survey of the main agent-based approaches begins with the model published by Balmann in 1997 [11], which laid the groundwork for the subsequent generation of agent-based models. This model considered firms acting individually and competing for land parcels across different markets, engaging in various production and investment solutions. To do this, each firm was designed to optimise its activities concerning its objective function, considering expectations, financial situation, and existing assets. This behaviour was simulated using a mathematical programming problem.

Moreover, the AGRIPOLIS model conveniently extended the Balmann model by including five main enhancements: (i) spatial environment so that the model considers a hypothetical landscape reflecting some properties of the actual landscape; (ii) policy environment, allowing a flexible implementation of decoupling policies; (iii) behavioural foundations, considering radical changes in policies and farm entry/exit decisions; (iv) market, taking into account the model's interface with aggregate sector models and enhanced regional markets; and (v) land market, including an adaptation to the specific land region properties, extending contract types and considering transaction costs and scale effects. (Agricore upgrades)

Regarding other models, emphasis has been placed on some additional and specific aspects:

- MP-MAS model (Mathematical Programming-based Multi-Agent Systems) [12]. It stands out for its combination of a microeconomic modelling approach and a choice of alternative biophysical modules that are either encoded as part of the software or coupled to it. MP-MAS is part of a family of models called multi-agent systems models of land-use/cover change (MAS/LUCC). These models couple a cellular component representing a physical landscape with an agent-based component representing land-use decision-making.
- MAS/LUCC model (multi-agent system models of land use/land cover change) [13]. It emphasises the interactions between farmers and the landscape. Specifically, the MAS/LUCC model combines a cellular landscape representation with an agent-based model that accounts for decision-making units. This structure simulates complex interactions such as land use and land cover changes. MAS/LUCC models have been applied in a wide range of settings yet have in common that agents are autonomous decision-makers who interact, communicate, and make decisions that can alter their environment.
- RegMAS model (Regional Multi-Agent Simulator) [14] allows farmers' behaviour to consider space explicitly. Specifically, RegMAS is initialised by real land use data using satellite information, and parcels are explicitly modelled within the agent problem as individual resources with spatial information.
- ABM model developed by Heckbert [15]. It considers additional market feedback for production factors beyond land, such as the fertiliser market, and analyses how specific policies (particularly restriction and exchange schemes) can improve ecosystem services (in such a model, water quality).
- SWISSLand model developed by Agroscope [16]. The SWISSland model system illustrates supply-and-demand quantities of agricultural raw products in the Swiss agricultural sector and projects future trends for these whilst taking account of (net) external trade of

farm goods on the global market. SWISSland evaluates the consequences of agricultural policy measures, the impact of internal and external market influences, and the effects of the heterogeneous site conditions specific to the alpine region on income trends, structural change and land management in the Swiss agricultural sector. Developed by the 'Economic Modelling and Policy Analysis' Research Group, Strategic Research Division (RD)' Competitiveness and System Evaluation' at Agroscope's Tänikon site, and employed primarily as a policy advisory tool, SWISSland has been used since 2011 to analyse agricultural policy issues.

Regardless of their purpose and specific capabilities, current agent-based approaches still have some significant disadvantages that have limited their widespread use for large-scale assessment. In particular, these models are highly time-consuming and require a lot of user input in terms of parameterisation and calibration. Furthermore, a standard limitation is their need for more interaction with the rest of the economy (for example, market prices are usually considered exogenous in the models, which cannot generate input-output prices).

In this context, the AGRICORE model (i) incorporates features and capabilities present in more developed and widely used agent-based approaches as a unified framework released as open-source while (ii) addresses the main disadvantages that hinder the widespread use of agent-based approaches today and (iii) leverages the latest advancements in ICT and computational science to enhance the ability to model new policies.

4 Leveraging AGRICORE Modules to Support Agricultural Policymakers: Project outputs and their transferability

The AGRICORE project, a cutting-edge initiative, offers a suite of modules designed to start the transformation of the way policymakers approach agricultural decision-making, adopting farm-level ABM. This section explores the diverse applications of AGRICORE modules, from data aggregation to simulation and impact assessment, to support policymakers in formulating evidence-based agricultural policies. In this deliverable, we delve into each module's functionality and highlight how they empower policymakers with data-driven insights, simulation capabilities, and tools for assessing the socio-economic, environmental, and climate impacts of their policies. With the AGRICORE suite and its modules, policymakers and agricultural researchers gain a powerful toolkit for addressing the complexities of the agricultural sector.

4.1 (Global Result) Agricore suite and associated research services

4.1.1 The AGRICORE suite

The AGRICORE suite has been developed to support policymaking and evaluate existing policies. A system with the AGRICORE characteristics can support policymakers in defining community agricultural policies in several ways:

- **Evidence-based Decision Making:** By providing access to comprehensive data and simulation capabilities, policymakers can make informed decisions backed by empirical evidence rather than relying solely on intuition or anecdotal evidence.
- **Policy Impact Assessment:** The model allows policymakers to assess the potential impacts of proposed policies before implementation. They can simulate various policy scenarios and evaluate their effects on different aspects of the agricultural sector, such as farm holdings, economic dimensions, and geographical locations.
- **Risk Mitigation:** Policymakers can use the model to identify proposed policies' potential risks and unintended consequences. By simulating different scenarios, they can assess the likelihood of various outcomes and adjust policies to mitigate risks.
- **Optimisation of Resources:** The model can help policymakers optimise resource allocation by identifying the most effective policy interventions. By simulating different policy measures, they can determine which interventions will likely achieve the desired objectives with the least resource expenditure.
- **Stakeholder Engagement:** The model facilitates stakeholder engagement by providing a platform for collaborative decision-making. Policymakers can involve various stakeholders in policy development, including farmers, industry representatives, and researchers, ensuring that diverse perspectives are considered.
- **Iterative Policy Design:** Policymakers can use the model for iterative policy design, refining policies based on simulation feedback and real-world data. They can continuously monitor the effects of implemented policies and make adjustments as needed to achieve desired outcomes.

The AGRICORE suite has been released as open-source, giving complete access to the scientific community to the platform and all the parts forming it. This fact is a highly relevant one regarding the transferability of the project results, as any entity, either an AGRICORE partner or any external one can easily adopt the developed system. Such adoption could be total, forking the repositories of the project to create new custom technologies and solutions based on it, or partial, this is reusing only one of its modules.

The status on which the AGRICORE project has released the AGRICORE suite is quite convenient to new adopters, as the system is able to support the users to generate new synthetic populations based on the data they have available, and simulate the evolution of the populations under custom policies that can easily be defined using the AGRICORE interface. This includes the simulation of significantly complex simulations, including a high number of individual farms without requiring excessively demanding computing power. This is a quite advantageous aspect as research groups can reuse the developed technologies to provide support to policy impact assessment to different stakeholders (from local to EU-level). Nonetheless, in order to be able to perform multi-year simulations that derive useful and accurate facts for policy making, new adopters should take over some of the upgrades the AGRICORE suite would require for this. This covers mainly the interconnection to a Continuous General Equilibrium model for the product market that can use the information provided by the AGRICORE suite each year (regarding production) and reinject in the system the expected prices for a campaign, the finally realised ones and the sold quantities. Other upgrades could be necessary depending the actual use case the adopter would be working on, as for instance the inclusion of more animal products (currently focused on milk) or the management of inventories at the end of each campaign.

Despite these required upgrades, the AGRICORE project has positively benefited the scientific community as all results have been offered openly to the community. This contrast to many other research activities and projects which could have produced highly valuable policy impact analysis for specific use cases, but nonetheless hinder reusing of the developed technologies by other scientists and researchers by keeping the developed source code closed to the community. Indeed, the AGRICORE suite, with its release, and as far as the AGRICORE members as aware, has become the first publicly available open-source platform for agricultural policy modelling embracing the ABM approach that is explicitly designed towards full population simulations (rather than other approaches as farm type-based or sample populations).

4.1.2 Research services based on AGRICORE advances and gained knowledge

All entities already working in the agricultural policy area (UNIPR, AUTH, UTP, IAPAS, CAAND, AKD) before AGRICORE have expressed their intention to reuse the knowledge gained during the project to improve the research and support services that they offer to other organisations. Each of these partners have advanced their knowledge and experience on their specific areas of expertise and, therefore, will exploit the project knowledge to provide better and more advanced services. Moreover, other entities (e.g. IDENER, AXIA) have entered into the agricultural research sector and also aim to use the gained knowledge to provide services to different stakeholders in the area.

The AGRICORE deliverable D8.2, *"Roadmap for the exploitation of project results"* describes the identified exploitation routes for the individual Key Exploitable Results developed within the project. From the identified KER's, the following ones are specially oriented to the exploitation of the overall knowledge gained during AGRICORE, not specifically oriented to one of its specific modules:

- KER 1 - Agent-based modelling and agent-based simulation engines
- KER 8 – Environmental and climate impact assessment
- KER 10 - Consultancy services in the agricultural area
- KER 11- Experience on data sources for agricultural analysis
- KER 16 – Consulting and modelling services in the agricultural area

In the context of KER 8, the AGRICORE partners more involved in the environmental and climate areas (IAPAS, UTP) have gained valuable knowledge and developed technologies that can improve the analysis they already provide to different national (Poland) agencies. Accordingly, these teams will reuse the gained knowledge to improve their current and future activities and services. For instance, the IAPAS team is already proposing the use of these advances in other research activities related to the analysis of the impact of pesticides on crop development, food production and environmental impact, which is relevant to agricultural policy impact assessment.

KER 11, "Experience on data sources for agricultural analysis", consists of the opportunity to utilise the knowledge gained during the project to identify, source, and secure relevant data for agricultural policy analysis. KER11 shares a similar target audience with KER4 "Socio-economic impact assessment module" but also targets data providers, knowledge experts, and information managers from national and international research institutions working on relevant applications in the field. AGRICORE use case leaders (UNIPR, CAAND/IDE, AUTH, IAPAS/UTP) have gained valuable knowledge (part of it transferred into the ARDIT tool) on the useful information sources towards agricultural policy modelling, including the design and execution of participatory research activities to complement the gaps on the available information. In this regard, these entities envisage providing services as the main option for market-oriented exploitation. In detail, the knowledge of datasets acquired and improved during the project will be instrumental in providing consultancy services to institutions or entities willing to develop their research projects or improve their data collection processes. Project partners but, especially, the universities and research centers (AUTH, UNIPR, IAPAS, UTP) plans to leverage the experience and knowledge gained within AGRICORE also towards improving their scientific production. Workshops are scheduled to be organised with national policymakers and researchers to maintain regular connections between those parties to facilitate knowledge transfer and support in the policymaking process. Additionally, presentations at conferences and the publication of scientific papers capitalising on the knowledge obtained from AGRICORE are also planned.

KER 1 - Agent-based modelling and agent-based simulation engines, *KER 10 - Consultancy services in the agricultural area* and *KER 16 – Consulting and modelling services in the agricultural area* are especially oriented to the exploitation of the overall knowledge gained within the project to support policy making and agroeconomics. During the project, the partners have cultivated a consistent and valuable collaborative relationship with numerous key stakeholders and policymakers in Spain, Greece, Italy, Poland and in Europe. The partners have been actively engaged in the exploitation of its AGRICORE results and outputs, including participation in conferences, workshops, and events and the publication of scientific papers. As such, the partners will further pursue new collaborations with such stakeholders, either at private level, on scientific activities or even by pursuing its involvement in new EU-funded research, exploiting AGRICORE knowledge and results for such activities. Overall, and especially UNIPR, AUTH, UTP and IAPAS will intensify their involvement in policymaking support and will invest more effort in strengthening such interactions.

Scientific exploitation (which indirectly can constitute support for the policymaker) will also comprise teaching and teaching-related activities since UNIPR, AUTH, UTP and IAPAS are education, research, and public engagement institution. Scientific exploitation activities also include planning for a master's thesis within the respective research groups. Scientific publications and presentations on relevant agro-economic conferences have been conducted during the project are also planned for the immediate future, capitalizing on the work within AGRICORE.

4.2 ARDIT

AGRICORE project provides the Agricultural Research Data Index Tool (ARDIT) as a web application with two well-defined objectives for the project. The first is to deliver an open data portal where researchers can freely access an index of available agricultural data sources. The platform serves the metadata of the datasets and the links to their origin or download URLs; this means that ARDIT does not store the indexed datasets. The second objective is to use this tool within the project to provide data necessary to fill the attributes of the farm agents that compose the synthetic populations used in the ABM.

In view of this, among the potentialities of ARDIT is that it allows policymakers and researchers on the field to discover and access a wide range of agricultural data sources, which can be instrumental in evidence-based policy development.

4.2.1 The objective of ARDIT and its utility for policymakers.

According to what was just mentioned, one of the objectives of ARDIT is to support agricultural researchers in identifying the most suitable datasets useful to model requirements and research questions without having to access the resources of these databases directly. This will significantly aid researchers and policymakers, as gaining preliminary access to datasets often proves time-consuming and may be futile if the data are inadequate (e.g., lacking key variables). Additionally, the sheer volume of data required for large-scale models or combinations of multiple models is likely immense. Hence, efficiently organising relevant datasets by selecting or manipulating portions of them is crucial. This process heavily relies on accessing comprehensive metadata describing the datasets' contents, especially the variables' characteristics.

This section aims to highlight the potential use of the tool by other research entities, as well as the possible adoption by the EU (assuming, for example, that ARDIT could be integrated or linked to MIDAS, the Modeling Inventory and Knowledge Management System of the European Commission).

Notably, impact assessment models quantify policy options' environmental, economic, and social impacts. MIDAS documents these models and their contributions to Commission impact assessments starting from July 2017, according to the recommendations of the Better Regulation Guidelines and the associated 'Toolbox' of European Commission. Specifically, MIDAS (Modeling Inventory and Knowledge Management System) and ARDIT (Agricultural Research Data Index Tool) serve different purposes in agricultural research and data management. However, they can be integrated or linked in several ways to enhance the accessibility and usability of agricultural data for researchers and policymakers. Here are some possible and potential integration points:

- **Data Discovery and Access:** ARDIT focuses on providing an open data portal for researchers to access agricultural data sources. MIDAS could complement ARDIT by providing additional metadata and information about specific modelling datasets available within the European Commission's inventory. This integration would allow researchers to discover raw agricultural data and modelling datasets in a centralised platform.
- **Cross-Referencing:** ARDIT could include links or references to relevant modelling datasets catalogued in MIDAS. This cross-referencing would provide researchers using ARDIT with additional resources and information about modelling datasets that could be used with raw agricultural data.
- **Data Integration:** Researchers may need to integrate raw agricultural data and modelling datasets into their analyses. ARDIT could provide information on accessing raw

data sources, while MIDAS could offer insights into how to access and use specific modelling datasets. This integration would provide researchers with a comprehensive understanding of available data resources for their analyses.

- **Collaborative Research:** ARDIT and MIDAS could facilitate collaborative research efforts by providing a platform for researchers to share and access raw data and modelling datasets. This collaboration could lead to the development of more robust and comprehensive research projects that leverage both types of data.

Integrating or linking MIDAS and ARDIT could create a more comprehensive and accessible ecosystem for agricultural research data. This would allow researchers to leverage both raw data and modelling datasets effectively, supporting more informed decision-making and policy development in the agricultural sector.

Moreover**,** agricultural research and policy impact assessment typically involve analysing multiple datasets with varying characteristics and complexities. Some datasets, like Eurostat, are statistically oriented, tracking statistical macroeconomic phenomena to provide structural or cognitive insights. They may facilitate forecast analysis (ex-ante) or policy evaluation (ex-post). Other datasets, such as FADN, are policy-oriented, furnishing specific information for policymakers and sectors like fisheries, environment, and agriculture. Governments or international organisations may develop these datasets with objectives like combating world hunger or rural development. Consequently, datasets are purposefully created and follow specific generation methodologies. A dataset should enable researchers to access information efficiently, promptly, and functionally, including standard or widely used variables, appropriate analysis units, and standardised measurement units. Moreover, dataset metadata, including this information, should be publicly available and easily interpretable during the data identification and search phase. Ontologies serve as tools to achieve this objective, providing a standardised way to conceptualise dataset characteristics, thereby facilitating metadata extraction and dataset grouping based on similar properties. The quality and utility of dataset descriptions hinge on the effectiveness and efficiency of the ontologies used by researchers for characterisation.

Within the AGRICORE project scope, a dedicated ontology (AGRICORE DCAT 2.0) was developed to capture information down to the variable level. This ontology forms the foundation for the structural design of ARDIT, a web-based tool for characterising, searching, and querying agricultural datasets.

As delineated in deliverable D1.9, ARDIT serves as an index of agricultural data sources, allowing public access to the characterisation of various datasets. Users can utilise ARDIT to locate data sources containing specific variables within particular geographical and spatial/statistical scopes. Additionally, users can propose new data source inclusions through a characterisation procedure. Once ARDIT maintainers approve the new characterisation, the data source is indexed..

Furthermore, coming back in regarding the replicability of the ARDIT tool in other sectors as a valuable support tool to provide policymakers with the capability to discover and access a wide range of agricultural data sources, here reported the hypothetical connection between ARDIT and the REWET project, aimed at reducing CO2 emissions through wetland recover. The REWET project will provide measurable contributions to achieve the following targets: Improve knowledge on the status of EU wetlands; Improve assessment of the added value of wetland, peatland and floodplain restoration approaches under different scenarios; Monitor their benefits and trade-offs; Analyse the degree to which these approaches related to wetlands are affected by various scenarios of climate change; Contribute to the evidence on ecosystem services provided by restored wetlands and their long-term management as an investment with significant societal benefits. For each of these objectives, benefitting from a cutting-edge tool like ARDIT represents a considerable strength in making the definition of research projects and community policies more efficient.

Lastly, a tool like ARDIT, while focused on agricultural data, could still support policymakers in defining policies other than agricultural ones in several ways:

- **Methodology and Instrumentation**: The methodology and tools used to develop ARDIT could be adapted to create similar tools for other sectors. For example, a similar version could be developed for public health, environment, or energy data. This would provide policymakers access to a wide range of sector-specific data useful for policy definition in other areas.
- **Experience and Knowledge**: The experience gained in developing and implementing ARDIT could be applied to creating similar tools for other sectors. This could include data collection, metadata management, and the creation of intuitive user interfaces for data access.
- **Knowledge Sharing**: Lessons learned during the development and use of ARDIT could be shared with other sectors to help them develop similar tools. This could occur through workshops, presentations, or scientific publications outlining best practices and challenges in developing a similar data portal.
- **Interdisciplinary Collaboration**: The experience gained through using ARDIT could promote multidisciplinary collaboration across different sectors. For example, an interdisciplinary version of ARDIT could be developed that integrates data from various thematic areas to support policy decisions requiring a holistic perspective.

While ARDIT is designed explicitly for agricultural data, the skills, methodologies, and experiences gained through its development could be successfully applied to support policymakers in defining policies in sectors other than agriculture.

4.3 Synthetic Population Generation Process

Synthetic population generation (SPG) is the process of obtaining an anonymized population of individuals or agents representing a set of technical, economic and geospatial characteristics from a sample of the real population, thus ensuring the fidelity of the data for use in simulations and analysis without compromising privacy. In this way, synthetic populations inherently preserve the in interrelationships and interdependencies among random variables observed in the original population.

The technology and the methodologies developed within AGRICORE regarding the SPG has a key potential impact not only on the agricultural (policy) research area, but also in many other fields. The primary target audience comprises research and technology organisations due to the scientific knowledge and their potential implication in projects that need synthetic populations, such as those using agent-based modelling. This novel modelling technique originates from the field of computing science but can be applied to various disciplines, including social sciences, economy, ecology, engineering or epidemiology. All these disciplines, in turn, introduce in the interaction field different actors such as universities, policymakers, and other experts and researchers that, while they can have minimal computational or coding knowledge, their study object may require the utilisation of such kind of computing tool.

Other target groups may extend their interest in the generation module going beyond the functional possibilities the module offered. In particular, target groups with a higher degree of programming knowledge will be able to understand the module operation in a greater depth, enabling them to modify or improve the current implementation, providing also further scientific advances.

From a policy analysis perspective, the creation of synthetic populations for the subsequent construction of agents may be of interest in other cases of public policy simulation. This extends to advertising/marketing activities, labour relations in business environments, urban planning and public health interventions, all while maintaining the anonymity of the individuals involved. Additionally, the SPG module offers significant opportunities for scientific and commercial exploitation:

- Scientific exploitation: The generation of new knowledge in the form of new synthetic populations will occur when the SPG module is used in future use cases and projects. Additionally, improved SPG and SPG modules for other purposes derived from the one developed in the AGRICORE project can be considered new knowledge.
- Commercial exploitation: The SPG module could be exploited to generate similar populations as long as sufficient and proper data are available.

Moreover, during the final dissemination of the AGRICORE project, presented to members of the DG-AGRI, the project partners delved in detail about the relevance, importance and potential impact of a global adoption by the EC of synthetic populations to foster policy design, modelling and impact assessment. The reasons behind this can be summarised on: a) Census are expensive to be done (cannot be done on a yearly basis nor for all countries); b) Allow wider access to the data; c) Resolve / minimize privacy concerns; d) Are required for proper ABM simulation approaches; and e) Incremental improvement of the population data. Although these reasons do not refer about how the project results (especially the SPG here covered) can be transferred, they do reinforce the idea that SPGs (and therefore the corresponding solutions developed within AGRICORE) can become highly relevant in the next future for policy modelling research. This fact reinforces the transferability of the project results because it foresees an incremental interest on the usage of synthetic populations on the next future at scientific and commercial levels.

4.4 Infrastructure for population simulation

From the outset, the AGRICORE tool was conceived to be a highly modular and customisable package, released as open source so that public institutions and academic organisations can transparently update and improve the tool as new needs arise. The partners designed the IT architecture, where the main modules and their interconnections were defined. To ensure modularity, the partners committed to improving this architecture within the project. The specification of the interfaces between the different modules and the design and selection of clear ontologies was another point considered fundamental, together with standardised communication protocols to ensure maximum compatibility.

The modules contemplated within the modular architecture of the AGRICORE suite were the following:

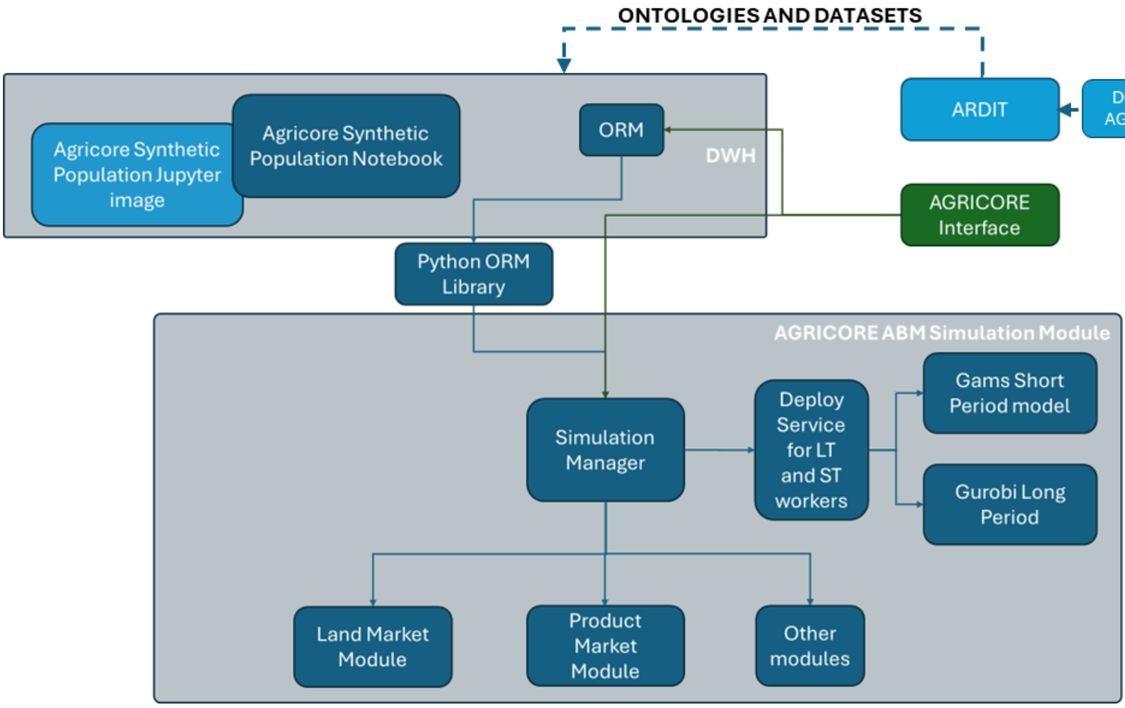

Figure 2 AGRICORE modular architecture and modules

The overall AGRICORE suite enables a cycle for performing simulations of ABM populations in a given environment that consists of:

1. Support the identification and access to relevant datasets
2. Generating synthetic populations combining census and statistical datasets
3. Defining contour conditions (e.g. policies) that should govern the simulation
4. Simulate the evolution of each one of the agents in the population across different years, considering 2 stages: decision-making and scenario-realisation.
5. Analyse the results of the simulation, embedding KPIs to identify key insights on the population evolution that are useful to the user.

All these steps are facilitated through the AGRICORE interface, as described in next figure:

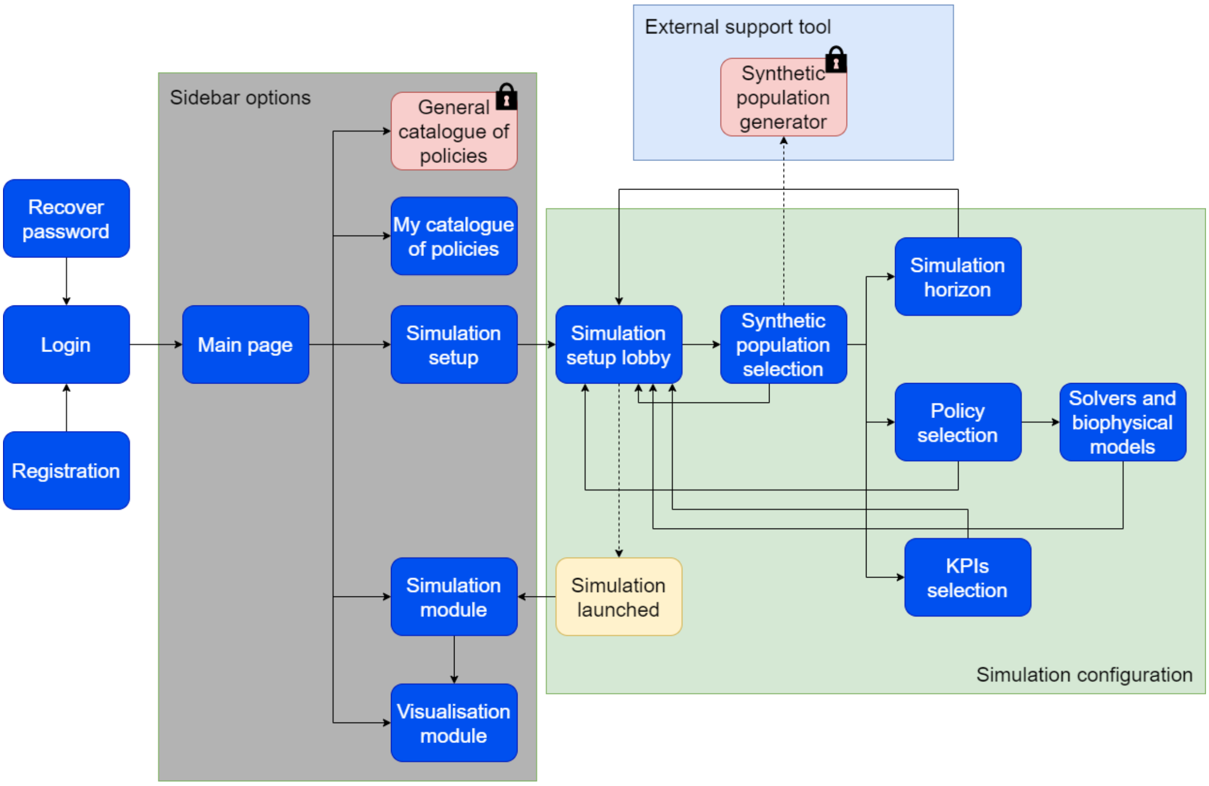

Figure 3: Interaction with the AGRICORE interface to perform simulations

In this way, the AGRICORE project uncouples relevant research tasks (e.g. development of the modules) of the actual use of the platform, potentially enabling non modellers to run simulations under different parameters and extract valuable information from the evaluation result.

This overall approach, within AGRICORE, has been tailored towards agricultural simulation and policy impact assessment (ontologies and datasets used, ABM tailored on farmers behaviour mimicking, KPI's specific for socio-economic and environmental aspects related to agriculture). However, the overall platform and the proposed approach could be transferred to other sectors (e.g. market analysis using ABM of customers). This would require significant efforts, as models, datasets and ontologies would need to be substituted but, in any case, would require significant less efforts that developing the platform from scratch. This is especially relevant as the AGRICORE suite already embeds very useful elements, as the SPG, the simulation manager and all its optimisations (which allow to perform simulations of highly dense populations using complex non-linear models in reasonable computation times) or the interface. Together, these advantages should work towards a high transference of the knowledge and tools generated in AGRICORE, especially due to the open-source release of the project code. Indeed, different project partners are interested and will explore the reuse of these elements to new research activities.

4.5 Other key modules and modular approach

As mentioned in the previous section, the AGRICORE tool encompasses several modules that are interconnected with standard communication protocols. This integration approach was considered in the design of the AGRICORE modules, achieving a high degree of modularity. All functionalities were interpreted as modules, such as Synthetic Population Generation, Impact Assessment and Land Market, among others. This provides a high level of customisation and room for improvement as modules can be replaced or aggregated to enhance and add functionalities. The next subsections explore the transferability potential and the relevance of AGRICORE advances for each of its main elements:

4.5.1 Farm ABM model

Among these modules, the ABM simulation (KER1-A: *Agent-based modelling and agent-based simulation engines* and KER1-B: Agent-based modelling short-period agronomic optimisation based on PMP) should be highlighted as the core element in the tool. This element is composed of two modules that mimic the behaviour of farmers during the simulation: the short-period model and the long-period model. UNIPR developed the former by using GAMS, and it is in charge of the agronomic optimisation based on a combined approach of agent-based modelling and positive mathematical programming. The second model was developed by IDENER by using Python as the programming language and Guroabi as the mathematical solver. This model deals with the financial decisions of the farmer with the objective of maximising the profitability of the farmer's activities and maintaining a suitable level of solvency.

Basically, the long-period model establishes the constraint of the short-term model, and the decisions made by the latter are reflected in economic terms in the calculations of the former. Thus, the long-period model is in charge of the accounting balance of the agricultural holding, including subsidies, costs and revenues, among others, and determining:

- The maximum amount of expenses for the current year for production costs and land acquisition if the accounting balance is positive,
- The financial actions to be performed (sell or rent land) to receive additional revenues to adjust the farmer's accounts if the accounting balance is negative.

Based on that, the short-period module executes the actions (i.e., what crop is cultivated, how many hectares are cultivated of each crop, etc.) to maximise the profit derived from the production sales. This innovative approach is a relevant advance as it is one of the factors that enabled AGRICORE to simulate so big populations while keeping a non-linear model for modelling the farmer behaviour in agroeconomics terms.

The ABM simulation module, together with the impact assessment modules, provides end-users with valuable insight into how the agents behave and what is the impact of the sector. In the case of policymakers, the information of interest is to know how agricultural policies affect the above.

KER 1-B "*Agent-based modelling short-period agronomic optimisation based on PM*" is defined based on the advances of the ABM-PMP approach, a short-term module of agronomic optimisation based on Positive Mathematical Programming. UNIPR, by extending and deepening its knowledge in this scientific area, will develop sufficient expertise to offer professional consultancy, training, and agricultural advisory services to public and private stakeholders. National and Regional Policymakers represent the main target audience, but it could also be extended to farmers and other civil society stakeholders. UNIPR intends to develop and streamline this ABM-PMP beyond the AGRICORE project to support national, regional, and local authorities in designing their rural policy better, which aligns with this document's primary objective.

The objective is to make the model more accessible and usable and to provide consulting and support to farmers and stakeholders in defining their agro-economic strategies, considering policy and environmental constraints.

Also, for these KERs, two different types of exploitation have been hypothesized:

- Scientific exploitation: The upgraded version of the ABM-PMP and the overall ABM simulation module can simulate various policy scenarios or as an additional existing module in future projects.

- Consulting exploitation: The ABM-PMP and the overall ABM simulation can be exploited to simulate profit-driven agents seeking maximum revenue due to their actions.

Overall, the work carried out in AGRICORE developing and applying the ABM-PMP approach represents a significant resource for policymakers in the agricultural sector, especially considering potential future challenges. Through the deep knowledge gained and the ability to conduct detailed socio-economic analyses, UNIPR can offer professional consultancy and decision support services to national, regional, and local authorities. These services enable policymakers to assess the socio-economic impacts of agricultural policies and adapt intervention strategies to the changing needs and challenges of the sector. Furthermore, IDENER and UNIPR's intention to expand and enhance the ABM-PMP approach beyond the AGRICORE project ensures continuous and innovative support to address future challenges and develop more effective and sustainable agricultural policies. In this way, one can strive to achieve the highest efficiency and effectiveness of agricultural policies, an objective that is more necessary than ever nowadays.

Finally, the publication of the two models and the required simulation infrastructure as open source can enable the uptake of the developed technologies by other teams, not necessarily requiring the involvement of the original AGRICORE members.

4.5.2 AGRICORE Interface Module and KPIs evaluation

The interface module serves as the central user interface for the AGRICORE suite, enabling:

- User Management: Account creation, password recovery, and credential-based access.
- Simulation Preparation: Non-sequential setup of simulations, including population inclusion, policy selection, solver and model choice, KPI selection, and simulation period.
- Simulation Control: Launch, monitor, pause, and cancel simulations.
- Results Visualization: Immediate or file-based viewing of simulation results.

This interface supports the original workflow conceived for the application of the AGRICORE suite for policy impact assessment. To assess the impact of a specific agricultural policy tool, it is crucial to gather data enabling the assignment of values to the attributes of the involved agents. These data must be statistically representative of the actual farm holdings affected by the policy measure in terms of type, size, and location. Detailed information on the policy measure itself, including beneficiary requirements, measure articulation, and program restrictions, is also necessary. Based on this information, the user can generate synthetic populations of agents different from the addressed use cases, but it requires advanced statistical and programming knowledge. While modules like DEM, DFM, and SPG, with their graphical interfaces, can assist in this process, it remains a complex procedure. Then, executing the simulation of the generated synthetic population requires communication mechanisms between agents and the solver computing agro-economic decisions for each simulated season. Interconnection between agents and biophysical models to simulate the evolution of different farms is also necessary. This execution also requires the simulation setup to configure parameters through AGRICORE's graphical interface, such as the selection of the synthetic population, policy measures to be tested, simulation base year, duration, and computed KPIs. Predefined KPIs are automatically calculated by the AGRICORE suite and displayed in the visualisation module, but additional KPIs might be calculated and visualised if the required simulation outputs are available. Users can continue operating with simulation results to obtain additional KPIs if needed. The visualisation module allows viewing or downloading graphs depicting KPI evolution, facilitating analysis and evaluation of the policy measure, which can be iteratively improved to meet policymaker objectives.

Although the AGRICORE interface (as the simulation module) is tailored to the AGRICORE methodology, the overall modularity of the project implementation allows transferring this result to other projects, especially when the overall AGRICORE approach for population simulation is adopted, and just some elements of the platform are replaced by improved or alternative ones.

4.5.3 KPIs, impact assessments and participatory research

Several KER's in the project (KER10: Consultancy services in the agricultural area, KER4- Socio-economic impact assessment module, KER8 – Environmental and climate impact assessment and KER15 – Participatory research activities design for the agricultural sector) derived from the work done in the project regarding the impact assessment of policies, either by focusing on the KPIs, the interaction and experience with stakeholders, or the extraction of key information (not already available) from farmers.

In the AGRICORE suite, the KPI calculation has been integrated into the AGRICORE interface, but the equations and relevance of such KPI's are described on WP5 deliverables. Environmental/Climate KPIs focus on evaluating environmental and climatic impacts, including metrics for GHG emissions, agricultural water pollution, and land exhaustion. Socio-economic KPIs assess the impact of policies on agriculture's role in rural systems, such as effects on agricultural labour and specific demographic groups like young or female farmers. Ecosystem Services KPI's provide indicators for ecosystem services across four areas: supporting, provisioning, regulating, and cultural. Although in AGRICORE the KPI's are integrated in the platform, the formulation of such indicators and its calculation methodology present in project deliverables is suitable to be transferred to other projects.

Indeed, these KERs leads to the mathematical formulation of the equations necessary to describe the effects of agricultural policy changes on the socio-economic characteristics of farms and rural territories. In this case, the target audience for these KERs consists of policymakers at the regional, national, and EU levels, as well as academia and researchers from research institutions engaged in relevant research and activities in the respective field. Farmer associations could also use these elements to support their activities. In this case, the desired exploitation route for this KERs would be a) market-oriented and b) scientific exploitation. Specifically, UNIPR considers the provision of analyses of the socio-economic impacts of changes in the agricultural policy as a service to institutions/policymakers/concerned parties, upon which this service is paid for in the form of a grant or a salary. AUTH, IAPAS and UTP have similar strategies for the exploitation of their respective impact assessment metrics. Supplementarily, UNIPR and AUTH are also examining the possibility of including in their exploitation intention the a) theoretical construction of additional existing and forthcoming policy scenarios and b) providing consultancy services on the technical extension to the model, demonstrating how to work in potential use cases and benchmarking (i. e., providing an initial estimate of the results) based on the outcomes of existing use cases. If resources are available, hiring additional personnel will be considered to facilitate consulting services to policymakers as part of a commercial exploitation plan.

For KER15- Participatory research activities design for the agricultural sector, the knowledge obtained by CAAND, AUTH, UTP, AXIA and IAPAS will be reused on future activities. The challenges posed by the COVID situation in the obtention and realisation of such participatory activities help to understand the limits that electronic-obtained information can have, even when having online interviews, as opposition to in-person interviews. Moreover, procedures, results and conclusions on the participatory activities have released in public deliverables allowing other stakeholders to understand or adopt the followed methodologies or results to other activities.

4.5.4 Other modules and experience transfer

Other activities within AGRICORE have also produced results and open-source code (e.g. land market module, DCAT-AP AGRICORE ontology, analysis and reports done in WP7) and are also suitable for exploitation by the AGRICORE partners. Moreover, all such results are openly available which will support the reuse of the generated knowledge.

Overall, all the presented innovations and results are suitable for reuse by project partners in new initiatives (market, research), but also by other research groups, thanks to the modular approach followed by the project for the implementation and to the open nature of AGRICORE, with all results (code, deliverables) published for public access.

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For preparing this report, the following deliverables have been taken into consideration:

Deliverable Number	Deliverable Title	Lead beneficiary	Type	Dissemination Level	Due date
D1.9	Agricultural Research Data Index Tool	AAT	Other	Public	M31
D2.4	Synthetic population generation module	AAT	Other	Public	M39
D6.1	AGRICORE Architecture and Interfaces	IDE	Report	Public	M18
D6.5	Integrated AGRICORE tool	IDE	Report	Public	M58
D8.2	Roadmap for the exploitation of project results	AXIA	Report	Public	M45