MIND STEP

MODELLING INDIVIDUAL DECISIONS TO SUPPORT THE EUROPEAN POLICIES RELATED TO AGRICULTURE

Deliverable Report D6.3
Report on stakeholder workshop on transferability, usability and functionality of the toolbox

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EXECUTIVE SUMMARY

The MIND STEP project has developed a model toolbox for analyzing EU agricultural and environmental policy. In the 3rd co-creation stakeholder workshop held online on October 26th and 27th 2022, the MIND STEP consortium introduced the toolbox and presented the first results, including the nitrogen reduction targets in agriculture, and the impacts of GHG emissions reductions and the adoption of GHG mitigation measures. The results of the model simulations suggest that a fertilizer tax and GHG tax could lead to a reduction in nitrogen use and greenhouse gas emissions in the agricultural sector, both at the sector and farm level. However, the results also indicate that there will be trade-offs between economic and environmental impacts that need to be taken into account when implementing such policies and further research is needed to better understand these impacts and how to mitigate them. In the course of the workshop, focus group methods were used to gather input from key experts to improve the simulation activities of the MIND STEP modelling teams. Participants were divided into three groups, focusing on scenario assumptions and results, management and technology, and policy design. The stakeholders discussed a combination of voluntary measures along with taxations may be a suitable enhancement of the scenarios. Explicitly considering the uptake of new technologies in order to accurately assess their potential impacts under different policy scenarios, was also seen as an important enhancement towards the final policy evaluation in MIND STEP. The potential political and administrative challenges of implementing a fertilizer or GHG tax, as well as the need to align such policies with other objectives such as social dimensions or food security were also highlighted. Overall, the MIND STEP toolbox and initial results were positively received by stakeholders, with the benefit of linking different models being emphasized. However, there is a need for greater transparency of assumptions and limitations in modeling activities.

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1. INTRODUCTION AND BACKGROUND

Over the last three years, the MIND STEP project has developed a model toolbox for analyzing EU agricultural and environmental policy. As part of its stakeholder engagement strategy, MIND STEP constantly aims to engage with stakeholders, including representatives of the European Commission, researchers and NGO's, in order to foster transparency of the project, build trust, and address the demands of stakeholders. In the 3rd stakeholder workshop held online on October 26th and 27th 2022, the MIND STEP consortium introduced the MIND STEP model toolbox and modeling teams, presented the first results of the toolbox. The objective was to gather input from key experts to improve simulation activities.

During the first day of the workshop, the first modeling team presented information on nitrogen reduction targets in agriculture at the farm and sector level. On the second day, the second modelling team presented information on the impacts of GHG emissions reductions and the adoption of GHG mitigation measures on the farm and sector level. During both days, participants split into three breakout groups to focus on scenario assumptions and results, management and technology, and policy design.

The report is structured as follows. First, an overview of the discussed benchmark scenarios is given, before the method of the co-creation workshop is described. Then, an overview of the simulation results of the model toolbox and the results of the focus group discussions is provided before conclusions for the further work in the MIND STEP project are derived.

1.1. Definition of benchmark scenarios

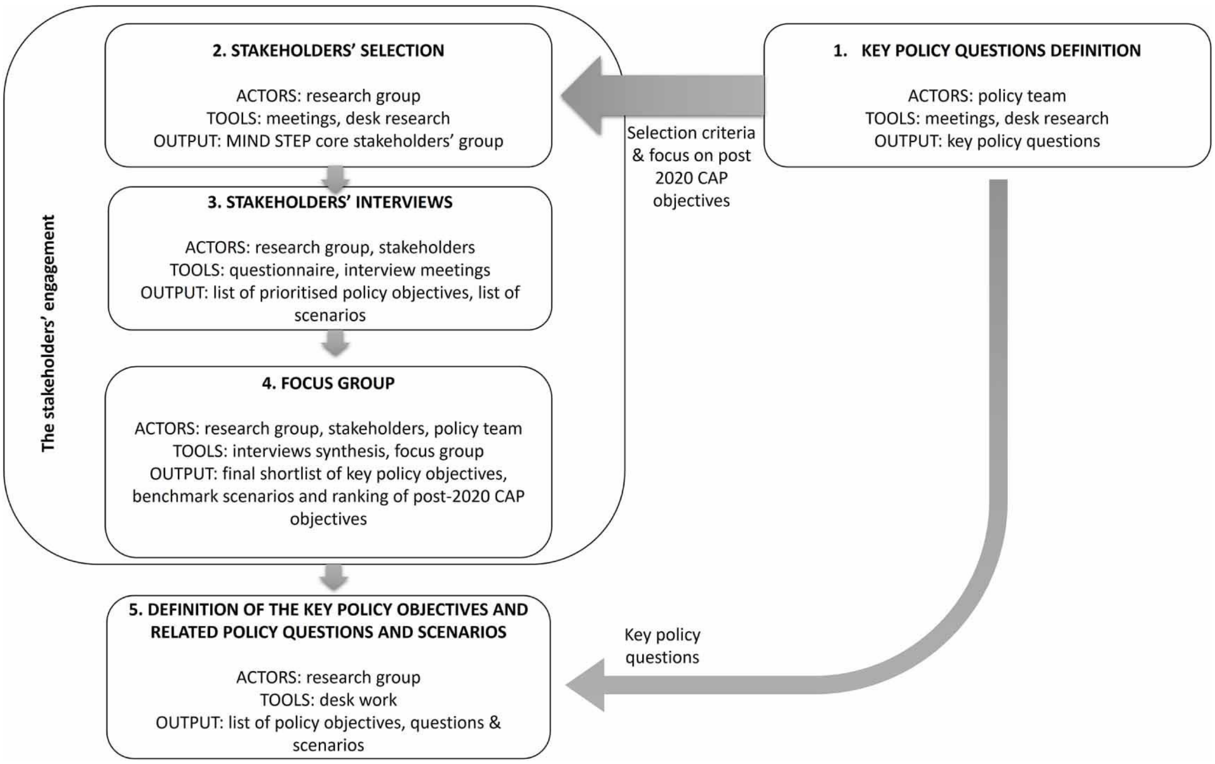

Figure 1. Actors, tools and ouput of each step of the proposed approach (Coderoni et al. 2021)

Coderoni et al. (2021) identify key policy objectives, related policy questions and benchmark scenarios that should be addressed by the MIND STEP toolbox. This study involved three working groups: the research group, the policy-expert team, and public and private stakeholders. Figure 1 illustrates the five-step process that was used to facilitate the assessment of policy questions and scenarios. The stakeholders' engagement led to a comprehensive definition of the policy objectives and brought up two major indications: (1) prioritising environmental issues and (2) jointly analysing

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the economic and environmental performances (at the farm and the territorial levels). The synthesis of the work yielded a list of key policy questions and related benchmark scenarios with a prevalence of environmental and low-carbon scenarios.

The following two sections present the storyline of the benchmark scenarios.

1.2. Chemical input use reduction (Scenario 1)

The reduction of nutrient losses in agriculture is a stated objective of ongoing EU-wide policy strategies to address the existing high levels of nutrient pollution in the environment. The European Commission aims at a reduction of nutrient losses by at least 50%, while ensuring that there is no deterioration in soil fertility, implying a reduction of fertilizer use by at least 20% by 2030. This will be achieved by implementing and enforcing the relevant environmental and climate legislation in full, by identifying with Member States the nutrient load reductions needed to achieve these goals, applying balanced fertilization and sustainable nutrient management and by managing nitrogen and phosphorus better throughout their lifecycle.

There are several conceivable policy measures to achieve this objective, such as imposing restrictions on fertilizer use, by supporting famers in switching to less input-intensive practices, or by creating market incentives for the reduction of fertilizer use, to name just a few. A tax on fertilizers could be such a market-based measure, which would create an incentive for farmers to reduce the application levels and possibly to invest in fertilizer saving technologies. In practice, the reduction of fertilizer use and transition to alternative fertilization technologies would require a combination of measures, possibly different at member state level, to address the specific situation of the respective farming sectors, considering the environmental and economic conditions of the affected farms.

From an impact-assessment perspective, it is relevant to identify the isolated and combined effects of the alternative policy measures on certain types of farms and on the sector as a whole. To ensure that the MIND STEP modelling toolbox can indeed be used for such a purpose and that the involved models show comparable and tractable results, the modelling teams have agreed on testing a taxation scenario for nitrogen fertilizer as a first step towards development of a wholistic policy. Taking inspiration in the climate mitigation potential literature, CO_2 tax levels ranging from 10 to 200 Euro per ton of CO_2 equivalent, are taken as a starting point to calculate comparable taxation levels of nitrogen fertilizers. This causes increases of nitrogen fertilizer prices between 4% and 54% if only the emissions from fertilizer application are considered. These price increases are then applied in the different models of the MIND STEP toolbox, namely the partial market models GLOBIOM and CAPRI, the farm-level supply models IFM-CAP and FarmDyn, as well as two empirical models of input demand within multi-crop systems.

1.3. GHG mitigation (Scenario 2)

The “Green Deal” has become the leitmotif for EU policies at the latest with the von der Leyen’s Commission’s proposal to lift the greenhouse gas (GHG) reduction target to at least 55% (2030 compared to 1990) and to speed up the path towards a climate-neutral European economy by 2050. In the EU, agriculture is responsible for about 13% of GHG emissions caused by enteric fermentation, agricultural soils, and fertilization (Eurostat, 2020). Hence, climate policy measures in the agricultural sector are of great importance to achieve the EU's ambitious climate target of net zero emissions in the AFOLU sector by 2035 and across all economic sectors by 2050.

The EU currently spends more than one-third of its budget on the agricultural and land-use sector, and thus having a powerful tool to transform the agricultural sector towards a sustainable and climate-friendly sector. So far, the EU agricultural policies and related budgets have little effective attention to climate protection.

From economic theory a tax on GHG emission would be the first best option to cost-efficiently steer the change in production technologies in GHG emission low production systems. In addition, carbon prices are commonly used in economic models to estimate cost-efficient mitigation potentials for policy support. However, the introduction of a tax on GHG emission in the agricultural sector will most likely meet with resistance, which makes its political implementation at least questionable.

Another approach would be the utilization of the existing above-mentioned spectrum of EU CAP funding and tools to further incentivize climate-friendly agricultural production. One option is to further shift the CAP funding from the first

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pillar to more targeted measures of the second pillar. A careful structuring of policy incentives has the potential to untap GHG emission reduction potentials in agriculture by e.g., deployment of abatement technologies to reduce direct GHG emissions from agriculture in particular in the livestock sector or further strengthening the environmental contribution of the sector via (collective) Agri-environmental measures (AES) (e.g. maintaining grassland areas as carbon sink).

The MIND STEP model toolbox is addressing the GHG mitigation scenario by investigating (1) the effects of a tax on agricultural non-CO_2 emissions at the farmgate level which steers the transition towards more GHG efficient production systems, (2) the adoption of mitigation technologies, and (3) the behavioral aspects that influence farmers' participation in (collective) AES.

Different farm management measures to mitigate GHG emissions and sources of GHG emission will be considered among others a) enteric fermentation, b) emission from stables and storage of manure, c) pasture droppings, d) emissions from manure application, and e) emissions from mineral fertilizer applications and upstream emissions related to purchased inputs. To consider impacts of use of innovative feed additives for mitigation of CH_4 from fermentation, we establish a link between the market model GLOBIOM and the bio-economic farm model FarmDyn. We identify the economic mitigation potential for agricultural non-CO_2 emissions in the EU including the potentials of these novel technologies by introducing a consistent set of carbon prices [20 – 50- 100- 200 EUR/tCO_2eq] as off 2020 across models. Selected results regarding production, use of feed, use of N from mineral fertilizer, GHG emission by source and income indicators will be presented at farm, regional, national and EU scale.

In contrast to this rather stylized taxation scenarios, simulations with the agent-based model AgriPoliS provide insights on the farm-level and regional effects of a hypothetical abolishment of the direct payments in Pillar I and a discussion of redirecting these funds for more targeted GHG reduction measures of Pillar II. Average in the EU-27 agricultural sector, the direct payment in Pillar 1 equals about 90 euro per ton CO_2 equivalent. The analysis of this shift in pillar I payment will be complemented by experiments with the agent-based participatory model FarmAgriPoliS which provide insights on how payment schemes of Pillar II should be designed and communicated to improve farmers' willingness to participate in AES, enhancing GHG emission reduction.

2. METHOD

MIND STEP is working to establish an open and transparent dialogue with stakeholders. Co-creation with stakeholders increases the relevance and effectiveness of research projects by directly addressing stakeholders' needs and concerns. As stakeholders bring different perspectives and expertise to the table, a co-creation approach could lead to more innovative and creative solutions. Further, it also enhance the transparency and accountability, as stakeholders are actively involved in the decision-making process.

As part of its stakeholder engagement strategy, MIND STEP held an online co-creation workshop on October 26th and 27th, where consortium members introduced the MIND STEP model toolbox and modeling teams, presented the first results of the toolbox and gathered input from key experts to improve simulation activities.

The workshop was organized in such a way that, after an overview of the policy background and the MIND STEP approach to ex ante policy analysis, half a day was devoted to each benchmark scenario. For each benchmark scenario, modeling results were first presented to all participants before participants were divided into three groups, focusing on scenario assumptions and results, management and technology and policy design. Appendix 7.1 provides the detailed agenda of the workshop.

To ensure a successful co-creation workshop, the MIND STEP team paid especially attention to the selection of stakeholders (section 2.1) and the design of the Focus groups (section 2.2).

2.1. Stakeholder selection

The stakeholders were selected to represent a diverse range of interests and to consider gender balance. Particular attention was paid to the inclusion of policy-makers, environmental NGO's and researchers. Policy-makers were

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included because of their focus on questions with a medium- to long-term time horizon and to foster the dialogue between science and politics at a more strategic level, representatives of environmental NGOs were included because of the selected key policy questions focusing on emissions to the environment and researchers were included because of their professional expertise as well as their experience in interdisciplinary contexts and modelling. We were e.g. not able to also include consumer organizations in our stakeholder group. Given the particular focus on the primary agricultural sector, this was considered reasonable.

To foster their engagement already in advance, a factsheet with the storylines of the benchmark scenarios, details on the simulated policy and farm management measures, and an overview of the analyzed indicators was provided at forehand along with the invitation.

In total 29 stakeholders attended the workshop, including representatives of the European Commission (DG-AGRI, DG-CLIMA), representatives from the Ministry of Agriculture of Bulgaria, Ministry of Agriculture of the Netherlands, ETH Zurich, JRC of the European Commission, Solidaridad Southern Africa, OECD, Institute of Agricultural Economics in Hungary (AKI), Helmholtz Centre for Environmental Research– UFZ, CEEweb for Biodiversity, Aristotle University of Thessaloniki, University of Parma, and the sister project AGRICORE. Appendix 7.2 provides the list of participants.

2.2. Focus group

Focus groups are "guided group discussion that is focused on a specific topic" (Dürrenberger et al. 1999) or more elaborately "a carefully planned [...] discussion [...] designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment" (Krueger und Casey 2015). Focus groups are used in research to obtain knowledge and opinions from stakeholders and to explore a topic more deeply. Stewart and Shamdasani (2014) describe the focus group technique as particularly useful in areas about which little is known, which also applies to ex-ante simulation of policy scenarios. Advantages of the focus group technique include group interaction, i.e., opinions can change during discussions and new perspectives and opinions can be formed (Stewart and Shamdasani 2014; Newig et al. 2008). However, the goal is not to produce unanimity among participants or to make decisions (van Asselt und Rijkens-Klomp 2002). However, there are also some difficulties in implementing focus groups. Particularly noteworthy are the group dynamics that arise and the possible dominance of individual participants, both of which can influence the results (Steyaert et al. 2006). Therefore, the generalizability of the data collected in the focus group is also not readily possible. Holding multiple focus groups on the same topic increases the validity of the data collected. Nevertheless, a general trend can be read from each focus group (Dürrenberger et al. 1999).

During the third MIND STEP stakeholder workshop, the modeling results were first presented to all participants to serve as input and stimulus for the subsequent focus groups discussions. On the first day, modeling team 1 presented information on reducing nitrogen levels in agriculture at the farm and sector levels. On the second day, modeling team 2 representatives presented information on the impact of reducing GHG emissions and adopting GHG mitigation measures on the farm and sector levels.

After that, participants were divided into three groups, focusing on scenario assumptions and results, management and technology, and policy design. Each group consisted of 3 to 10 participants, one moderator and one reporter. Each focus group discussion lasted approximately one hour. First, a round of introductions begins, in which each participant in the group briefly introduces themselves. Then the moderated discussion begins, which was based on a pre-agreed guideline and questions (Figure 2). Within the discussion, various moderation techniques were used to enable balanced contributions and to record the results.

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Break out group 1: Joint assessment of plausibility and adequacy of scenario assumptions and results:

- On scenario assumptions:
  - relative price and yield developments
  - What assumptions you like? Do you miss any key one?
- On plausibility of results:
  - Would you expect the simulated effects in reality?
  - how plausible are they (from the policy, farmers, etc point of view)
  - How transferable are presented results to other sectors and regions?

Break out group 2: Joint assessment with stakeholders about GHG emission reduction technologies/farm management measures to reduce GHG emission

- Discussion on barriers for the wide-spread adoption of GHG mitigation technologies
- What could be potential reactions/adaptation strategies of farms?
- What farm management measures are we missing?
- What could be the impact of the GHG policy measures on investments and farm size/structural change
- What could be the impact of R&D on GHG emission mitigation options?

Break out group 3: Joint assessment of policy design

- Tax on Nitrogen from mineral fertilizers (Day 1); tax on GHG emission in agriculture (Day 2)
  - How realistic is this? how is it possible to monitor and control emissions and losses?
  - How could the tax revenue be best reinvested in the agricultural sector to circumvent income and production losses
- Collective agri-environmental measures in Pillar II of the CAP (Day 2)
  - What are the strengths, weaknesses, opportunities and threats of collective agri-environmental measures to reduce GHG emissions?
  - Can the results of the experiments be transferred to reality?
  - (What (non-simulated) actions are there to increase the willingness of farms to participate in collective agri-environmental measures?)

Figure 2. Guiding questions for Focus Groups

3. RESULTS

3.1. Scenario on chemical input reduction (Scenario 1)

3.1.1. Results of MIND STEP toolbox (Scenario 1)

The discussion of obtained model results focusses on a comparison of general economic farm indicators like changes of farm income or production levels, and on the potential reduction of nitrogen use at sector and farm-level, depending on the levels of taxation. Not surprisingly, the farm-level models show more pronounced reduction levels than the market-level models, since price changes on input and output markets are not considered in models that cover only agricultural supply decisions. The inclusion of market-level models, however, provides an insight into Europe-wide impacts, as well as potential leakage effects of a taxation policy. The comparison of the model results however permits eliciting a range of possible outcomes of the policies.

The FarmDyn model results suggest for livestock farms that a fertilizer tax has no effect on herd size and no substantial decrease in total gross margin. In terms of tax impacts on farm management, the model implies a substitution of grass silage with maize silage in animal rations. This tendency is more pronounced on intensive dairy farms. For extensive

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farms the model results imply a reduction of mineral fertilizer use. The econometric model from INRAE implies limited responsiveness of fertilizer uses to fertilizer price changes from taxation. This is probably due to the current high yielding crop production practices. There is a limited (but still statistically significant) substitution of pesticides for fertilizers. Very limited effects of fertilizer prices increase on crop yield levels, consistent with input use responses. The results of IFM-CAP on crop production indicate a negative effect of fertilizer taxation on rapeseed and sugar beet area, however, soya and rye production quantities are positively affected. The model also indicated an economic effect on the gross margins of farms, which is negatively impacted. In terms of the distributional impacts across farm typologies and farm size, the preliminary results suggest that crop producing farms are by far the most affected and that smaller farms are affected in larger proportion. CAPRI results indicate that a taxation of solely fertilizer application would fall short of the intended target by 2030. A joint taxation of nitrogen fertilizer production and application would imply a 16% reduction in mineral fertilizer application. In terms of the geographical distribution CAPRI results indicate the most pronounced reduction of mineral fertilizer application in Spain, Italy and eastern Europe. The most extreme case of 200 €/t CO_2eq would results in a 12.03% reduction of farmers' income if both application and production are taxed. The results from GLOBIOM suggest that when the EU implements taxes on nitrogen fertilizers, it leads to a decrease in EU production of crops and an increase in imports. Additionally, the model suggests that EU taxation of nitrogen fertilizers have leakage effects on the rest of the world in terms of increasing cropland growth and global greenhouse gas emissions.

3.1.2. Breakout group discussion (Scenario 1)

Group 1: Scenario Assumption and Results

In the discussion, it was noted that various assumptions could be made in order to make the simulations more plausible, including the use of marginal social costs and different taxation rates. The farm models (FarmDyn and IFM-CAP) were questioned on whether output prices were endogenous. It was explained that the market models have endogenous prices that could ideally be passed to the farm models, which use exogenous prices for profit maximization. The linkages between the models was highlighted as a major benefit, with the prices from market models to farm models being a helpful link. The type of fertilizer used was discussed, with it being noted that the average of two fertilizers (ammonia and urea) was used for price and N-content as provided by the FarmDyn model. It was also mentioned that crop rotations were considered in the endogenous model choice of extensive/intensive systems. The dependence of the FarmDyn model on the soil of a farm was also mentioned, with it being noted that sometimes there are only a few farms in a given farm type category in the sample.

During the discussion on scenario results, it was noted that the response of farmers in the FarmDyn model to taxation may not be realistic. Some participants raised concerns about the realism of these results, noting that farmers in reality have more options than what is presented in the models. Particularly the lack of mitigation options in GLOBIOM and CAPRI was highlighted. These will be included in the final scenario runs. It was also pointed out that it is important to be transparent about the limitations of the models, e.g. the GLOBIOM model was mentioned as having inertia and parameters which may address issues with jumps in activities and land use. The distinction between static and dynamic models was also mentioned as potentially being tricky to implement. The group also discussed the issue of presenting profit margins by farm type and size with a potential sampling effect of certain farm-types having predominantly similar size. In terms of transferability of the results, the group recognized that the models currently being used are based on Western Europe and it would be interesting to see if farm level insights could be extrapolated to other regions. The group also discussed the potential for including results from Italy in the final analysis.

There is a recognition that the combination of models is key in understanding the impacts of the tax, and that different models have value as they focus on different aspects. It has also been suggested that it would be interesting to compare the results of global models and to consider models as complementary. The trade impacts of the tax are also a topic of interest.

Group 2: Management and Technology

The focus group discussed the use of Nitrogen input technologies and farm management measures, focusing on the barriers to the widespread adoption of these mitigation technologies. The group discussed the potential reactions and adaptation strategies of farms, the impact of Nitrogen reduction targets on investments and farm size/structural change, and the impact of research and development on input use.

They also considered the effectiveness of nitrification inhibitors and feed additives in reducing Nitrogen in manure and the problems with data quality in modeling these technologies. The group discussed the use of crop sector-related technologies, such as better timing for fertilization, nitrification inhibitors, precision farming, and variable rate technology, as well as the challenges of extrapolating the impacts of these technologies to the EU level due to the quality and availability of data. They also discussed the use of livestock-related technologies that produce organic or renewable fertilizers, and the challenges of scaling up the results of these technologies at the management level using models such as FarmDyn. Finally, the group emphasized the importance of addressing uncertainties through stochastic modeling and considering the uptake of technologies in order to accurately assess their potential impact.

Group 3: Policy Design

In the policy design discussion, the participants noted that CO_2 taxes could be used to achieve both GHG emission reduction and nutrient loss reduction goals, but that multiple instruments may be needed to do so efficiently. They pointed out that farmers' emission abatement costs and pollution damages are likely to be heterogeneous, meaning that differentiated tax rates may be necessary for efficient regulation. The implementation costs of different policy instruments were also discussed, with uniform taxes seen as relatively cheap to implement but subsidies and farm-level instruments being more expensive. The use of tax revenue and the impact of recent increases in fertilizer prices on model validation were also mentioned.

3.1. Scenario on GHG mitigation (Scenario 2)

3.1.1. Results of MIND STEP toolbox (Scenario 2)

To analyze the economic impacts and GHG mitigation potentials of a tax on agricultural non-CO_2 emissions on farm, regional, national, EU and worldwide levels, different models from the MIND STEP model toolbox were used. The economy wide model MAGNET was used to analyze economic impacts and distributional effects between EU and the rest of the world of an economy wide 100 euro per ton CO_2eq tax in the EU only. The EU dairy sector would experience lower production volumes (about -8%), higher output prices (about 17%), lower income possibilities (about -7%) and lower GHG emissions, namely about -19%. At the same time exports to countries outside the EU would decrease and imports from outside the EU would increase. As a comparison MAGNET also assesses a worldwide implementation of a 100 euro per ton CO_2eq tax. The impacts this scenario on production and economy in the EU dairy sector are much less, while mitigation impacts on CO_2eq emissions are about the same as in the scenario with GHG tax in the EU only. This points at different production technologies in the EU dairy sector in the two scenarios. Looking at the primary agricultural sector as a whole, EU only implementation of a GHG tax has limited effects on economy and caloric consumption in the rest of the world (ROW), although emissions in the ROW slightly increase by about 1%. Worldwide implementation of a GHG tax has a more severe effect on the ROW compared to the EU. Producer prices in the ROW increases relatively sharply and caloric consumption decreases by 1%.

The partial equilibrium (PE), regional, global coverage, bottom-up land use model GLOBIOM was used to analyze novel GHG mitigation technologies for the dairy sector. Four new technologies were considered. The extra costs and GHG mitigation potential per activity in GLOBIOM were linked to the outcome of the bio-economic farm model FarmDyn. A tax of 100 euro per ton CO_2eq decreases CO_2eq emission from agriculture with about 30%. This decrease in emission is comparable with the decrease in the CO_2eq emission in the EU primary agricultural sector in MAGNET. The decrease in agricultural production in GLOBIOM is however much larger, namely about -15 %, against -3% in MAGNET. Within Europe, largest GHG emission reduction potentials are found in Central Europe, contributing 1/3 of the total abatement. Emission reduction is more limited in Southern Europe, which contributes about 20% of the total abatement. This is among others explained by the different composition of the primary agricultural sector in the different regions in the EU. With relatively large share of ruminants with high GHG emission intensities, in agricultural production in Central Europe. Adoption of new mitigation technologies can deliver additional extra 10% of GHG abatement in EU agriculture by 2050. New technologies appear rather costly and get adopted only at carbon prices above 100 euro per ton CO_2eq. At these high carbon prices, availability of new technologies slightly reduces the emission reduction coming from decreasing livestock production levels in the cost-efficient mitigation portfolio.

The bio-economic farm model FarmDyn was used to analyze impacts of a tax of 100 euro per ton CO_2eq on representative farm groups within the Dutch dairy sector. The milk production per cow is assumed fixed. Intensive dairy farms with high costs of purchased feeds and high costs from manure disposal from the farm, decreases production by about 15 % while GHG emission decreases by about 20%. With the feed additive Bovaer® included the emission decreases with about 30%, while production decreases are about the same as in the scenario without the feed additive Bovaer®. The group of relatively low variable costs producing, extensive dairy farms keep the production constant while decreasing emissions by about 5%. Including Bovaer® the GHG emission decreases by about 15%. At regional level the decrease in GHG emission is largest in the sand regions in the Netherlands. This is explained by the high concentration of intensive dairy farms in these regions. Average for the Netherlands as a whole, a tax of 100 euro per ton CO_2eq decreases agricultural production by about 10% and GHG emission by about 15%. The impact on gross margin is extensive, provoking extra decreases in number of dairy farms, decreasing prices of agricultural land and production rights in the somewhat longer term. These impacts can be dampened by increased output prices. So far input and output price changes at market levels are not included in FarmDyn.

Given the results above the introduction of a tax on GHG emission in the agricultural sector will most likely meet with resistance, which makes its political implementation at least questionable. Another approach would be the utilization of the existing spectrum of EU CAP funding and tools to further incentivize climate-friendly agricultural production. One option is to further shift the CAP funding from the first pillar to more targeted measures of the second pillar. A careful structuring of policy incentives has the potential to untap GHG emission reduction potentials in agriculture by e.g. deployment of abatement technologies to reduce direct GHG emissions from agriculture in particular in the livestock sector or further strengthening the environmental contribution of the sector via (collective) Agri-environmental measures (AES) (e.g. maintaining grassland areas as carbon sink). Experimental research with FarmAgriPoliS was conducted to gain insights into the question, what influences farmers' participation in agri-environmental schemes. Offering the participants in the experiment different payment schemes (collective or fixed payment) and framing of the payment schemes (neutral, economy focus, ecologic focus) it appears that the payment scheme and the framing affect the willingness to participate in (GHG mitigating) AES.

In general, the different models in the MIND STEP model toolbox are quite complementary showing results across different scales and modelling approaches. The scenario results go into the same direction. Between GLOBIOM and MAGNET, differences in production appear larger than differences in emissions. Detailing the results further to the farm level, show deviations within the Dutch dairy sector depending on farm characteristics and deviations between average impacts in the Dutch dairy sector and EU regional and EU total average results. So far input and output price changes at market levels are not included in FarmDyn.

3.1.2. Break out group discussion (Scenario 2)

Group 1: Scenario Assumption and Results

The participants discussed GHG emission reduction scenarios for the agriculture sector. They talked about the need to consider various farm types, such as the beef sector, and to include more farm management measures in the models. They also discussed the need to find out the costs and possible mitigation amounts of reducing emissions, and to transfer farm-level insights to the GLOBIOM model. The participants discussed the importance of energy prices and relative prices of energy versus outputs, as well as the feasibility of scenarios and the potential for structural change in the agriculture sector. They also talked about the use of protein crops as a potential solution for reducing GHG emissions and the demand for protein crops, as well as the potential for structural change in livestock farms. They discussed the need to align technical assumptions, such as the simulation year and shock region, and the possibility of allowing for base emissions and taxing excess emissions. The participants also talked about the AGRICORE project and its focus on behavioral assumptions rather than specific GHG emission assumptions.

Group 2: Management and Technology

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The participants discussed various options for reducing GHG emissions in the agricultural sector, noting that an integral view of GHG mitigation is necessary in order to consider the tradeoffs and interrelations between different environmental measures. They emphasized the importance of considering the characteristics of farmers and their willingness to adopt GHG mitigation measures, noting the difficulty in modeling these characteristics and the mismatch between modeled measures and actual adoption of measures by farmers.

The group also discussed the potential for reducing energy use and increasing energy efficiency on farms, highlighting the role of precision farming and other techniques in achieving this. The use of GLOBIUM in analyzing GHG mitigation options was also discussed, with a need for more data on farm management practices and technologies identified.

It was acknowledged that there is already an impressive list of options, but more research could be done on farm management measures, the replacement of concentrates, and the use of domestic legumes. The group emphasized the importance of considering the potential impacts of GHG mitigation measures on farm income and the potential for unintended consequences. They also highlighted the potential benefits of extending lactation and using breeding techniques to lower CH4 emission factors.

Overall, the group emphasized the importance of an integrated approach when considering GHG mitigation options and to consider the interaction between different measures.

Group 3: Policy Design

The Breakout Group discussed various options for reducing GHG emissions in the agricultural sector and the use of tax or voluntary measures to achieve this goal. Participants discussed the strengths and weaknesses of an emission tax, noting that it can be economically efficient but may be difficult to implement and align with other objectives such as social dimensions or food security. They also discussed trade-offs, as different groups of nations have different interests and the tax may not be beneficial for all. It is noted that the level of the tax should not be homogenous and that it should be lower for the EU, as agricultural production is already more GHG efficient. They also noted that it can be difficult to measure the exact impact of taxation and that emission efficiency is included in the models but the cost of current policies is not.

The group further discussed the potential for eco-schemes, which provide payments for beneficial practices, and how they could be linked to Pillar one of the CAP and used to cover expenses for climate-neutral inputs in agriculture. They acknowledged the potential resistance of farmers to results-based schemes and the behavioral aspect to consider when determining whether a carbon tax or direct payment scheme would be easier to implement.

As a third option, the potential for voluntary measures, such as agro-environmental schemes, were discussed. The results of an experiment with FarmAgriPoliS showed that motivation for collective action is lower when payment is uncertain, but higher when it is fixed. It was mentioned that collective action might be further influenced by cultural factors, such as the history of cooperative work in certain regions. The idea of combining voluntary measures with taxation was mentioned as a potential solution, such as the approach taken by the Netherlands where farmers have had voluntary measures in place for the past few years.

4. CONCLUSIONS

In conclusion, the results of the model simulations suggest that a fertilizer tax and GHG tax could lead to a reduction in nitrogen use and greenhouse gas emissions in the agricultural sector, both at the sector and farm level. However, the farm-level models indicate more pronounced reduction levels and income effects than the market-level models, among others due to the lack of consideration of price changes on input and output markets. The inclusion of market-level models also provide insight into Europe-wide impacts, as well as potential leakage effects of a taxation policy. It is clear that there will be trade-offs between economic and environmental impacts and among environmental impacts that need to be taken into account when implementing such policies and further research is needed to better understand these impacts and how to mitigate them.

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It was noted that a combination of voluntary measures along with taxations may be a suitable approach to mitigate these impacts. The idea of considering the willingness of farmers to adopt such measures and their behavior towards such policies was also discussed. The potential political and administrative challenges of implementing a fertilizer or GHG tax, as well as the need to align such policies with other objectives such as social dimensions or food security were also highlighted. The modelling groups also acknowledged the need to improve consistency between impacts per farm, impacts on farm size and number of farms, and impacts per sector per region in order to get a clearer picture of the potential impacts. The limitations of the models, in particular the assumption on farmers' response, should be noted, as well as the challenges of extrapolating the impacts of these technologies to the EU level due to the quality and availability of data, and the importance of addressing uncertainties through stochastic modeling and explicitly considering the uptake of new technologies in order to accurately assess their potential impact. The explicit modelling of adoption and investments in new technologies is considered most important.

Overall, applications of the MIND STEP toolbox and the joint discussion of the initial results were considered very useful by the stakeholder group. The linkage between the models was highlighted as a major benefit and the group recognized that different models have value as they focus on different aspects. However, the discussions indicated that modelling activities would benefit from greater transparency of the assumptions and the limitations of the models. The findings and challenges will be helpful for further refinement of the final policy scenarios in MIND STEP and improvement of the MIND STEP model toolbox. The findings are also useful for research in general and for the design of policy measures.

5. ACKNOWLEDGEMENTS

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7. APPENDIX

7.1. Agenda

Agenda Day 1: 26 October 2022				
Time	**Topic**	**Presenters**	**Chair**	**Material/remark**
13.30	Introduction: • Welcome • Policy background and the MIND STEP approach to simulate policy impacts • Set-up and purpose of the workshop	WR/IAMO/JRC	John Helming	Notes: Marc Müller
13.45	Nitrogen reduction target in agriculture at the farm and sector level	Tamas Krisztin		Material: MIND STEP fact sheet (storyline, policy measures, farm management measures and selected indicators and results)
14:00	Selected results MIND STEP approach to simulate policy impacts	Representatives of modelling teams		
14.40	Introduction to the break out groups	Tamas Krisztin (IIASA)		
14.45	Coffee break			

15.00	Feedback from stakeholders and audience in 3 different break out groups to discuss questions how to further improve the simulation activities in MIND STEP: **1.Scenario Assumptions and results** Joint assessment of plausibility and adequacy of scenario assumptions and results: • On scenario assumptions: ○ relative price and yield developments? ○ What assumptions you like? Do you miss any key one? • On plausibility of results: ○ Would you expect the simulated effects in reality? ○ how plausible are they (from the policy, farmers, etc point of view)?	1 Chair: Tamas Krisztin (IIASA)	1 Reporter Niklas Hinkel (IIASA)

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	○ How transferable are presented results to other sectors and regions? **2. Management & Technology** Joint assessment with stakeholders about Nitrogen input use technologies/farm management measures; discussion on barriers for the wide-spread adoption mitigation technologies: • What could be potential reactions/adaptation strategies of farms? • What farm management measures are we missing? • What could be the impact of the Nitrogen reduction target on investments and farm size/structural change • What could be the impact of R&D on input use? **3. Policy Design** Joint assessment with stakeholders about policy design: Input taxes in agriculture • How realistic is this? how is it possible to control emissions and losses? • How could the tax revenue be best reinvested in the agricultural sector to circumvent income and production losses?	2 Chair: Marc Müller (WEcR) 3 Chair: Paolo Schokai (UCSC)	2 Reporter: Davit Stepanyan (Thuenen) 3 Reporter: Alain Carpentier (INRAE)
16:00	Summary and outlook Reporter from the break out groups summarise the discussion, chair ends with conclusions and outlook	Tamas Krisztin (IIASA)	
16:30	End of meeting		

Agenda Day 2: 27 October 2022				
Time	Topic	Presenters	Chair	Material/remark
9.00	Welcome, objectives for 2nd day	WR/IAMO/JRC	Marc Müller	Notes: John Helming

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9.15	Impacts of GHG emission reduction on the farm and sector level.	John Helming		Material: MIND STEP fact sheet (storyline, policy measures, farm management measures and selected indicators and results)
9:30	Selected results MIND STEP approach to simulate policy impacts	Representatives of modelling teams		
10.10	Introduction to the break out groups	John Helming		
10.15	Coffee break			
10:30	Feedback from stakeholders and audience in 3 different break out groups to discuss questions how to further improve the simulation activities in MIND STEP: **1.Scenario Assumptions and results** Joint assessment of plausibility and adequacy of scenario assumptions and results: • On scenario assumptions: ○ Relative price and yield developments ○ What assumptions you like? Do you miss any key one? • On plausibility of results: ○ Would you expect the simulated effects in reality? ○ How plausible are they (from the policy, farmers, environmental, society, etc. point of view) ○ How transferable are presented results to other sectors and regions?		1: Chair: Marc Müller (WecR)	1 Reporter Niklas Hinkel (IIASA)

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	2. Management & Technology Joint assessment with stakeholders about GHG mitigation technologies/farm management measures; discussion on barriers for the wide-spread adoption of GHG mitigation technologies: • What could be potential reactions/adaptation strategies of farms? • What farm management measures are we missing? • What could be the impact of the GHG policy measures on investments and farm size/structural change • What could be the impact of R&D on GHG emission mitigation options? **3. Policy design** • CO2eq emission tax in agriculture ○ How realistic is this? how is it possible to control emissions and losses? ○ How could the tax revenue be best reinvested in the agricultural sector to circumvent income and production losses • Collective agri-environmental measures in Pillar II of the CAP/results of experimental approach ○ What are the strengths, weaknesses, opportunities and threats of collective agri-environmental measures to reduce GHG emissions? ○ Can the results of the experiments be transferred to reality? ○ What (non-simulated) actions are there to increase the willingness of farms to participate in collective agri-environmental measures?	2: Chair: Stefan Frank (IIASA) 3 Chair: Franziska Appel (IAMO)	2 Reporter: Pieter Willem Blokland (WEcR) 3 Reporter: Zuzana Kristkova (WecR)
11.30	Summary and outlook Reporter from the break out groups summarise the discussion, chair ends with conclusions and outlook	John Helming (WecR)	
12.00	End of meeting		

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7.2. Participants list

Wednesday 26 October 2022

Name	Organisation
Filippo Arfini	University of Parma
Lisa Baldi	University of Parma
Sara Calzolai	University of Parma
Margarita Dineva	Ministry of Agriculture of Bulgaria
Francesco Gianola	European Commission, DG AGRI
Jordan Hristov	European Commission, Joint Research Centre (JRC)
E. Patricia Hualde	European Commission
Eva Iglesias Martinez	University Polytechnical of Madrid
Karin Kleinbooi	Solidaridad Southern Africa
Jussi Lankoski	OECD
Nana Larsen	European Commission, DG CLIMA
Marion Maignan	European Commission
Stefan van Merrienboer	Rabobank NL
Anthony Cristian Medina Paredes	Institute of Agricultural Economics (AKI)
Birgit Müller	Helmholtz Centre for Environmental Research - UFZ
Gabriella Nagy	CEEweb for Biodiversity
Dimitrios Natos	Aristotle University of Thessaloniki
Orsolya Nyárai	CEEweb for Biodiversity
Matteo Rasponi	University of Parma
Andrea Schievano	European Commission, Joint Research Centre (JRC)
Johannes Schuler	European Commission
Ben VanDoorslaer	European Commission, DG AGRI

Thursday 27 October 2022

Name	Organisation
Filippo Arfini	University of Parma
Lisa Baldi	University of Parma
Sara Calzolai	University of Parma
Margarita Dineva	Ministry of Agriculture of Bulgaria
Françoise Divanach	Ministry of Agriculture of The Netherlands
Katarzyna Dyja	European Commission
Robert Finger	ETH Zurich
Francesco Gianola	European Commission, DG AGRI
Reina Groen	Province Flevoland The Netherlands
Jordan Hristov	European Commission, Joint Research Centre (JRC)
E. Patricia Hualde	European Commission
Eva Iglesias Martinez	University Polytechnical of Madrid
Karin Kleinbooi	Solidaridad Southern Africa
Simon Kay	European Commission, DG CLIMA

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Jussi Lankoski	OECD
Nana Larsen	European Commission, DG CLIMA
Marion Maignan	European Commission
Stefan van Merrienboer	Rabobank NL
Anthony Cristian Medina Paredes	Institute of Agricultural Economics (AKI)
Gabriella Nagy	CEEweb for Biodiversity
Dimitrios Natos	Aristotle University of Thessaloniki
Orsolya Nyárai	CEEweb for Biodiversity
Matteo Rasponi	University of Parma
Andrea Schievano	European Commission, Joint Research Centre (JRC)
Johannes Schuler	European Commission
Frank van Tongeren	OECD
Ben VanDoorslaer	European Commission, DG AGRI

From the MIND STEP team, among others (both days)

Name	**Organisation**
Franziska Appel	IAMO
Pieter Willem Blokland	Wageningen Economic Research
Alain Carpentier	INREA
Stefan Frank	IIASA
John Helming	Wageningen Economic Research
Niklas Hinkel	IIASA
Zuzana Kristkove	Wageningen Economic Research
Tamas Krisztin	IIASA
Hans van Meijl	Wageningen Economic Research
Marc Müller	Wageningen Economic Research
Marta Perez Soba	JRC-ISPRA
Paolo Sckokai	UCSC
Davit Stepanyan	Thuenen

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