Introduction to CLEWs

Hands-on lecture 6: Introduction to the land system

V2.0

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Disclaimer: These worksheets have been adapted from work kindly provided by the United Nations Department of Economic and Social Affairs (UNDESA) and KTH Royal Institute of Technology.

Cite as: K. Alexander, D. Darmawan, G. Ifeanyi, S. Savanur, C. Lo Guidice, F. Gardumi, E. Ramos, T. Alfstad, L. Martindale, 'Introduction to CLEWs Hands on lecture 6: Introduction to the land system, Climate Compatible Growth, 2025. DOI: 10.5281/zenodo.17551498.

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

Useful links:

1) Energy Modelling Community (EMC) Discourse Forum – please use this for any CLEWs-related discussions, especially troubleshooting queries!
2) EMC LinkedIn.
3) CCG YouTube.
4) Hands-on Solutions can be found here.

Pre-requisites:

1) Successful completion of all the activities under Hands-on Lecture 5.

Learning outcomes

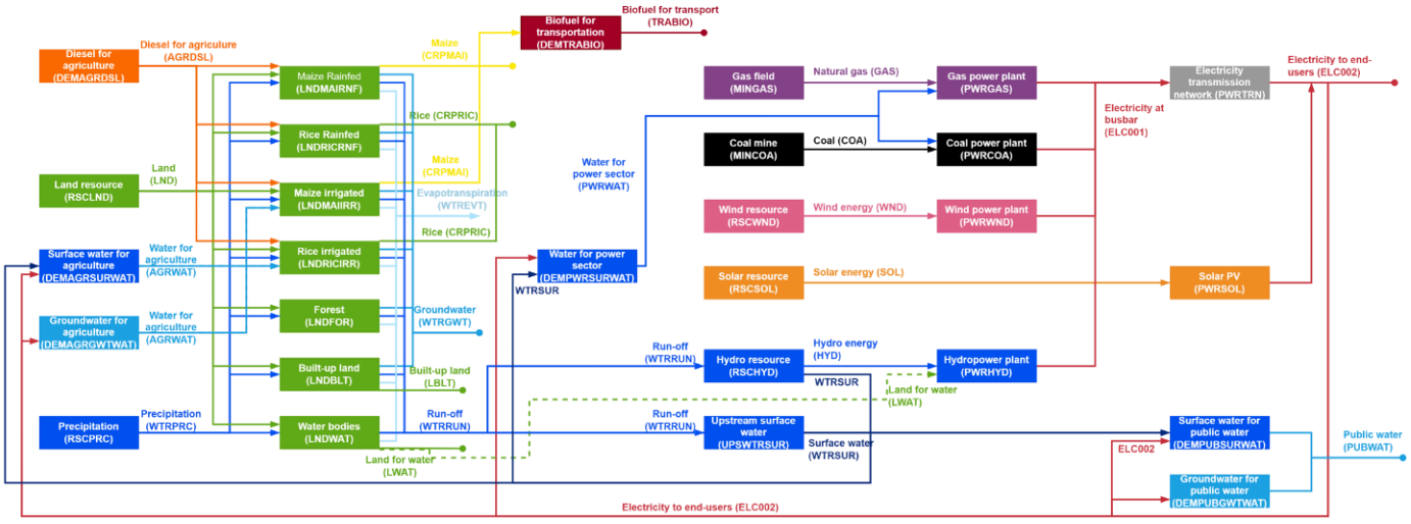
By the end of this exercise, you will be able to:

1) Explain basic concepts of land systems
2) Create an engineering and simplified representation of land systems on a CLEWs model
3) Understand implications of land use planning on other CLEW systems

Overview

Until now, you have been building the aspects of an energy system into the model. From this hands-on exercise, you will create commodities and technologies to represent land-cover and land-use in the CLEWs model. Additionally, you will learn how to differentiate between the rainfed and irrigated land representations in the model.

Reminder of the RCLEWs you are working towards:

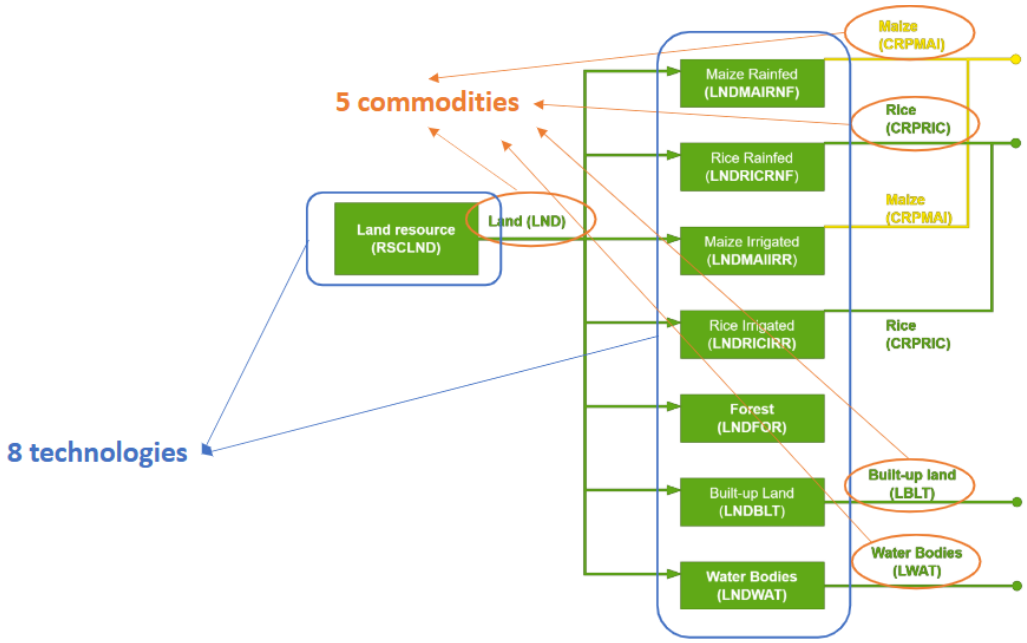


Before starting the work on land use representation, you will have to copy the model you created in the previous hands-on section, as a reminder:

1. Go to the left panel and click on the 'Home' button.
2. Click on 'Copy Model' to copy/clone your last model.
3. Go to the left panel and click on 'Configure model'.
4. Update the model name and description as you wish, then save the changes by clicking on 'Update model data'.
5. Make sure to back up your previous model also (as a .zip)!

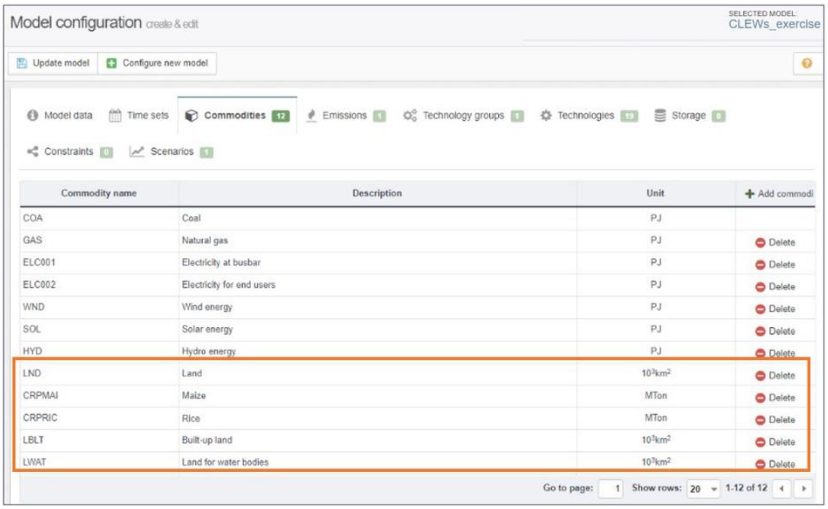
Activity 1 – Introducing agricultural and non-agricultural land-use types

This exercise involves the creation of new commodities and technologies to represent the land system. Land use is split into different land categories and includes cultivation technologies that produce food crops to meet nutritional demands.



1. In the "**Configure model**" section, select the "**Commodities**" tab to add the 5 commodities of the land system (lines in the diagram).

    - LND - Land ($10^3 km^2$)
    - CRPMAI - Maize (MTon)
    - CRPRIC - Rice (MTon)
    - LBLT - Built-up Land ($10^3 km^2$)
    - LWAT - Land for Water Bodies ($10^3 km^2$)



2. Select **"Update model"** to save your edits.

3. In the "**Configure model**" window, select the "**Technologies**" tab and **create 8 technologies** (boxes in the diagram) using the **"+ Add technology**" button to the right. **"Update model"** to save.

Technology	Description	Technology Group	Unit Capacity	Unit Activity	Input Activity Ratio	Output Activity Ratio
RSCLND	Land resource	-	10^3 km^2	10^3 km^2	-	LND
LNDMAIRNF	Rainfed maize cultivation	-	10^3 km^2	10^3 km^2	LND	CRPMAI
LNDRICRNF	Rainfed rice cultivation	-	10^3 km^2	10^3 km^2	LND	CRPRIC
LNDMAIIRR	Irrigated maize cultivation	-	10^3 km^2	10^3 km^2	LND	CRPMAI
LNDRICIRR	Irrigated rice cultivation	-	10^3 km^2	10^3 km^2	LND	CRPRIC
LNDFOR	Forest land	-	10^3 km^2	10^3 km^2	LND	-
LNDBLT	Built-up land	-	10^3 km^2	10^3 km^2	LND	LBLT
LNDWAT	Water bodies	-	10^3 km^2	10^3 km^2	LND	LWAT

4. Create a "Technology group" in the respective tab in "Model configuration" named **"Land use"** and assign it to the land technologies according to the table below. "**Update Model**" to save the technology group, and again after assigning the technologies to it.

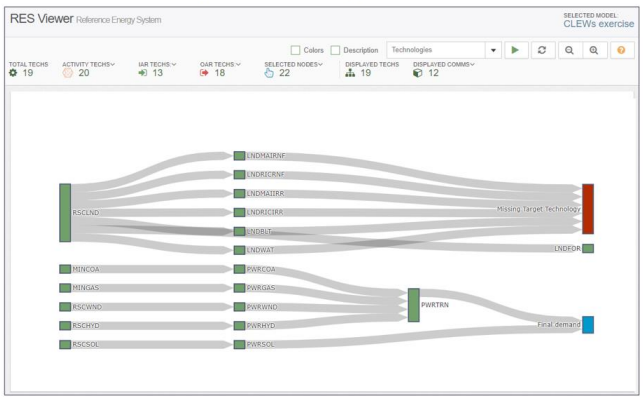
5. The “Technology” tab, with the new technologies added, **should look something like:**

Storage 0 Constraints 0 Scenarios 1

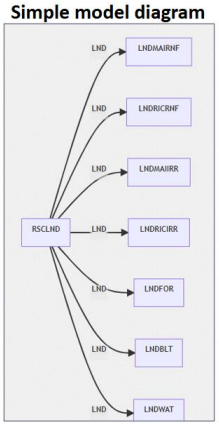
Technolo	Description	Technol…	Unit of …	Unit of …	Input Activit…	Output Activ…	Input To N…	Input To T…	Emission …	Add tech
LNDWAT	Water Bodies	Land Use	10^3km^2	10^3km^2	LND	LWAT				Delete
LNDBLT	Built-up Land	Land Use	10^3km^2	10^3km^2	LND	LBLT				Delete
LNDFOR	Forest Land	Land Use	10^3km^2	10^3km^2	LND					Delete
LNDRICIRR	Irrigated Rice	Land Use	10^3km^2	10^3km^2	LND	CRPRIC				Delete
LNDMAIIRR	Irrigated Maize	Land Use	10^3km^2	10^3km^2	LND	CRPMAI				Delete
LNDRICR…	Rainfed Rice	Land Use	10^3km^2	10^3km^2	LND	CRPRIC				Delete
LNDMAIR…	Rainfed Maize	Land Use	10^3km^2	10^3km^2	LND	CRPMAI				Delete
RSCLND	Land Resource	Land Use	GW	PJ		LND				Delete

6. At this stage, you can visualise the “Model diagram” with the land system sets created.

Dynamic model diagram



Simple model diagram

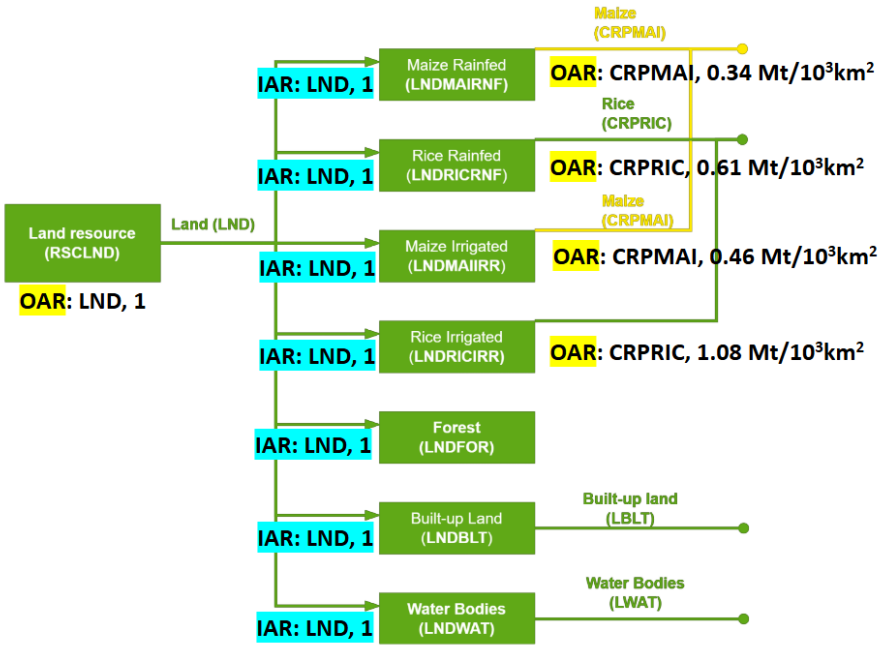


Since there are no interlinkages defined between the Energy system and the Land system, these show separately in the “Simple” view.

7. Add the values for the parameters “Input Activity Ratio” and “Output Activity Ratio”.

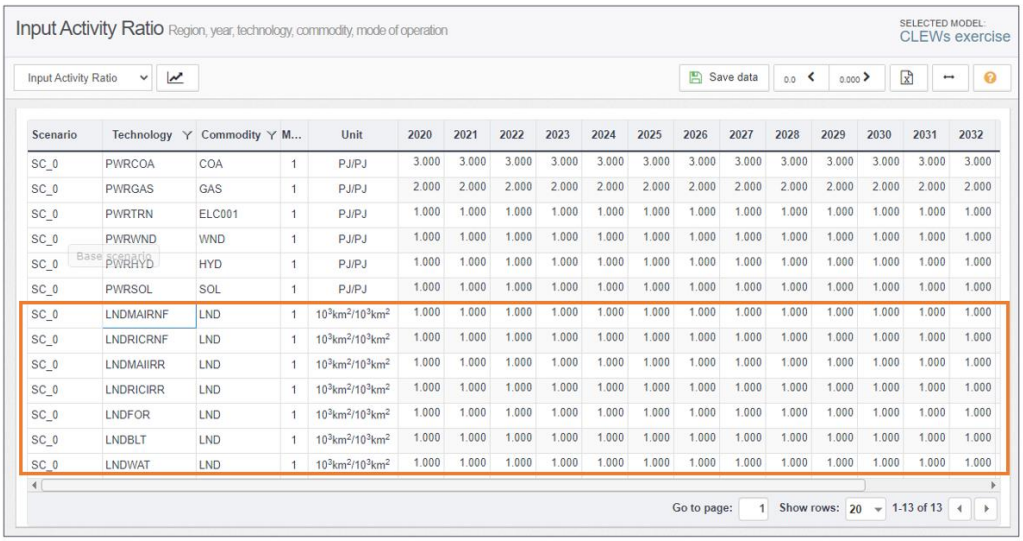
8. Starting with “**Input activity Ratio**”, note that all land cover technologies have the commodity “Land”(LND) as an input with a value of 1 (or 10^3km^2), while the land resource technology, “RSCLND”, has an output of 1.

    - This means that for each unit of land that enters a land cover technology, an equivalent amount must be produced by “RSCLND”. The amount of land allocated to the different land uses is therefore limited to the amount of land available from the land resource
    - *Example:* if 7 x 10^3km^2 of land is available from the land resource, the sum of land allocated to the 7 different land cover types cannot exceed this number.



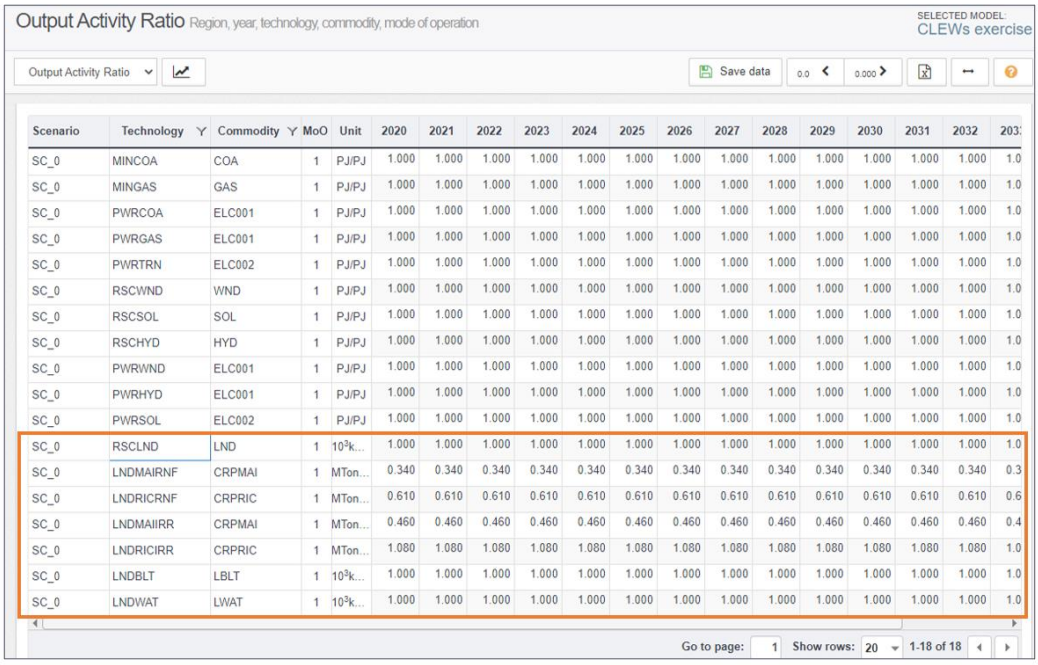
9. To add the "**Input Activity Ratios**" for the land technologies, go to "**Data entry**" and search for the parameter's name. Add inputs according to the table below, then click "**Save data**" to save your edits.

Technology	Commodity	MoO	Unit	Input Activity Ratio (2020-2035)
LNDMAIRNF	LND	1	10^3km^2 / 10^3km^2	1
LNDRICRNF	LND	1	10^3km^2 / 10^3km^2	1
LNDMAIIRR	LND	1	10^3km^2 / 10^3km^2	1
LNDRICIRR	LND	1	10^3km^2 / 10^3km^2	1
LNDFOR	LND	1	10^3km^2 / 10^3km^2	1
LNDBLT	LND	1	10^3km^2 / 10^3km^2	1
LNDWAT	LND	1	10^3km^2 / 10^3km^2	1



10. To add the "**Output Activity Ratios**" for the land technologies, go to "**Data entry**" and search for the parameter's name. Add outputs according to the table below, then click "**Save data**" to save your edits. Note that the technologies indicating cropland have an output of crops, which is different from one. That output is the crop 'yield', that is, the quantity of the crop (in MTon) produced by one land unit.

Technology	Commodity	MoO	Unit	Output Activity Ratio (2020-2035)
RSCLND	LND	1	10^3km^2 / 10^3km^2	1
LNDMAIRNF	CRPMAI	1	Mton / 10^3km^2	0.34
LNDRICRNF	CRPRIC	1	Mton / 10^3km^2	0.61
LNDMAIIRR	CRPMAI	1	Mton / 10^3km^2	0.46
LNDRICIRR	CRPRIC	1	Mton / 10^3km^2	1.08
LNDBLT	LBLT	1	10^3km^2 / 10^3km^2	1
LNDWAT	LWAT	1	10^3km^2 / 10^3km^2	1



Output Activity Ratio Region, year, technology, commodity, mode of operation

SELECTED MODEL: CLEWs exercise

Output Activity Ratio | Save data

Scenario	Technology	Commodity	MoO	Unit	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	203
SC_0	MINCOA	COA	1	PJ/PJ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	MINGAS	GAS	1	PJ/PJ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	PWRCOA	ELC001	1	PJ/PJ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	PWRGAS	ELC001	1	PJ/PJ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	PWRTRN	ELC002	1	PJ/PJ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	RSCWND	WND	1	PJ/PJ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	RSCSOL	SOL	1	PJ/PJ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	RSCHYD	HYD	1	PJ/PJ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	PWRWND	ELC001	1	PJ/PJ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	PWRHYD	ELC001	1	PJ/PJ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	PWRSOL	ELC002	1	PJ/PJ	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	RSCLND	LND	1	10^3k...	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	LNDMAIRNF	CRPMAI	1	MTon...	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.3
SC_0	LNDRICRNF	CRPRIC	1	MTon...	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.6
SC_0	LNDMAIIRR	CRPMAI	1	MTon...	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.4
SC_0	LNDRICIRR	CRPRIC	1	MTon...	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.0
SC_0	LNDBLT	LBLT	1	10^3k...	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0
SC_0	LNDWAT	LWAT	1	10^3k...	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0

Go to page: 1 Show rows: 20 1-18 of 18

Activity 2– Introducing crop demands and land-use demands

Two crops are produced from agricultural activities:

- Maize and Rice.
- The annual crop production demands are estimated based on the annual per capita consumption and population growth.

A) Crop Assumptions:

- Maize per capita consumption (2020) = 20kg /capita/year
- Rice per capita consumption (2020) = 80kg /capita/year
- Population (2020) = 18,000,000 inhabitants
- Population annual growth rate = 2%

Calculation example:

"Maize demand (2020) = 20 kg * 10-9 Mt/kg * 18 * 106 = 0.360 Mt/year"

"Rice demand (2020) = 80 kg * 10-9 Mt/kg * 18 * 106 = 1.440 Mt/year"

Then there are "demands" to input for land representing built-up and water bodies:

B) **Built-up Land Assumptions:**

- In the reference year, 5% of the country's area had built infrastructure.
- Over the modelling period, this area increases at a rate of 1% per year (somewhat following the increasing trend in economic activity and population).

C) **Water Bodies Assumptions:**

- Water bodies cover 25,000 km² of the country's area.
- Since there is no economic incentive for the model to maintain this area, a demand is created for the area to be maintained (which means we are assuming that the water bodies are not shrinking).

1. Open the Excel doc named "CLEWs OU Data File", and in the sheet "Assumptions", go to line #220, with the title "Exogenous demands in the model". Find the demands for maize (CRPMAI), rice (CRPRIC), built-up land (LBLT) and water bodies (LWAT).

2. Add the data to "**Accumulated Annual Demand**" in the respective commodities. Go to "**Data entry**" to find the parameter. "**Save data**" after adding the demands.

Scenario	Commodity	Unit	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
SC_0	COA	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
SC_0	GAS	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
SC_0	ELC001	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
SC_0	ELC002	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
SC_0	WND	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
SC_0	SOL	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
SC_0	HYD	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
SC_0	LND	10^3km^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
SC_0	CRPMAI	10^3km^2	0.360	0.367	0.375	0.382	0.390	0.397	0.405	0.414	0.422	0.430	0.439	0.448	0.457	0.466	0.475	0.48
SC_0	CRPRIC	10^3km^2	1.440	1.469	1.498	1.528	1.559	1.590	1.622	1.654	1.687	1.721	1.755	1.790	1.826	1.863	1.900	1.93
SC_0	LBLT	10^3km^2	15.000	15.150	15.300	15.450	15.610	15.770	15.920	16.080	16.240	16.410	16.570	16.740	16.900	17.070	17.240	17.41
SC_0	LWAT	10^3km^2	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.00

Activity 3 – Running the Model

Firstly, copy your previous model and name it accordingly.

This is the first time running the model containing both the energy system and the initial representation of the land system of the CLEWs model.

NOTE: Refer back to the previous hands-on if you have forgotten how to view results.

In this activity, you should explore the results for **three variables**:

1. **Use By Technology By Mode**: Shows the use of input commodities to a technology by mode of operation. In this exercise, it will inform on the **amount of land area ($10^3 km^2$) used in the different land covers**.

a) Change the graph from default (Accumulated New Capacity) to **'Use by Technology by Mode'.**
b) Filter case (right click and go to field settings) to only the case run for HO6.
c) Add Technology Description and untick Tech from **Columns** (or leave as tech if you want the naming conventions on your graph).
d) Add Commodity to **Filters** and filter out for only **LND**.
e) You should now see a result for how much land is being used by each technology. **Create a view** and give it a nice title, then you can save that view and download the graph if you wish!

2. **Production By Technology By Mode**: Shows the number of outputs produced by a technology. In this exercise, it will inform on the **volume of crops (MTon) produced by each cropland type** (i.e., rainfed and/or irrigated).

a) Again, you should follow a similar process as above. However, you want to **filter out commodities to only CRPMAI and CRPRIC.**