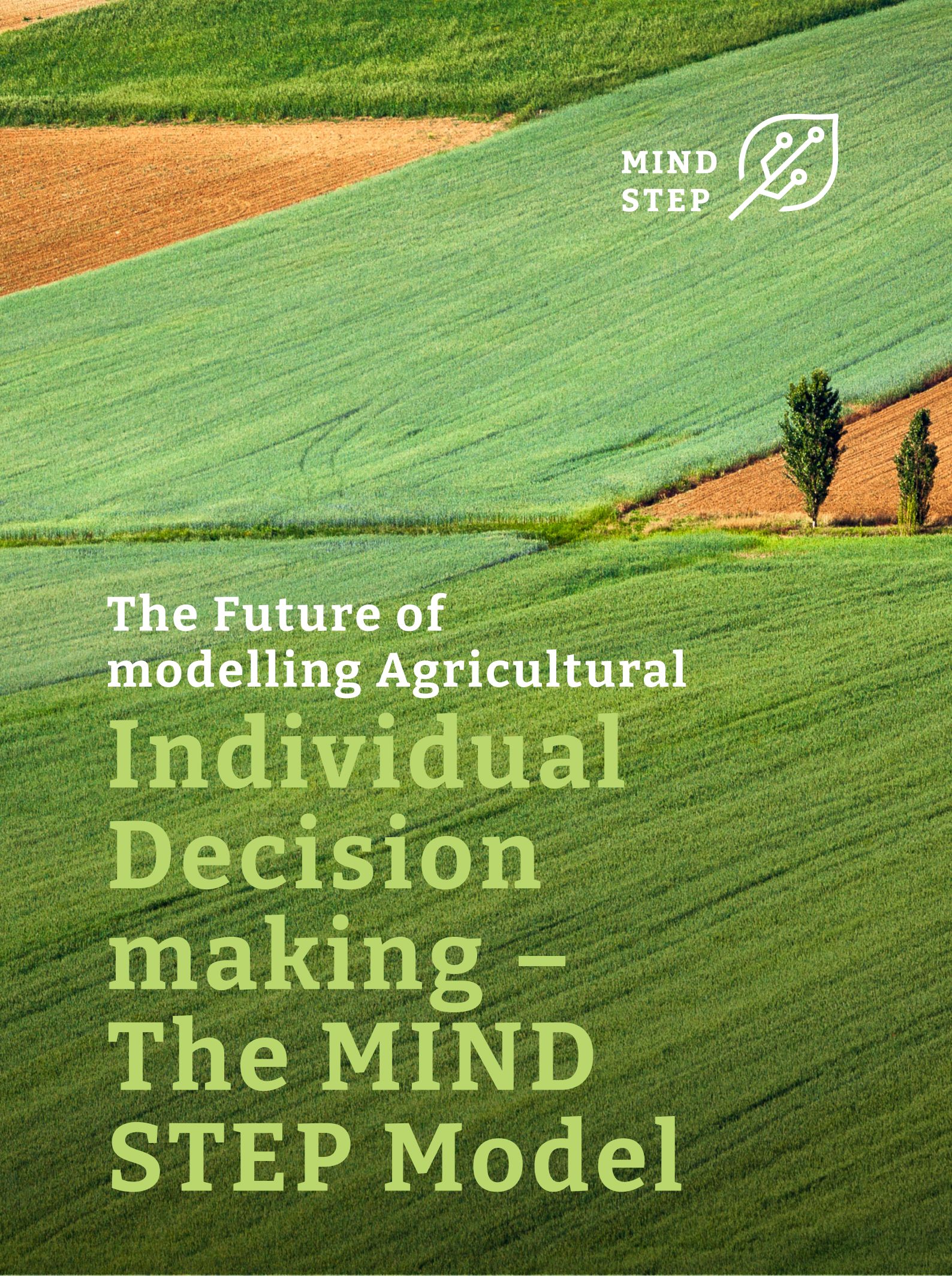

The Future of modelling Agricultural Individual Decision making – The MIND STEP Model

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Introduction

The overarching objective of the **EU project MIND STEP was to support public decision-making in agricultural, rural, environmental, and climate policies** related to agriculture, e.g. the Common Agricultural Policy (CAP) of the EU. Particular attention was devoted to the representation of individual decision making behaviour at farm level. Over the past four years MIND STEP has **developed tools and models** at different scales to do exactly this: monitor and assess policies related to agriculture and take aspect of individual decision-making into account. In describing and modelling the complexities and ever-evolving landscape of agriculture the MIND STEP project has become a beacon of innovation and progress. Now it's time to explore the transformative capabilities of the MIND STEP toolbox and answer the crucial question: **What can we do now that we couldn't do before?**

Better representation of the diversity of farms heterogeneity in modeling

The MIND STEP project has achieved groundbreaking milestones in modelling behaviour of individual decision makers in the agricultural sectors. **MIND STEP has developed detailed bio-economic, farm level, mathematical programming, and econometric models.** These models are firstly based on individual farm data in the **EU Farm Accountancy Data Network (FADN).** The FADN delivers farm level financial economic and structural (farm size, ha of land, number of animals, number of workers, investments in machinery and buildings, number of workers, etc.) data of a sample of representative farms of all farms in the EU. Econometric cost accounting tools and models have been developed to assign different cost components in the EU FADN from aggregate farm level to specific production activities, like dairy cows, or winter wheat. MIND STEP has developed tools to combine farm level data with biophysical data. Using biophysical data, **MIND STEP developed probabilistic spatial allocation of representative farms in the EU FADN.** Accounting for so-far unobserved biophysical heterogeneity between farms e.g. soil and climate conditions, importantly improves the local modelling of environmental emissions and leakages. Grassland is an important activity in agriculture, but data regarding specific production systems are difficult to obtain from farm-level statistics because grass outputs are typically produced and used on farm. MIND

STEP developed grassland yield response curves, combining remote sensing data regarding number of cuts of grassland at parcel level, statistical information from census data at farm level and data from agronomic literature. **Statistical data have been augmented with surveys on individual farmers, preferences** and behavior. These surveys focus on adoption of risk management instruments and socio-psychological factors driving intentions in adopting of GHG mitigation measures. The latter allows classification of farmers based on their preferences and characteristics, thus permitting a more targeted and realistic impact assessments of agricultural policies. Based on FADN and supplementary surveys, behavioral theories (prospect theory and/or heuristics) were tested to econometrically estimate risk-utility function parameters. The risk behavioural parameters can be extrapolated to all farms in FADN, capturing heterogenous individual risk behavior. The **innovative risk module has been implemented in the bio-economic farm model FarmDyn,** allowing integrated assessment with other farm management measures. MIND STEP improved the modelling of crop management practices at farm level including unobserved heterogeneity of farmers' responses (e.g., farmers' skills, soil and climate conditions, etc.) and regime switches (including 'new' crops in the cropping plan) in empirically estimated econometric models. A specific Deliverable (D3.2 An overarching IDM model structure: Interfaces within the MIND STEP model toolbox) has been published, describing the realization of a modular approach to model integration. The focus is on the integration of analytical tools at farm level as modules into an overarching farm model structure. An important conceptual decision was selecting the FarmDyn model as the integrative core within the overarching framework and developing interfaces to empirical and methodological works accordingly. While this modular set-up greatly improved the flexibility and analytical capacity at farm-level, it also increases the complexity of the modelling system.

For practical applications, this implies that there are no standardized test cases to evaluate model behaviour and that there is increased importance of training of users and developers. Based on these observations, **the report concludes with an elaboration on the importance of a network of model developers and users** for the continued development of a generic and flexible overarching structure with a **farm-level simulation** model at its core.

Interactions between farms

MIND STEP developed innovative models and tools focusing on interaction between individual farms relevant for economic and environmental outcomes of policy interventions:

- **The estimation of farm exit rates,** exemplified for Germany and Norway, as basis for integrating structural change in the agricultural sector into representative farm-level or sector-wide models. The innovative approaches include the utilization of neighbourhood effects on farm exit estimates.
- **The investigation of farmers' preferences** and related behavior regarding the participation in collective environmental schemes through computer and group experiments. The new models and approaches include factors beyond economic incentives and combine Agent Based Models (ABM) and behavioral experiments
- **The estimation of conjectural elasticities** that capture market power along the supply chain and specifically (and for the first time) the power of farmers arising from contractual agreements or the formation of producer organizations.
- **The training of surrogate models** using machine-learning techniques to address the computational challenges arising when trying to incorporate detailed farm level models into representative larger scale models, here specifically into ABMs, to model interactions between individual farms on land markets. Technically, MIND STEP achieved an integration of the bio-economic farm model FarmDyn in the ABM AgriPolis using deep learning surrogate modelling. In combination with the farm exit model, this integration of detailed farm models in a regional agent-based model allows capturing structural change implications for the farm population and the spatial distribution of environmental outcomes.

Improved interfaces between data and models at different scales (farm, regional, national, EU)

MIND STEP made important contributions to improved **micro-economic underpinnings of models** frequently used by the European Commission for assessments of policies related to agriculture at various scales: **the individual farm model IFM-CAP, the global bio-economic, agricultural sector model GLOBIOM, and the global and economy-wide model MAGNET.** The improvement of IFM-CAP includes endogenous changes in farm size (a component of structural change). This was achieved applying a statistical land market mechanism to redistribute land. The available land for redistribution is provided by the MIND STEP farm exit module for Germany as described above.

MIND STEP contributed to improvements of GLOBIOM and MAGNET, especially focusing on harmonising production systems and farm typologies (GLOBIOM), splitting primary factors to include live animals (MAGNET), calibrating behavioural parameters (GLOBIOM), improving risk representation (GLOBIOM) and addressing greenhouse gas emission reduction potentials and costs (GLOBIOM, MAGNET). Harmonising production systems and farm typologies in GLOBIOM resulted in an improved farm- and cost representation in GLOBIOM using FADN.

The different steps included

1. ***Harmonizing the management systems in GLOBIOM with the farming systems in FADN***
2. ***Estimating farm cost allocation model (activity based) and***
3. ***Integrating estimated costs in GLOBIOM. Livestock disaggregated from total capital stock in MAGNET uses data from EU-FADN (share of breeding livestock in total fixed assets).***

This split allows modelling livestock markets in MAGNET and linking emissions directly to as the standing herds as opposed to previously used output indicators. **The bio-economic farm model FarmDyn has been used to generate greenhouse gas emission reduction** potentials and costs of different technologies and related investments and adjustments in farm management. These costs and potentials translated to activities and sectors, have been used to enlarge the list of GHG emission reducing technologies in GLOBIOM and improve the GHG marginal abatement cost curves (MACC) in MAGNET.

Transparency of methods, sustainable software development and model validation

MIND STEP partners gained **important experiences** in the fields of **1) model validation and concept proofing 2) importance of stakeholder engagement, e.g. in workshops, and 3) policy evaluation.** The proofs of concept focused on applying MIND STEP models and tools outside the case-study regions. This revealed large regional variation within Europe and the challenge of specific data requirements for models, which are often not readily available for a intended application region. Collaboration with local experts and stakeholders enabled capturing unique regional characteristics and was a prerequisite to the validation of data and models. Stakeholder workshops engage regional partners and local stakeholders and ensures model plausibility through continued dialogues between modelers and users. **The MIND STEP project's achievements, in particular its toolbox enables better policy evaluation, identification of policy options with special emphasis on the CAP, scenario development and impact assessment for European agricultural production systems.**