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AFD AND

Macroeconomic Modelling Tools for the Ecological Transition

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macroeconomic modelling tools: GEMMES and ESTEEM

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countries are developing GEMMES or ESTEEM models with AFD to document their long-term trajectories

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institutional and academic partners of the programs

AFD has been developing quantitative modelling tools for analyzing the macroeconomic aspects of the ecological transition. Modelling scenarios include financial and monetary risks associated with the impacts of global warming, ecological disturbances and transition policies. These tools help to make informed macroeconomic decisions taking into account pressing environmental issues and systemic imbalances.

#WorldInCommon

GEMMES and ESTEEM:
Two AFD macroeconomic modelling tools for the ecological transition

The AFD macroeconomic modelling research program aims to contribute to national and international public policy dialogue around the ecological transitions. Ecological transition refers to the evolution of socio-economic structure of specific countries when implementing policies aiming at reducing impacts of the economy on nature (greenhouse gas emissions, biodiversity destruction) or when facing damages due to climate change or biodiversity collapse. These transitions are likely to have pervasive effects, such as employment creation or destruction, change in income distribution, financial instability related to loss of production in certain sectors, improvement or worsening of trade balances, etc.

1 *Modelling tools based on the strong sustainability approach*

- **The non-substitutability rule:** AFD models consider that all objectives – ecological, social, economic and financial – must be addressed altogether and cannot be substituted with one another.
- **Multidimensionality:** each model uses multidimensional indicators, both economic and biophysical ones (water and land resources, greenhouse gas emissions...), in order to assess the consequences of specific transition dynamics.

2 *Tools to promote public policy dialogue*

- **Decision-making tools:** GEMMES and ESTEEM models provide a long-term perspective and allow the test of different scenarios and policies, making explicit tensions and synergies between the different political objectives (economic, social or ecological).

3 *A robust methodological basis*

- **Integrating economic imbalances into the models:** the projects consider transitions as structural changes causing macroeconomic disequilibrium (assets prematurely losing their value, decline of certain industries while others emerge, etc.), some of which particularly important for developing and emerging economies (trade balance and balance of payments deficits for example). The models were built taking into account these permanent or temporary imbalances, and their causes and consequences, with the objective of generating realistic macroeconomic scenarios for these economies.
- **Taking into account sectoral heterogeneity:** the way in which transition dynamics emerge depends on the economic structure of the country. Economies depending on fossil fuel exports or economies that already produce green products will not be impacted in the same way. The models thus account for structural heterogeneity among economic sectors, as they are different in terms of market structure, access to financial markets, hiring of employees, as well as their socio-ecological impacts. In addition, they have different technologies, use specific inputs and raw materials and have different impacts on climate, natural resources and biodiversity.

Our strengths

Macroeconomic modelling know-how

Cross-disciplinary research

Co-construction with academic and institutional partners

Fostering dialog between researchers and policy-makers

Contributing to debates on public policy

At AFD, research is positioned at the intersection between the academic world and the world of decision-makers. For example, GEMMES country models are part of AFD's activity through three strategic dialogue memoranda (in Côte d'Ivoire, Morocco and Tunisia) and through technical cooperation.

Our models

GEMMES

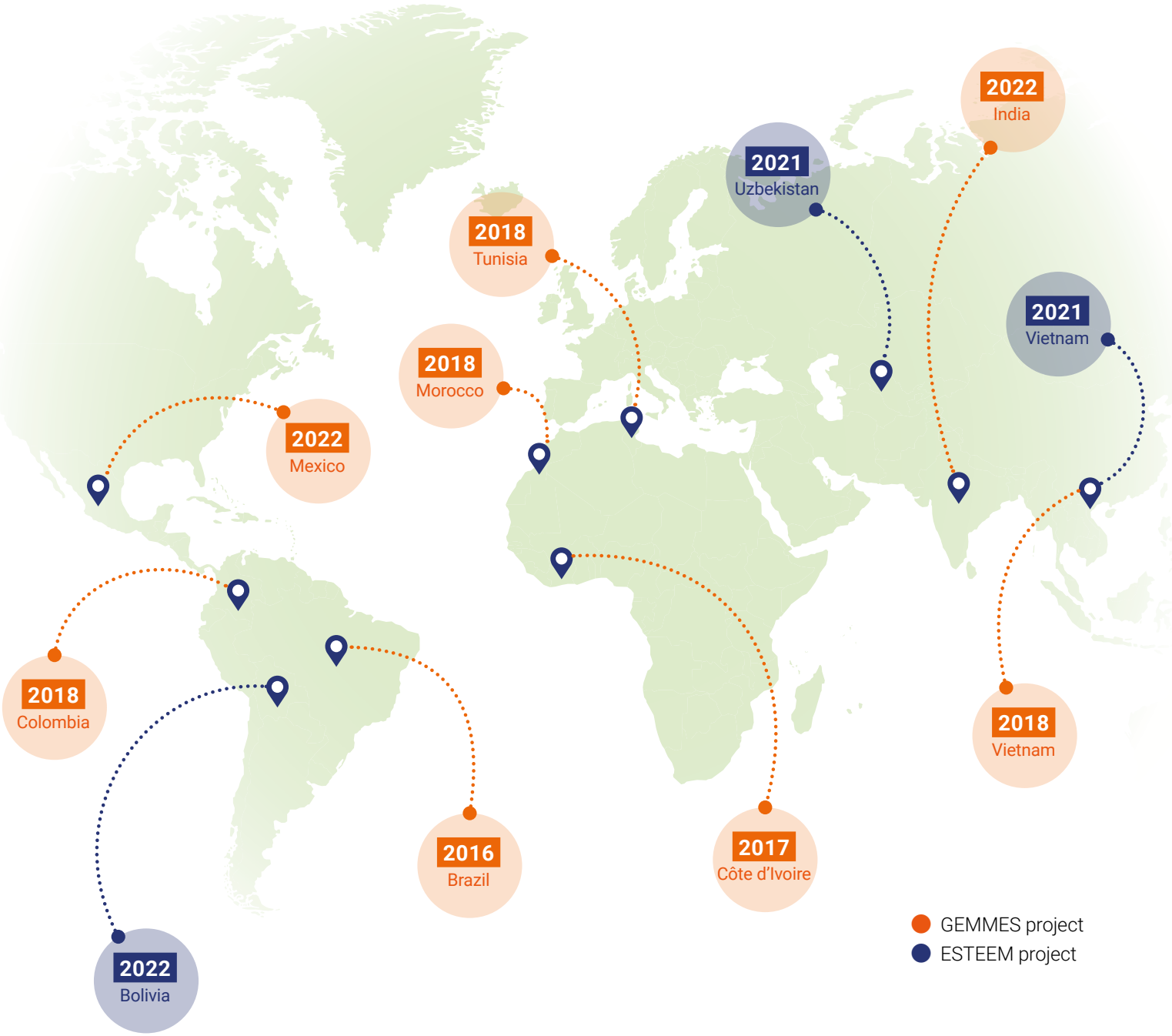
The GEMMES model (General Monetary and Multisectoral Macrodynamics for the Ecological Shift) is a dynamic macroeconomic tool for analyzing policy scenarios. Policy scenarios are quantitative representations of possible futures. As such, they require understanding the drivers of transition trajectories and explicitly represent them. Based on a stock-flow consistent approach, this model is highly comprehensive: it highlights the interactions between the financial sector and productive industries, which guarantees that all spheres of the economy are taken into account in the transition scenarios. They are tailor-made to represent specific institutional settings (for example central bank mandate, role of trade unions in negotiating wages, importance of the public sector, etc.).

ESTEEM

The ESTEEM model (Exposure to Structural Transition in an Economic-Ecological Model) is a tool that identifies the macroeconomic risks to which developing countries are exposed to in the context of an ecological transition. Based on hybrid input-output tables, which shows the productive and physical interrelations between industries and between countries, it assesses economies' dependence on sunset industries in three dimensions that may constraint the transition: external, fiscal and socio-economic.

Our projects

Each project aims at improving our understanding of the interactions between the economy and other spheres and sectors, such as agronomy, energy, climatology and biodiversity, and the consequences of various policy responses to these dynamics. Projects have a global or a country-level focus. Country projects provide AFD's partner countries with a decision-making tool to assess the socio-economic impacts of their environmental policy choices at the macroeconomic level.



GEMMES Côte d'Ivoire

Assessing the macroeconomic and socio-economic impacts of energy transition policies

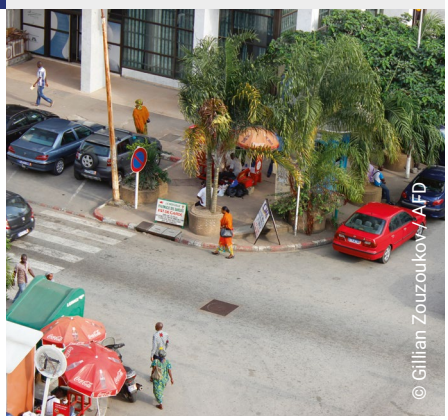
START YEAR:
2017

PARTNERS:
Ivorian Ministry of Energy and Planning, CI-Energies, Institut national polytechnique Félix Houphouët Boigny, Mines ParisTech, CIRES Unit for the Analysis of Economic Policy (CAPEC)

The GEMMES Côte d'Ivoire project aims at providing Ivorian policy-makers with insights to define an energy transition strategy for 2050, in line with the country's poverty reduction and climate objectives.

Most of Côte d'Ivoire's electricity comes from natural gas (70%) and hydroelectric dams (30%). However, the country's low-carbon scenario predicts that renewable energy – especially solar – should comprise 45% of the electricity mix by 2030.

To provide Ivorian policy-makers with decision-making tools, the modelling team developed three scenarios to quantify the macroeconomic impacts of the energy transition and their capacity to create conditions conducive to poverty reduction. This academic work has been complemented with a more policy-focused dialogue with public stakeholders.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KEY RESULTS

Developing renewable energy in Côte d'Ivoire could lead to

Reduction or limited increase of the average energy production cost

- In all scenarios, the development of **a solar-battery sector** (2 to 5 gigawatts of solar in 2050) helps reducing the average production cost and contributes to the energy sovereignty of the country.
- The impact of the **decarbonization of the electricity mix** by 2050 on the average production cost is between -20% and +5%, depending on the plausible evolution of the costs of coal and solar technologies.

Positive socio-economic impact on growth, employment, income and the balance of payments

- A significant development of **the solar-battery sector** generates positive socio-economic impacts: up to +0.5% growth per year, +27% of jobs in the electricity production sector and one month of additional monetary reserve imports. This creates an economic-financial environment that is more favorable to the deployment of specific policies to combat poverty.
- The development of 500 MW of installed **bioelectricity capacity** improves the income of 2 million people in rural areas for a small increase in the average cost of production (+1% in 2050).

LESSONS LEARNED

Bridging the gap between research and policy-making

The project has conducted the first GEMMES modelization exercise incorporated in the public policy dialogue between AFD and Ivorian public stakeholders. It has provided the Ivorian government with an energy-social-financial modelling nexus to highlight the opportunities and contradictions in the country's trajectory between energy choices, environmental agreements and macro-public financial consequences.

GEMMES Vietnam

Assessing the socio-economic impacts of climate change and adaptation strategies

START YEAR:
2018

PARTNERS:
Department for Climate Change of the Ministry of Natural Resources and Environment of Vietnam (MoNRE), French Research Institute for Sustainable Development (IRD)


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Funded by the Facility 2050, the GEMMES Vietnam project aims at understanding the socio-economic impacts of climate change as well as adaptation strategies, at the national level and in the Mekong delta region.

Vietnam is often presented as one of the most vulnerable countries to climate change. The GEMMES Vietnam project brought together more than 80 Vietnamese, French and international researchers and experts to produce a special assessment report on the socio-economic impacts of climate change and adaptation strategies. After the release of the first GEMMES Vietnam report at COP26 in 2021, two new reports were published for COP27 in November 2022.

KEY RESULTS

The "Climate change in Vietnam: Impacts and adaptation" 2022 report develops a new set of climate scenarios using the latest models from the 2022 IPCC report. It also looks at the industrial and technological opportunities for Vietnam in a "green race" scenario to net zero emissions. Finally, it provides a dynamic assessment of climate impacts and adaptation strategies at the macroeconomic level.

The report "The Mekong Delta Emergency" investigates the consistency between current adaptation plans and scientific knowledge on environmental changes; proposes different possible adaptation options to tackle the corresponding pressures; investigates how intermediary levels of governance could help drive the biophysical dynamics of the Mekong Delta in a sustainable direction.

Download the reports on www.afd.fr

8.1% GDP loss

For a **1.5°C** increase in temperature compared to pre-industrial times and with no adaptation, the report warns Vietnam could lose **up to 8.1%** of its GDP by 2050

LESSONS LEARNED

Interdisciplinary work providing sectoral and regional insights

The GEMMES Vietnam project couples a wide range of climate scenarios with data on specific sectoral and regional damages – with a strong focus on the Mekong Delta. This led to the elaboration of adaptive pathways and recommendations in a collaborative prospective approach.

Watch online: "The future for the Mekong Delta, with Marie-Noëlle Woillez"

GEMMES Colombia

Understanding macroeconomic vulnerabilities and opportunities related to low carbon transition

START YEAR:
2018

PARTNERS:
Colombian National Department of Planning (DNP), Colombian Ministry of Finance (MHCP), National University of Bogota (UNAL)

The GEMMES Colombia project aims at understanding the macroeconomic consequences of the investments needed to implement Colombia's Nationally Determined Contribution (NDC), with a focus on fiscal and financial aspects.

The project studies the vulnerabilities and opportunities related to Colombia's low carbon transition, while taking into account global economic dynamics – given the country's strong dependency on commodity exports and its relatively important integration in international financial markets. In this context, the UNAL has produced a framework that identifies these vulnerabilities for three specific aspects: monetary, fiscal and trade balance impacts.


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KEY RESULTS

The GEMMES model allows the DNP to evaluate scenarios that could not be modelled before. It complements the existing models in order to incorporate in an accurate way the various policies that need to be implemented around the energy transition.

Two concrete applications of the GEMMES model

Analysis of typical shocks and their consequences
The DNP used the model to analyse short-medium run consequences of typical shocks: the loss of Colombia's investment grade, reduction in coal exports and hence drop in the connected royalties, failure of Evergrande in China.

Policy analysis on financing Colombia's climate plans
Those policy analysis documents highlight the importance of relying on a combination of private investment and public green bonds to finance Colombia's NDC.

> **"The project provided us with a tool we did not have before"**
>
> Gabriel Piraquive, Chief Economist of the Colombian National Department of Planning

LESSONS LEARNED

A fruitful collaboration between public institutions and the academic world

The partnership between governmental and academic institutions has allowed the projects to produce robust and relevant outcomes. On the one hand, the partnership with the University of Bogota guarantees the quality of the scientific analysis, while on the other hand the partnership with DNP ensures the policy relevance.

A report summarizing the results of the project will be published in 2023. An academic course at UNAL on sustainable development, partially based on the project results, was organized in 2022 to increase global awareness of the topic.

GEMMES Morocco

Analyzing the impacts of different climate scenarios on Moroccan agriculture

START YEAR:
2018

PARTNERS:
Directorate of Financial Studies and Forecasts (DEPF) of the Moroccan Ministry of Economics and Finance, Directorate of National Meteorology of Morocco (DMN), Water Research and Planning Directorate (DRPE), Mediterranean Institute of Biodiversity and Ecology (IMBE)

Funded by the Facility 2050 and co-constructed with Moroccan public stakeholders, the GEMMES Morocco project aims at informing public decision-making and action in the formulation, support and evaluation of public policies related to adaptation to climate change in the agricultural sector.

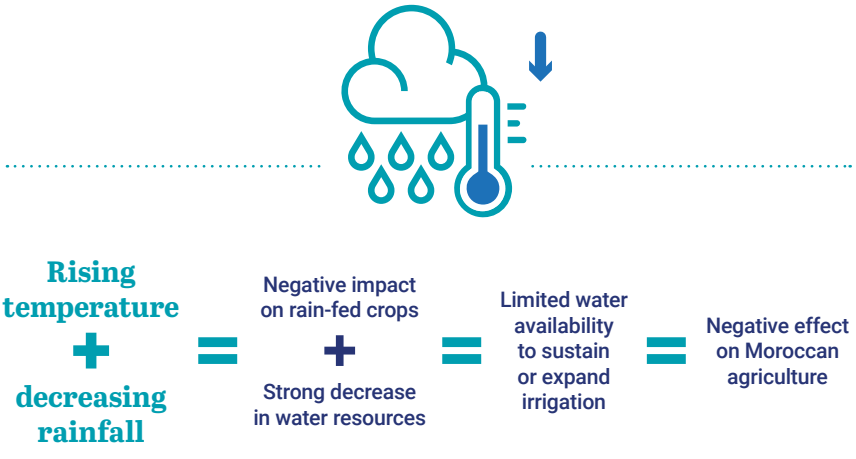
The project analyzes the impacts of possible climate scenarios on the Moroccan economy, particularly under the pressure of water stress. The goal is to carry out simulations of agricultural production and necessary surface water resources by 2050 and compare these figures with the resources that will actually be available.

To do so, the project team coupled two models after calibrating them for Morocco: the GEMMES macroeconomic model and the Lund-Potsdam-Jena managed Land (LPJmL) model. LPJmL is a gridded hydro-agricultural model, using climate projections as inputs to simulate surface hydrology and crop yields for 10 of the most important crops in Morocco.


© Toa Heftiba

KEY RESULTS

The results highlight the negative impacts of climate change on the Moroccan agriculture by 2050, particularly if irrigation is constrained. For the worst-case scenario of IPCC, in 2050, an irrigation level corresponding to 75% of what a plant needs to grow optimally would lead to an agricultural production 3.7% higher than if only 50% of the irrigation needs were covered. GDP and household consumption would then be 0.5% higher. Hence, the State's efforts in water infrastructure investments and in an effective integrated water resources management framework could be decisive in mitigating these negative effects.



LESSONS LEARNED

The need for a common language

The GEMMES Morocco project highlights the importance of constructing a common language between economists, agronomists, climatologists and hydrologists. Culture ("dry year", "investment impacts", etc.) have different meanings depending on the domain of expertise. The coupling of the two models made explicit these different perceptions and led to more relevant policy discussion. The ensuing policy dialogue helped develop a prospective vision of the consequence of climate change in Morocco.

GEMMES Tunisia

Investigating the impact of hydric stress on agriculture and water cycle and the economy

START YEAR:
2018

PARTNERS:
Tunisian Institute of Competitiveness and Quantitative Studies (ITCEQ), Ministry of Agriculture of Tunisia

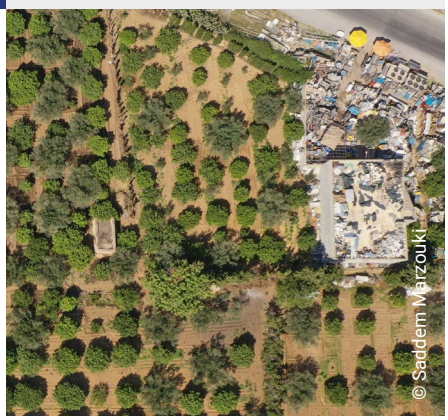
The GEMMES Tunisia project examines the impact of climate change on Tunisian agriculture in particular, and the macroeconomic impact of these changes in general, as well as the benefits of various adaptation policies to offset these impacts.

A close collaboration with the Ministry of Agriculture has also been in place for the projection of agricultural yields until 2050, as well as for the planned adaptation policies, their costs and their possible benefits for agricultural production.

KEY RESULTS

With a large structural current account deficit hovering around 10% of GDP and relatively limited resources to finance it, the significant fall in agricultural production due to climate change puts additional economic pressure on Tunisia, causing a sizeable increase in the financing needs of the country. In the business-as-usual scenario without appropriate adaptation policies, this will lead to a significant increase in public and/or private foreign debt, as well as threatening the food security of Tunisia. Depending on the chosen policies to finance the additional deficit, the domestic currency could lose its value, causing a large drop in the global purchasing power of the Tunisian population.

The project also tests several adaptation policies such as mechanization of agricultural production, improvements in agricultural practices and investment in water resources in order to mitigate/offset the drop in agricultural yields. Our results show that the benefits of these adaptation policies may outweigh their costs significantly, both ensuring food security and mitigating the negative socio-economic impacts of climate change such as rising rural unemployment, rapid urbanization and falling per capita incomes.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LESSONS LEARNED

Quantifying the impacts of climate change in a context of limited data availability

AFD's partnership with local research institutes and government bodies has enabled to better understand the challenges of quantifying the impact of climate change on agriculture in the long-term. Further, the project has demonstrated the difficulties of constructing country models with limited macroeconomic data availability. This encouraged the team to construct possible solutions in such cases such as testing a wide range of scenarios, bringing together different data sources and establishing across-the-board partnerships to better reflect the characteristics of Tunisia.

ESTEEM

Analyzing the vulnerabilities to ecological transitions


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The ecological transition is a complex and unique type of structural change, where green industries (sunrise industries, such as renewable energies) grow and high-emission and non-ecological industries (sunset industries, such as coal) decline.

This process affects countries' productive, commercial and financial structures, which, as a result, generates transition risks. The ESTEEM model identifies those risks and provides relevant information to address them, in order to define the best trajectory for each country.

There are three types of transition risks defined in ESTEEM:

› **External:** if a country depends on sunset industries as a source of foreign currency, the transition will affect its balance-of-payments and the country's capacity to import goods and services

› **Fiscal:** if a country depends on sunset industries as a source of fiscal revenue, the transition will reduce its budgetary resources and the funding available for public policies

› **Socio-economic:** if a country depends on sunset industries as a source of employment, the transition will lead to the destruction of jobs and higher unemployment

Since sunset industries' dependence may constrain the transition, developing countries need to:

› **Raise foreign currency** and avoid balance-of-payment constraints, especially because the transition demands imported machinery and inputs

› **Avoid fiscal imbalances,** especially because the transition demands relevant public investment in green infrastructure and social expenditure

› **Guarantee employment and wages:** even though the impact is generally positive, it is not homogenous across countries and industries, which requires targeted measures in affected sectors (social protection, continuous training…)

ESTEEM is a tool to better understand each country's transition trajectory, by:

› **Evaluating the transition risks** that an economy might face, bringing the main constraints that may emerge, and how they may be addressed to guarantee an adequate transition path

› **Taking into account the ecological and environmental specificities** of countries, since they are impacted differently according to their financial and productive structure of production and their trade relations with other economies

Download our research paper on www.afd.fr


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GEMMES and ESTEEM: Developing countries' perspectives and their particularities

GEMMES and ESTEEM are complementary analytical approaches to understand the dynamics of the ecological transition in a multidimensional framework. While GEMMES brings this discussion from a macroeconomic perspective, addressing the financial constraints that may emerge and its impacts on economic activities, ESTEEM is a multisector approach that allows us to understand how these activities interact domestically and internationally, and what the consequences are on the socioeconomic level, as well as for the macroeconomic stability of the economies.

Both approaches are built with the aim of analyzing the transition dynamics from different perspectives and comprehending the interactions between different sectoral objectives. They are by definition multidimensional in nature. These modelling tools therefore hold the potential to nourish strong sustainability analyses, and progressively pave the way towards truly sustainable development trajectories where objectives and interactions between the social, macro-financial and ecological spheres are taken into account. In this sense, they can help build a more coherent dialogue between Sustainable Development Goals (SDGs) and, ultimately, preventing decision-making in thematic silos and boosting partnerships between actors.

Since their objective is to account for the countries' specificities and their different institutional, political and economic structures, these two approaches are constantly evolving. Despite their well-structured frameworks, they are flexible as they can address different objectives and enlightened decision-making from a scientific base. They are intended to be adopted by development trajectories stakeholders. Depending on their targets and available data, decision-makers may wish to use GEMMES or ESTEEM as the more appropriate analytical framework. While the former is more suitable for examining monetary policies and financial constraints that may emerge, which are more useful for Central Banks, the latter would suit a more varied audience, involving different players, such as energy and environmental agencies and ministries.

Agence Française de Développement (AFD) implements France's policy on international development and solidarity. Through its financing of NGOs and the public sector, as well as its research and publications, AFD supports and accelerates transitions towards a fairer, more resilient world. It also provides training in sustainable development (at AFD Campus) and other awareness-raising activities in France.

With our partners, we are building shared solutions with and for the people of the Global South. Our teams are at work on more than 4,000 projects in the field, in the French Overseas Departments and Territories, in 115 countries and in regions in crisis. We strive to protect global public goods – promoting a stable climate, biodiversity and peace, as well as gender equality, education and healthcare. In this way, we contribute to the commitment of France and the French people to achieve the Sustainable Development Goals (SDGs). Towards a world in common.

December 2022

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