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Martin Henseler

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The AGREE-model

Martin Henseler

EDEHN (Equipe D'Economie – le Havre Normandie), Le Havre Normandy University

Contact: martin.henseler@univ-lehavre.fr

Abstract

The AGREE model is an integrated framework to quantitatively analyse the impacts of changes in the economy and policy on Agriculture, Resources, Environment and Energy. While covering the four domains, the model framework is kept as simple as possible to reduce the complexities to a maximum. As a flexible framework, the application to different study cases and extensions by other models is possible. The model's simplicity and flexibility require a careful analysis of the results. The model provides relative values instead of absolute values, ranges instead of levels, and considers sensitivity analysis for relevant scenarios and model parameters. Thus, insecurities from a simple model are systematically covered. The AGREE-model is a "light" version of an integrated assessment model being used for the first and fast analysis of economic shocks and policy changes. This paper presents the conceptual framework of the AGREE model.

Keyword: integrated model, economic model, agriculture, environment, assessment model

JEL classification: C610, Q11, Q15, Q200, Q300, Q400, Q500

The AGREE model

1 Introduction

Two extremely dry growing seasons in Northern Europe within five years (2018, 2022), reforms of environmental and agricultural market policies in 2021, Covid19-pandemic (in 2020) and the Russo-Ukrainian-War (since early 2022) -- all these events created distortions in markets for cereals, oilseeds, fertilisers and energy and impact agricultural production and the interlinked sectors. The roles of the agricultural sector are known: its relevance for the supply of food, fibre and energy; its interlinkages to other economic sectors, its role as a major user of land and other natural resources and its role in environmental negative and positive impacts. However, the interlinkages of sectors within this nexus are complex, and the reaction of the economic system facing economic shocks or policies is difficult to quantify.

Since the Club of Rome introduced in the 1970s the concept of sustainable growth, interdisciplinary and integrated research has gained increasing relevance as an approach to investigating economic and environmental systems in a holistic and interlinked way. Researchers use integrated assessment and interdisciplinary models to address research questions on sustainable growth, production, resource usage, environmental pollution, greenhouse gas emissions, and economic and climatic change impacts.

The AGREE (**AG**riculture, **R**esources, **E**nvironment and **E**nergy) model represents an agricultural sector model framework to address research questions on the nexus between agriculture, (natural) resources, energy and environment.

Integrated economic and interdisciplinary assessment models have been developed to address questions on environmental, resource and sustainable growth topics. GLOBIOM (Global Biosphere Management Model) is a partial-equilibrium model representing land use-based activities of agriculture, forestry and bioenergy sectors. It is applied to analyse the land-use competition between the sector under global change and policy scenarios. The model covers represent the land-use world-wide and simulates the impact on the production of food, forest fibre, and bioenergy (Havlík, 2018; IIASA, 2022a, 2022b). The IEEM platform (Integrated Economic-Environmental Modeling Platform), is a recursive dynamic computable general equilibrium model. The focus of research topics is for the medium and long-run analysis of public policies and investments and the interaction between the economy and the environment. The regional focus is Latin America (Banerjee et al., 2019; Banerjee and Cicowiez, 2020). CAPRI (Common Agricultural Policy Regionalised Impact) Modelling System consists of different economic models, like regional Partial Equilibrium and Computable General Equilibrium models. CAPRI is applied to analyse the impact of agricultural policies and global change on the agricultural sector and linked sectors. The regional focus is Europe (CAPRI Network, 2022a, 2022b). The interdisciplinary model framework of the project CC-LandStraD (Climate Change - Land Use Strategies) links 10 economic and scientific models to analyse land-based mitigation measures under global scenarios and their impact on agriculture, forestry, settlement, water and soil. The model framework is developed for Germany (Baum et al., 2021).

The presented models are only a few selected examples of integrated or interdisciplinary models. Most of these models are used in policy support and research projects. Therefore, the list of scientific articles based on these models is long. Furthermore, some of these models have long development history and are developed and maintained in institutions (research centres) which are linked to policymakers. Therefore, most of these sophisticated assessment models are developed as consistent with economic indicators relevant to policymakers. A stakeholder-oriented development also allows for experts' based validation of the models and their results.

With the AGREE model, we aim at developing an integrated model covering the aspects of agricultural and interlinked sectors as simple and flexible as possible. The model should be: (i) flexible to apply to different study cases, (ii) flexible to vertical and horizontal linkages and extensions and (iii) simple to be described and understood

Section 2 presents as methodology the conceptual idea of the AGREE model. Section 3 presents and discusses as results the outcomes we expect from this model. Section 4 concludes on the potential and the caveats and sketches the way forward.

2 Methodology

2.1 Integrated AGREE model

Figure 1 represents a schematic overview of the AGREE model with the sectors of agriculture, resources, energy and environment. The centre of the AGREE model is an agricultural supply model representing the production of crops and animals and the generation of agricultural income. The agricultural supply model considers the linkage to natural resource stocks either by the demand for production factors (e.g., soil, water) or by external effects, like resource usage conflicts and pollution (e.g., forestry, fishery). While agricultural production uses energy, it has become relevant as an energy supplier. Agriculture produces feedstock for energetic usage either by growing raw material (e.g. energy crops) or by recycling (e.g., manure for biogas production). Furthermore, the agricultural sector also produces energy (e.g., biogas, wind-farms). The impacts of agricultural production on the environment are positive and negative. While the positive impacts are often overlooked (services for landscaping and retaining biodiversity), the negative externalities are gaining increasing attention by society and policy maker (e.g., emission of greenhouse gases and water pollution). Using the AGREE-model for simulating economic shocks and/or policy measures allows for creating information on agricultural production, income and the impact on resources, energy and the environment.

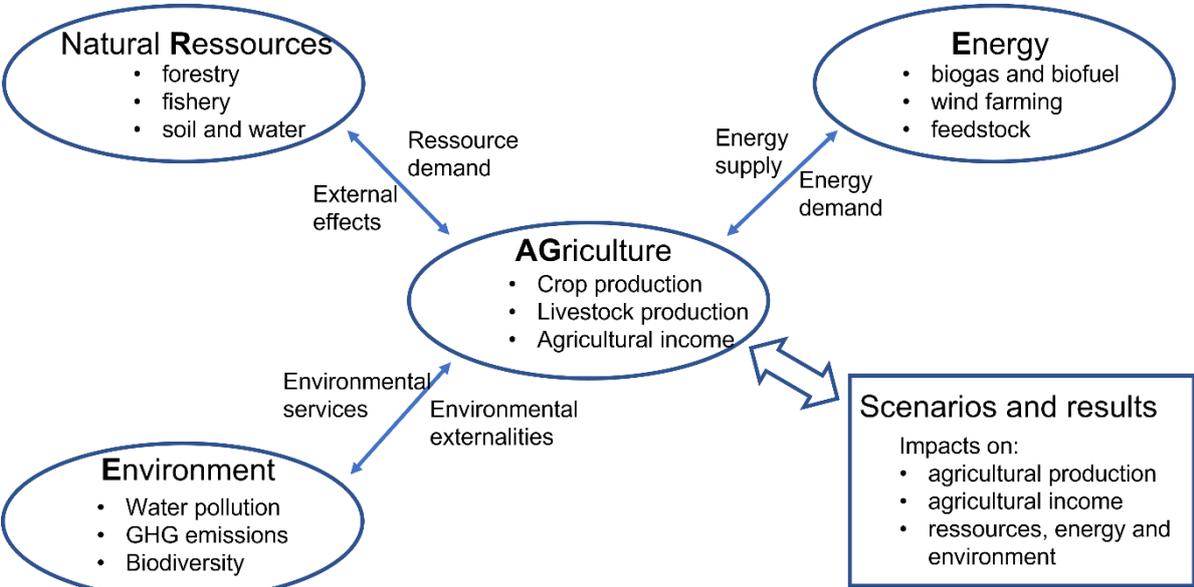


Figure 1 Schematic presentation of the AGREE model

2.2 The process-oriented programming model

The agricultural supply model as the centre of the AGREE-model will be based on the positive mathematical programming (PMP) approach according (Howitt, 1995) and (Röhm and Dabbert, 2003) and (Röhm, 2001). The model is a process analytical non-linear oriented to different elements of applied agricultural supply models PMP models and represents a

synthesis of elements of existing models. Table 1 presents the different models and referenced studies

Table 1 Overview of applied PMP models serving as orientation for the development of AGREE model

Model name	Project name	Reference
ACRE-Danube	GLOWA-Danube ^b	Winter (2005), Wirsig et al. (2007), Wirsig (2009)
ACRE-Neckar	RIVERTWIN ^c	Henseler et al. (2009)
ACRE-BadenWuerttemberg ACRE-SouthernGermany	Agro-economic policy analysis with the regional production model ACRE – A case study for Baden-Wuerttemberg	Henseler (2011)
RAUMIS model ^a	RAUMIS96, CC-LandstraD, SynaKlim ^a	Henrichsmeyer et al. (1996), Henseler and Dechow, (2014), Röder et al. (2015), Henseler et al. (2015)
Tarim-Model	Multiple Policy Instruments for Sustainable Water Management in Crop Production - A Modeling Study for the Chinese Aksu-Tarim Region	Feike and Henseler (2017)

(a) For the RAUMIS model only selected projects and references are presented. Numerous applications in research projects and as policy decision support tool have created a long list of academic articles and technical reports. (b) Project homepage: <http://www.glowa-danube.de/de/home/home.php> (c) <https://cordis.europa.eu/project/id/505401/reporting>.

2.3 Vertical and horizontal extension

While the integrated AGREE-model represents bases on an agricultural supply model horizontal and vertical extensions can be developed. Horizontal extensions complement the sector level of the AGREE-model by complementary economic, social science or scientific models (e.g., agricultural market models, forestry sector models). As vertical extension the economic sector level can be extended by macro- or microeconomic models. With vertical extensions the AGREE-model can function as top-down (or bottom-up) model chain, e.g., by linking the models in a soft way (Britz, 2008). Table 2 presents the AGREE model framework and the model extensions.

Table 2 The AGREE model with different levels and extensions

Economic level	Spatial/organisational level	AGREE-model type	Horizontal extension	Vertical extension
Macro-economic level	World region, national			CGE model
Sector-level	National, regional	AGREE-model	Complementary sector models	
Microeconomic-level	Individual			Microeconomic models

3 Results and discussion

3.1 Applied regional case studies for first shot assessments

By keeping the complexity of the AGREE model as low as possible and the database access, AGREE-model represents a "light" version of a larger complex and sophisticated integrated assessment model. AGREE-model can be used for the first and fast analysis of economic shocks and policy changes. With reduced complexity, the AGREE-model might reach a lower degree of in-depth analysis than the complex and sophisticated models. The established models are often expert-validated results and are recognised by stakeholders. For the AGREE-model we consider the limitation in the analysis of the model results:

- The AGREE-model provides primarily relative results (e.g., as shares, per cent change, or percentage points change). Therefore, results on absolute measures need to be considered carefully and as supplementary.
- The AGREE-model provides results in terms of ranges instead of defined levels.
- The AGREE-model results are accompanied by sensitivity analysis for relevant parameters.

Keeping the AGREE model simple and flexible requires permanent development. Therefore, we already know with starting the development, that the AGREE-model will never reach its final state. It will rather remain under development, in line with Lemelin and Savard (2022) statement “CGE (and other) models are useful to contribute insights to the policy debate on fiscal reform, while leaving some room for improvement — no model is perfect, no model is complete. It would be fair to say that every model should be considered as a work in progress” (Lemelin and Savard, 2022: 771).

3.2 Application in interdisciplinary context on nexus topics

If focusing on the economic level (e.g., the macro, sector, micro) or as a holistic approach, many research questions require interdisciplinary analysis. This applies particularly for research topics on sustainable growth and development. Many research institutions provide analytical data, which are easily accessible. The intuitions often use in-house assessment models for analysis at different economic scales. Of course, each analysis requires model specification, calibration and model linking. With each study, this process will need to be done new. Thus, the AGREE-model development will build upon previous existing models but will often start from scratch for each new research question in the new study region. This approach can be found for computable general equilibrium (CGE) modelling, where the CGE standard models are used as a template and are customised to particular study regions and research questions.

Table 3 Comparison between established integrated/interdisciplinary models and the AGREE-model

	Existing models	AGREE
Development history	long term	Short term
Database	high-quality data / raw data often not accessible	accessible base data
Stakeholder orientation	stakeholder oriented	no primary stakeholder orientation
Consistency framework	respected	not binding
Degree of complexity	high	low
Regional focus	fixed to defined study region	flexible
Extensions linkages	Fixed to developed modules	flexible
Stand-alone model	available and specified	requires often: new specification and calibration for new regions and research questions

4 Conclusion

In this paper, we present the idea and the concept of the AGREE-model. The AGREE-model aims at covering different aspects of the nexus between agriculture, resources, energy and the environment. It aims to be kept simple in its model design and flexible for horizontal and vertical extensions by sector and macro- and microeconomic models. It also aims at flexibility to the study regions. The simplicity and flexibility require particular presentation and analysis of the results to consider the uncertainties of results, creating a lower degree of sophistication.

The AGREE-model is still an idea described in this concept paper. Many models have been developed based on similar concepts with comparable objectives. Then the models were

developed and applied in research or policy support. Either the model development stopped (e.g., after finished research projects or PhD thesis), or the development continued, and the models became sophisticated applied simulation models. The value-added of the conceptual idea presented here can be only evaluated once an AGREE-model will have been developed and applied to a research question. Development on the AGREE-model's prototype started in summer 2022. The model will represent the nexus for the French Normandy region, as a model called "AGREE-Normandy".

This paper presents the AGREE model in its earliest stage of development which needs to be developed and operationalised. However, in its early stage of development, it is already clear that the AGREE-model will never be perfectly finalised and stay in a model version as a work in progress (Lemelin and Savard, 2022).

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