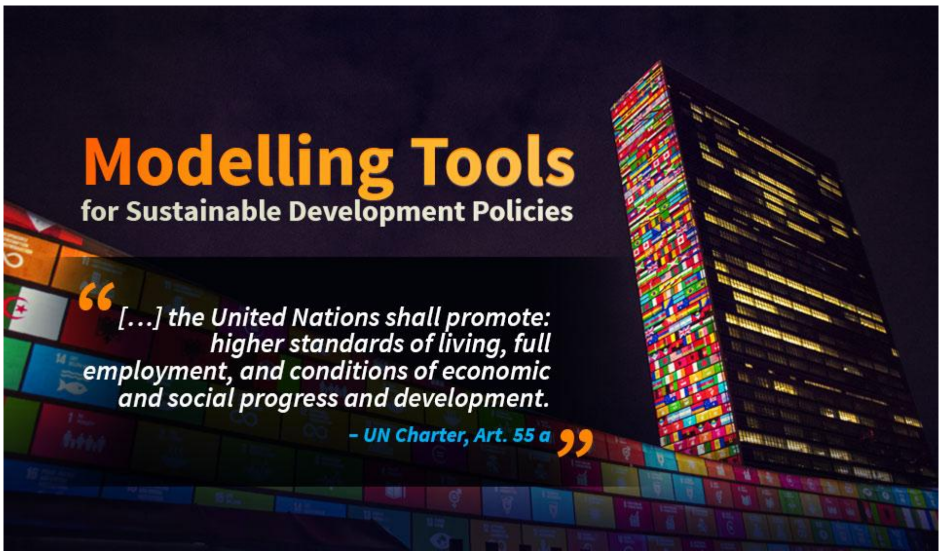

Understanding the Contribution of Modelling Tools to Sustainable Development

MODULE
THE 2030 AGENDA: A READER

Modelling Tools to Inform Policies for the 2030 Agenda for Sustainable Development

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PRESENTATION

SUMMARY

The international commitments adopted by countries in 2015 pose serious challenges for policy decision makers. These commitments include the 2030 Agenda for Sustainable Development, the Addis Ababa Action Agenda at the Third International Conference on Financing for Development, the Sendai Framework for Disaster Risk Reduction and the Paris Agreement under the United Nations Framework Convention on Climate Change. Policymakers face the complex task of balancing global goals and targets with national development aspirations and plans. Based on the best available data and science, policy decision-making will benefit from incorporating a systematic analyses of policy options with a clear understanding of possible trade-offs and synergies across the three dimensions of sustainable development. Quantitative modelling tools can assist in managing a complex agenda. United Nations organizations in partnership with scientists and academics are making available a suite of modelling tools that allow national planners and decision makers to address their most pressing development challenges, which often lie in a multiplicity of domains.[1]

LEARNING OBJECTIVES

- Understand the complexity of designing integrated policies for sustainable development.
- Understand the potential contributions that modelling tools can make to policy decisions to both retain sector pertinence and ensure links across sectors.
- Explore the three strands of global models shaping quantification of sustainable development, i.e., climate change, integrated assessment and economy-wide models.

[1] The suite of tools discussed in this document has been developed by experts at the United Nations Department of Economic and Social Affairs, the World Bank, Universidad de la Plata, KTH Royal Institute of Technology in Stockholm (KTH) and international Atomic Energy Agency (IAEA), among others. They are used in capacity development activities jointly implemented with the United Nations Development Programme. Such activities aim to build country expertise in using modelling tools to inform policy decisions.

- Appreciate the usefulness of developing capacity in countries to assess policies assisted by modelling tools that offer an integrated analytical framework.

OUTLINE

1. The 2030 Agenda for Sustainable Development and other international commitments
2. Modelling tools and the 2030 Agenda for Sustainable Development
3. Global models and national policies
4. Integrated assessment and national sustainable development policies
5. A suite of modelling tools to address the complexity of sustainability

QUESTIONS TO ACTIVATE RELATED KNOWLEDGE

- What are the three dimensions of sustainable development?
- What is a nationally determined contribution?
- What are the main characteristics of integrated assessment models?
- What is a “nexus” approach to policymaking?

1. THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT AND OTHER INTERNATIONAL COMMITMENTS

The 2030 Agenda aims to end the tyranny of poverty, protect the planet and ensure prosperity for all

In 2015, world leaders took significant steps towards forging sustainable development pathways to fulfil the promise to eradicate poverty, reverse environmental degradation, and achieve equitable and inclusive societies.

In June 2015, the United Nations General Assembly endorsed the Sendai Framework for Disaster Risk Reduction 2015-2030, recognizing the primary responsibility of governments to reduce disaster risk and loss of lives, and preserve livelihoods.

In July 2015, the Third International Conference on Financing for Development adopted the Addis Ababa Action Agenda, including a global framework for mobilizing resources and facilitating policy implementation for sustainable development.

In September 2015, Heads of State and Government, in the high-level plenary meeting of the General Assembly, made a commitment to reach the Sustainable Development Goals (SDGs) as part of the outcome document, Transforming our world: the 2030 Agenda for Sustainable Development

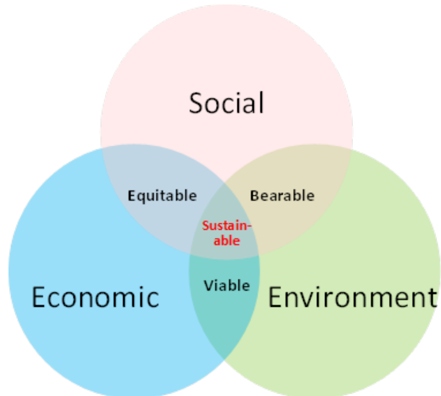
In December 2015, the Conference of the Parties to the United Nations Framework Convention on Climate Change, at its 21st session, adopted the Paris Agreement, through which countries committed to reduce greenhouse gas emissions and support adaptation efforts.

The 2030 Agenda for Sustainable Development holds the promise of setting the world on a sustainable development pathway if universally applied. It builds on the Millennium Development Goals (MDGs) as well as on the previous work of the United Nations Commission for Sustainable Development, and seeks to complete remaining challenges. Crucially, the 2030 Agenda is transformative, inclusive, comprehensive and integrated, leaving no one behind. Seventeen SDGs and 169 targets translate the Agenda into quantified global ends to be achieved by 2030. The SDGs are integrated and indivisible, and they seek to balance the economic, social and environmental dimensions of development.

Critically important climate action (SDG 13) has benefited from the unprecedented global consensus reached in December 2015 in the Paris Agreement. The agreement entered into force on 4 November 2016. It confirms the global goal of controlling greenhouse emissions to hold the rise of global average temperatures in this century below 2 degrees Celsius above pre-industrial levels, and if possible to less than 1.5 degrees Celsius.

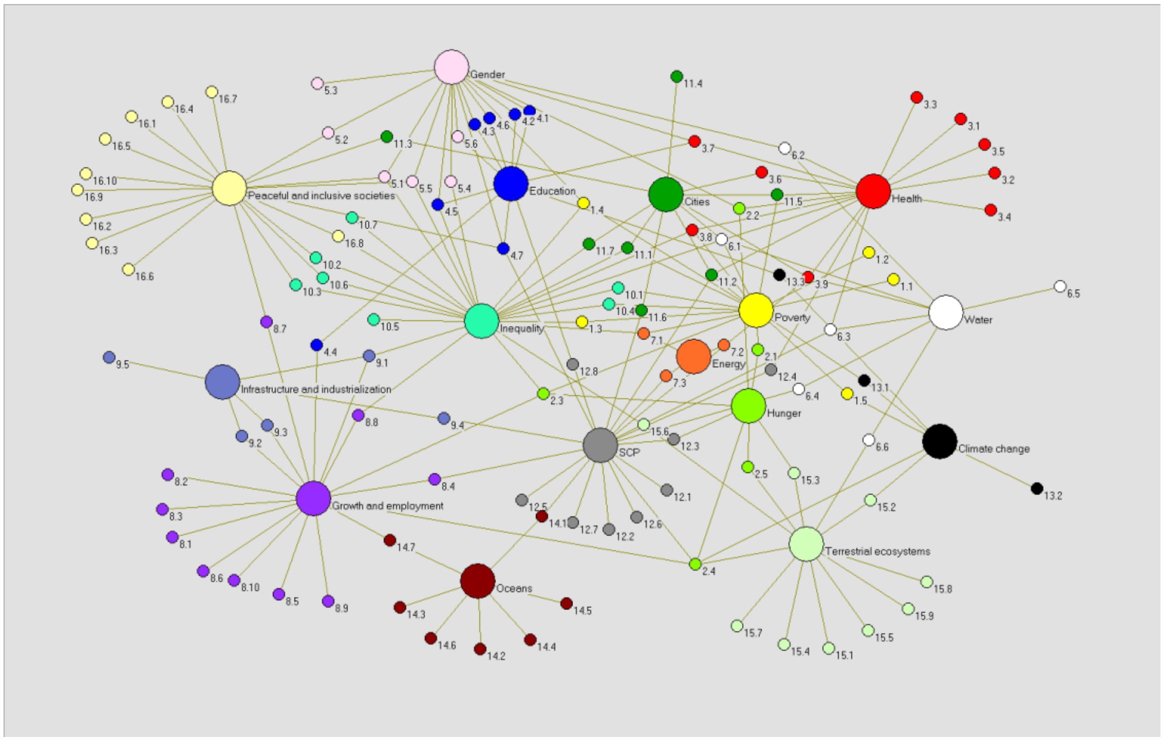
Implementation of the vision and commitments embedded in the 2030 Agenda inevitably rests in countries. National governments are called to set country-specific transformative targets in line with national planning processes and development priorities. Under the Paris Agreement, 189 countries have submitted nationally determined contributions as of November 2016, but countries have yet to formulate the detailed national policies and action plans that will lead them to realize their stated contributions, including an increasing level of ambition to effectively cap the increase in global temperature to 2 degrees. Similarly, the formulation of national policies to achieve the 2030 Agenda aiming at transforming our world towards sustainability, with no poverty, increased prosperity and no one left behind, poses complex challenges to each individual country.

Figure 1: Pillars of sustainable development



Establishing monitoring mechanisms to assess progress on the 2030 Agenda, towards meeting the 17 SDGs and 169 targets, is a lengthy process that has already started, including through the efforts of the United Nations Statistics Commission. It is responsible for identifying the indicator framework for global monitoring of progress. Nonetheless, it will take some time to put the framework fully in place, since data for many indicators need to be generated. Countries formulating strategies to implement the 2030 Agenda and committing to emission reductions under the Paris Agreement face the formidable task of balancing the three dimensions of development. Global commitments and agreements do not provide clear guidance for national implementation. That is not their purpose. The 2030 Agenda, nevertheless, illustrates the myriad and complex interlinkages across the various goals and targets, a challenge for implementation.

Figure 2: The SDGs and a Network of Targets



Source: Le Blanc 2015.

The 2030 Agenda represents a comprehensive synthesis of the sustainability challenges the world is facing; the 17 SDGs and 169 targets provide an illustrative integrated template for the formulation of national development plans. An initial step forward would involve comparing, matching and adding interlinkages that deserve special attention in the national context. Comparing and matching global goals to national strategies is useful, and many countries have engaged in precisely such exercises. In doing so, countries often find significant commonality between the list of global SDGs and targets, and national development plans. This should not surprise anyone. Economic, social and environmental concerns have been prominent issues in many countries, and they have been widely reflected in national development plans for many years/decades, including in terms of an increasing recognition of the interlinkages across them. This does not mean, however, that countries are already on a sustainable development path.

Questions to formulate well-integrated national sustainable development policies:

How can we ensure that choices related to the SDGs and targets are well balanced and lead towards sustainable development?

How can we identify when an emphasis on integration sacrifices effectiveness in achieving sector- or SDG-specific objectives?

How can we identify when the acceptance of specific trade-offs does not compromise the achievement of national development aspirations?

Comparing the 2030 Agenda with national development plans can only be a first step in building an integrated and context-specific agenda for sustainable development. The SDGs, their targets and interlinkages are, by themselves, no guide for the formulation of policy priorities needed to put countries onto development paths capable of realizing the transformative changes that bring about sustainability at national levels, and, by aggregation, to the entire world.

Figure 3: The SDGs

The SDGs comprise 17 discrete tasks designed along traditional sector and ministerial demarcations. Take, for example, quality education (SDG 4), which is clearly the domain of education ministries; or affordable and clean energy (SDG 7), which is the realm of energy ministries; or climate action (SD13), which is the responsibility of environment ministries. Achieving any of these goals requires a good understanding of the interlinkages with other goals under the responsibility of respective ministries.

Sector institutions hold the knowledge and expertise to take on the challenges of their own sectoral mandates, for example, in education, energy and the environment.

But sector dedication does not mean losing sight of both positive and negative impacts on other sectors, which may need complementary policy actions.

Given the great importance of sector policies, the process to implement the 2030 Agenda has started in many countries by assigning goals to different ministries. Sector-specific institutions are best placed to implement specific policies to reach the SDGs, for they hold the knowledge and expertise to take on the challenges of improving education, extending access to energy and protecting the environment, among all other areas where urgent action is needed. Sector-dedicated policies will be central to the implementation of the 2030 Agenda. But this does not mean that integration should be overlooked. Progress in some sectors often needs concerted action in other sectors, and might also mean, if not properly managed, regressions in other sectors. Charting national sustainable development paths requires integrated sustainable development policies to balance sector relevance and cross-sector interlinkages, and shape national sustainable development pathways.

Policy decision-making will benefit from analyses that, based on the best data and science available, carefully assess trade-offs and synergies across the various dimensions of sustainable development. Quantitative or mathematical models can assist in the task of handling a complex agenda by producing simple, but not too simple, insights to enrich the evidence on which policy decisions can shape transformative changes.

Box 1. SDG 13: CLIMATE ACTION

The energy and climate change interlinkage is a nodal point for global models and national development action. It is represented by SDG 7 and SDG 13, and it figures in the nationally determined contributions. Mitigating climate change is synonymous with energy system transformation, i.e., addressing the twin mandate of rapidly ramping up the share of non-greenhouse gas emitting energy sources and significantly raising energy productivity, as well as improving energy demand efficiency.

The updated synthesis report of the United Nations Framework on Climate Change on the aggregate effect of nationally determined contributions from 189 countries indicates global warming of around 3 to 3.5 degrees Celsius by 2100. This is a notable improvement, but still not enough to keep temperatures from rising over the 1.5- to 2 degree ceiling. Yet, these emission reductions require frontloading enormous investments in low-carbon electricity generation, energy efficiency measures and infrastructure adaptation. The national commitments, if implemented, will correspond to pathways where investments in zero-carbon electricity generation would be, over the next 15 years, the equivalent of about $1.25 trillion to $2 trillion in efficiency measures. Putting global emissions on a 2 degree trajectory would further increase cumulative investment needs by another 50 per cent. Aggregated long-term mitigation costs are about 1.5 to 2.1 times higher for 1.5 degree than for 2 degree futures, with a larger effect on near-term costs.

Numerous studies have evaluated the costs of mitigation policies aimed at reducing emissions. Aggregate mitigation cost estimates vary widely and are highly sensitive to the underlying methodology and assumptions regarding economic growth, techno-economic characterization of technologies, or the timing and stringency of climate policy. Models have found that the macroeconomic costs are modest compared to the expected economic growth even for holding warming below 2 degrees. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, mitigation efforts would result in a loss of global consumption of between 1 per cent and 4 per cent of global gross domestic product in 2030 and between 2 per cent and 6 per cent in 2050. This is equivalent to an annualized reduction of consumption growth of between 0.04 to 0.14 percentage points. Ostensibly modest mitigation costs result from:

1. **The historically low share of energy costs in the economic production process (compared with capital and labour);**
2. **The progressive shift from operational expenditures for energy services over the life time of plants and equipment, especially fuel outlays, to upfront investments in renewable technologies and efficiency improvements, and**
3. **Several idealizing assumptions such as an equilibrium state of the economy, a universal participation in mitigation efforts, a uniform international carbon price as well as rational consumer and producer behaviour resulting in least-cost global energy transformation and climate mitigation pathways.**

Such a modest annualized mitigation costs disguises the enormous challenges and the associated short-run financial burden. Add to this the investment needs to fuel energy demand growth, especially associated with access, and the cost issue cannot be ignored.

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 inter-linkages. 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.[2]

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.

[2] 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).

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.

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.

4. INTEGRATED ASSESSMENT AND NATIONAL SUSTAINABLE DEVELOPMENT POLICIES

As captured by the 2030 Agenda and the 17 SDGs, sustainable development requires important changes in energy sectors. Countries will need to embark on policies aimed at transforming the way energy services are provided and used, while making sizeable investments in economic and social infrastructure and services.

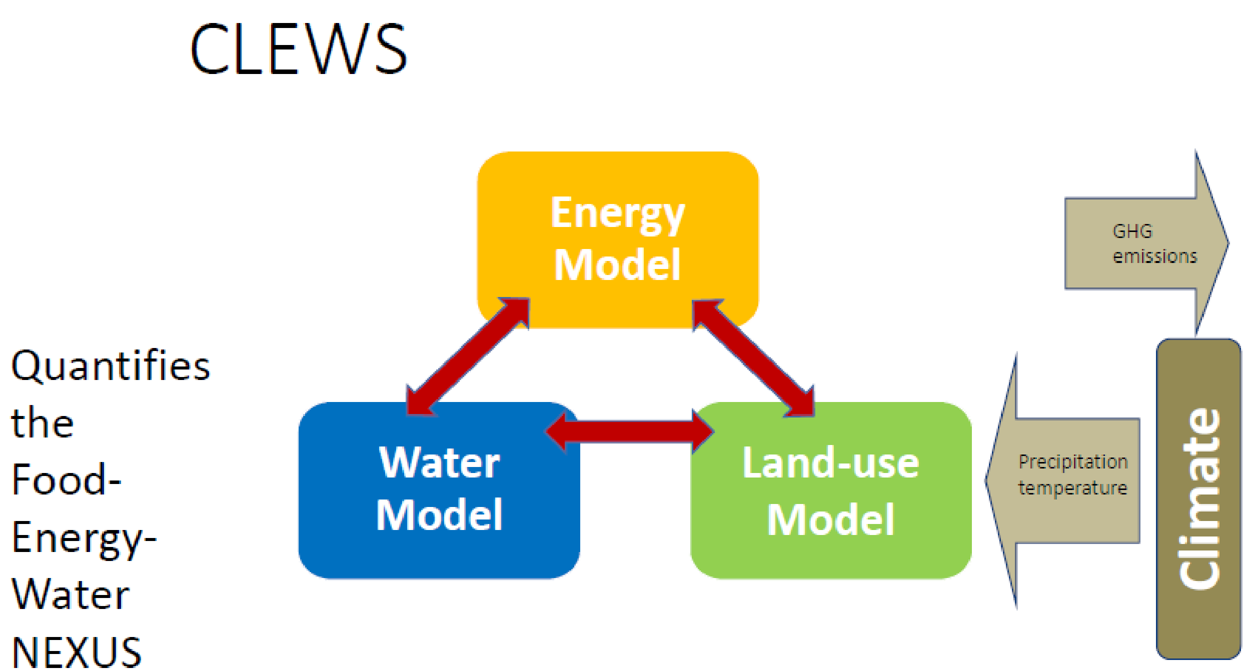
Decarbonizing the economy is key for setting the world on a sustainable development path. But this poses daunting challenges. It requires increasing energy investments, fostering technology development in low-carbon sources, and refurbishing a good part of the productive and social infrastructure of the economy. As challenging as it is, full decarbonization of the economy is not by itself enough to achieve sustainability. Eradicating poverty, leaving no one behind and the whole spectrum of other objectives contained in the 2030 Agenda also need to be achieved. An array of models and quantitative methodologies can assist in the formulation of policies.

CLEWS AND THE FOOD, ENERGY, WATER NEXUS

A good starting point for furnishing evidence to inform sustainable development strategies is to build a national, country-specific, integrated assessment model capable of simultaneously accounting for energy, water, land use and climate change. Ensuring adequate energy infrastructure for development and energy security, and a sustainable national energy supply mix are policy concerns ranking high in most, if not all, countries. For example, countries wishing to accelerate the rate of access to reliable, clean and affordable electricity might consider a range of complementary but integrated energy policies, such as fostering the market penetration of renewable electricity, clean fuels in transport, and energy efficiency policies ranging from retrofitting buildings to sustainable production and consumption.

Such policies are sufficiently complex in themselves, yet they immediately call for supplementing policies in other sectors. Energy is closely interrelated with the use of water and, in some cases, with the use of land. Providing energy, e.g., electricity and fuels for transport, may compete with food production in the use of land and water, while food production itself usually requires access to energy. While water is used at varying degrees in the production of electricity, energy is essential for pumping water and for treatment of wastewater. Energy, food (land use) and water often pull in different directions, leading to important trade-offs. All of this underscores the importance of an integrated approach simultaneously looking at these resources (land use, water and energy), particularly in countries where water and land are already under stress.

Figure 4: The Climate, Land, Energy and Water Systems model



A new breed of models termed CLEWS (climate, land use, energy, water strategies) has been recently developed to account for individual food, energy and water systems and the links among them in individual countries (see figure 4). The model components (water, energy and land use) should be precise enough to capture these specific systems in their relevant geographical reference context, e.g., national, subnational, local and even trans-boundary. This means model components should use, to the extent possible, spatial data on land resources, energy supply infrastructure and energy demand, and water sources and withdrawals.

Like most quantitative models, CLEWS is data intensive. For each county assessment, data must be gathered and incorporated into the model architecture from scratch. An advantage of CLEWS is that its components are modular with varying degrees of complexity reflecting data availability. It allows analysts to get started with small data requirements and reduced complexity, and leave, for later stages, the addition of complex interlinkages when more data become available, or when the fine-tuning of policies calls for the investigation of additional impacts. Above all, however, the CLEWS model requires the capacity-building of national experts for:

a. Appreciating the challenges of this nexus;
b. Understanding data requirements, model set up and structure;
c. Learning operational aspects; and
d. Interpreting results and policy formulation.

Global integrated assessment models have limited scope in terms of water and land systems. They do not allow for a detailed representation of, for example, surface and undersurface water sources, agricultural productivity, water use intensity and biodiversity, as these differ greatly from one location to another. Yet decision-making at the national, subnational and village levels requires relevant information, including on current rates of access to modern energy, electricity usage, local energy resource endowments

Sector-specific modelling tools are most relevant for providing detailed information for policy decision-making. Some of these analytical tools are connected within the integrated CLEWS approach to provide deeper understanding of interlinkages.

and flows, water availability and use, land allocation to agriculture, forest coverage, weather changes, employment, income poverty and inequality, and budgetary and foreign currency constrains, among other issues.

To address sustainable development challenges with relevant data, countries need modelling tools appropriate to the policy issue under consideration, based on relevant data and parameters.

ENERGY-ELECTRICITY SYSTEM MODELS FOR MID- TO LONG-TERM PLANNING

Integrated assessment and nexus models like CLEWS provide an integrated approach to sector issues, but cannot be a replacement for single-sector models. The CLEWS model might not allow for the detailed capacity and infrastructure expansion needed in energy planning, for instance. Comprehensive energy planning – from energy resource extraction to the provision of energy services to consumers – requires an energy systems model. In the 1970s, analysts applied energy systems thinking to create energy systems models. These models use linear programming to find the least-cost energy infrastructure and generation mix under alternative future price, technology and policy scenarios over medium- to long-term planning horizons. The models quantify the emissions from the supply and use of energy, hence allowing an assessment of the energy system's impact on the environment and contribution to climate change.

Mid- to long-term energy planning involves decisions over a vast portfolio of technologies and distribution options, from grids to off-grid and standalone solutions. Technology costs and performance (conversion efficiencies, emissions, reliability, etc.) vary considerably between technologies with a seemingly identical output, e.g., electricity. The performance of otherwise identical technologies, say wind power plants, can have distinct location dependent performance profiles – among other factors, wind movement is not uniform (see the energy systems modelling tool). Energy systems models provide a way to handle these complexities. They are also good at planning for complex patterns of energy demand, with its peaks, lows and seasonality, and putting these together with the supply decisions on a range of generation, transmission and distribution technologies in a unified framework.

Energy systems models are powerful tools to assess, for example, energy planning scenarios featuring investments in generation, transmission and distribution of electricity based on costs and emissions. They can also help in assessing the engineering and economic feasibility of ambitious increases in renewable sources of energy, and of policies aiming to ensure national energy security. With some similarities with short-term electricity dispatch models, energy systems models are routinely used in developed countries and some developing countries to assess energy paths over the medium term.

GEOSPATIAL ELECTRIFICATION MODELLING

Until recently, access to electricity was mainly approached through the extension of transmission lines to connect population settlements and the expansion of electricity generation capacity to supply the central grid. Recent innovation in off-grid technologies, such as wind farms and solar panels, now can provide electricity at much lower costs locally than electricity delivered via grid expansion and central generation. The spread of geospatial data availability provides vastly improved information on local energy resource flows, settlement patterns, demand densities and infrastructure availability. Geospatial data combined with technology performance data such as on costs and technological efficiency as well as emission factors have opened new opportunities for rural electrification and energy access based on off-grid supply alternatives.

ECONOMY-WIDE MODELS

Decisions on sustainable development policies need, as already stated, to have sufficient sector detail to make them relevant to analysing and assessing policy options. One key component of integrated assessment is the economic impact of investments, expenditures, incentives, taxes and regulations, as well as the impact of shocks that affect countries, such as increases in tariffs, changes in commodity prices and climate change. While there are several tools capable of analysing the impacts of policies and shocks, economy-wide models have emerged as a preferred tool to analyse the types of policies and shocks that are relevant to sustainability questions at the global, regional, national and subnational levels.

Economy-wide models use national accounts data and econometric estimates of the behaviour of economic agents to assess the direct and indirect effects of policies and shocks. In the recent past, economy-wide models have successfully assessed the macroeconomic implications of alternative financing schemes to fund policies aiming to achieve the MDGs. The analysis has shed light, for example, on the synergies that could be achieved when simultaneously pursuing several MDGs, as opposed to pursuing them in isolation. These models have also helped to quantify the effects of external shocks associated with the 2008 crisis – e.g., reduced remittances, reduced export revenue, etc. – on the pace of progress towards the MDGs. They have helped to define the implications of MDG policies for sector output and employment, and have been used to quantify the medium-term productivity paybacks of increased investment in education. The methodology has also been used to assess the economic implications of energy investments in a sustainable development framework as well as the effect of declining oil and gas prices on electricity and investments in energy infrastructure.

MICROSIMULATION METHODOLOGIES

Assessing the effects of sustainable development policies on poverty, inequality and vulnerable socioeconomic groups is of paramount importance. There is a long-held view, for example, that some emissions reduction policies might have negative effects on inequality. The assessment of policies supporting sustainable development – such as the promotion of biofuels, reducing water stress, energy security and the elimination of energy subsidies, among others – needs to be informed with an analysis of their impacts on the well-being of individuals and households.

The microsimulation methodology uses household surveys and administrative data on households and individuals to probe the impacts of policies and shocks on households and on specific population groups. In projects led by the United Nations Department of Economic and Social Affairs, the methodology has been linked to economy-wide modelling. In a first step, the modelling carries out an economy-wide scenario simulation. From the employment changes simulated by the economy-wide model, microsimulation then maps these results for all households in the data. The procedure allows the generation of estimates of the impacts of policies and shocks on poverty and inequality for the entire society as well as for specific socioeconomic groups, if they are statistically represented in the household survey.

The use of microsimulation in policy decision-making is extensive. It can probe the effects of a variety of policies, such as cash transfer schemes, employment generation programmes, vaccination campaigns, the introduction or lifting of subsidies, and changes in food prices, among many others. It can also be used to assess how, for example, the demand for electricity might change over the medium term under accelerated electricity access programmes or ambitious redistributive programmes that provide energy subsidies to low-income households. Results from this exercise detail important information for planning investments to expand energy services.

5. A SUITE OF MODELS TO ADDRESS THE COMPLEXITY OF SUSTAINABILITY

The models described above are powerful tools to inform a wide range of policy questions. By themselves, however, they cannot shed light on all issues relevant to sustainable development policies. Different policy questions call for different modelling tools. Proper assessment of interlinkages also requires the use of several modelling tools that can "talk to each other." The question then arises of how best to expand the range of issues that an integrated assessment can cover. There are two practical ways for how a suite of analysis and planning tools, such as the one introduced in this training course, can best be used to inform and test sustainable development policies.

SOFT LINKING AND INTEGRATED ANALYTICAL FRAMEWORKS

The technique involves running two or more models sequentially, and interactively feeding the results of one model as inputs to the other model until a desired level of convergence is achieved. For example, the CLEWS integrated analytical framework can help in assessing the feasibility of biofuel production compared to alternatives, such as concentrated solar energy and wind farms. It can be complemented with an energy systems model shedding light on, for example, how alternative energy technologies interplay with pre-existing installed capacity in the country and with the potential capacity the country has for hydropower. One can take a step further and introduce an economy-wide model to take the sectoral changes implied in the CLEWS analysis to shed light on their economy-wide implications. Investment schedules of the different scenarios produced by the energy systems model can be used to run alternative scenarios in the economy-wide model to find out the sectoral and budgetary impacts. It is also possible to take the employment changes from the economy-wide model and run a microsimulation to probe the poverty and inequality impacts of each scenario. Different policy questions will lead to different ways of making modelling tools interact with each other.

Another example might be the soft-linking of an energy systems and an economy-wide model to find out what the demand for electricity will be under certain growth and development scenarios. Then modellers will run the energy systems model to find out, using the detailed technological information, the lowest cost option to satisfy electricity demand derived from the economy-wide model. Modellers might use these results as inputs in the corresponding sectors contained in the economy-wide model, run the model again and obtain a newly estimated demand for electricity. Then, the energy systems model could find the least cost supply and investment option to satisfy the new demand. These procedures can be iterated until a certain desired level of convergence is achieved in, for example, the estimated demand for electricity.

Soft-linking requires feeding new data to the model and even modifying certain equations to reflect consecutive changes considered in various soft-linking iterations.

AN INTEGRATED SYSTEMS MODEL

To expand the range of issues that can be addressed with a primary modelling tool, analysts can add or "hard-link" key equations or loops from other models or derived from partial quantitative analyses. For example, a CLEWS analysis intended to also shed some light on the employment impacts on non-CLEWS sectors might extend the model to embrace a small input-output matrix. Another example is the introduction of loops accounting for pollutant emissions to assess their impact on health. Analysts can then use studies looking at the links between health and labour productivity to investigate in an economy-wide model how changes in labour productivity translate to changes in different parts of the economy.

The integrated systems model and hard-linking procedures might be the preferred route under certain conditions, but it is important to recognize that the number of additions to a model is limited before its practical usefulness is jeopardized.

Determining which of the above options is the preferred one will depend on the questions the analysis is posing and the skills modellers might readily have. An important point is that even a straightforward soft-linking of models might provide relevant insights for policy decision-making.

6. CONCLUDING REMARKS

In 2015, world leaders agreed on a wide range of critical development issues, and assumed global and national responsibility for their implementation. The vision inspiring these agreements is the transformation of the world, putting it on a sustainable development path with no poverty and no one left behind. Countries are already committing to achieve national sustainable development objectives that call for important changes in the way economies and societies function. Some of these commitments, as expressed in the nationally determined contributions, do not add up to the transformations envisioned in the 2030 Agenda. They fall short of the promise of curbing emissions to avoid temperature increases greater than 2 degrees Celsius. Moreover, global initiatives do not specify the policies, actions and investments that will have to take place in each country to achieve the global goals and national development aspirations. Policy design for transformative changes faces difficult challenges.

To assist countries in the design of policies dealing with the complexities of sustainable development, a range of partners are collaborating to bring together relevant experts from a variety of science and engineering fields, and to make readily available a suite of open source modelling tools. The aim of this initiative is to bring state-of-the-art, yet practical and transferable modelling tools to countries, and to contribute to building capacity to use them for informed policy decision-making. The modelling tools incorporated in this course shed light on the trade-offs and synergies implied in policy decisions intended to make progress towards a sustainable development future.

In making available a suite of tools, there is an underlying principle that no single model can address all the relevant issues involved in a complex system, such as that implied by sustainable development. Tools can effectively address specific sector challenges and, through skilful interplay, offer an integrated analytical framework. To ensure realistic and sound sustainable development paths, the modelling practice should be based on the best and most transferable tools, incorporate up-to-date knowledge, and create analytical capacity in countries, particularly in the least developed.

The practice of modelling requires time, financial and human resources. It is a demanding practice, but it can make a distinctive contribution to bringing scientific and technical knowledge to policy decisions. Good modelling practice explicitly acknowledges the unavoidable assumptions that must be made in any analytical endeavour and the quality of data used. This is essential to better assess the weaknesses and strengths of modelling practices. Enhanced transparency also facilitates cross-ministerial dialogue and consensus-building, and facilitates the revision and adjustment of policies when needed.

The potential contributions that modelling tools can make to sustainable development policies need to be understood and discussed more widely. Towards this end, this outreach training course has been developed for United Nations staff, government officials and members of the development community who do not wish, or are not in a position, to engage in the practice of modelling. It is intended as a general introductory guide to the actual and potential uses of modelling to inform sustainable development policies.

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