Understanding the Contribution of Modelling Tools to Sustainable Development

MODULE:
CLEWS GLOBAL MODEL: A READER

Assessing Climate, Land, Energy and Water Strategies

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PRESENTATION

LEARNING OBJECTIVES

- Identify and quantify the interlinkages among climate, land, energy and water at the global scale.
- Describe sustainability trade-offs and synergies of alternative global development scenarios.
- Demonstrate how integrated assessment models arrive at results.
- Provide national sustainable development policy decision-making with contextual global evidence on sustainability.
- Understand the contributions of the integrated assessment of sustainable development at the global scale and its limitations for national policymaking.
- Identify the potential contribution of a suite of modelling tools to inform policy decisions that both retain sector pertinence and make links across sectors.

OUTLINE

1. Modelling tools, the 2030 Agenda and the global CLEWS model
2. Modelling tools and the 2030 Agenda
3. Global models and national policies
4. The global CLEWS model
5. Concluding remarks

THE GLOBAL CLEWS MODEL: QUESTIONS TO ACTIVATE RELATED KNOWLEDGE

- What emissions trends are associated with current policy and ongoing economic activity trends?
- Is it feasible to control emissions in a way that climate change can be averted?
- How important are carbon taxes and carbon markets in climate change policies?

1. MODELLING TOOLS, THE 2030 AGENDA AND THE GLOBAL CLEWS MODEL

Global integrated assessment models have been at the core of the scientific work informing discussion on sustainable development and climate change. The Intergovernmental Panel on Climate Change (IPCC) systematically collects and assesses the results of climate integrated assessments to inform discussions and decisions about key sustainable development policies and the estimated impact of human activity on carbon emissions and other primary sustainability variables. It is always instructive to visit the IPCC website and look at the reports of the discussions of working groups, and the various technical and non-technical summaries. Reviewing the efforts of diverse institutions around the world that have disseminated the findings of integrated assessment modelling tools can further enlarge understanding of the complexities of sustainable development and climate change. Examples include the climate change calculator, footprint simulations and even games that address this complex issue.

A partnership between the United Nations Department of Economic and Social Affairs and KTH has made its own contribution to efforts aiming to increase understanding of these complexities. On the eve of the Rio+20 conference, the two organizations built the global Climate, Land, Energy and Water Systems (CLEWS) model. The model produces estimates of the evolution of emissions and other relevant sustainability variables between 2012 and 2050 for alternative policy scenarios within the range of estimates of models considered by the IPCC. The global CLEWS model makes two important contributions. It provides contextual information to intergovernmental processes. And since it has the same architecture as country CLEWS models used in United Nations capacity development projects, it can be easier to understand.

This reader reproduces two sections of the reader of the 2030 Agenda module. It does so to provide a reference for hands-on exercises using the global CLEWS model.

2. MODELLING TOOLS AND THE 2030 AGENDA

Long before the advent of the 2030 Agenda, researchers developed analytical tools and mathematical models for the study of sustainable development and its underlying interlinkages. One strand of models, climate change models, linked changes in global temperatures and climate global patterns with human generated CO_2-equivalent emissions. These models provided the important insight that the world needs to control emissions to avoid potentially catastrophic consequences.[1]

Models are a formal framework to represent ideas. Among other purposes, they can be built to:

1. **Understand**
2. **Quantify**
3. **Visualize**
4. **Predict**
5. **Simulate different aspects of the world**

A second strand of research produced integrated models to simultaneously look at the various dimensions of development. They are known as integrated assessment models (IAMs) and include the word "assessment" to emphasize their important objective of assessing policy options. These tools evolved from energy systems models, an important class of models developed in the 1970s to design the reconfiguration of national energy systems after oil price increases. IAMs bring together climate change models and energy-economy systems models using emissions and feedback loops as the transmission belt between the two modelling frameworks. IAMs have been instrumental in informing policy and decision-making on global sustainable development issues, including options for combating climate change.

A third strand of models, economy-wide models, has also been extensively used to calculate the cost of actions to avert an increase in emissions. Commonly known as computable general equilibrium (CGE) or applied general equilibrium models, economy-wide models were developed to assess the direct and indirect effects of specific policies and external shocks.

[1] G. N. Plass (1956). "The Carbon Dioxide Theory of Climatic Change." *Tellus* 8(2): 140–154. DOI:10.1111/j.2153.

These models have been extensively applied at the national, regional and global levels. They can also be used at subnational and even at village levels.

Based on input-output tables – which record purchases and sales of commodities and services among economic sectors – these models also incorporate the behaviour of consumers, producers, investors, governments and other economic agents. Agents in these models react to changes in prices allowing the identification of the impacts of a given policy or external shock throughout the economy. Economy-wide models have been used to analyse tax, trade and environmental policies. In these cases, the models are often applied in a bi-directional way, i.e., in analysing the impacts of economic activity on the environment as well as the impacts of environmental changes on the economy.

Some reasons to apply a model:

1. **Explain**
2. **Guide data collection**
3. **Illuminate core dynamics**
4. **Suggest dynamic analogies**
5. **Discover new questions**
6. **Promote scientific inquiry**
7. **Link outcomes to impacts**
8. **Illuminate core uncertainties**
9. **Demonstrate trade-offs**
10. **Suggest efficiency gains**
11. **Challenge prevailing theory**
12. **Test prevailing wisdom**
13. **Reveal the complexity of apparently simple things**
14. **Reveal the simplicity of apparently complex problems**

Based on Epstein (2012). NEED IN REFERENCES

Similar to IAMs, economy-wide models use emissions as the "transmission belt" linking climate models and economic processes, typically using climate-related functions and including, in some instances, feedback links between economic activity and climate.

With the advent of the 2030 Agenda and the nationally determined contributions of the Paris Agreement in place, IAMs should be more extensively deployed to explore key intersecting systems and their interdependencies. These include the interlinkages of the energy, water and land (food) nexus as well as the enhancement and adaptation of the technological and institutional infrastructure needed to advance the 2030 Agenda. Economy-wide models looking at interactions between the economy and emissions reductions, sustainable energy investments and climate change need to be more extensively used to inform policy options. This course is built on a suite of modelling tools capable of addressing key development issues retaining relevance of different sectors while simultaneously considering them within an integrated framework.

3. GLOBAL MODELS AND NATIONAL POLICIES

The insights gained using global models provide important information on the challenges faced by national decision makers in the short and long terms. Global findings, however, do not offer options and strategies that account for national circumstances and specific contexts. In an IAM or economy-wide tool, where Africa is almost inevitably modelled as an aggregate or a single quasi-homogeneous region, it is next to impossible to identify the challenges of any specific African country. Even if this could be done, the results would be gross continent-wide averages, with little or no relevance for any single country.

Modelling is particularly useful for the analysis of complex systems. Since complex systems have a multiplicity of factors at play, they defy simple explanations. The lack of single causal relations points to the need for using multiple models.

To make sense of complex processes, we need many lenses.

Building country-specific, national versions of global IAMs or global economy-wide models is a difficult and perhaps an unnecessary task. A more useful route is to build national models from nationally relevant data and to bring data and modelling results from global models as needed. National planners and decision makers need practical, simple, yet powerful models capable of providing useful insight to address pressing development issues, which often pertain to multiple domains. The temptation to build an all-encompassing model containing multiple domains is strong. The problem is that such models are too large and complex, which makes them less amenable to effectively informing policy decision-making. It is a well-established practice in the modelling of complex systems to build a set of models that, together, provide policymakers with a comprehensive understanding of complex issues and their interactions.

BOX 1. PLANNING AND SUSTAINABLE DEVELOPMENT

- **What is planning?**

Planning occurs every day – from the highly trivial (where do we go for lunch) to major consumption and far-reaching investment and policy decisions.

- **What is the type of planning that countries might need to achieve the 2030 Agenda?**

Countries need planning for the optimal allocation of scarce natural, financial and human resources while managing security and sustainable development challenges. Planning for sustainable development is about comparing the options at hand today as well as tomorrow.

Long-term planning helps avoid recurrent stop-gap measures. Long-term comprehensive sectoral planning in tandem with integrated planning across sectors is essential for sustainable development and the implementation of the 2030 Agenda.

- **Is *qualitative* planning useful?**

Yes. Even a first approach to planning (the mental model) enables some sense of priority actions. For example, recognizing the environmental risks and benefits of action, say, on affordable access to energy services, is a first important step towards the ultimate objective of the 2030 Agenda: a fundamental transformation of the world to make it sustainable.

But in this first approach, the policy options and their technical, economic, social and environmental interconnections are often not quantified; thus, it is difficult to assess interlinkages.

- **Is quantitative planning useful?**

Quantitative planning is not only useful but also necessary. Planning is a prerequisite for informed decision-making

Decision-making is better served by a planning practice offering transparent, quantified options, including adequate specification of interlinkages.

4. THE GLOBAL CLEWS MODEL

The global CLEWS model was designed to capture the life cycle of key materials. It was developed as a transparent, accessible, modular and scalable model using the open-source energy modelling system.

The global CLEWS model consists of three modules: the energy sector; land and food; and material production. It does not comprise separate water or climate modules. Instead, the energy, land and materials modules account for and are affected by restrictions made in the model on water use and greenhouse gas emissions. Unlike previous CLEWS-related country work, the different sectors of the global CLEWS model are fully integrated.

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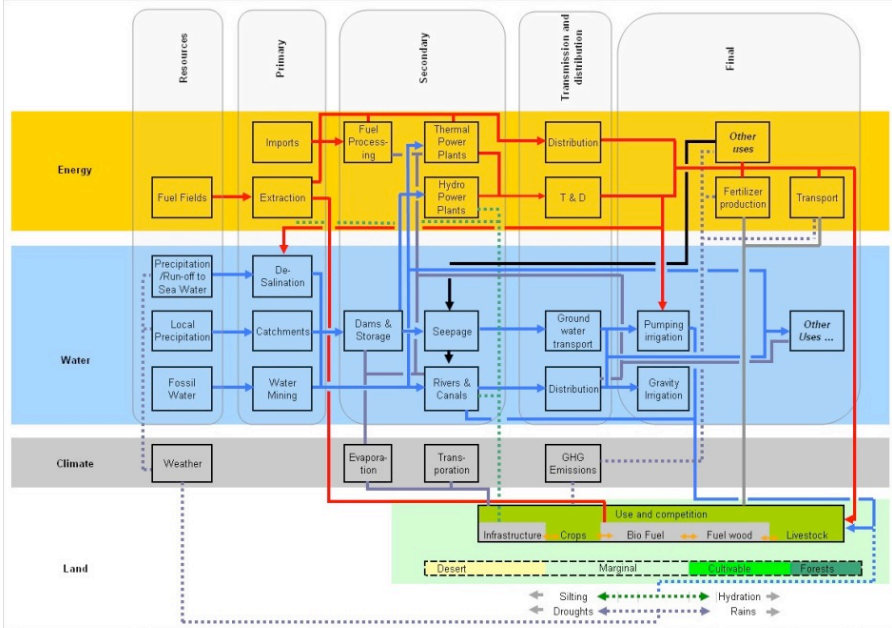
The energy module was developed in a way similar to the leading major global energy models (e.g., those used for the Global Energy Assessment and by the International Energy Agency), which inspired the choice of technology options and energy demand categories. Figure 1 shows a simplified version of the reference energy system. Final energy demand was divided into electricity, heat and transport. Industrial heating demand was treated separately and linked to the materials production module. Transport was divided into maritime, aviation, railways and road travel. Technology specifications and initial energy demand projections were primarily based on International Energy Agency sources. The power generation sector includes 26 technology options, while the heat generation sector has 20 technology options. Both centralized and decentralized options were considered. The model allows the assessment of future investment potentials in unconventional infrastructure, and technology shifts in the primary energy supply, such as coal or biomass gasification, coal-to-liquids and gas-to-liquids, and in generation, such as carbon capture and sequestration. The transport sector allows for market penetration of technologies using biofuels or electricity.

FIGURE 1: SIMPLIFIED GENERIC AGGREGATE CLEWS REFERENCE DIAGRAM



The lines in the diagram represent "flows" between activities or technologies aligned in columns. Technologies or activities convert input flows into outputs. Together they represent the reference energy system.

The land module establishes links between agricultural production, its associated land use, land degradation and energy use, and the production of biomass for energy purposes. Besides links with the energy module, the land module is also connected with the materials model, as it draws fertilizer from the materials module to increase the yield of land. The land module consists of 12 main land categories, which are characterized by different climatic conditions. These are divided by temperature (cold, temperate, hot), yield (low, medium, high) and level of agricultural intensity (low, high). An additional land category has been added for forest cover to account for fuelwood use. All land categories produce biomass as output, which can either satisfy demand for meat and vegetarian food or be used for energy purposes. The consumption of both food types leads to the generation of combustible waste, which can also be utilized in the energy module. Yield improvement of land and food production was based on Food and Agriculture Organization projections, while demand for food was coupled with population projections.

The materials module assesses the extent of energy use and environmental loading in sectors, as well as the potential for material and energy efficiency improvements. Sustainable use of materials implies reduction in material consumption and associated energy flows, by addressing the supply (e.g., through efficiency improvements in manufacturing) or the demand side (e.g., altered consumer behaviour). This can be achieved to a considerable extent through adaptation in lifestyles and societal behaviour, improved system design, cooperation among industries for a decrease in waste heat and material losses, and the incorporation of policy frameworks that facilitate such changes. The materials sector is interconnected with the land and energy module in several ways. Extraction of raw materials results in land degradation and emissions release, and requires energy input. Transformation of raw materials into consumer products is a very intensive process, while market globalization means that products need to be shipped across great distances from the source of supply to the point of demand. At the same time, equipment requirements in energy and agricultural production processes affect the demand of certain key materials, such as aluminium, cement, iron and steel. Inclusion of all these aspects can guide informed decision-making. In the present version of the model, the materials module consumes energy. The pulp and paper, iron and steel, aluminium, cement, fertilizers and petrochemicals industries take in energy in various forms (e.g., heat, electricity, fuels) and use it either to drive conversion processes or as feedstock. Efficiency improvements have been assumed based on existing projections.

5. CONCLUDING REMARKS

Global IAMS are important inputs informing international policy decisions and actions on climate change and sustainability. They also offer relevant contextual information for national policy decisions defining national sustainable development and climate change strategies. The global CLEWS model is crafted to highlight the main drivers of sustainability and climate change in a simplified structure, helping to facilitate global dialogue about sustainability and climate change policies. It uses an approach that approximates the one used by the main IAMS informing international dialogue, and that has the added benefit of being easily applicable to the design of national sustainability and climate change planning scenarios. Assisted by the global CLEWS model, this module has shown how current policies are not sustainable, has provided insights on what it takes to arrive at a development path where emissions are kept under control, and has shed some light on the potential role of a global carbon tax on the prevention of emissions increases.

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