DART-BIO — Modelling the Bioeconomy in a Global Context

DART-BIO is the bioeconomy and land-use version of the Dynamic Applied Regional Trade (DART) model developed at the Kiel Institute for the World Economy. It is a multi-regional, recursive-dynamic computable general equilibrium (CGE) model designed to analyse how agricultural, energy, climate, and land-use policies ripple through the global economy — and how food, feed, and fuel markets interact along the way.

Key Features

🌎 **Global coverage with a bioeconomy focus**

DART-BIO resolves 38 sectors, 45 products, and 21 factors of production, with a regional aggregation that can be chosen flexibly to match the research question. A common configuration splits the world into 23 regions covering the major biofuel-producing and biofuel-consuming economies — including the United States, Brazil, Germany and France — as used, for example, in Delzeit et al. (2018) and Heimann et al. (2024). For other questions, the regional breakdown is reshaped: Argueyrolles, Heimann & Delzeit (2025), for instance, use a tailored aggregation that explicitly represents OPEC countries in order to study how fossil-fuel subsidy reforms in those economies interact with global biofuel mandates. This flexibility means the model can zoom in on the regions that matter most for any given policy question, while preserving global market closure.

🌱 **Explicit representation of the bioeconomy**

DART-BIO's defining feature is its detailed mapping of the vegetable oil industry and the biofuel sector (bioethanol and biodiesel), including by-products such as oilseed meals used as animal feed. This makes it possible to study the food–feed–fuel nexus in a single consistent framework rather than treating each market in isolation.

🗺️ **Sophisticated land-use modelling**

Land is treated as a heterogeneous, partially mobile production factor. A multi-level constant-elasticity-of-transformation (CET) structure governs how land shifts between crops, pasture, and managed forest in response to relative returns — calibrated to empirical land-supply elasticities and grounded in the GTAP land-use and land-cover database.

⚙️ **Recursive-dynamic CGE framework**

Built on microeconomic foundations, the model simulates the behaviour of producers and consumers under resource constraints and macroeconomic closure rules. It solves period-by-period for a general equilibrium across all product and factor markets,

enabling long-run projections of how economies adjust to policy shocks or external shifts.

📊 Calibrated to the GTAP database

DART-BIO is calibrated to the Global Trade Analysis Project (GTAP) database, which provides consistent global data on bilateral trade, production technologies, and sectoral output. This anchors the model in observed economic structure rather than stylised assumptions.

🔄 Modular and extensible

DART-BIO belongs to a wider family of DART model versions. Its sectoral and regional aggregation can be tailored to the research question at hand, and the model is regularly updated to new GTAP releases and methodological advances. It has also been coupled with biophysical models (e.g. the global crop-yield model PROMET) to integrate economic and ecological dynamics.

What DART-BIO Can Answer

The model has been applied to a broad range of real-world policy and research questions, including:

Biofuels and energy policy

- The interaction of gasoline and diesel subsidy reforms with global biofuel mandates, using a regional aggregation tailored to OPEC economies (Argueyrolles, Heimann & Delzeit, 2025).
- The economic and land-use consequences of phasing out palm and soy oil biodiesel in the EU, based on the standard 23-region configuration (Heimann et al., 2024).
- The potential and trade-offs of cellulosic ethanol in the European Union (Schuenemann & Delzeit, 2022).
- The land-use implications of biofuel policies combined with taxes on meat and dairy products (Delzeit, Winkler & Söder, 2018).

Land use, cropland and food systems

- The effects of profit-driven cropland expansion and conservation policies (Schneider et al., 2024).
- Global cropland-saving potentials under alternative land-use strategies (Schneider et al., 2022).

- The interaction of forest restoration and agricultural expansion (Delzeit, Pongratz, Schneider, Schuenemann, Mauser & Zabel, 2019).
- Global impacts of future cropland expansion and intensification on agricultural markets and biodiversity (Zabel, Delzeit, Schneider, Seppelt, Mauser & Václavík, 2019).
- Trade-offs between biodiversity and cropland expansion for food security (Delzeit, Zabel, Meyer & Václavík, 2017).

Climate policy and international cooperation

- Economic gains from global cooperation in fulfilling climate pledges (Thuebe, Delzeit & Henning, 2021).
- A global economic–biophysical assessment of mid-term scenarios for agricultural markets, covering biofuel policies, dietary patterns, cropland expansion and productivity growth (Delzeit, Klepper, Zabel & Mauser, 2018).

Emerging linkages

- Quantifying the connection between aquaculture and agricultural markets — "land for fish" (Heimann & Delzeit, 2024).

Selected Publications

- Argueyrolles, R., Heimann, T. & Delzeit, R. (2025). Impact of gasoline and diesel subsidy reforms on global biofuel mandates. *GCB Bioenergy*, 17(2), e70019.
- Schneider, J. M. et al. (2024). Effects of profit-driven cropland expansion and conservation policies. *Nature Sustainability*, 7(10), 1335–1347.
- Heimann, T. & Delzeit, R. (2024). Land for fish: Quantifying the connection between the aquaculture sector and agricultural markets. *Ecological Economics*, 217, 108090. Heimann, T. et al. (2024). Phasing out palm and soy oil biodiesel in the EU: What is the benefit? *GCB Bioenergy*, 16(1), e13115.
- Schneider, J. M. et al. (2022). Global cropland could be almost halved: Assessment of land-saving potentials under different strategies and implications for agricultural markets. *PLoS ONE*, 17(2), e0263063.
- Schuenemann, F. & Delzeit, R. (2022). Potentials, subsidies and trade-offs of cellulosic ethanol in the European Union. *Ecological Economics*, 195, 107384.
- Thuebe, S. D., Delzeit, R. & Henning, C. H. C. A. (2021). Economic gains from global cooperation in fulfilling climate pledges. *Energy Policy*, 160, 112673.
- Delzeit, R., Pongratz, J., Schneider, J. M., Schuenemann, F., Mauser, W. & Zabel, F. (2019). Forest restoration: Expanding agriculture. *Science*, 366(6463), 316–317.

- Zabel, F., Delzeit, R., Schneider, J. M., Seppelt, R., Mauser, W. & Václavík, T. (2019). Global impacts of future cropland expansion and intensification on agricultural markets and biodiversity. *Nature Communications*, 10, 2844.
- Delzeit, R., Klepper, G., Zabel, F. & Mauser, W. (2018). Global economic-biophysical assessment of midterm scenarios for agricultural markets - biofuel policies, dietary patterns, cropland expansion, and productivity growth. *Environmental Research Letters*, 13(2).
- Delzeit, R., Winkler, M. & Söder, M. (2018). Land-use change under biofuel policies and a tax on meat and dairy products: considering complexity in agricultural production chains matters. *Sustainability*, 10(2), 419.
- Delzeit, R., Zabel, F., Meyer, C. & Václavík, T. (2017). Addressing future trade-offs between biodiversity and cropland expansion to improve food security. *Regional Environmental Change*, 17, 1429–1441.