Wageningen Economic Research Agency Report – MAGNET activities 2022-2023

1 Introduction

Wageningen Economic Research part of Wageningen University and Research (WUR), has been a member of the GTAP consortium since November 1996. The standard GTAP model constitutes the basis of the MAGNET model, a modular CGE model approach developed at Wageningen Economic Research. Hence the name MAGNET, short for "Modular Applied GeNeral Equilibrium Tool". MAGNET has the V7 GTAP model at its core with all extensions added in a modular fashion. It allows the user to select which additional modules he/she wishes to include by adjusting the model settings and by including the relevant data. In addition to Wageningen Economic Research, MAGNET is used and developed by researchers from the Joint Research Centre of the European Commission (JRC) and the Thünen Institute (TI), with the cooperation being organized in a MAGNET consortium.

Extensions to the GTAP model and database in MAGNET are driven by our motivation to navigate to a more equitable and sustainable future world. Our focus is on integrative macro-economic analyses through cooperation within the MAGNET team and by connecting to other models. We deliver foresight macro-economic analyses of climate change, food and nutrition security, inequality and the biobased economy.

This report presents a summary of the activities of the MAGNET team at Wageningen Economic Research in 2022/2023. It again has been a busy year. Next to a wide variety of model developments (expanding our contributions in integrated assessments jointly with biophysical models, increasing detail on food system functioning, better capturing inclusiveness, green investments and R&D, wealth and capital stock modelling, linking to spatially explicit assessments of environmental, modelling biodiversity and circularity and food security impacts) we initiated several new large collaborative projects financed by the Horizon Europe Programme. We also ran policy focussed projects such as the FSEC, Scottish Government and policy-oriented projects to support the Joint Research Centre of the European Commission.

The future looks bright with several large projects being granted, securing funds for future work on inclusiveness, further links to spatial micro-simulation models, better capturing the role of forestry in the bioeconomy, measuring and where possible internalizing externalities of food production and modelling of biodiversity and natural capital. The new projects also make a stronger connection to academics by hiring new PhD students and participating in various stakeholder platforms and foresight groups. The MAGNET website (www.magnet-model.org) provides access to project information, module descriptions, and publications and presents the MAGNET team members.

There have been several composition changes for the MAGNET team in the past year. Monika Verma and Patrizio Lecca left the team. Whereas Marcos Esau Dominguez Viera and Elisa Bardazzi joined the team.

2 Journal papers

George Philippidis, Robert M'barek, Kirsten Urban-Boysen, Willem-Jan van Zeist (2023). **Exploring economy-wide sustainable conditions for EU bio-chemical activities**. Ecological Economics, 210, pp. 107857.

Saeed Moghayer, Monika Zurek, Maliha Muzammil, Daniel Mason d'Croz, John Magrath, Andrzej Tabeau, Joost Mattheus Vervoort, Thom Achterbosch (2023). **A low-carbon and hunger-free future for**

Bangladesh: An ex-ante assessment of synergies and trade-offs in different transition pathways. Frontiers in Environmental Science, 10.

Gatto, A, Kuiper, M., van Meijl, H. (2023). **Economic, social, and environmental spillovers decrease the benefits of a global dietary shift**. Nature Food. DOI: 10.1038/s43016-023-00769-y

Shinichiro Fujimori, Wenchao Wu, Jonathan Doelman, Stefan Frank, Jordan Hristov, Page Kyle, Ronald Sands, Willem-Jan van Zeist, Petr Havlik, Ignacio Pérez Domínguez, Amarendra Sahoo, Elke Stehfest, Andrzej Tabeau, Hugo Valin, Hans van Meijl, Tomoko Hasegawa, Kiyoshi Takahashi (2022) **Land-based climate change mitigation measures can affect agricultural markets and food security,** *Nature Food* 3, 110–121. https://doi.org/10.1038/s43016-022-00464-4.

Zuzana Smeets Kristkova, David Hao Cui, Robert M'Barek et al. (2023) **Economic, social and environmental impacts of green transition investments in a holistic modelling approach**, PREPRINT (Version 2) available at Research Square [https://doi.org/10.21203/rs.3.rs-2199831/v2].

Pyka, A., G. Cardellini, H. van Meijl, P.J. Verkerk (2002) **Modelling the bioeconomy: Emerging approaches to address policy needs, *Journal of Cleaner Production*,** Volume 330, 129801, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2021.129801.

Jonathan C Doelman, Felicitas D Beier, Elke Stehfest, Benjamin L Bodirsky, Arthur H W Beusen, Florian Humpenöder, Abhijeet Mishra, Alexander Popp, Detlef P van Vuuren, Lotte de Vos, Isabelle Weindl, Willem-Jan van Zeist and Tom Kram (2022) "**Quantifying synergies and trade-offs in the global water-land-food-climate nexus using a multi-model scenario approach**." Environmental Research Letters 17.4, 045004.

Fujimori, S., Wu, W., Doelman, J., Frank, S., Hristov, J., Kyle, P., Sands, R., Van Zeist, W.J., Havlik, P., Domínguez, I.P. and Sahoo, A., 2022**. Land-based climate change mitigation measures can affect agricultural markets and food security**. Nature Food, 3(2), pp.110-121.

Shinichiro Fujimori, Wenchao Wu4, Jonathan Doelman, Stefan Frank, Jordan Hristov, Page Kyle, Ronald Sands, Willem-Jan van Zeist, Petr Havlik, Ignacio Pérez Domínguez, Amarendra Sahoo, Elke Stehfest, Andrzej Tabeau, Hugo Valin, Hans van Meijl, Tomoko Hasegawa, Kiyoshi Takahashi (2022) **Land-based climate change mitigation measures can affect agricultural markets and food security**, Nature Food 3, 110–121. https://doi.org/10.1038/s43016-022-00464-4.

3 Reports

Bartelings, H and Smeets Kristkova, Z (2022), **Research for PECH Committee – Workshop on impacts of the EU-UK Trade and Cooperation Agreement on fisheries and aquaculture in the EU – Part II: Trade aspects**, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.
https://www.europarl.europa.eu/RegData/etudes/STUD/2022/690907/IPOL_STU(2022)690907_EN.pdf

van Meijl, Hans ; Bartelings, Heleen ; van Berkum, Siemen ; Cui, David ; Smeets-Kristkova, Zuzana ; van Zeist, Willem Jan**., Impacts of the conflict in Ukraine on global food security.** Wageningen : Wageningen Economic Research, 2022. 43 p. (Report / Wageningen Economic Research; 2022-052).

Allianz Research (2023), **The new risk frontier in finance: Concepts, challenges and a first quantitative case study on pollination biodiversity loss.**[1] Here, MAGNET contributed scenarios including productivity loss due to pollination decline.

[1]https://www.allianz.com/en/economic_research/publications/specials_fmo/biodiversity-finance.html

C. van Haren, M. van Eupen, P. Verweij, M. Vittek, S. Islam, C. Terwisscha van Scheltinga, S. Hasan, C. R. Saha, A. Banik, M. A. Rashid, S. Moghayer, M. Herens (2022). **Land use classification Bangladesh: combining and downscaling existing databases.** NA.

Marcos Esau Dominguez Viera, Zuzana Smeets Kristkova, Anali Castellanos-Gutierrez, Carolina Batis, Marrit van den Berg, Joana C. Chapa Cantu (2022). **Economic pathways to healthy, sustainable and culturally acceptable diets in Mexico.** NA.

Willem-Jan van Zeist, Hans Verkerk, Ana Rosa Gonzalez-Martinez, Myrna van Leeuwen, Yasmin Maximo, Robert M'barek, Alexander Moiseyev, George Philippidis, Viktoriya Sturm, Rodrigo Xavier Álvarez, Hugo Gonzalez Hermoso, Sergey Zudin (2023). **Operational enhanced BioMonitor Model Toolbox – A short demonstration of toolbox results & accessibility to analysis**. BIOMONITOR.

George Philippidis, Robert M'barek, Kirsten Boysen-Urban, Willem-Jan van Zeist (2022**). D5.3: Report on Economy-wide effects of new bio-based material sectors**. BIOMONITOR

Zuzana Smeets Kristkova , Hao David Cui, Michiel van Dijk, Petjon Ballco, Hugo Ferrer Pérez, Pilar Gracia de Rentería, George Philippidis, Ana Sanjuán López**. Green Economy – Improvements of Investments and Indicators Module**, Final Report of the AgEconEurope Framework Contract.

Michael Haverty, Zuzana Smeets Kristkova, David Hao Cui, James Webster: **Analysis on the Impact of Future UK FTA Scenarios on Scotland's Agricultural Food and Drink Sector** (RESAS/004/21).

4 Presentations

4.1 Upcoming Conferences

Willem-Jan van Zeist & Hans van Meijl, Land use modelling in MAGNET, June 1st 2023, presentation at a workshop organised by the World Bank titled "**Expert Consultations on Land Demand and Land Allocation in Nature-Aware Macroeconomic Models at the World Bank**"

GTAP 2023 – June 14-16:

- Bartelings, Heleen and George Philippidis**, Modelling of food waste from farm to fork within a CGE framework**
- Marijke Kuiper, Willem-Jan Van Zeist: **Can a Carbon Border Adjustment Mechanism (CBAM) reduce negative social and environmental international spillovers from EU food consumption?**
- Gatto, A., Kuiper, M., van Meijl, H., van Middelaar, C. **Policies promoting a circular food system with a specific role for livestock in the EU can decrease greenhouse gas emissions but have mixed effects on land use and agricultural wages**.
- Thijs de Lange & Michiel van Dijk, **Macro-economic, socio-economic, environmental and health trade-offs in different diet scenarios in Bangladesh using a CGE modelling approach.**

EcoMod 2023– July 3-5:

- Van Zeist, Smeets Kristkova et al: **Decomposing GDP and welfare changes in scenarios of biodiversity collapse**
- Dominguez-Viera, Smeets Kristkova et al: **Economic pathways to healthy, sustainable and culturally acceptable diets in Mexico**
- Moghayer, S., de Lange, T., van Dijk, M., **Economy-wide and household level impact of dietary changes on the future of agri-food system in Bangladesh: a CGE-Microsimulation approach**

LCM 2023 – Sep 6 – 8: Roel Helmes, Willem-Jan van Zeist et al. "**Challenges and methods for quantifying the benefits of recycling in LCM**"

EAAE 2023– Aug 29 - Sep 1:

- Gatto, A., Kuiper, M., van Meijl, H., van Middelaar, C**. Policies promoting a circular food system with a specific role for livestock in the EU can decrease greenhouse gas emissions but have mixed effects on land use and agricultural wages**.
- Smeets Kristkova, Z., Dominguez-Viera, M., de Lange, T. and Achterbosch, T.: **Towards more modernized food systems with better nutrition and affordability outcomes: an ex-ante CGE analysis.**

4.2 Conferences

Smeets Kristkova, Z., Cui, D., van Dijk, M'Barek, R., Boysen Urban, K: **Methodological improvements to analyse the impact of Investments for Sustainable Growth in MAGNET CGE model**, EcoMod Conference, Ljubljana, September 2022.

Hans van Meijl, Heleen Bartelings, Siemen van Berkum, David Cui, Zuzana Smeets-Kristkova and Willem Jan van Zeist, **Impacts of the conflict in Ukraine on global food security - CGE analysis.** EcoMod Conference, Ljubljana, September 2022.

Mohammadian Moghayer, S., Conijn, J. G., van Eupen, M., Liu, C., van Meijl, H., Mostert, P. F. & Verweij, P. J. F. M. (2022), **Circular bio-economy as a climate strategy: an integrated quantitative assessment of its potential and costs in agri-food sector**, Circular@WUR 2022: Wageningen University & Research

Van Meijl, H., Bos, H. L., Elbersen, B. S., Meeusen, M. J. G., Dagevos, H., Vural Gürsel, I., de Haas, W., Jongschaap, R. E. E., Mohammadian Moghayer, S. & Visser, S., (2022), **Multidisciplinary science based tools enabling transitions towards a sustainable circular bioeconomy,** Circular@WUR 2022: Wageningen University & Research

Van Meijl, H., Woltjer, G. B., Panoutsou, C. & M'Barek, R., (2022) **Introduction - Modelling the circular economy with sectoral and macro-economic models** Circular@WUR 2022: Wageningen University & Research

Gatto, A., Chepeliev, M., Kuiper, M. H. & van Meijl, H., (2022), **Healthier but wasteful? Changes in food loss and waste along global supply chains with healthier diets** Circular@WUR 2022: Wageningen University & Research

4.3 Other presentations

- **Presentation at the Wageningen model and data steward workshop (24th November 2022).** Jason Levin-Koopman from the MAGNET team presented the MAGNET model and operational philosophy to an audience of modellers and data stewards from Wageningen UR, during the Wageningen model and data steward workshop. In addition to presenting the model itself, the presentation focused on the importance of teamwork in maintaining a flexible module-based, continuously evolving model and how this way of operating can assist in collaborating across models and disciplines.

- **Presentation and discussion of exploratory study on nature-based services in CGE model MAGNET,** Willem-Jan van Zeist & Heleen Bartelings, April 20th 2023. Presentation given to a group of interested participants from DG AGRI, to update on the progress made in the implementation of **the Gross Ecosystem Product in MAGNET** (see also below) funded by JRC.

- **MAGNET and the GEP module**, Willem-Jan van Zeist & Heleen Bartelings, April 17th 2023. The presentation was given to the sounding board of a project funded by the Dutch Ministry of Agriculture, with various interested parties from CBS, CPB, PBL, and other government bodies.

- **Results of global CGE Simulations of Policy Bundles with the MAGNET model**, Marijke Kuiper, 27th of February. Presentation for the Food System Economics Commission (FSEC).

- Alessandro Gatto presented the **MAGNET global Food Loss and Waste database** and a study on circular food systems to the D.4 Unit of the Joint Research Center (JRC) in Sevilla.

- Zuzana Smeets Kristkova and David Cui presented the results of the study "**Analysis on the impact of future UK FRA scenarios on Scotland's agricultural food and drink sector**" to the Scottish Government, July 14, 2022.

- Saeed Moghayer, Invited Speaker for the **''Grand Challenge Seminar – Global Shortages in a Changing Climate"** at Oxford University, 12 May 2023, Oxford, UK

- David Cui, **An introduction to MAGNET for Non-CGE modelers**. Presentation at CGE training course for new researchers at International Policy, Wageningen Economic Research, 8 November, 2022.

- David Cui, **Dhaka food system socio-economic modelling course**. Presentation at CGE training course for the Dhaka food system project, Wageningen University & Research, April 2023.

5 Projects

As the MAGNET team is large (13 current members) we also run a large number of projects (a total of 32 at the end of 2022 we highlight the areas we work in, grouping work in different projects together by topic.

Integrated assessments of sustainability

- *KB-Integrated toolbox for climate and circularity, KB-Multiple scales, Macroeconomic modelling for integral decision making (LNV), JRC, Allianz, KOEVOET*

MAGNET has a long-standing cooperation with other models (like IMAGE and GLOBIO from the Netherlands Environmental Assessment Agency and GLOBIOM at IIASA). Building on this experience we are developing stronger links to the many biophysical-oriented models available at Wageningen University and Research. These projects, where MAGNET provides the socio-economic complement to detailed biophysical analyses in other models generally focus on integrated assessments of sustainability. Furthermore, in two recently started projects for the Dutch Ministry of Agriculture and JRC, we are exploring how the incorporate concepts of natural capital and ecosystem services into the model, thus integrating the impacts of biodiversity changes back into economic modelling. For Allianz, a preliminary analysis was provided on the economic impacts of the loss of pollination services.
For the KOEVOET project specifically, but also for other applications, we have developed a global value chain analysis approach to generate environmental virtual flows/footprints directly based on the MAGNET data. In KOEVOET these are used to investigate scenarios to halve the Dutch footprint from consumption (e.g. of virtual/imported land use, emissions).

Food system assessments

- *A4NH Food systems foresight, Dhaka food systems, BGD Deltaplan, SHIFT, MITIGATE, Addressing Synergies and Trade-Offs in the Food System Transformation for the Food System Economics Commission (FSEC), PATHWAYS, Connected Circularity, JRC project X21: Modelling features, MINDSTEP, ECO-READY, biodiversity, Foodcost*

The Food system work started in the FoodSecure and SUSFANS projects work continues with modelling food system interventions, analysing the system impacts of primary production, supply chain and consumption

interventions. These studies vary in terms of global scope with aggregate regions, zooming in on how different economic characteristics alter impacts of comparable policies to country-focussed studies (Nigeria, Ethiopia, Bangladesh, Vietnam) enabling the connection to sub-national analyses with micro simulations at household level (Ethiopia) or with a metropolitan focus (Dhaka). This line of work builds on work developed in different strands of research (like SDGS or climate) bringing these together to identify trade-offs and synergies. For FSEC we are currently working on designing policy bundles for food system transformation taking capturing context through a new food system typology. For the recently initiated OneCGIAR initiative SHiFT, we are applying MAGNET to assess the socio-economic and environmental trade-offs associated with dietary change (e.g. the adoption of the EAT-Lancet) in three countries (Bangladesh, Ethiopia and Vietnam). developing a dynamic spatial microsimulation model that is able to produce subnational projections of income, poverty and food security. The model uses input from MAGNET on wage and price projections to ensure consistency with global-to-national linkages. To aid targeted food system interventions MAGNET sector splits are continuously expanded (current detail is 125 sectors and 160 commodities), where possible cross-checked with technical experts (for example in livestock production). The current focus is on better modelling animal feed, better capturing animal-specific feeding restrictions and the role of breeding capital. Moreover, part of the food systems assessments are focusing on feedback and externalities. In particular, on one side it aims to recognize, categorize, and dissect the drivers that affect food security across Europe. Moreover, it targets the quantification of "real" food costs, aiming to internalise the externalities for better policy evaluation and driving the food system transition. Finally, part of the projects aim to assess food systems-related material flows and ecological footprint, including e.g. the food systems impacts in terms of biodiversity losses, which connects to the Integrated assessment and Bioeconomy and circularity topics.

Bioeconomy & circularity

- *Connected Circularity, PATHWAYS, BIOMONITOR, MAGNET bioeconomy modelling, Data for bioeconomy, DG-ENV biobased plastics, KB-Integrated toolbox for climate and circularity, Contribution Bio_economy EU, JRC project X28: foodwaste and loss @Member States*

Early influential work on land and agriculture exemplified by the EUruralis project has expanded in recent years to modelling the bioeconomy in a wider sense to address the food-feed-fuel-fibre competition. When combined with more technical data and modelling efforts MAGNET proves to have an edge in pulling analyses together into an economywide framework beyond the grasp of the partial technical models. The major challenge in this line of work is to combine the dollar-based quantities with biophysical material balances in a consistent manner. Specific extensions of MAGNET are the development of a waste module and associated database to analyse different options for using waste and the sectors associated with this; the development of a database on biophysical flows accounting for food loss and waste (FLW) jointly with the GTAP centre; current and future to better capture technical details of livestock production and options for a more circular economic system; further enhancement of the modelling of industrial use of biomass (e.g. for bioplastics). The waste module has been extended to include food waste along the supply chain: including post-harvest production loss, processing food waste and retail food waste. At the moment, only data for the EU member states is included but this is being extended with data from the rest of the world. MAGNET has been used by JRC for an impact assessment of the Farm to Fork policy. It is also intended to include the possibility of using food waste as a source of animal feed. As a small extension to the bio-economy module, biogas made from landfill gas, mono-crops or agricultural residue has been included this year. We will include manure as an alternative fertilizer. When manure is included the biogas sector will also be able to use this as a feedstock. Furthermore, MAGNET has been extended with a biodiversity indicator: Gross Ecosystem Services (GEP). The GEP measure can be used alongside the GDP measure to calculate the impact of policy changes on both the environment and the economy. So far only data for EU member States have been included but this will be extended this year.

Climate & energy & water

- *AGCLIM IV, AGCLIM V, PATHWAYS, SSP scenario updates (PBL), Global Environmental Outlook (PBL), MINDSTEP*

While connected to the bioeconomy and integrated assessments several projects focus explicitly on climate change mitigation and/or water use. Linked to the analysis of the role of livestock in the circular bioeconomy work is planned to add biogas, manure and swill, adding again more details to the interaction between food and energy sectors. Improving the tracing of biophysical flows (like respecting energy balances) also forms an important component in this strand of work. It is needed to communicate MAGNET stand-alone results in terms of physical units relevant for policy design as well as enabling a better link to biophysical models

in integrated assessments. Moreover, it developed scenario analysis of the impacts of climate change on agriculture were explored in a coalition with other AgMIP models in the JRC-funded AgClim50 projects. AgClim50 IV explored water as an agricultural production factor in global agro-economic models. Finally, a new calibration of the Marginal Abatement Cost Curve has been implemented, calibrated all the single 28 EU countries with their specific curve and testing scenario building for the assessment of emission abatement-related technological innovation in Europe (both relative to the milk production sector), which could have potential benefit in assessing topics such as policy incentives to achieve a greener economy.

Technical change and investment towards a greener economy (Green Deal)

- *MAGNET Green CAP, Bioeconomy to Green Deal, Green investments modelling*

Technical change is an old theme that got revived by changes in the policy landscape: the European Green Deal aims to transform the EU into a resource-efficient and competitive economy, with no net emissions of greenhouse gases in 2050. Using MAGNET for investment impact analysis requires that modelling investments is guided by a proper sector investment allocation mechanism, allowing to steer investments into the sectors that are "green", or aligned with the EU taxonomy (this was completed in 2021). The new advancements in this area are the incorporation of foreign assets and liabilities (i.e. the "wealth" module) to gain better insights into the role of foreign ownership of the new green capital. An international database of different types of public R&D has been built with the purpose of disaggregating R&D sector in MAGNET and detailed modelling of R&D effects in for obtaining insights into the role of R&D policies in the Green Deal. Alongside these model enhancements policy focused work for the Dutch Ministry of Agriculture is ongoing on the impacts of a greener EU on the Netherlands.

Trade

- *UK FTA's impact on Scotland, Ukraine, Brexit fisheries, BATmodel*

The revived interest in trade policies continued in our projects with a mix of policy and modelling-focused projects. For the Dutch government, we assessed the impact of the Ukraine war on food trade and prices. For the Scottish government, we are analysing the impact of UK FTA's on Scotland. Longer-run modular developments in MAGNET's ability for trade analyses are planned in the EU H2020 BATModel project (2020-2024). The overall goal of BATModel is to improve existing trade modelling tools and approaches, equipped for the analysis of 21st-century trade issues with a focus on agriculture and food to support policy analysis. The current needs of the users are to better account for previously neglected or insufficiently covered issues such as NTMs, GIs, zero trade flows and quality differentiation, as well as GVCs and distributional and sustainability impacts of trade liberalisation and trade policy. MAGNET's contributions in BATModel focus on (1) broadening welfare measurements (specifically employment & income distribution, nutrition & health and SDGs); (2) modelling of Global Value Chains; (3) collaborating with peer research organizations to improve on GTAP's MRIO database; (4) making all CGE model developments available through coding the GEMPACK versions of the BATmodules that will be made publicly available in the course of the project (alongside GAMS versions coded by other consortium members).

Inclusiveness, income distribution and SDGs

- *BATmodel, Addressing Synergies and Trade-Offs in the Food System Transformation for the Food System Economics Commission, KB-Multiple scale, Brightspace*

Work on modelling of labour markets improves as it provides one important channel for changes in income distribution that can be tackled with a global CGE model like MAGNET. Building on the labour-focussed inclusiveness measures for the IFAD rural development report we are currently working on inclusiveness for the Food System Economics Commission in a project aimed at designing policy-bundles that transform food systems towards more inclusiveness, health, and environmental sustainability. This work also builds connections to the spatial downscaling efforts in the KB projects on multiple scales. For the BATMODEL a review has been made on how to broaden trade assessments beyond GDP and monetary welfare measures, also addressing the challenges of communicating a myriad of indicators in a useful way for policy design. Furthermore, the BrightSpace project actively addresses the aim of designing effective and sustainable strategies to navigate within a Safe and Just Operating Space, being defined as a space where the Safe component reflects the planetary bio-physical boundaries and the Just component quantifies the requirements for the human well-being component.
Moreover, a multi-project effort is directed at improving SDG-related indicators within the model, such as indicators related to social externalities, biodiversity (losses), and health-related indicators.

Spatially explicit downscaling

- *KB-Multiple Scales, KB 1C, Dhaka food systems, Innovation project "Bridging the macro-micro gap", OneCGIAR SHiFT, PATHWAYS, BATMODEL, LAMASUS, Forest navigator, Brightspace*

Linked to the work on food security and inclusiveness (calling for an assessment at the household and not national level) and climate change (with spatially heterogenous impacts) work on downscaling MAGNET results continues. One initiative involves the development of MAGNETgrid, which is a separate model that combines spatially explicit economic and biophysical data to pixelate MAGNET output, most importantly, land use and crop area projections. MAGNETgrid allows MAGNET output to be combined with output from biophysical models (e.g. water and crop models) for more detailed and integrated assessments. The model is currently being developed and tested in several WUR internal knowledge base (KB) projects and features in several upcoming projects. Another initiative is the development of the Spatial Simulation of Income Dynamics (SSID) model. SSID is a dynamic spatial microsimulation model that is able to produce subnational projections of income, poverty and food security. The model uses input from MAGNET on wage and price projections to ensure consistency with global-to-national linkages. SSID is currently developed and tested for several countries (e.g. Ethiopia, Bangladesh and Pakistan) as part of CGIAR SHIFT and KB projects.

Simultaneously, efforts to explicitly introduce a higher level of spatial aggregation within the model have been directed to the implementation of AEZ and NUTS2 level modules, with the expectation of improving the perception of sub-regional specific dynamics in responses to specific climate or policy shocks.

Maintenance and quality control

- *KB-Regieteam modellen, Data Stewards, MAGNET improving modelling features, WECR investment*

Maintaining a model developed by a large team in a project-based environment with limited to no funds for maintenance and quality control remains a constant battle. This year we will update MAGNET with the newest GTAP 11 data and update all the external data we use for the various sector splits in MAGNET. We will put effort into updating the procedure of implementing the sector splits and removing any legacy code. Alongside the data overhaul, we are developing a standardized set-up for MAGNET baselines which has highlighted the importance of the indicators chosen to judge a baseline and their possible conflicts. Given the breadth of scope offered by the MAGNET modules, some pragmatic guidance is needed on what to check for in a baseline to avoid potential lopsided calibration driven by the project or modelers' specific indicator focus.

Large investments have also been made in automating the transfer & concatenation of model solution files in the DataWareHouse (DWH) developed for database management at WEcR. Through this DWH model solution files are versioned (key for quality control) and made available for further analyses. PowerBI templates of commonly reported MAGNET variables are further developed, allowing easy and interactive access to model results. For example, using PowerBI Sankey diagrams of waste flows can be generated to visually communicate complex economywide waste flow. MAGNET results in the DWH can also be queried for further analysis in R or through dashboards developments with Shinyapps. The DHW allows queries of MAGNET solution files facilitating data exchange need for linking to other models, like MAGNETgrid which spatially downscales MAGNET results and ongoing work on spatial micro-simulation models. So far only results are stored in the DWH but that will be changed this year to also include the model basedata in DWH. By adding a version control on the basedata we want to improve the reproducibility of model results and reduce the investments needed to update the data periodically.

This year our interface program called DSS will be completely rewritten to fix bugs, improve functionality and to ensure a stable link between MAGNET and DWH.

Part of the maintenance and quality control objectives are now addressed by implementing a new Agile working format (see Team coherence and synergies section).

6 Other Activities

6.1 Team coherence and synergies

Starting from January 2023, the team implemented a series of Agile working activities, divided in 6 subgroups. Some of these groups focus on maintenance or specific broad topic identified as potential common goods e.g. Data management.
In general, Agile working is defined as a strategy to improve communication, connection and flexibility for the employees, allowing them to find the most appropriate and effective way to approach their objectives. In particular, this way of working has been applied by setting regular meetings to evaluate the appropriate division of the macro-task into sub-task, quantification of the estimated time for completion of the tasks and re-evaluation of overall deadlines and tasks segmentation to achieve the overall goal.

Furthermore, as part of our effort to consolidate and develop MAGNET we hold regular update meetings and research workshops at Wageningen Economic Research to present research and address specific issues in depth. Below is an overview of presentations at these workshops. Their aim is to tackle model development relevant to multiple projects to increase synergies across projects and team members. Typically they consist of short presentations of project results or model issues around a particular topic followed by discussions on how to take these further in ongoing and future projects.

- **GTAP 2022 conference summary (June 14, 2022)**
    - Presentations of Michiel van Dijk, Thijs de Lange and Alessandro Gatto
- **MRIO research and Links to MAGNET work (July 12, 2022)**
    - Presentations given by Oliver Taherzadeh (Leiden University)
- **Modelling Extensions in the area of wealth and capital dynamics (October 13, 2022)**
    - Presentations given by Zuzana Smeets Kristkova and David Cui
- **Joint WECR- JRC seminar on Modelling extensions in MAGNET (October 13, 2022)**
    - Food Waste modelling in MAGNET (Heleen Bartelings)
    - Short-run features in MAGNET (Saeed Moghayer and David Cui)
- **MAGNET off-site workshop (January 16 - 17, 2023)**
    - Presentation on agile working for MAGNET
    - Creating joint research agenda and cross-project collaborations in 2023
- **MAGNET off-site workshop (March 14, 2023)**
    - Using the Power BI software to analyse and visualise results from MAGNET (by Marijke Kuiper)
- **Joint WECR- JRC - CITA seminar on (April 13, 2023)**
    - WECR, CITA and JRC plans for MAGNET extensions and applications in 2023
- **Water implementation for Water-Energy-Food assessment (16 May 2023)**
    - Explicit water modeling as a factor of production to address competition and synergies between food and energy production under different climate change scenarios: Elisa Bardazzi
- **The inns and outs of the new Closure tool in MAGNET (16 May 2023)**
    - Heleen and Willem-Jan guide a practical training on how to use the new closure tool to detect closure problems in MAGNET

6.2 Education and training

The group of MAGNET developers and users is constantly expanding. Therefore it is important to provide adequate training, both in-house for new MAGNET team members as well as for our important clients and potential users, such as new PhD students. Below is a list of training activities organized in the period 2021-2022:

MAGNET Summer School – Global Change and the Challenge of Sustainably Feeding a Growing Planet, Wageningen School of Social Sciences (29 August – 2 September 2022, Wageningen)
Linked to Hans van Meijl's professorship at Wageningen University a MAGNET-focused summer school has been organized in September and hosted by the Wageningen School of Social Sciences. In 2022 the MAGNET team organized its first summer school for MSc and/or PhD students with prior economic and mathematical

knowledge. There were 10 participants across different European institutions that were interested in MAGNET model applications in the areas of bioeconomy, food security and others. The theoretical part of the course introduced general equilibrium theory and applications in a systematic way - from the basics of CGE modelling, introduction to GTAP, to specifics of MAGNET model, its modules and the potential future advancements. The practical part under the guidance of experienced MAGNET modellers provided the participants with a unique opportunity to build step-by-step their own simple CGE model in Gempack software.

This training may become the basis for a regular CGE course at Wageningen University to help attract junior researchers with the required technical skills for modeling. The MAGNET summer school will probably bi-annual. There will be 2 types. One summer school provides both an overview of MAGNET model and important applications in the area of bioeconomy and food security as well as practical hands-on training in building your own CGE model from scratch using the GEMPACK programming language.. A follow-up MAGNET course will be offered using the first open-source version of MAGNET, learning how to devise policy shocks and analysing the results. The next MAGNET summer school will be in August 2024. More info can be found of:
https://www.wur.nl/en/activity/global-change-and-the-challenge-of-sustainably-feeding-a-growing-planet-1.5-ects.htm

MAGNET training for JRC (September 2022, February 2023)
These periodical trainings provided for the JRC staff are focused on the practical use of MAGNET model and all the interfaces such as the DSS software. It guides the participants from building their own MAGNET aggregation to running and interpreting MAGNET scenarios. Attention is also paid to checking the correctness of the solution and solving potential errors such as closure problems, etc.

CGE model training in Bangladesh (March and May 2023)
The practical trainings provided for the researcher at CEGIS institute in Bangladesh and Dhaka urban food system experts and experts from the local government. The course was carried out in a four-week online course focusing on the fundamentals of food system analysis using CGE, followed by an intensive two-day onsite course on results interpretation and visualisation by applying R shiny dashboards.

More information

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