QDD.

A Question of Development

Synthesis of AFD studies and research

JULY 2025
No. 93

How can research inform public policies in Viet Nam in the face of climate change and energy transition?

Viet Nam is aiming for Net-Zero greenhouse gas emissions by 2050, while sustaining economic growth. Achieving these targets is even more challenging due to global warming, especially increased climate extreme events. This work presents how the research program GEMMES Viet Nam creates synergies to inform public policies through climate modeling, macroeconomic simulations and social analyses.

In 2025, countries engaged in the Paris Agreement, aiming to limit *temperature increase to well below 2°C above pre-industrial levels*. However, current policies and global greenhouse gas (GHG) emissions trajectories are still largely insufficient to meet this target. Without changes, the 2°C threshold could be reached by mid-century, and exceeded in the second half of the century (UNEP, 2024). Although gradual, an energy transition is ongoing globally to curb emissions and realign current trajectories. A consequence of ongoing climate change is the increase of the frequency and/or intensity of extreme weather and climate events (or "climate extremes"), such as heat waves, droughts and heavy rainfall. Even at a global warming level (GWL) of 1.5°C, popu- lations and ecosystems will face unprecedented climate extremes, and Viet Nam, who has been historically exposed, is no exception. Increasing climate hazards intertwine with changing socio-economic vulnerability stemming from rapid urbanization, demographic changes, and from risks associated to rising pollution, infrastructure strain and environmental stress. At the same time, Viet Nam is also at a turning point in its development trajectory, aiming for Net-Zero GHG emissions by 2050, and to achieve high-income status by 2050. These two objectives demand profound structural transformations—across the energy sector, the labor market, public finances, and infrastructure. To support decision-making amid transitions and climate hazards, interdisciplinary research is key to decipher

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Authors

Gaëlle Le Treut
Cecilia Poggi
Marie-Noëlle Woillez

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pathways under pressure. The research program GEMMES Viet Nam [1] (hereafter GEMMES-VN) supports this effort, through climate modeling, macroeconomic simulations and social analyses. It aims to provide some quantified answers to guide consistent long-term strategies.

1. Viet Nam in the face of climate extremes

A highly exposed country

With over 60% of the workforce employed in weather-dependent sectors such as agriculture, construction, and manufacturing, Viet Nam's economy is highly vulnerable to climate change. Droughts are ranked as the third most costly natural hazard, frequently causing substantial economic losses. For instance, during the strong El Niño events of 1997–1998 and 2015-2016, drought damages exceeded $500 million and $670 million respectively, and millions of people grappled with water scarcity (Nguyen-Xuan *et al.*, 2025). Viet Nam also regularly faces large flood events driven by heavy rainfall, some of it related to typhoons. Extreme heat can also lead to various damages on human health, infrastructures and ecosystems.

What does the future holds?

With the prospect of more frequent and intense climate extremes at higher GWL, it is of paramount importance to provide detailed climate projections, in order to identify Vietnam's areas that will be most exposed and support the building of relevant adaptation strategies. GEMMES-VN tackles heat hazards, droughts and heavy rainfall at the country scale, using climate projections from global climate models dynamically or statistically downscaled.

Large increase in extreme heat conditions

Results for different extreme heat indices (i.e. measures of how hot it feels) unequivocally show large increases in future decades. At 2°C GWL the annual number of hot days (maximum daily temperature above 35°C) could increase by 22 days/year on average at the national scale, for a total of ~34 days/year, with higher values in the South regions. At 3°C GWL, this number could reach 56 days/year nationally and 80 days/year in the Mekong Delta. In a worst-case scenario of 4°C GWL, this region could even face continuously hot conditions for about 7 months per year (Tran-Anh *et al.*, 2025). However, air temperature is not the only variable to take into account to assess heat stress: air humidity, wind and radiations are also crucial. Considering all these factors, the number of days with peak heat implying 75% rest per hour to safely perform medium work would increase in all regions. Again, the largest increases are projected in the Southern region, where the rise could be 60-90 days/year (resp. 120 days/year) at 2°C GWL (resp. 3°C GWL) (Nguyen-Le *et al.*, 2025). Such long periods of extreme heat could have broad social and economic impacts, in particular through reduced agricultural productivity, increased healthcare costs, and decreased labor productivity. Heat hazards will be further enhanced in urban area, where the temperature can be up to several Celsius degrees higher than in surrounding rural areas due to the urban heat island effect. The combined effects of climate change and urbanization on the local climate at the city scale is also under investigations within GEMMES-VN.

Uncertainties in heavy rainfall and droughts: a challenge for adaptation

By contrast, the evolution of water-related climate extremes are more difficult to assess. Results suggest an increase in heavy rainfall in all Vietnamese regions (Tran-Anh *et al.*, 2025), which could increase flooding risks and could challenge the flood regulation capacity of major dams in some river basins. On the other hand, droughts could shift towards fewer events on average, but with more very severe events, especially in the Northeast and Central Highlands regions. However, for several precipitation-related extremes, there is a large spread in the projections from different climate models, which is a significant challenge for adaptation policy. The findings highlight that policymakers cannot rely on a single climate scenario. They have to make decisions under a certain level of uncertainty and develop targeted and flexible adaptation strategies, aligned with the level of risk that society is willing to cope with and able to prepare for. In this context, to prioritize robustness over optimization might be a relevant strategy. Some trade-offs in the management of climate extremes could emerge, for instance in regions facing both more severe drought events and heavier rainfall increasing the risk of flooding.

2. Social and economic pathways under pressure

Climate change is increasingly disrupting Viet Nam's economy

Climate-related economic losses are estimated at $10 billion for 2020, or 3.2 percent of its GDP (World Bank, 2022). These figures may be underestimated, as climate-related damage and cascading effects are difficult to quantify, even when considering climate extremes. Furthermore, the literature warns clearly that, globally as in Viet Nam, the poorest and more marginalized populations are the most affected in their livelihoods and capabilities by climate change and the energy transition, with the latter posing risks and enabling pathways for social justice beyond compensation. Policy changes are needed to prevent and remedy negative socio-economic impacts.

While floods and droughts are clearly identified as natural disasters, extreme heat can also have negative impacts, especially on health. These include physiological and psychological changes, like damage to organs' function, heat strokes, chronic diseases, and reduced work capacity. Beyond damages at the individual level, extreme heat may have broader effects, affecting economic productivity, energy demand and production. For instance, the increased electricity demand for air-conditioning during the severe heatwave in Hanoi in May 2023 led to power cuts. High temperatures also accelerate pollutants' formation and can alter the effects of airpollution on health. GEMMES-VN explores how extreme weather and pollution events interact, and affect labor

[1] https://www.afd.fr/en/gemmes-vietnam-analysis-socio-economic-impacts-climate-change-energy-transition-and-adaptation-strategies

productivity at the district-level, identifying some policy responses to support workers. Heat-related risks are overlooked in medium and long-term adaptation strategies. The first results of GEMMES-VN highlight the need to better include them and develop heat adaptation plans.

Challenges of the energy transition

There will also be impacts from the energy transition itself. In Viet Nam, significant changes in land use and private energy consumption are required, alongside policy adjustments to address emerging socioeconomic constraints. Decisions involve energy production localization, the availability of low-emission technologies and affordable energy policies (Luu and Pham, 2025), and the impacts of policy instruments in other areas of policymaking. For example, GEMMES-VN explores how current environmental policies overlap with energy policies, and how they could support changes in households' energy behavior, through measures like "Payment for Forest Ecosystem Services" (Nguyen *et al.*, 2025), or *via* the perception of households on renewables availability and their use of ecosystem services, defined as the benefits people obtain from nature, such as water, timber, climate regulation or erosion control.

Assessing climate hazards and energy transition's needs are key to support the ongoing revisions of Vietnam's occupational safety and health (OSH) and industrial regulations. Revisions could also benefit from research on Vietnamese firms' readiness to meet changes, particularly small and medium-sized ones (SMEs). GEMMES-VN investigates how key industries, such as the Information and Communication Technology (ICT) manufacturing sector is preparing for these changes. The initial results identify the characteristics of ICT SMEs and some common OSH challenges they face. Forthcoming research assesses their barriers to renewables' adoption and employment management, critical to thrive in the transition.

Furthermore, policy intervention in vocational training and labor market strategies is essential to accompany the energy transition. The shift away from fossil fuels is changing labor demand, but workforce skills often do not match emerging industries' needs. To bridge this gap, research like the case study proposed for Ninh Thuan province in GEMMES-VN provides knowledge on renewables' production employment and skills' needs, and on training programs equipping workers with the competences needed.

On top of the importance of accounting for social aspects, the achievement of Viet Nam's energy transition depends on its macroeconomic foundations and perspectives. In other words, ambitions must align with the economic viability of the transition, and investment capacity with a coherent policy orientation.

3. Balancing energy roadmaps and macroeconomic challenges

Aligning policy ambitions, economic constraints and upcoming shifts

Achieving Net-Zero emissions by 2050 means fast transformation of the energy system. Beyond technical considerations, there is a need to analyze the long-term implications of such a shift, especially in a context marked by global volatility and domestic fiscal constraints.

External uncertainties—such as fluctuations in world energy prices, interest rate hikes, and exchange rate pressures—can delay green investment, increase technology costs, and heighten external debt risks. Public debt remains moderate in Vietnam, around 35% of GDP in 2023, providing some fiscal room to support the transition. Still, the substantial investment required to phase out coal by 2050, the expansion of new renewable capacity, and the development of energy storage solutions, alongside with grid upgrading cannot be met by public finance. Improving revenue mobilization and public spending are important steps, but mobilizing private capital and international climate finance will also be essential. At the same time, to avoid long-term carbon lock-in, energy planning must account for structural shifts of demand, driven by industrial expansion, electrification, and climate change adaptation through an increase of appliances. In this context, research on climate extremes and on the socio-economic impacts of the energy transition is key to validate and complement findings from macroeconomic energy scenarios, whether by assessing the vulnerability of renewable production to climate hazards, anticipating the heat-related rise in energy demand for cooling, or investigating the consequences of reduced workers' productivity driven by extreme heat exposure.

Bridging energy planning and economic strategies in modeling framework

Aligning long-term energy strategies with short- and medium-term economic challenges must be grounded in quantified, data-driven scenarios that translate political commitments into consistent roadmaps. Modelling tools can support decision-makers in their assessment of the technical, economic, and financial implications of different policy choices. Energy models like LEAP are well-suited to assess the technical feasibility of decarbonization pathways; however, on their own, they do not capture macroeconomic and financial feedbacks. The GEMMES macroeconomic model, applied to Vietnam's economy, aims to bridge these gaps (see Box).Coupled with LEAP, it provides an integrated platform to assess how different energy transition strategies affect macro financial flows. It sheds light on how economic, financial, and industrial policies should be coordinated to maintain macroeconomic stability.

GEMMES is a country-scale Stock-Flow Consistent model designed to capture endogenous macroeconomic financial dynamics within a disequilibrium framework. It accounts for imbalances that result from different economic dynamics, such as investment decisions, trade and fiscal balance adjustments, and exchange rate fluctuations. As a country-specific model, it supports policymakers in developing sustainable strategies, as well as discussing the different financing mechanisms that may support these strategies, considering their short- and long-term social, environmental, and economic impacts.

To support strategic planning, several transition scenarios are being developed using the LEAP model—varying in terms of the levels of investment, the timing and scale of renewable energy deployment, and the pace of coal phase-out. These include a reference scenario aligned with current policy trends, a scenario consistent with Vietnam's updated Nationally Determine Contribution commitments, and a Net-Zero pathway. Specific LEAP outcomes for each scenario, such as investment requirements, are fed into the GEMMES model to assess how each pathway affects economic growth, financial dynamics, employment, inflation, and the external balance. Key outputs from the GEMMES model, such as growth and productions levels are then fed back into LEAP to update energy trajectories. This iterative procedure is operated until the two models converge. This approach enables a better understanding of both the feasibility and the economic trade-offs of different strategies.

Informing systemic transition strategies

While quantitative results are forthcoming, the LEAP-GEMMES modelling framework already helps clarifying key strategic questions for the energy transition. It highlights, for example, how early investment in clean energy infrastructure may avoid lock-in, reduce long-term costs and mitigate macroeconomic risks. It also enables exploration of the economic consequences of different transition speeds. In addition, the framework sheds light on how various financing strategies (domestic tax reform, green bonds, etc.) shape macroeconomic stability and external vulnerability. It also offers an opportunity to explore how the resilience of a given strategy depends on the finance sources: public, private, or international climate finance. Hence, the approach contributes to building consistent strategies for a resilient transition.

4. Beyond research: science and policy dialogue

Robust analyses and scenarios are essential, but research and modeling gain impact when they foster collaboration between stakeholders, and translate knowledge for institutional processes and decision-making. Thus, GEMMES-VN is a scientific initiative designed to strengthen the science-policy dialogue on the adaptation to climate change and the energy transition.

First, the research goals, key outputs and communication materials are co-developed by AFD, researchers and the ministerial counterpart, to serve national dialogue. This three-way collaboration lives throughout the project thanks to dedicated human resources.

Second, the project offers a multi-disciplinary perspective, with diverse methodological approaches and scales, from climate modeling to macroeconomic simulations and social analyses. The establishment of a large and mostly Vietnamese network of researchers, through regular plenary sessions, enhances research quality and fosters interdisciplinary dialogue.

Finally, GEMMES-VN outputs are crafted to be operational. Further to academic publications, the project's deliverables include policy documents for policymakers and outreach documents targeting a wide audience. This science-policy dialogue is the final piece of the complex puzzle of synergies essential to navigating Vietnam's ongoing ecological transitions and adaptation to climate change.

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Agence française de développement (AFD)
5, rue Roland Barthes | 75012 Paris | France
Publishing director Rémy Rioux
Editor-in-chief Thomas Mélonio
Graphic design MeMo, Juliegilles, D. Cazeils
Layout Ferrari
Translation Cadenza Academic

Legal deposit 3th quarter 2025 | **ISSN** 2428-8926
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Printed by the AFD reprographics department

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