# Summary of Deliverable 6.2 - Report on the validation of the MIND STEP toolbox and the proof of concept.

This report (D6.2) provides an overview of the validation and quality management measures for the MIND STEP toolbox. In doing so, we focus on two main tasks of Work Package 6: (1) compiling the validation measures for all models of the MIND STEP toolbox and (2) selecting promising models and approaches for replication in other agricultural regions. We thus aim to both increase transparency and demonstrate the application and flexibility of the MIND STEP toolbox.

## Validation - Capturing the Status Quo

In order to obtain an overview of the validation processes of the MIND STEP toolbox, a survey was first conducted on the measures used in the individual models. The focus was on data validation, empirical validation, and process validation. Toolbox validation was assessed in terms of model calibration, quantification of model uncertainty, and model validation. Although these aspects were considered relevant for all models, the survey shows that there is still room for improvement in actual implementation.

**There is a disconnect between validation needs and implementation.**

Thus, model calibration was considered important overall, but of the 14 models in the MIND STEP toolbox, only 8 models are calibrated, 3 models are not calibrated, and calibration is not possible for 3 models. The importance of quantifying model uncertainty was judged to be medium to very high. For some models this was done with the help of sensitivity analyses, Monte Carlo simulations or statistical inference. But here, too, a need for improvement in implementation was seen overall.

## Proof of concept: replication in other regional contexts.

Within the MIND STEP toolbox, quality assurance took place mainly through replications (direct and/ or conceptual replication). That is, the quality of the models was tested by applying them to new regional contexts. Our goal was to demonstrate the usability of the models and to test how the models used and developed in the MIND STEP project can be transferred to other regions and contexts. In order to present these replications in a more systematic way, these replications followed a protocol that specifically also addressed the challenges and potential solutions for applying the MIND STEP toolbox in different agricultural regions in Europe.

To this end, we selected five models:

1. **FarmDyn** is a detailed bioeconomic farm model that can simulate different agricultural sectors such as dairy farming, beef production, pig fattening, arable farming and biogas plants. It is parameterized for Germany and the Netherlands and uses farm planning data in combination with agricultural structural statistics. The model is based on GAMS and has a graphical user interface. It allows the systematic simulation of different farm realizations and framework conditions such as prices or emission limits.
2. The **Green House Gas emissions model** is based on a Data Envelopment Analysis (DEA) and allows for the consideration of GHG emissions and land redistribution. The linear programming model was implemented using R and requires farm-level data on inputs, outputs, and GHG emissions. It calculates the degree of inefficiency with which farms could simultaneously increase production and reduce greenhouse gas emissions, taking land redistribution into account. The model was applied to Dutch dairy farms.

3. **AgriPoliS** is a spatially explicit and dynamic agent-based model that can simulate the evolution of agricultural structures over time. It is mainly used to study the impact of policy measures on agricultural structural change. The model can be calibrated with empirically collected data for real regions and contributes to a better understanding of past and future structural changes. In AgriPoliS, individual farm agents maximize their profits or household income using a mixed-integer programming model and can respond to price or policy changes by renting or leasing land, changing their production system, or deciding to quit farming. These farm agents compete in the land market with their neighbouring farms in repeated auctions.
4. The **Cost Allocation Model** is a panel data model based on accounting identities. It accounts for the unknown heterogeneity of farms due to randomly determined parameters and the potential relationship between input use per crop and acreage decisions. The model is estimated using the SAEM algorithm and uses additional information on the distribution of random parameters to ensure realistic estimates of input use. An R package called WInputAll was developed to estimate the cost-allocation model on different FADN datasets.
5. The **Multi-Crop Model** (ERS-MCEM) is an econometric model with endogenous regime change developed by an INRAE team. It consists of a system equation for crop yields, input use, and area choice, and an equation for crop choice grown. Most of the parameters in the model are farm-specific random parameters to account for heterogeneity in farm management behaviour. After estimation, the model parameters can be calibrated individually for each farm to obtain farm-specific simulation models of cropping decisions. An R package called RPMulticrop was developed to estimate the ERS-MCEM model on FADN data and run farm-specific simulations.

Our proof of concept - applying the selected five models of the MIND STEP toolbox to other regions - identified several **fundamental challenges**:

a. Regional differences: There are strong regional differences between European regions that need to be considered. For example, fertilizer and pesticide expenditures differ between southwestern European and north western European regions due to different farming practices.
b. Data management: The data basis is of great importance, as the models often require specific information that is not generally available. This requires additional quality assurance and verification measures to ensure reliability.
c. Regional expertise: Collaboration with project partners and local stakeholders who have expertise in regional specificities is critical to capture the uniqueness of each region and validate data as well as models.

## Concluding remarks:

In summary, the successful application of the MIND STEP toolbox is based on a combination of technical solutions, stakeholder engagement, and collaboration between modelers and potential users.

**Consideration of regional specifics, different data sets and specific expertise are essential for a successful application of the MIND STEP toolbox.**

Collaboration with regional partners and local stakeholders has proven effective in addressing the uniqueness of each region and ensuring model accuracy or making adjustments. Communication and model documentation are critical to facilitate adoption and dissemination of the MIND STEP toolbox beyond the project.

It is also recommended that a network of modelers and users be established to address various technical and conceptual challenges through knowledge sharing and collaboration on regional application and further development of the models.