RESEARCH GUIDE FOR WATER-ENERGY-FOOD NEXUS ANALYSIS

Insights from “The Water-Energy-Food Nexus: Global, Basin and Local Case Studies of Resource Use Efficiency under Growing Natural Resource Scarcity” project

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INTRODUCTION

Global food security faces increasing challenges from climate change, global population pressures, and increased urbanization. The Sustainable Development Goals demand progress on key dimensions of human development and environmental sustainability. However, as a result of growing natural resource scarcity, making progress in one area, such as food security, will likely adversely affect progress toward desired outcomes in other areas, such as water security or environmental sustainability. As a result, business-as-usual approaches are no longer an option. Instead, advances in food security need to be addressed within a nexus perspective incorporating key interlinkages with related sectors, including water and energy.

These challenges are of particular concern in the Eastern Nile region, which is characterized by rapid agricultural, water and energy development. The project titled “The Water-Energy-Food Nexus: Global, Basin and Local Case Studies of Resource Use Efficiency under Growing Natural Resource Scarcity“ (2015-2018), which was supported by the Federal Ministry for Economic Cooperation and Development, Germany, and was undertaken as part of the CGIAR Research Program on Water, Land and Ecosystems. The project set out to develop research methodologies and insights globally as well as for the Eastern Nile Technical Regional Organization (ENTRO) of the Nile Basin Initiative (NBI) and Egypt, Ethiopia and Sudan[1] to support efforts for enhanced water, energy and food security and environmental sustainability.

The toolkit describes both qualitative and quantitative methods that have been used in the research project. It is not meant to be an exhaustive list of information and tools related to the analysis of the water, energy and food (WEF) nexus. The overall focus of the tools has been on economic analysis of the linkages across water, energy and food--to complement other studies and method developments that focus on biophysical linkages across the WEF nexus. The toolkit is aimed, primarily, at researchers interested in the analysis of the water, energy and food nexus. However, the studies summarized here also provide insights for practitioners implementing Nexus projects.

Table 1 summarizes the types of methods used in the study that will be detailed in the following sections.

[1] Data availability was too limited for analyses in South Sudan.

Table 1 Methods used in this Project

Methods	Geography	Nexus	Reference
Qualitative Methods			
• Electronic survey	Egypt, Ethiopia, Sudan	Water, Energy Food	Berga et al. (2017)
• Key Informant Interviews	Egypt, Ethiopia, Sudan	Water, Energy, Food	Berga et al. (2017)
• Focus Group Discussions	Ethiopia	Energy, Food, Land	Villamor et al. (2018)
Quantitative Methods			
• Computable General Equilibrium (CGE) Modeling cum Partial Equilibrium (PE) Modeling	Global	Water, Energy, Food	Ringler et al. (2016)
• CGE Modeling	Ethiopia, Egypt, Sudan	Water, Food, Climate Change	Siddig et al. (2018); Al-Riffai et al. (2017); Wiebelt (2017)
• Energy systems modeling (MARKAL/TIMES/LEAP/GAMS)	Ethiopia, Egypt, Eastern Nile	Energy	Mondal et al. (2017, 2018, under review); Mirzabaev et al. (under review)
• Hydro-Economic Modeling (HEM)	Eastern Nile (Egypt, Ethiopia, Sudan)	Water, Energy (partial), Food (partial)	Berga et al. (2019)
• Gendered Agent-based modeling	Ethiopia (sub-national)	Food, Energy	Villamor (under review)
• Econometric analyses	Ethiopia (sub-national)	Energy, Food, Water	Mirzabaev et al. (2018). Mimeo.

Source: Authors.

QUALITATIVE METHODS

Qualitative data are generally collected to help understand complex topics, to contextualize quantitative findings or to explore topics in greater depth than is feasible through surveys where answer choices are pre-set and constrained. Depending on the method used, it also allows for a more interactive conversation both between the respondent and interviewer or the interviewer and a group of respondents. The benefits of using qualitative tools include the ability to capture details that may not be evident from numbers and statistics. For example, respondents may be more able to express themselves and to discuss topics that are of importance to them than in pre-structured questionnaires. At the same time, the interviewer can explore interesting issues that merit further discussion. On the other hand, structuring and analyzing the data collected can provide challenges for the researchers tasked with extracting relevant insights, conclusions and recommendations. The following tool description includes a brief overview of the tool, followed by a list of benefits and challenges in use, a description of the use of the tool in this project, and a list of outputs from the project using the tool in question as well as other resources that have used the same tool (generally in a different context).

Electronic surveys (E-surveys)

Key informants are individuals that have specialized knowledge on a specific topic of interest. They are able to speak on behalf of a group and have an overview over issues that might otherwise be difficult to gather information on. They are usually interviewed individually with a semi-structured open-ended series of questions.

Benefits:

- Allows to quickly reach a relatively large number of potential respondents from various sectors, such as the WEF sectors
- Cost-efficient way to sample across large areas, such as entire countries or large river basins

Challenges:

- Responses are skewed to those with good internet access and those with an affinity to respond to online surveys; as such responses need to be treated with caution
- To reach respondents, e-surveys typically need to be translated into national or even local languages to ensure adequate response numbers
- In some societies and contexts e-survey response levels are very low

In this project, an electronic survey was implemented to reach key stakeholders in the water, energy and food sectors in Egypt, Ethiopia and Sudan. The protocol of the e-survey can be found in Berga et al. (2017).

Resources

Project Resource:

Berga, H., C. Ringler, E. Bryan, H El Didi and S. Elnasikh. 2017. Addressing Transboundary Cooperation in the Eastern Nile through the Water-Energy-Food Nexus: Insights from an E-survey and Key Informant Interviews. *IFPRI Discussion Paper No. 1655*. Washington, DC: IFPRI.

Related Resource:

Bryan, E., Q. Bernier, M. Espinal and C. Ringler. 2018. Making climate change adaptation programmes in sub-Saharan Africa more gender responsive: insights from implementing organizations on the barriers and opportunities. *Climate and Development* 10(5): 417-431.

Key Informant Interviews (KII)

Key informants are individuals that have specialized knowledge on a specific topic of interest. They are able to speak on behalf of a group and have an overview over issues that might otherwise be difficult to gather information on. They are usually interviewed individually with a semi-structured open-ended series of questions.

Benefits:

- Allows to sample purposefully among large populations
- Individuals with expertise can provide an overview on a topic or help fill gaps
- Allows to bring in views from different sectors, for WEF Nexus analyses, and for complex, cross-sectoral challenges, in general

Challenges:

- It can be difficult to identify relevant key informants
- Individuals are sometimes difficult to reach
- While KII allows for purposeful sampling, key stakeholders or stakeholder groups might be excluded

In this project, KII were implemented in Egypt, Ethiopia and Sudan with e-survey respondents who were willing to provide more in-depth insights on water-energy-food linkages in the three countries as well as among the three countries.

Resources

Project Resource:

Berga, H., C. Ringler, E. Bryan, H El Didi and S. Elnasikh. 2017. Addressing Transboundary Cooperation in the Eastern Nile through the Water-Energy-Food Nexus: Insights from an E-survey and Key Informant Interviews. *IFPRI Discussion Paper No. 1655*. Washington, DC: IFPRI.

Related Resource:

Aberman, Noora-Lisa; Birner, Regina; Haglund, Eric; Ngigi, Marther; Ali, Snigdha; Okoba, Barrack; Koné, Daouda and Alemu, Takei 2014. Understanding the policy landscape for climate change adaptation: A cross-country comparison using the Net-map method. *IFPRI Discussion Paper 1408.* Washington, D.C.: IFPRI.

Focus Group Discussions (FGDs)

Focus Group Discussions (FGDs) consist of a group discussion of approximately 6 - 12 persons guided by a facilitator, during which group members discuss a series of guided topics or questions. The purpose of FGDs is to obtain in-depth information on concepts, perceptions, and ideas of a group in relation to a specific topic, such as the WEF Nexus. FGDs can be useful to: (1) explore problems in greater depth, investigating its possible causes; (2) elicit perspectives of particular groups (e.g. women and men); (3) collect data and insights for models or other quantitative tools; (4) help understand and solve unexpected problems in interventions and understand complex, underlying causes of phenomena; and (5) explore controversial topics.

Benefits:

- FGDs are cost- and time-efficient allowing to elicit information from groups rather than individuals
- They can help identify underlying power structures and structures in populations that might otherwise not be known
- They can identify hitherto unforeseen linkages and problems

Challenges:

- Causality is generally not known
- Information cannot be linked back to individuals and follow up can thus be difficult
- FGDs do not lend themselves to highly sensitive topics

In this project, gender-disaggregated FGDs were implemented in Gebezermariam and Bichena Debir in Amhara, and Sire Morose in Oromia, Ethiopia, using the Actor, Resources, Dynamics, and Interactions (ARDI) method (Etienne et al. (2011)). The ARDI method was used to co-conceptualize WEF nexus systems according to gender types through a series of focus group discussions and workshops, where male and female farmers were aided by facilitators to collectively articulate a mental model of a particular WEF nexus system.

Resources

Project Resource:

Villamor, G. B., Guta, D., Djanibekov, U., and A. Mirzabaev. 2018. Gender specific perspectives among smallholder farm households on water-energy-food security nexus issues in Ethiopia, ZEF – *Discussion Papers on Development Policy No. 258*. Bonn: Center for Development Research.

Related Resources:

Etienne, M., D. R. Du Toit, and S. Pollard. 2011. ARDI: A co-construction method for participatory modeling in natural resources management. *Ecology and Society* 16(1): 44.

Stein, C.; Barron, J.; Nigussie, L.; Gedif, B.; Amsalu, T.; Langan, S. 2014. Advancing the water-energy-food nexus: social networks and institutional interplay in the Blue Nile. Colombo, Sri Lanka: IWMI. CGIAR Research Program on Water, Land and Ecosystems (WLE). 24p. *WLE R4D Learning Series 2*.

QUANTITATIVE METHODS

Quantitative tools include both simulation and econometric analysis methods. Both rely on the collection of large amounts of data that are then analyzed using mathematical or statistical techniques to develop or understand inter-relations and future developments between variables in the population of interest. Simulation models generally simulate alternative futures based on a base year or in comparison to a baseline or reference case. Simulation models can simulate a single sector, such as energy supply and demand, or food and water supply and demand, but also the interlinkages across these three sectors, although WEF simulation models that provide equal weight to all three sectors are not yet available. The best known and established models are single-sector focused.

Econometrics is an established approach to the discrete choice problems using statistical methods, which are typically applied to household or individual surveys with underlying questionnaires that include generally fixed response options. Data are analyzed using statistical or econometric techniques using statistical packages for data analysis, such as STATA or SPSS. In the WEF context, econometric analyses can provide insights on linkages across the water, energy and food sectors as they are experienced by households or individuals in the household.

Quantitative methods have both pros and cons. The benefits of using econometric techniques include their ability to capture sufficiently large sample sizes so that data can be representative of the populations of interest, as well as their ability, sometimes, to infer causality. Data of interest are often available as secondary data, although there are few, if any, household survey data focused on addressing WEF Nexus topics. Both econometric and simulation modeling provide data that are of interest to decision makers. Challenges of using quantitative methods include the need to collect large volumes of data, and the lack of nuances in responses in survey data, or the lack of details or variations in years of data availability for simulation modeling.

Global Computable General Equilibrium (CGE) Modeling cum Partial Equilibrium (PE) Modeling

A global CGE model represents the global economy-wide structure of production, demand and international trade at regionally and sectorally disaggregated levels. As the spatial disaggregation level of global CGE models is limited and as the representation of biophysical constraints is generally limited to non-existent, a linkage with a more spatially and sub-sectorally disaggregated Partial Equilibrium (PE) model can improve insights for Nexus analysis. PE models take into consideration only a part of the market to attain equilibrium. For example, food supply and demand models clear markets for agricultural commodities but take income levels as well as prices in other markets as a given. This simplification allows PE models to develop much greater granularity for the specific sector they have been developed for.

Benefits:

- Allows to assess economy-wide impacts of interventions in the WEF space
- Can provide important insights for policies and interventions geared by providing insights on regionally and nationally disaggregated impacts on water, energy and food security and selected environmental impacts.
- Results from CGE and PE models can be easily communicated to policymakers due to the quantitative and economy-wide insights on welfare, income and WEF securities.

Challenges:

- CGE and PE models are highly data intensive and generally require years to develop and constant maintenance
- CGE and PE models can represent important biophysical and economic linkages, but it remains challenges to incorporate and assess all important linkages. An example is feedback effects for climate change from changes in agricultural practices as a result of an intervention in the water or energy sectors
- The use of CGE and PE models for Nexus analysis requires substantial capacity development of end users
- Due to data limitations, some results are only available at the regional and not at the national or sub-national levels where they might be needed or most relevant

In this project, the global CGE model GLOBE, an extended recursive-dynamic version of the comparative-static GLOBE model, was linked with IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) version 3 PE model. The CGE model, in addition to incorporating capital accumulation, population growth, labor force growth and technical progress, features a detailed representation of the technical substitution possibilities in the power sector. IMPACT3 is a modular integrated assessment model, linking information from climate models, crop simulation models and water models to a global, partial equilibrium, multimarket model centered on the agriculture sector. The multimarket model simulates the operation of national and international markets, solving for production, demand, and prices that equate supply and demand across the globe. The joint application of both models allowed to assess interlinkages across the WEF sectors as a result of a shock, specifically considered here was a carbon tax on fossil fuels.

Resources

Project Resource:

Ringler, C., D. Willenbockel, N. Perez, M. Rosegrant, T. Zhu and N. Matthews. 2016. Global linkages among energy, food and water: an economic assessment. *Journal of Environmental Studies and Sciences:* 6(1): 161-171.

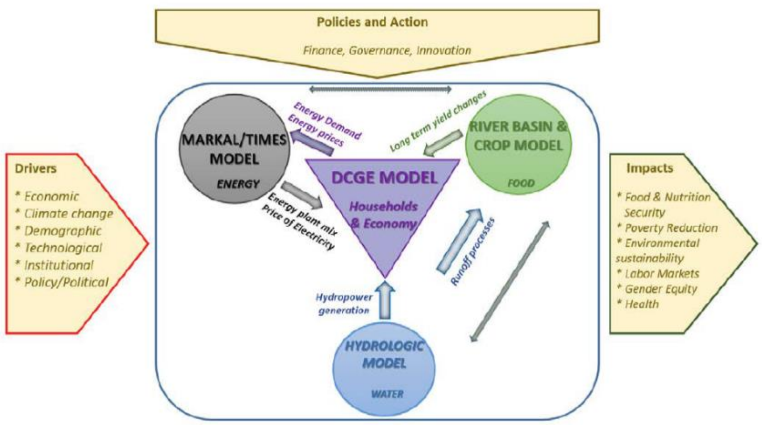
Related Resource:

Willenbockel, D., S. Robinson, D. Mason d'Croz, M.W. Rosegrant, T. Sulser, S. Dunston and N. Cenacchi. 2018. Dynamic computable general equilibrium simulations in support of quantitative foresight modeling to inform the CGIAR research portfolio: Linking the IMPACT and GLOBE models. *IFPRI Discussion Paper 1738*. Washington, DC.: International Food Policy Research Institute (IFPRI).

Computable General Equilibrium (CGE) Modeling

A CGE model represents the national economy-wide structure of production, demand and welfare simulating a competitive economy with flexible prices and market clearing conditions. The national economic structure is reflected in Social Accounting Matrix (SAM) data developed based on the most recent input-output tables and supported by various other macro- and micro-level datasets. Agents represented in the CGE model are consumers who maximize utility, producers who maximize profits, and the government. The economy is connected to the rest of the world via trade and capital flows. The evolution of the economy over time is described by a sequence of single-period static equilibria connected through capital accumulation, changes in the supply of labor and agricultural land, and sector specific technical progress. This project developed a national CGE modeling framework that directly links to water and energy models (Figure 1). For this, three component models were linked with a dynamic recursive CGE model (DCGE): A hydrological model, a river basin management and crop model and an energy systems model (MARKAL or TIMES). The DCGE connects the energy and biophysical components and allows to analyze the impacts of changes in water and energy supply on the economy as a whole and on poverty and income distribution. The DCGE can be used to design water and energy sector and broader economic policies and strategies to support Nexus analysis.

Figure 1 Nexus implementation in the Sudanese CGE model



Source: Al Riffai et al. (2017).

Benefits:

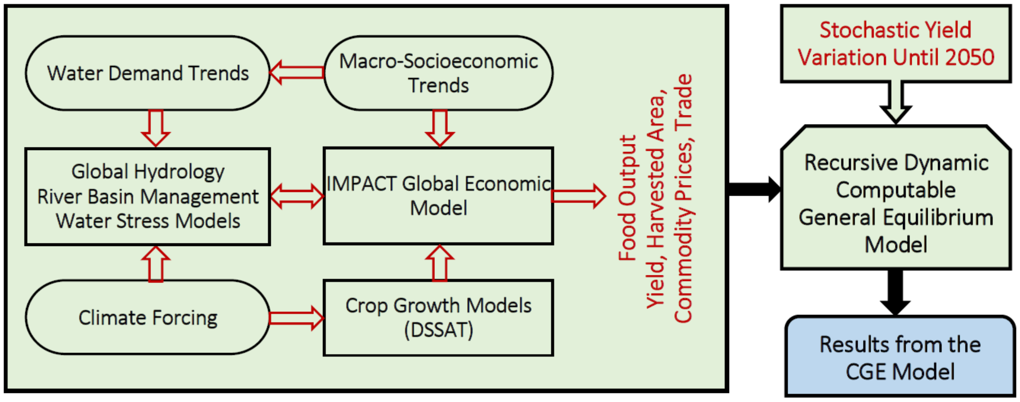
- A CGE model is a government investment planning tools. Linking WEF components with such a modeling system can reach government planning entities, such as Ministries of Finance, relatively easily, and thus can enhance policy uptake.
- A CGE model allows to assess the impact of alternative WEF strategies on the overall economy and welfare, parameters that are of similar interest to government planning entities.

Challenges:

- Ensuring that the biophysical details do not get aggregated, averaged or lost can be a major challenge in such modeling efforts.
- Temporal and spatial boundaries of biophysical models generally do not coincide with those of administrative planning bodies, and maintaining spatial granularity remains a challenge.

The CGE Nexus model was implemented differentially in the different countries of the Easter Nile Basin. For example, in the Sudan, the key Nexus constraints relate to the water and food sectors as they are affected by climate change. Figure 2 describes the CGE-Nexus specification used for the Sudanese case study.

Figure 2 Nexus implementation in the Sudanese CGE model



Source: Siddig et al. (2018).

Resources

Project Resources:

Siddig, K., D. Stepanyan, T. Zhu, M. Wiebelt and H. Grethe. 2018. Climate Change and Agriculture in the Sudan: Impact pathways beyond changes in mean rainfall and temperature. *MENA RP Working Paper 13*. Washington, D.C. and Cairo, Egypt: IFPRI.

Al-Riffai, P., Breisinger, C., Mondal, A., Ringler, C., Wiebelt, M. and T. Zhu. 2017. Linking the Economics of Water, Energy, and Food: A Nexus Modeling Approach. *Egypt SSP Working Paper 04*. Washington DC: IFPRI.

Al-Riffai, P., S. Moussa, A. Khalil; F. Hussein, E. Serag, N. Hassan, A. Fathy, A. Samieh, M. ElSarawy, E. Farouk, S. Souliman, and A. Abdel-Ghafour. 2016. A disaggregated social accounting matrix: 2010/11 for policy analysis in Egypt. *Egypt SSP Working Paper 02*. Washington, DC and Cairo, Egypt: IFPRI.

Siddig, Khalid; Elagra, Samir; Grethe, Harald; and Mubarak, Amel. 2018. A Post-separation Social Accounting Matrix for the Sudan. *MENA RP Working Paper 8*. Washington, D.C. and Cairo, Egypt: IFPRI.

Energy Modeling (MARKAL/TIMES/LEAP)

Energy systems models include energy balance or accounting models, such as the Long-range Energy Alternatives Planning System (LEAP) and energy flow models that include a reference energy system that depicts all activities involved in the production, conversion and utilization of energy for a specific country or region. MARKAL (Market Allocation Model) and TIMES are examples of this type of energy systems models. They allow incorporation of existing as well as future technologies in the system and to assess economic and environmental impacts of alternative energy development pathways. Such models can be loosely connected with CGE models. This project also used economic optimization modeling using GAMS to study the potential of decentralized energy uptake in Ethiopia.

Benefits:

- Energy systems model provide useful insights into energy balances (LEAP) and energy flows (MARKAL/TIMES)

- Optimization models, such as MARKAL/TIMES allow the assessment of impacts on least-cost energy development strategies in response to changes in costs and prices and new technology development
- Economic optimization models, such as GAMS, support the modeling of the informal and decentralized energy sector based on household survey data

Challenges:

- Data needs and skill requirement are high for MARKAL and TIMES models
- Informal sector energy use is not depicted in standard models (but can be assessed in custom-built models)
- Energy technologies are modeled assuming that water resources are available and of sufficient quality. To overcome this challenge such models can be linked with water and food sector models.

This project used LEAP, MARKAL and TIMES to analyze alternative energy development strategies in Egypt and Ethiopia as well as the potential benefit from inter-regional trade in the Eastern Nile Basin. It also developed a GAMS model to assess decentralized energy options in Ethiopia.

Resources

Project Resources:

Mondal, A.H., C. Ringler, P. Al-Riffai, H. Eldidi, C. Breisinger, and M. Wiebelt. 2019. Long-Term Optimization of Egypt's Power Sector: Policy Implications. *Energy*. 166(1): 1063-1073.

Mondal, Md. A. H., E. Bryan, C. Ringler and M. Rosegrant. 2017. Ethiopian power sector development: Renewable based universal electricity access and export strategies: *Renewable and Sustainable Energy Reviews* 75: 11-20.

Mondal, Md. A. H., E. Bryan, C. Ringler, D. Mekonnen and M. Rosegrant. 2018. Ethiopian energy status and demand scenarios: Prospects to improve energy efficiency and mitigate GHG emissions. *Energy* 149: 161-172.

Mondal, A.H. and C. Ringler. Long-term optimization of Eastern Nile Basin regional power sector development: Implications of RETs and cross-border electricity trading. *Under preparation*.

Mirzabaev A., U. Djanibekov, D. Guta and M. Bekchanov (2018). Impacts of decentralized energy use along the Water-Energy-Food Security Nexus in the rural areas of the Nile River Basin in Ethiopia. Case Study Report, Center for Development Research (ZEF), Bonn, Germany. Mimeo.

Hydro-Economic Modeling (HEM)

HEM models typically need a network flow diagram, a series of hydrological data, information on water supply and hydropower infrastructure and operations, information on water demand, information on irrigated crop production, and information on economic costs and benefits of all sectoral water uses modeled. Water demand typically includes irrigation demands (the largest water user in many developing country settings), as well as non-irrigation demands (e.g. domestic and industrial uses) and environmental demand (such as for instream flows). As water allocation processes are subject to institutions and rules these should also be collected and incorporated into the modeling, as feasible.

Benefits:

- A river basin is a quintessential WEF Nexus entity as water is withdrawn from and returns to basin water bodies following its use in irrigated agriculture, hydro-electric generation, and domestic and industrial uses, or has important instream environmental uses
- Results from river basin models can be used straightforwardly for communication with river basin organizations, such as ENTRO or NBI, which are familiar with both input data and typical model outputs
- Allows to bring in views from different sectors, for WEF Nexus analyses, and for complex, cross-sectoral challenges, in general

Challenges:

- It can be challenging to obtain adequate data for water usage in the domestic and industrial sectors and to identify and model environmental needs and impacts from interventions in the WEF sectors
- Both the food and the energy sectors are only partially represented in most HEM, as some renewables (wind/solar) and some non-renewables (coal/gas) are not directly linked to river basin nodes or their water uses are not available. In the food sector. HEM typically focus on irrigated crops, but in many locations rainfed crops continue to dominate food production patterns

The HEM updated and expanded for this project is a transboundary optimization model that maximizes the economic benefits from crop and hydropower production through optimal regulation and allocation of water flows over time, space, and crop activities.

Table 2 Typical HEM Outputs

Category	Outputs
• Water Management	Water balance • Flow by location and time • Reservoir storage, reservoir evaporation • Water withdrawals, return flows Water allocation • Water use by sector, location, time
• Agriculture	• Crop area, yield, and production
• Hydropower	• Hydropower production
• Economic benefits	• Benefits from water use (monetary) • Shadow value of water, by location and time

Resources

Project Resource:

Berga H. 2018. The Water-Energy-Food Nexus in the Eastern Nile Basin: Transboundary Interlinkages, Climate Change and Scope for Cooperation (submitted to University of Bonn dissertation committee). Defense January 25, 2019.

Berga H and C. Ringler. 2017. The Water-Energy-Food Nexus: Opportunities for the Eastern Nile. *Ppt.*

Related Resource:

Arjoon, D., Y. Mohamed, Q. Goor and A. Tilmant. 2014. Hydro-economic risk assessment in the eastern Nile River basin. *Water Resources and Economics* 8: 16-31.

Gendered Agent-based Modeling (Gen-ABM)

Agent-based models (ABMs) simulate the actions and interactions of autonomous agents (both individual or collective entities such as organizations or groups) with a view to assessing their effects on the system as a whole. Gendered ABMs focus on differential actions of women and men in households or larger groups. ABMs typically include: (1) numerous agents specified at various scales; (2) decision-making heuristics; (3) learning rules or adaptive processes; (4) an interaction topology; and (5) an environment. They are generally implemented as computer simulations that show or test how changes in individual behaviors will affect the system's emerging overall behavior.

Benefits:

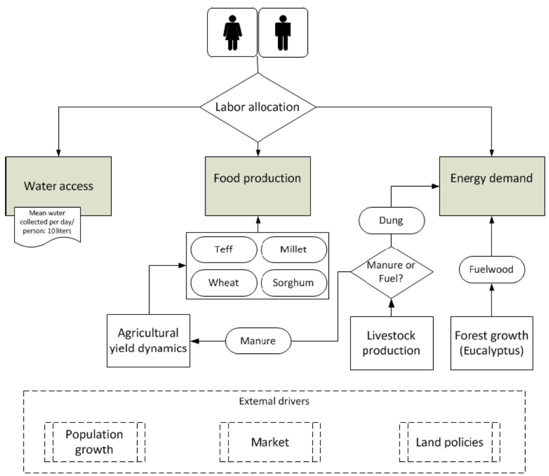
- ABMs can provide insights into the collective behavior of agents
- ABMs are highly flexible in development and application and are used in numerous disciplines
- Given their flexibility they are highly suitable to assess Nexus interactions

Challenges:

- Given the flexibility of ABM development, replicability is a challenge
- ABM verification, calibration and validation are also constraints
- Adequate description of agent interactions can be highly data intensive

This project developed the first ever gendered agent-based model to understand the food-energy-land nexus system in response to the specific decisions of male- and female-headed households in two case study sites of Ethiopia based on the ABM framework depicted in Figure 3.

Figure 3 Gendered ABM framework, Ethiopia case study



Source: Villamor (under review).

Resources

Project Resources:

Villamor, G. B. Gender specific perspectives among smallholder farm households on water-energy-food security nexus issues in Ethiopia. Under review.

Villamor, G.B., D. Guta, U. Djanibekov, and A. Mirzabaev. 2018. Gender specific perspectives among smallholder farm households on water-energy-food security nexus issues in Ethiopia. *ZEF Discussion paper series No. 258*. Bonn: Center for Development Research.

Econometric Approaches

Econometric analysis applies statistical methods for inferring relationships and causality among variables of interest often using large volumes of primary (e.g. household surveys) or secondary data (e.g. statistical data). Econometric analysis is an empirical way for testing theoretical hypotheses. There are numerous econometric techniques which can be applied depending on the nature of the dataset and variables. The major sources of data used in econometric analysis are of three types: cross-sectional (data on many subjects at one point of time), panel (data on many subjects at two or more points of time), and time series (sequence of data on subjects over many points in time). Econometric techniques follow these three types of data sources. All three types of data analyses can be used for Nexus-related studies. However, most econometric studies of the Nexus have used cross-sectional data sources.

Benefits:

- Obtain information about Nexus trade-offs and synergies which are representative at regional or national scales
- Quantitatively explore variations over time, when panel data are available
- Go beyond potentially spurious correlations to infer causality

Challenges:

- High costs of data collection usually through conducting custom-made surveys
- Analyzes only observed information, cannot be used for simulating the future impacts of new, yet unobserved, phenomena
- Requires sufficiently high number of observations for inference. For example, if only a handful of households adopted solar panels, cannot provide reliable conclusions about the drivers or impacts of solar panel adoption
- Standardized responses can miss nuances that are not easily measurable

In this project, econometric analyses were used to identify trade-offs and synergies along the WEF Nexus using a cross-sectional sample of 1,000 households in the Eastern Nile River basin within Ethiopia. Since households make decisions about food and energy production and consumption simultaneously, the major econometric challenge was to infer causality by addressing the confounding effects of such simultaneous decision making.

Resources

Project Resource:

Mirzabaev A., Bensch G. and D. Guta. 2018. Water-Energy-Food Security Nexus trade-offs and synergies in the Nile river basin in Ethiopia. Case Study Report, Center for Development Research (ZEF), Bonn, Germany. Mimeo.

Related Resource:

Mekonnen, D., Bryan, E., Alemu, T. and C. Ringler. 2017. Food versus fuel: examining tradeoffs in the allocation of biomass energy sources to domestic and productive uses in Ethiopia. *Agricultural Economics*, 48(4), 425–435.

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