Modelling Individual Decisions to Support the European Policies related to agriculture (MIND STEP)

John Helming, Hans Vrolijk and Hans van Meijl

John.Helming@wur.nl
Wageningen Economic Research (WECR), Wageningen University and Research,
PO Box 29703, 2502 LS The Hague, The Netherlands

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1. Introduction and objective

Policies related to agriculture are expected to address an increasing number of objectives as demanded by society. As a result, agricultural policies, like the European Union (EU) Common Agricultural Policy (CAP), increase their scope to incorporate for example objectives of the Paris climate agreement and the Sustainability Development Goals (SDGs). More specifically, the nine objectives of the future CAP (2021-2027) are to ensure farm income, increase competitiveness, rebalance power in the food chain, climate action, environmental care, preserve landscape and biodiversity, support generational renewal, vibrant rural areas and protect food and health quality (https://ec.europa.eu/commission/sites/beta-political/files/budget-may2018-modernising-cap_en.pdf). A further objective is to significantly simplify and shift the emphasis from compliance and rules towards results and performance of individual farms. The one-size-fits-all approach will be replaced by a more flexible system with greater freedom for EU countries to decide how best to meet the common objectives consistent with specific needs of their own farmers and rural communities. Farm specific measures that will be included in the future CAP are e.g. higher levels of support per hectare for small and medium-sized farms and rewards for farmers for going beyond mandatory agri-environmental and/or climate requirements. Impact assessment tools should include this wider scope and the particular behaviour of individual farmers taking into account initial agronomic, bio-physical, financial, economic and social farm characteristics. In impact evaluations, much more attention has to be paid to the way the CAP is regionally implemented. For effective and efficient policies the EU needs to take local and regional conditions and policies into account in evaluating its policies at farm, regional, national and global levels. The objective of this paper is to describe the four year H2020 project MIND STEP, Grant Agreement Number 817566, that will start in September 2019. MIND STEP gives an answer to the question if existing agricultural models, that are currently intensively used by the EU commission meet new developments towards the wider scope of policies and farm specific measures and discusses and implements new data, tools and models that are needed to evaluate policy impacts on environmental and economic performance at the farm, regional, national and global levels. The result of MIND STEP is a toolbox that includes new models based on individual decision making units (IDMs) and improved existing models.

2. The MIND STEP project

The **overall objective** of **MIND STEP** is defined as: *To support public decision making in agricultural, rural, environmental and climate policies taking into account the behaviour of individual decision making units in agriculture and the rural society.*

During the last twenty years individual farm, agricultural sector and economy wide models, hereafter referred to as current models, are intensively used by the EU Commission for public decision making in among others the areas of agriculture, sustainable management of natural resources, ecosystem services and climate change. Models of special importance for the EU Commission are: IFM-CAP (Individual Farm Model for Common Agricultural Policy, Louhichi et al., 2017) an EU-wide farm-level static positive mathematical programming model focusing on agriculture, CAPRI (Common Agricultural Policy Regionalised Impact Modelling System, Britz and Witzke, 2014) a regionalised partial equilibrium model representing the agricultural sector with a focus on the EU (Member States, regions, farm types, grid, etc.), GLOBIOM (Global Biosphere Management Model, Havlík et al. 2014) a global partial equilibrium model of agriculture and forestry, with detailed bottom-up supply side representations differentiating between individual production systems linked with biophysical models and spatially explicit datasets, including land use change, and MAGNET (Modular Applied GeNeral Equilibrium Tool, Woltjer *et al*. 2014) an economy wide global computable general equilibrium (CGE) model, with a modular structure and a focus on food security and old and new bio-economy sectors focusing on the global and economy wide scale. With the exception of IFM-CAP the current models were originally developed when the CAP was shifting from market interventions to coupled support. At that time researchers had no or quite limited access to single farm observations. Most current models are not able to deliver impacts for individual farms or local impact as they are specified at higher levels of aggregation. They also struggle to analyse policies specific to the individual farmer or for which interaction between farms and with other agents are crucial for policy outcomes. In many cases they only provide summary results for the population. Currently, only the IFM-CAP model simulates single farms across the EU drawing on FADN (Louhichi et al., 2017). Although an important tool, IFM-CAP has several limitations, being a static positive mathematical programming model. Promising tools, such as agent-based models (ABMs) so far face difficulties with application at larger scale. This leads to the five following specific objectives of **MIND STEP**:

Specific objective 1: To develop a highly modular and customisable suite of Individual Decision Making (IDM) models focussing on behaviour of individual agents in the agricultural sector to better analyse impacts of policies.

MIND STEP develops a modular and customisable suite of IDM models which focus on behaviour of individual farmers, interaction between farmers, other actors in the agricultural food chain and non-food chain actors. The focus of the new IDM models result from the "conceptual framework" developed at the beginning of the **MIND STEP** project, with involvement of farmers, food industry, regional, national and EU policy makers and other stakeholders. **MIND STEP** develops a modular framework that is flexible and sustainable in use (keeping complexity within certain limits) and allow further improvements with additional models and data as needs arise. **MIND STEP** develops a clear protocol to ensure modularity between the new models.

Specific objective 2: To develop linkages between the new IDM models and current models used at the European Commission to improve the responsiveness of the current models.

Improved micro-economic underpinning of the current models (the above mentioned sector and economy-wide models) solves limitations and main weaknesses of the current models. Specific objective 2 requires a methodological typology identifying the challenges and potential methodological solutions for linking different types of IDM models (static, dynamic, with and without farm household interaction) with different types of current models (e.g. farm level, partial equilibrium, general equilibrium models). **MIND STEP** develops innovative procedures for upscaling IDM models e.g. via development of meta-models to overcome complexities related to the large number of agents and interactions. The resulting integrated system of IDM models, ABMs and improved current models is the **MIND STEP model toolbox**.

Specific objective 3: To develop an integrated data framework to support analysis and monitoring of policies related to agriculture.

The **MIND STEP** data framework, part of the **MIND STEP model toolbox,** supports the new IDM models, ABMs and improved current models to analyse and monitor policies related to agriculture. The data framework contains financial, economic, social and biophysical drivers and indicators needed in impact assessments, identifying different policy instruments and understanding the behaviour of farmers in relation to policies and the wider environment they operate in, including incentives from the food chain. The **MIND STEP** data framework includes geo-referenced datasets to link socio-economic data to biophysical data and is integrated regarding the IDM model requirements and requirements regarding upscaling and linkages to current models at various geographical scales (regional, national, EU, global).

Specific objective 4: To apply the **MIND STEP model toolbox** to analyse regional and national policies and selected EU CAP reform options and global events affecting the IDM farming unit, working together with policymakers, farmers and other stakeholders.

The **MIND STEP model toolbox** provides scientific evidence to assess and monitor the effects of policies relevant for IDM units in the agricultural sector. To make it attractive and useful for policy makers the tools need to be understandable, trusted, customisable, flexible in use and easy to improve as needs arise. **MIND STEP** investigates with regional, national and EU policy makers, farmers, food industry, and other stakeholders what makes a model attractive and useful and therefore can make policy tasks easier. At regional and national level **MIND STEP** investigates with policy makers and other stakeholders how they can use the **MIND STEP model toolbox** to do their own analysis based on own configuring and parameterisation of models e.g. to analyse impacts of the national CAP strategic plans, risk behaviour of farmer or participation in Rural Development (RD) measures in Pillar 2 of the CAP. **MIND STEP** demonstrates the usefulness of the **MIND STEP model toolbox** at EU level via an impact assessment of selected EU CAP reform options, climate policies and global events on a broad set of indicators related to CAP, Paris climate agreement and the SDGs.

Specific objective 5: To safeguard the governance and future exploitation of the **MIND STEP model toolbox**, including an Intellectual Property Rights (IPR) legal framework for the partners and a mechanism aimed to accept new partners in the years to come.

MIND STEP develops an Exploitation Strategy and Plan (ESP) to guarantee the sustainability of the project results upon its completion. The exploitation plan will investigate potential routes to the exploitation of the results after the project completion, starting from the analysis of the IPR. The ESP plan will draw on the experience of partners in the creation of impact for policy and regulatory or managing authorities. Development of the ESP will be a progressive, iterative process, co-developed with stakeholders and aim at an open research infrastructure in which new partners are welcome.

3. MIND STEP: concept and Methodology

The approach of **MIND STEP** can be pictured as an ICT and stakeholder platform supporting three components (Figure 1). The first component develops the overall conceptual framework for the project as a whole, in the sense that the entire data, modelling and policy analysis work conducted during the project will refer to the identified set of policy questions, drivers, indicators and model gaps. The second component develops the modular system of IDM models with a focus on individual farm behaviour, interactions between farmers and other individual agents in and outside the agricultural sector. The third component links the IDM models to current models to also include policies and global events with clear sector and economy wide implications via changes in agricultural and non-agricultural input and output markets.

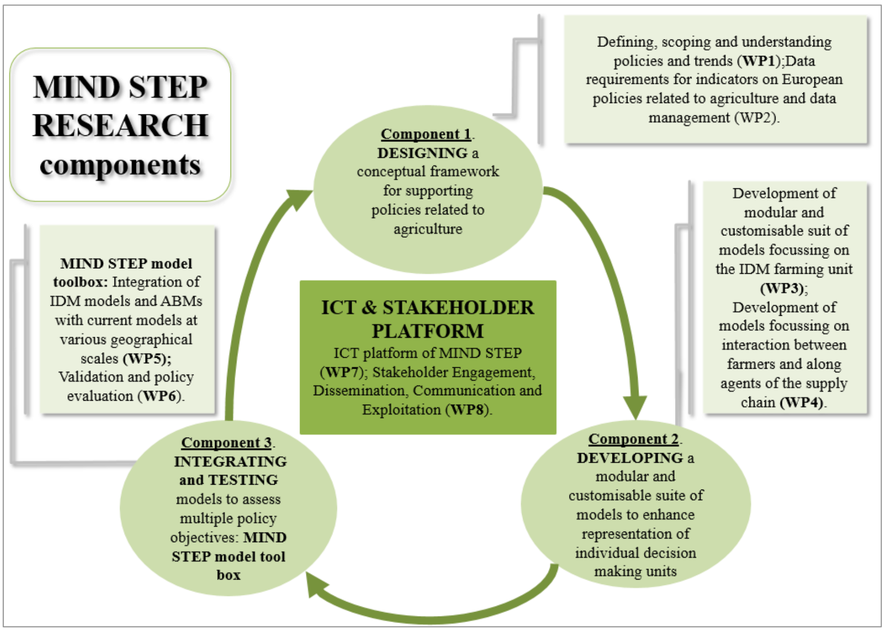

Figure 1. **MIND STEP** research components for developing new models supporting policies related to agriculture.

Component 1: Designing a conceptual framework for supporting policies related to agriculture.

The CAP legislative proposals released in June 2018 are the starting point for identifying the key policies and drivers affecting IDM units in EU agriculture, since they identify several key challenges to be addressed and suggest areas for new and/or revised policy tools that may address such challenges. These policy tools include among others: (a) income support through regressive direct payments to farmers, linked to labour input and with a stronger focus on redistribution; (b) environmental and climate practices as new conditionality tools for obtaining farmers income support; (c) reinforced cooperation among farmers through Producers' Organisations (POs) as a vehicle of knowledge and innovation sharing, investment support, increased bargaining power along the chain, reduced costs and improved competitiveness; (d) renewed risk management tools to address price and yield volatility, including mutual funds, insurances and other financial instruments; (e) support to new business models for farmers, including new bio-based rural value chains such as renewable energy, bio-based industries and ecotourism; (f) payments for facilitating new entrants and generation renewal in agriculture. In addition, **MIND STEP** considers also some relevant global drivers that are likely to affect farm activities (i.e. climate change, technological innovations, consumer preference trends, food waste and others; several of them through contracts and sustainability schemes from retailers and food processors). This review of (existing and future) policies and global drivers will lead to the identification of the key policy questions to be addressed by the **MIND STEP** modelling system, see table 1 for examples of economic, social and environmental indicators that will be addressed in MIND STEP. Finally, WP1 will review the existing IDM models, ABMs and existing agricultural models and identify the major gaps in terms of policy and global driver coverage, in order to clarify the key innovations needed with respect to the existing modelling systems.

Table 1 Possible indicators for measuring sustainability impacts of policies related to EU agriculture

Economic impacts	**Social impacts**	**Environmental impacts**
Farm/household income	Food and Nutrition Security at national/EU level	Land use change and intensity
Farm production	Employment in rural areas	Use of chemicals
Farm sizes	Food safety	Water use
Land prices	Food waste	Biodiversity
Structural change in farm numbers	Healthiness of diets	GHG emissions
Value added along the food chain	Income distribution	Fish Resources
GDP/welfare	Food self sufficiency	Air pollution
International trade		Forest resources
Market prices		Nutrient (N, P) balance

The research work in WP1 will be carried out mainly through (a) desk research and literature review; (b) active consultation with public and private stakeholders (EU, national and regional policy makers, farmers' organisations, consumer organisations, environmental groups, non-governmental organisations, and researchers), in order to identify the policy questions and the related indicators; (c) active interactions with the institutions/research groups that are maintaining the current models, and the users of the models, in particular with the European Commission, national and regional services. The interaction with the stakeholders is crucial, since a key objective of **MIND STEP** is developing a toolbox tailored to the research and policy questions identified in collaboration with the main stakeholders.

Given the policy requirements, the modelling cases are much broader than the traditional structural and economic applications, therefore requiring a much broader perspective on the need and availability of data (WP2). Given the independent existence and continuous changes of the database, including the increasing availability of high spatial and temporal resolution farm and biophysical data, **MIND STEP** designs database specific interfaces instead of building one big database, which is soon outdated and impossible to maintain. The design of interfaces are set up such that they integrate data from multiple heterogeneous sources at flexible geographic scales. The interfaces comprise the conceptual data framework and input for the new models but can also be used independently for data analyses. Our applications build on traditional (but valuable) data sources such as FSS, price statistics, market balance sheets and FADN and FADNTOOL (Neuenfeldt and Gocht, 2014). Administrative data (such as IACS, plot data) also provide valuable information, as do data from smart agriculture applications and farm management support tools. Opportunities and conditions to access these data differ strongly between countries and the willingness of famers to share the data. **MIND STEP** explores and creates access (within legal constraints) to this broader set of data sources. For example for sustainability (environmental, social and economic-financial) we apply for access to data from national FADNs (which are in many cases much broader than EU FADN), FLINT project type of data and other national sources, including information from the Land Parcel Information System (LPIS). The FLINT project (coordinated by Wageningen Economic Research) has defined a set of sustainability indicators (people, planet, profit) relevant for policy making (Poppe et al., 2016). The project has collected data on the sustainability performance at farm level on 1100 farms in Europe in the scope of the EU FADN. The project has shown how policy analysis improves with additional indicators on the sustainability performance of farms.
MIND STEP collects state-of-the-art soil databases from the European Soil Data Centre (ESDAC). Furthermore, it explores the use and efficient processing of high spatial and temporal resolution data collected by satellites, weather stations (MARS) and other environmental data collection facilities. We also build on experiences and the existing infrastructure of the Dutch open AGRODataCube (http://agrodatacube.wur.nl). Project partners already have access to several of these sources at national and European level (Leip et al., in prep). Different statistical matching and imputation techniques are explored to combine and complete big datasets, defined at different levels and from different sources e.g. matching FADN to soil, climate, topography, land use, hydrology and ecosystem services data to allow for a better connection of biophysical conditions and economic responses (Gocht and Röder, 2014). MIND STEP develops interfaces to existing databases, instead of building one big database. The newly developed database interfaces and processing procedures and tools provide a high degree of flexibility and are all made publicly available. In addition,

databases from current models, both input data and results, are integrated in the **MIND STEP** data framework.

Component 2: Developing a modular and customisable suite of models to enhance representation of individual decision making units
In WP3 the focus is on the behaviour of the individual farmer including key functionalities, while WP4 takes these single farm models and combines them with regional level models, such as ABMs, considering the interaction between farms and other actors in the agricultural food chain and non-food chain actors. The **MIND STEP** suite of models is a modular framework where functionality can be added with additional models and data. The system of interlinked models centred around individual decision making units is pictured in Figure 2. **MIND STEP** first develops an overarching IDM model that re-uses and improves existing modules. For that purposes IDM models as IFM-CAP (Louhichi et al., 2017), FES (Nowicki et al., 2009), FARMDYN (Britz et al., 2016), AGRISPACE (Mittenzwei and Britz, 2018) and the ABM AgriPoliS (Sahrbacher et al., 2014; Happe et al., 2006) are useful starting points. AgriPoliS allows to perform experiments with artificial economic agents interacting in a dynamic and spatially explicit manner, especially focussing on structural change and land markets. IFM-CAP is an EU-wide individual farm level model aiming to assess the impacts of CAP towards 2020 on farm economics and environmental effects.

Figure 2: **MIND STEP**: system of interlinked models centred around individual decision making units

The Dutch Farm Economic Simulation (FES) model focusses on farm viability. Based on financial-economic indicators like own and external financial resources, liquidity, solvability and other financial securities, the investment behaviour of the farmer and the modernity of the equipment, FES provides information on investment possibilities and resulting farm structures (Nowicki et al., 2009). FARMDYN provides a dynamic, flexible, modular template to simulate economically optimal production and investment decisions in detail at individual farm level. The current version of FARMDYN depicts various farm branches (arable cropping, pig fattening, piglet production, dairy, beef fattening, biogas plants). The behaviour module maximizes the net present value over a longer simulation horizon, taking into account detailed restrictions related to feeding, fertilisation, further biophysical and environmental constraints and farm endowment constraints: labour, land, financial assets, equipment and buildings. Integer variables depict indivisibilities in labour use and investment decisions. AGRISPACE consistently combines production, factor use and exit decisions for all individual farms in Norway with a regionalized partial equilibrium model. As such AGRISPACE also acts as a test-bed for the integration of IDM data and models in current models like MAGNET. Examples of improvements and extensions of the system of interlinked IDM models in **MIND STEP** are discussed below.

Improvements and extensions of the IDM models
Environment, climate change and eco-system services. Analysis of the future CAP and policies focussing on eco-system services and improving the conservation of the EUs wild flora and fauna via preservation of farm-genetic resources, biodiversity and habitat require multi-input multi-output IDM models. Climate policies for example require IDM models of farm management mitigation options that are available to reduce greenhouse gas emissions and the trade-offs with other environmental and animal welfare policies, as well as income and risk (Spiegel et al., 2018). The modelling of GHG

emissions and related mitigation options builds from the technology rich, mathematical programming IDM model FARMDYN (Britz et al., 2016; Lengers et al., 2014). Econometric multi-crop models have been developed at INRA for a few years (Carpentier and Letort, 2012; Koutchadé et al., 2018). These models allow to simulate changes in crop management practices (CMP) and acreage choices (land-use) that are necessary to reduce the use of chemical inputs (Femenia and Letort, 2016) or to increase carbon sequestration in soils. **MIND STEP** extends these econometric models to include livestock decisions and land substitution between arable crops, fodder crops and grassland. Empirical results can be used to parametrise the IDM models as FARMDYN, but also to improve parameterisation of current models, see below.

Farm management. Studies have shown that agricultural production and the allocation of inputs is affected by the behaviour of the farmer towards risk (Arata et al., 2014). Farmers are on average risk averse and willing to sacrifice some income to ensure against uncertain outcomes. With this in mind and given the increased price and yield uncertainty due to the greater market orientation of the CAP and climate change, the CAP legislative proposals released in June 2018 includes renewed risk management tools, including mutual funds, insurances and other financial instruments. The current CAP also includes a detailed system for managing risks, but the uptake of a number of these tools remains low. To better understand the risk behaviour of the IDM farming unit and to improve the modelling of adoption of RMIs, **MIND STEP** develops and applies new models based on behavioural theories (e.g. heuristics) and machine learning tools (e.g. regression trees, LASSO). Interactions on the land market are central for a variety of farmers' decision and crucially influence policy outcomes. Farm exit and structural change are core variables for policy makers and farmers as they affect (factor) input prices and production and farm income possibilities of continuing farms (Neuenfeldt et al, 2018). Given the availability of detailed individual farm data, farm exit estimations are first conducted for Norway and Germany using machine learning approaches, with existing approaches developed by **MIND STEP** partners UBO,THUENEN and NIBIO as a back-up (Storm et al. 2015, Neuenfeldt et al. 2018). The Norwegian case is considered because the available data includes the exact geolocation of each farm. This provides an interesting case to explore possibilities that can be transferred to EU members once such data is available. While ABMs are promising for policy analysis in order to endogenously model farm growth and development, capturing complex interaction between farms, they are limited with respect to the number of agents and/or the complexity of farm decision behaviour due to computational demands. Ideally we would directly include the highly detailed IDM models developed in WP3 as the farm agents decision algorithm within an ABM. However, in a direct way this is hardly feasible due to computational constrains. To overcome these limitations, **MIND STEP** explores innovative possibilities to develop meta-models (or surrogate models) to approximate computationally expensive IDM model behaviour (Hoog, 2017). For this, flexible Deep Neural Network (DNN) are employed in order to approximate the input/output relations of the underlying IDM. The **MIND STEP** meta-model approach aims to reduce the computational costs such that more complex IDMs can be considered and such that the ABM can cover a larger regional area.

Integration of agriculture into the rural society. RD measures in Pillar 2 of the CAP are seen as the basic policy issue behind the issue of "Integration of agriculture into the rural society". **MIND STEP** applies an extended version of the recently developed experimental model FarmAgriPoliS (Appel et al., 2018) to allow players to decide on the participation in RD measures for specific case studies in the Netherlands (focussing on environmental collaboration) and Germany. Results can, e.g., be used to feed ABMs as in Schouten et al. (2012) or Grashof et al., (2017). Integration of agriculture in the rural society also relates to the position of the individual farmer in the value chain and how this affects decisions and income possibilities. Decision making is more and more influenced by contracts (and sustainability schemes) of food processors. Here we focus on issues as price transmission and options for farmers for enhancing bargaining power (direct sales, contracts) (Soregaroli et al., 2011). In MIND STEP the modelling is first applied to sectors in Germany and Italy.

Socio-economic aspects: behavioural economic theories, participatory approaches and machine learning. **MIND STEP** enhances IDM models in the field of a) biophysical resolution b) diversity of farm types and agricultural sectors c) definition of farm activities d) description of alternative activities, technologies, investment options, etc. e) behavioural characteristics and f) implementation of risk and price volatility. **MIND STEP** improves on the issue of weak parameterisation and calibration of the IDM models, with a strong focus on profit maximisation. **MIND STEP** explores novel machine learning-based techniques and behavioural economic theories (prospect theory, Benefit-of-the-Doubt (BoD) and the Theory of Planned Behaviour (TPB)) to better understand and more realistically calibrate farm management and strategic behaviour of farmers beyond pure profit maximisation (Lamperti et al., 2017; Cherchye et al. 2007; Kahneman and Tversky, 1979). Outcome of the TPB (yes/no for specific measures) may e.g. trigger the investment (if supported by positive Net Present Value (NPV)) in new machinery and buildings and/or the adoption of a new farm activity. **MIND STEP** investigates the use of participatory approaches and collected data from farmers through citizen science-based approaches to further improve parameterisation of IDM models. The experimental model FarmAgriPoliS can be used as an example of this approach.

*Component 3: Integrating and testing models to assess multiple policy objectives: **MIND STEP model toolbox**.*

Given the need to "develop modelling at various geographic scales – from regional to global", and the wider scope of EU policies to also contribute to the Paris climate agreement and the Sustainability Development Goals (SDGs), the IDM models are linked with current EU-wide and global models, see Figure 3. The EU-wide and global models provide a spatially comprehensive set of sustainability indicators, such as food security (availability, access, utilization, stability), employment, national income (GDP), biodiversity, greenhouse gas emissions, and land and water use, beyond the regions/countries and sectors covered by IDM unit approaches. This approach also allows to take into account the indirect effects of global events and EU policies, mediated through European and international markets. **MIND STEP** improves current models based on the newly developed IDM models and data. This also ensures consistency of the **MIND STEP model toolbox**. The link between the IDM models and the current models consists of two components: Bottom-up (Arrow A in Figure 3) – Improvement of current tools used at the European Commission, and Top-down (Arrow B in Figure 3) – downscaling of current model results to provide scenario relevant input to IDM models and complement the assessment for questions or geographies not covered by IDM models.

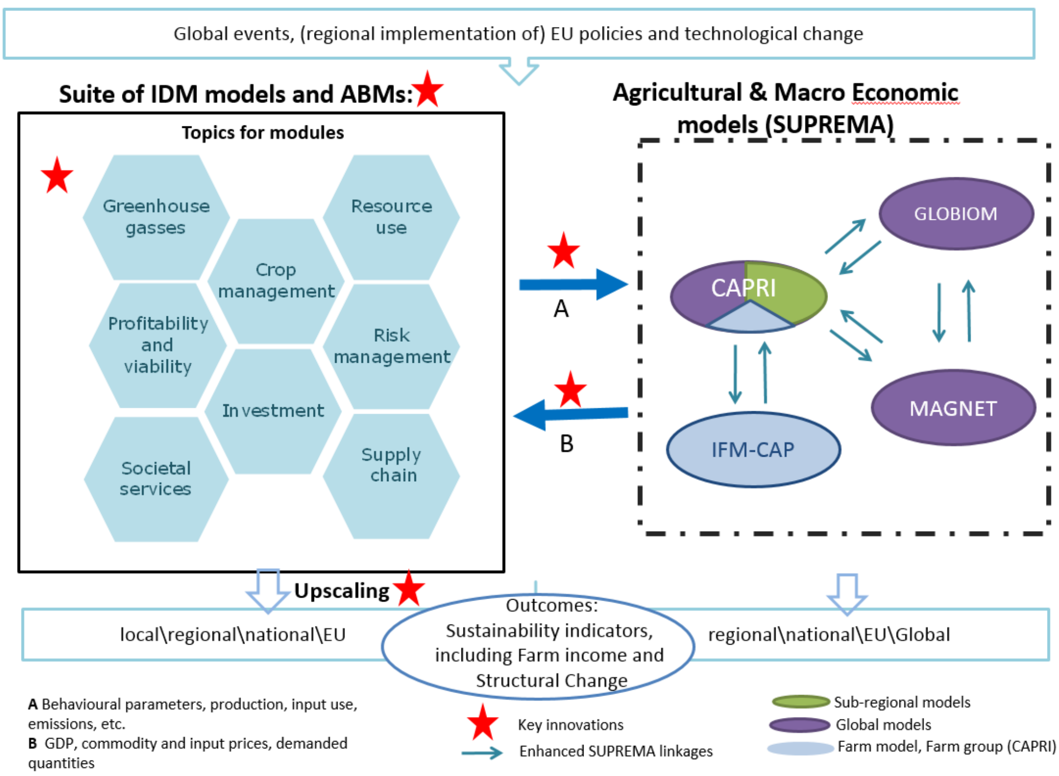

Figure 3: **MIND STEP model toolbox:** Integration of Individual Decision Making (IDM) models and current models

The IDM models and econometric estimates based on the integrated data framework of **MIND STEP** can be used to generate behavioural parameters such as price, production and substitution elasticities for the current models. The IDM results in terms of productivity, intensity, or adoption rates of new technologies can also be used by the current models directly. The improvements can be clustered in four main areas.

1. *Behavioural parameters for choice of agricultural output and input levels*. Calibrating large scale models with spatially explicit production systems representation, is a particular challenge, as multiple dynamics need to be taken explicitly into account, and the necessary data is scarce. Here, micro-econometric models are used together with existing data from biophysical crop

growth models to improve the calibration of yield and acreage elasticities, as well as elasticities of substitution between different land use types, including pasture. In addition, results from the structural change models, are used to inform future input/output coefficients in the current models, for example the empirical results regarding farm exit and structural change are the basis for improving the representation of farm exit decision within the land market module in IFM-CAP.

2. *Risk perception and management*. Risk aversion of farmers is implicitly represented in the supply behaviour of the current models. However, these parameters do not provide accurate answers if the future variability should substantially change, as projected for example for the crop yields due to climate change. **MIND STEP** explores how findings from IDM/ABM models could be integrated either through changes in behavioural parameters or in cost mark-ups in the current agricultural sector and economy and world wide models used by the European Commission.
3. *Adoption of new technologies*. New challenges require new solutions, as in the case of climate change mitigation. Here we build on the work carried out with IDM models and literature to better inform the additional costs associated with adoption in CAPRI, GLOBIOM and MAGNET, as well as benefits from these technologies, e.g. in the form of improved productivity or additional income from energy produced in bio-digesters. The current models are also augmented with variables reflecting the farmer’s willingness to adopt new technologies.
4. *Market power and price transmission*. The newly developed modular IDM models will be used for improving the CAPRI - MAGNET parameterisation through conjectural elasticities and/or price transmission elasticities estimated at disaggregated product level.

Validation and policy evaluation (WP6). In general, validation concerns whether a model correctly represents important characteristics and reproduces the behaviours of a real-world system. More specific, this incorporates the validation of objectives, data, theory and assumptions, processes, and the validity of the results.Validation in the **MIND STEP** project represents a cross-section Task and will be performed on the individual model level as well as on **MIND STEP model toolbox** architecture. In WP6 selected models are replicated to other EU regions and sectors as well, taking into account possible regional specialities. MIND STEP further validates and tests the readiness (of combined use) of the **MIND STEP model toolbox** via an impact assessment of (i) specific EU CAP policy measures (e.g. CAP strategic plans by the EU MS), (ii) climate policies (mitigation and adaptation plans) and (iii) a global event (e.g. climate change, weather variability).

4. Expected impacts and next steps

The combined IDM models and agricultural sector and economy wide models in the **MIND STEP model toolbox** will have a significant impact on the effectiveness and efficiency of policies. The suite of models will help policy makers to take better decisions in the design, monitoring and evaluation of policies. This is summarised in the following three impacts:

- *Impact 1: In the short term: improvement of the capacity to model policies dealing with agriculture and related natural resources, food and international trade*
- *Impact 2. In the medium to long term: improvement of policy design, impact assessments and monitoring*
- *Impact 3: strengthened transdisciplinary research and integrated scientific support for relevant EU policies and priorities.*

MIND STEP is based on the idea that the optimal agricultural model would be a bottom-up, interlinked system of micro or individual models describing behaviour and options for national and international farmers, suppliers, processors, transporters, retailers, consumers etc. Next step is to make use of progress in micro models and underpinning theories and apply innovations in the ICT, big data and data science area.

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