Introduction to CLEWs

Hands-on lecture 8: Energy, Land and Water system interlinkages

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Tags: CLEWs; Climate; Land; Energy; Water; Systems Modelling; Integrated; Policy Coherence; System interlinkages; Nexus; Hands-on; Climate Compatible Growth; Open Source; Teaching Kit;

Useful links:

1) Discussion forum for CLEWs
2) Results from this Hands-on

Pre-requisites:

1) Successful completion of all the activities under Hands-on lecture 7

Learning outcomes

By the end of this Hands-on, you will be able to:

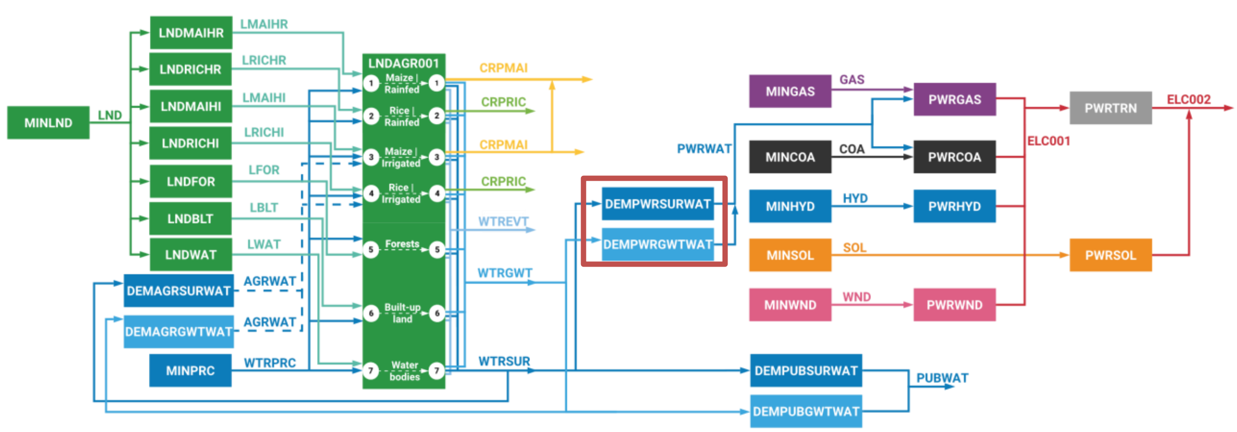
1) Understand the linkages between the energy, water and land systems
2) Represent the interlinkages between the resource systems in a modelling setup
3) Reflect upon the importance of the linkages between the CLEWs systems for the implementation of coherent policies

Overview

Until now, you have been building aspects of energy, land and water systems into the model. In this hands-on, you will create commodities and technologies to represent the interlinkages between the different systems. You will gradually establish the following linkages: water for energy, energy for water, energy for land and land for energy. You may note already now (and reflect upon) that the linkages have a *direction*.

Activity 1 – Water for energy

This activity will introduce the necessary links to capture the water needed for cooling in thermal power plants. The figure below illustrates the new linkages.



You will introduce the following two new technologies and commodity to capture the amount of water that is to be used by the gas and coal power plants.

Name	Entity	Description

DEMPWRSURWAT	Technology	Technology to account for cooling water from surface sources
DEMPWRGWTWAT	Technology	Technology to account for cooling water from underground sources
PWRWAT	Commodity	Water for cooling in thermal power plants

It is essential to note that all the above technologies will operate in **mode 1** (default). The input and output connections between the different technologies are specified below. It is noticeable that coal power plants will consume more water for cooling to generate a unit of electricity than gas plants. Once all the connections are made, rerun the model and visualize the results using the online platform. The focus of this activity is on the results related to the water demand for the power sector.

Technology	**Description**	**Parameters**
DEMPWRSURWAT	Water supply technology that uses 1 unit of WTRSUR to produce 1 unit of PWRWAT	InputActivityRatio & OutputActivityRatio
DEMPWRGWTWAT	Water supply technology that uses 1 unit of WTRGWT to produce 1 unit of PWRWAT	InputActivityRatio & OutputActivityRatio
PWRGAS (Add extra input of 'PWRWAT')	1 unit of activity (PJ) of the gas powerplant requires 0.03 billion m^3 of PWRWAT for cooling	InputActivityRatio
PWRCOA (Add extra input of 'PWRWAT')	**1 unit of activity (PJ) of the coal powerplant** requires 0.05 billion m^3 of PWRWAT for cooling	InputActivityRatio

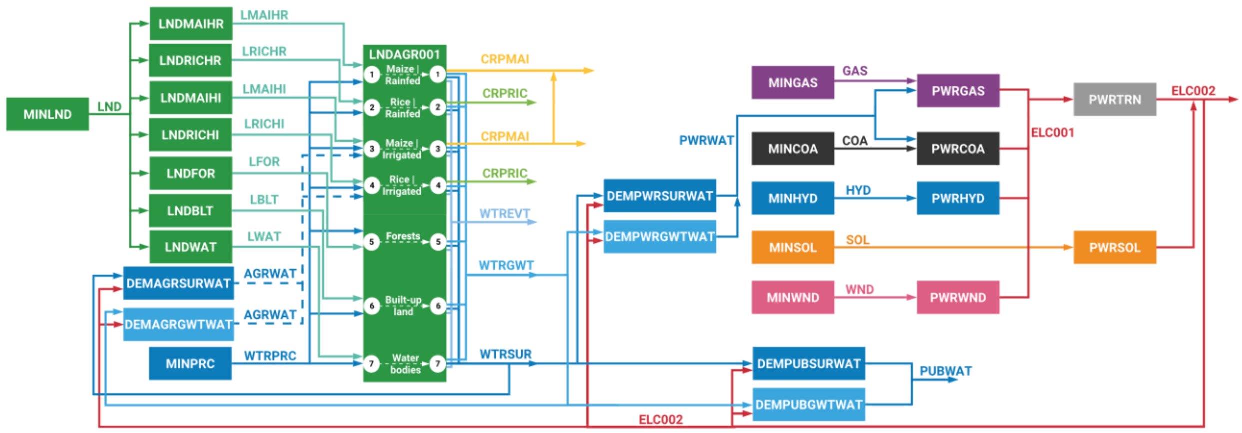
Own reflection

Optional (no deliverable needed)

- Reflect on the link that you introduced in this exercise. Reflect on what messages for planning and policy coherence representing such link could give.
- Reflect on the relevance of this final use of water as compared to other final uses that you introduced previously in the model.

Activity 2 – Energy for Water

This activity will introduce the necessary links to capture the energy (electricity-**ELC002**) needs for different activities in the water system. Energy is needed for pumping water from surface and groundwater sources for irrigation, thermal power plant cooling, and public water supply. The figure below illustrates the new linkages.



It is essential to notice that the energy input is actually the electricity produced by the power plants. This creates a loop in the model that is essential for capturing the energy links. In this activity, no new technologies and commodities will be added, and all the inputs will be in **mode 1**.

The following table details the necessary linkages and ratios that need to be established.

Technology	**Description**	**Parameters**
DEMAGRSURWAT	1 unit of activity of the water technology requires 0.2 PJ of ELC002 for pumping	InputActivityRatio
DEMAGRGWTWAT	1 unit of activity of the water technology requires 0.1 PJ of ELC002 for pumping	InputActivityRatio
DEMPUBSURWAT	1 unit of activity of the water technology requires 0.2 PJ of ELC002 for pumping	InputActivityRatio
DEMPUBGWTWAT	1 unit of activity of the water technology requires 0.1 PJ of ELC002 for pumping	InputActivityRatio

DEMPWRSURWAT	1 unit of activity of the water technology requires 0.2 PJ of ELC002 for pumping	InputActivityRatio
DEMPWRGWTWAT	1 unit of activity of the water technology requires 0.1 PJ of ELC002 for pumping	InputActivityRatio

Once the data entry is complete, rerun the model and visualize the results using the online platform. The focus should be on the increase in electricity demand due to the internal links.

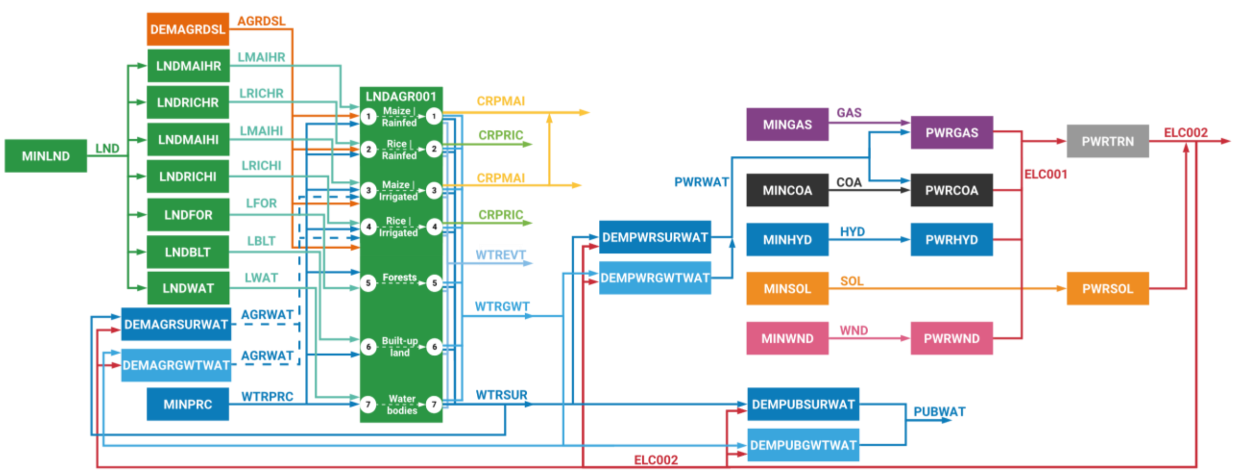
Own reflection

Optional (no deliverable needed)

- Reflect on the linkages that you have introduced in this activity. Are there cases where it would be particularly important to consider these linkages in planning? What can happen if they are not considered?

Activity 3 – Energy for Land

This activity will introduce the necessary links to capture the energy needs for different activities in the land system. Energy (diesel) is used for operating agricultural equipment in the land used for Maize and Rice cultivation. To represent the need for diesel inputs, you will need to create a new technology (DEMAGRDSL) and a commodity (AGRDSL). The figure below illustrates the new linkages.



The new diesel commodity will be consumed by the LNDAGR001 technology, and only in the modes where Maize and Rice are cultivated. It can also be observed that the irrigated land cover types consume more diesel as they use more equipment to manage the higher harvest.

Technology	**Description**	**Mode**	**Parameter**
DEMAGRDSL	1 unit of activity (PJ) produces 1 PJ AGRDSL	1	OutputActivityRatio
LNDAGR001	1 unit of rainfed maize cropland in mode 1 (1000 sq.km) uses 0.08 PJ of diesel (AGRDSL)	1	InputActivityRatio
LNDAGR001	1 unit of rainfed rice cropland in mode 2 (1000 sq.km) uses 0.08 PJ of diesel (AGRDSL)	2	InputActivityRatio
LNDAGR001	1 unit of irrigated maize cropland in mode 3 (1000 sq.km) uses 0.12 PJ of diesel (AGRDSL)	3	InputActivityRatio
LNDAGR001	1 unit of irrigated rice cropland in mode 4 (1000 sq.km) uses 0.12 PJ of diesel (AGRDSL)	4	InputActivityRatio

Once the data entry is complete, rerun the model and visualize the results using the online platform. The focus should be on the diesel consumption in the agricultural sector.

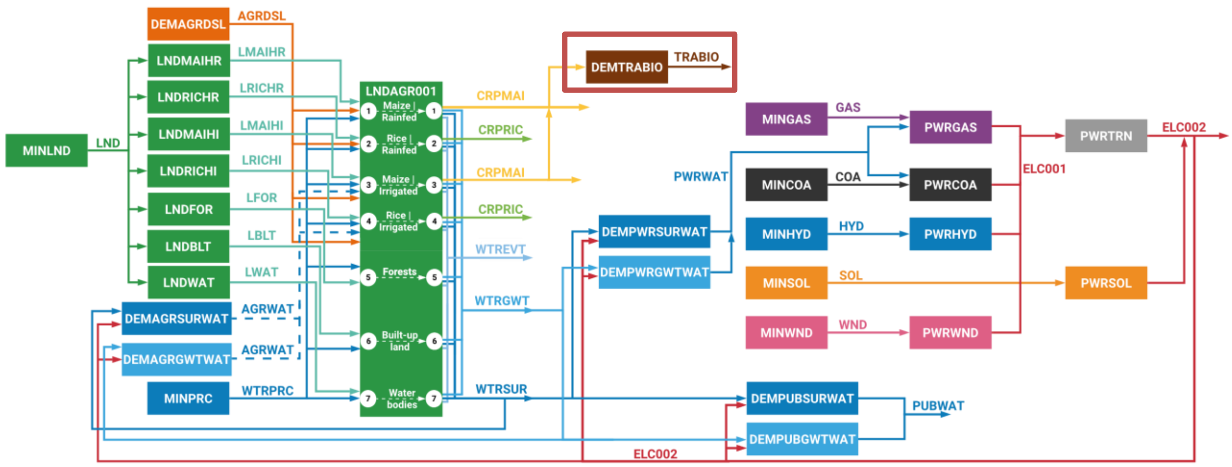
Own reflection

Optional (no deliverable needed)

- Reflect on the link that you introduced in this activity. How can one such link affect the energy supply matrix of a region/country?
- Why can it be important to consider this link in planning and in climate mitigation policies?

Activity 4 – Land for Energy

This activity will introduce the necessary links to capture the land area needs for energy-related activities. We will take the example of using Maize to produce biofuel for consumption in the transport sector. The actual process of producing biofuel from food crops has many intermediate steps. Therefore, a simplistic representation of a complex biofuel chain is employed to explain the systemic inter-linkages.



In this activity, you will add a new technology (DEMTRABIO) to represent in a simplified and aggregated fashion the set of steps that convert Maize to a new biofuel (TRABIO) commodity. From now, there will be competition for land to grow Maize for the purpose of food and biofuel production. Here, we will assume that the demand for biofuel (TRABIO) increases from 30 PJ in 2019 at an annual growth rate of 2% until 2022. You will use the parameter "**AccumulatedAnnualDemand**" to include the biofuel demand in the model. The table below details the different inputs and outputs relevant for the representation of this biofuel chain.

Technology	Commodity	Mode	Description	Parameter
DEMTRABIO	CRPMAI	1	1 Million tonnes of Maize (CRPMAI) is used to produce 6 PJ of biofuel (TRABIO)	InputActivityRatio
	TRABIO	1		OutputActivityRatio

Once the data entry is complete, rerun the model and visualize the results using the online platform. The focus should be on the land allocated for Maize cultivation to meet the demands for both food crops and biofuel.

Own reflection

Optional (no deliverable needed)

- Reflect on the link you have introduced in this Activity. Why is it important to consider this link in planning? Does introducing this link unveil potential conflicts in land uses? If so, can you think of real-life examples?