

CLEWs

Hands-on lecture 6: Introduction to the land system

Useful links:

- 1) Link to open [Momani](#) in the local computer
- 2) [Discussion forum](#) for OSeMOSYS
- 3) [Results from this Hands-on](#)

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:

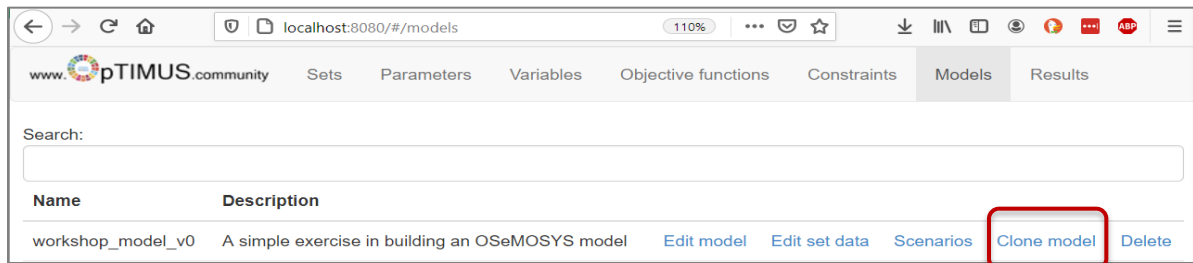
- 1) Understand the concept of modes-of-operation from a land-use perspective
- 2) Add technologies to represent the different land-use categories
- 3) Add commodities to represent land and the different outputs like crops

Overview

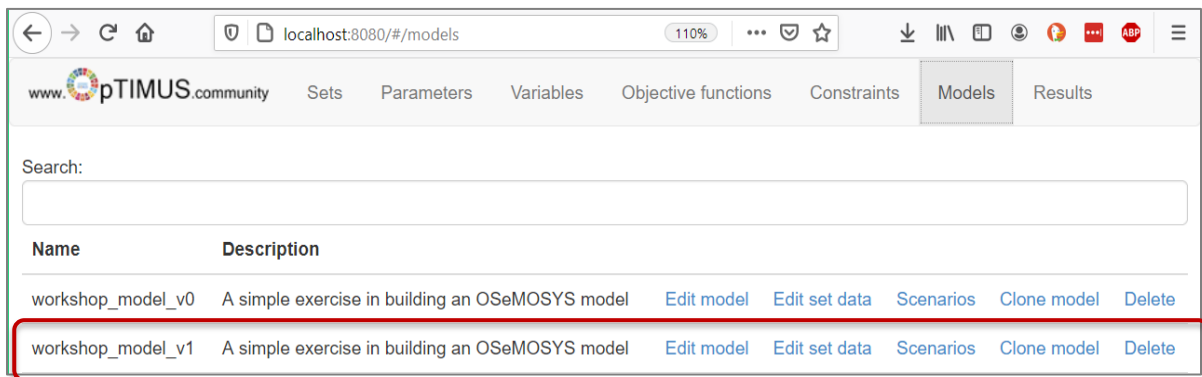
Until now, You have been building the aspects of an energy system into the model. From this hands-on exercise, you will create commodities and technologies to represent land-cover and land-use in the CLEWs model. Additionally, you will learn how to differentiate between the rainfed and irrigated land representations in the model. Before you dive into the land representations, it is essential to recollect the concepts of modes-of-operation and how to use them. Kindly refer to the fourth section of lecture 6 (6.4) for detailed information on why and how modes of operation are used.

Before starting the work on land use representation, you will have to clone the model you created in the previous hands-on section.

NOTE! Clone your model before starting hands-on lecture 6



Enter a name and continue hands-on lecture 6 on this new version



Note: From now, after successfully completing each activity, you will have to create a new version of the model by cloning it.

Activity 1 – Introducing rainfed landcover types

This activity will introduce the following structure to the existing model that includes only the power system.



You will be adding the following new technologies to the model.

- MINLND: The land resource technology (used to account for the total available land).
- LNDMAIHR: An accounting technology that keeps a tab on the land used for rainfed Maize cultivation.
- LNDRIHR: An accounting technology that keeps a tab on the land used for rainfed Rice cultivation.
- LNDAGR001: The technology where we specify the difference between the various land-cover types.

You will also add the following commodities

- CRPMAI: Commodity that represents the Maize crop
- CRPRIC: Commodity that represents the Rice (Paddy) crop
- LMAIHR: Land representing rainfed maize cultivation
- LRIHR: Land representing rainfed rice cultivation
- LND: Central land resource

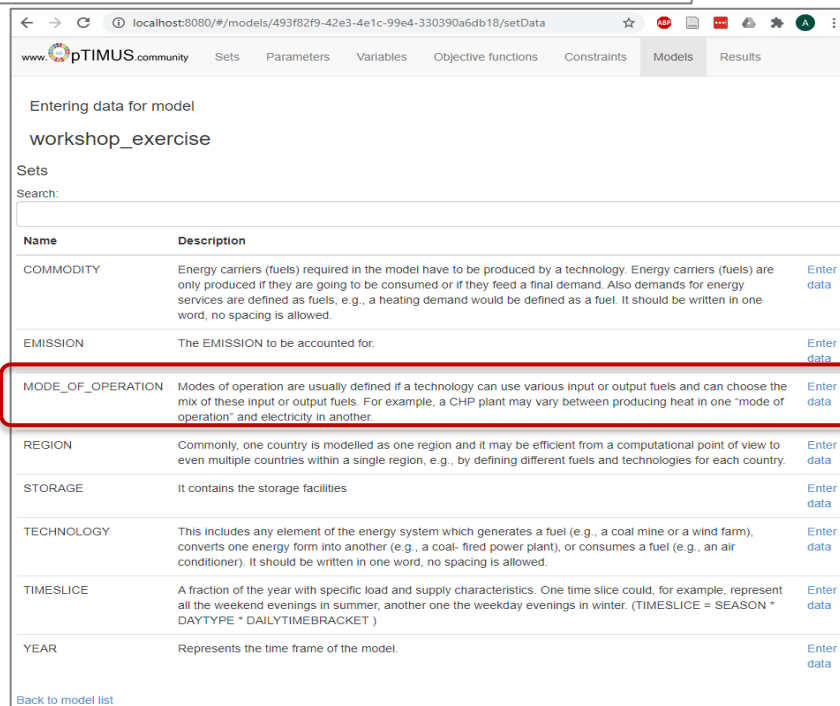
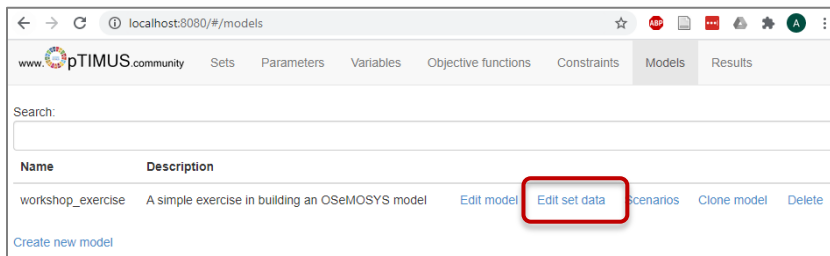
In this activity, you will introduce two types of rainfed crops: Maize and Rice. This is the first step in introducing land cover. Therefore, we begin with the rainfed categories and will gradually introduce the irrigated options. Similar to the energy systems, you will have to add the technologies and commodities for the land system using the **“Edit set data”** tab under the newly cloned model. When in doubt, please refer to **Hands-on lecture 3** on how to introduce technologies and commodities.

After you have added the new technologies and commodities, the modes of operation need to be created. For this, we again will have to refer to the **“Edit set data”** tab and create two new modes that will represent the land allocated for rainfed maize and rice cultivation.

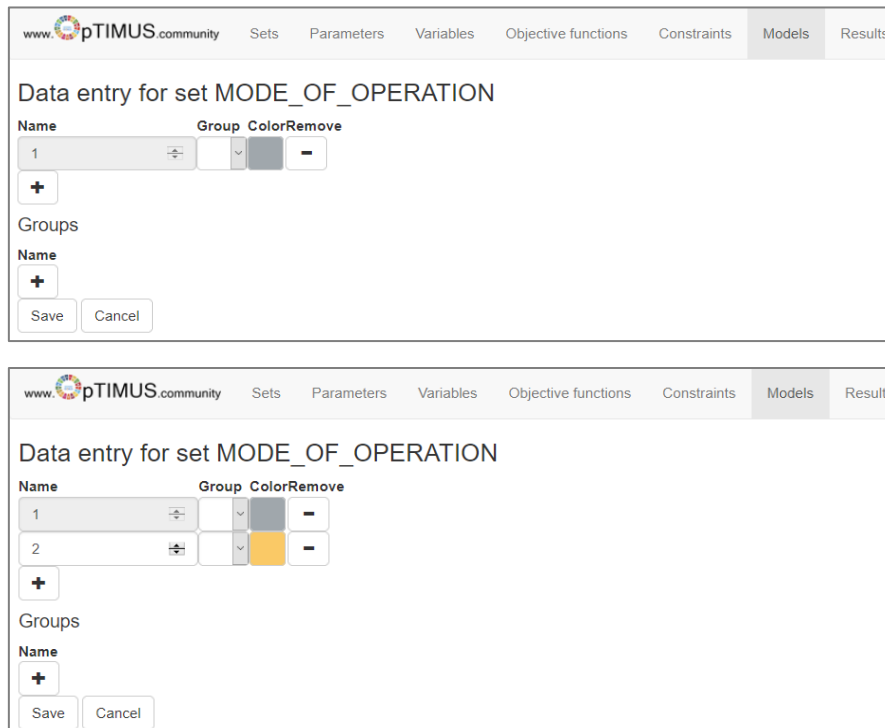
Modes to be used:

- Mode 1: represents land allocated to rain-fed Maize cultivation (the mode is already defined from previous activities, no need to define it)
- Mode 2: represents land allocated to rain-fed Rice cultivation (new, to be added)

The following figures can be used to guide on how to add the modes of operation.



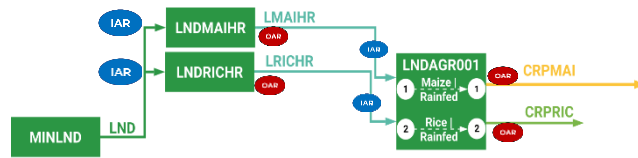
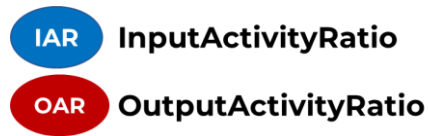
Please use the “+” button in the “set MODE_OF_OPERATION” screen to add a new mode, as shown in the figures below. After including the two modes, click on the “save” button to save the new additions.



After adding the new technologies, commodities and modes, the next step is to start including the data for the newly added entities. You will start from the demand side by adding demands for the two crops Maize and Rice.

| Commodity | Value | Parameter used |
|----------------|------------------------|-------------------------|
| CRPMAI (Maize) | 40 Million tonnes (Mt) | AccumulatedAnnualDemand |
| CRPRIC (Rice) | 30 Million tonnes (Mt) | AccumulatedAnnualDemand |

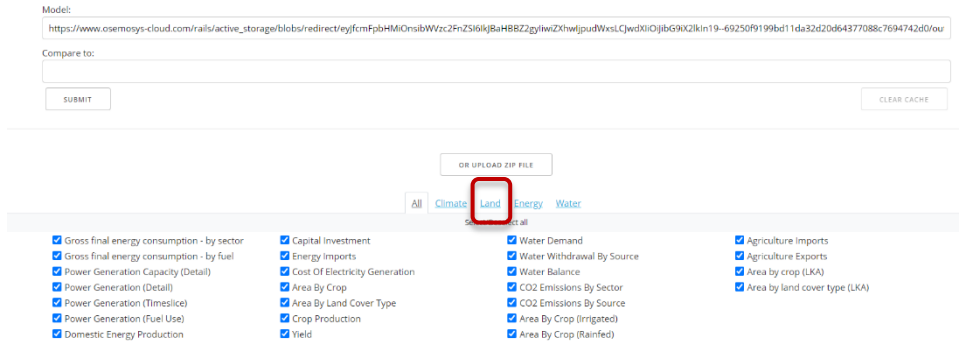
The “**AccumulatedAnnualDemand**” parameter is used for those commodities with no requirement for the demand to be met in a particular “**TimeSlice**”, unlike electricity demand in the energy system. It is important to note that the crop demand, in this exercise, is expected to remain the same for all the years. The parameter AccumulatedAnnualDemand can be found in the same place where you found the other parameters like Input and output activity ratios. In the next step, you will have to enter the input and output activity ratios for the technologies detailed below. Most of them will be in the unit of 1000 sq. km land per 1000 sq. km activity. That is, the intended unit for the activity of land technologies is 1000 sq. km.



| Technology | Commodity | Mode Of Operation | Value | Parameter |
|------------|-----------|-------------------|--------------------------|---------------------|
| MINLND | LND | 1 | 1 1000sq.km/1000sq.km | OutputActivityRatio |
| LNDMAIHR | LND | 1 | 1 1000sq.km/1000sq.km | InputActivityRatio |
| LNDRICHR | LND | 1 | 1 1000sq.km/1000sq.km | InputActivityRatio |
| LNDMAIHR | LMAIHR | 1 | 1 1000sq.km/1000sq.km | OutputActivityRatio |
| LNDRICHR | LRICHR | 1 | 1 1000sq.km/1000sq.km | OutputActivityRatio |
| LNDAGR001 | LMAIHR | 1 | 1 1000sq.km/1000sq.km | InputActivityRatio |
| LNDAGR001 | LRICHR | 2 | 1 1000sq.km/1000sq.km | InputActivityRatio |
| LNDAGR001 | CRPMAI | 1 | 0.8 Mt/1000sq.km | OutputActivityRatio |
| LNDAGR001 | CRPRIC | 2 | 0.2 Mt/1000sq.km | OutputActivityRatio |

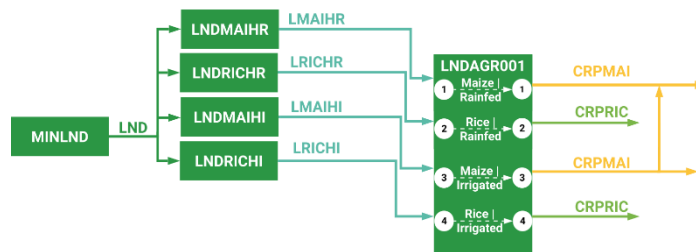
It must be noted that the default mode of operation is “1”. Unless specified, all the parameters will be defined for the first mode. In the table above, we can notice that the modes are different only for the technology **“LNDAGR001”**, where modes are essential. Every unit of land in this model is equal to 1000sq.km. This arrangement is made to minimize the number of digits used to represent the value. Effectively, in this setup, the technology LNDAGR001 takes 1 unit of land allocated for rainfed maize (as input) and produces 0.8 million tonnes of CRPMAI (Maize) in mode 1.

Now, you will make another optimization run of the model by following the same steps that you performed for the previous activity. After the model run is completed, please analyze the results. To visualize only the results of the land system, you can choose the land category in the visualization platform after the results are loaded (as shown in the following figure).



Activity 2– Introducing irrigated landcover types

In this activity, you will add two more modes of operation to include irrigated land cover types. In addition to the 1st and 2nd, you will add modes 3 and 4 to include the irrigated alternatives for Maize and Rice crop, as shown in the following figure.



You will first need to add two new modes by following the same process described in **Activity 1**. Additionally, you will add two technologies and two commodities to account for the land allocated to the irrigated land cover types.

Technologies to be added:

- LNDMAIHI: An accounting technology that keeps a tab on the land used for irrigated Maize cultivation.
- LNDRIHI: An accounting technology that keeps a tab on the land used for irrigated Rice cultivation.



Commodities to be added:

- LMAIHI: Land representing irrigated maize cultivation
- LRICHI: Land representing irrigated rice cultivation

It is important to note that for each of the modes in the LNDAGR001 technology, a pair of technology and commodity will need to be created to account for the land allocated to that mode. It is essential to note that these accounting technologies can also be used to specify capital and fixed costs for land. This will be discussed at a later stage.

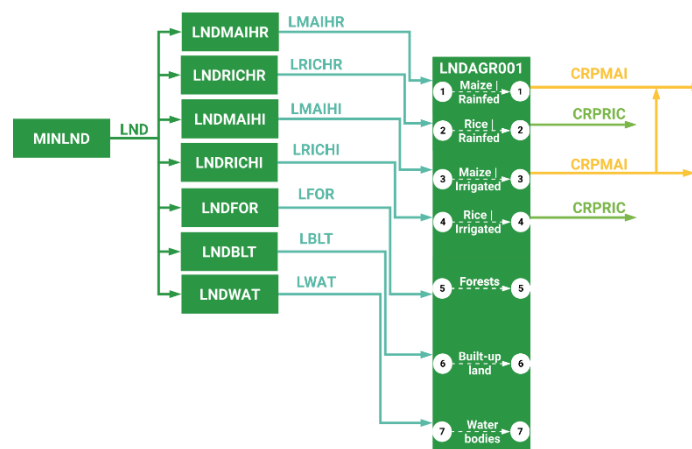
Please note that the outputs for Maize crop in modes 1 and 3 are the same commodity. As you might have guessed by now, the only difference between the rainfed and irrigated modes will be the improvement in crop yield, which will be represented by using the output activity ratios. The table below details the necessary inputs.

| Technology | Commodity | Mode Of Operation | Value | Parameter |
|------------|-----------|-------------------|--------------------------|---------------------|
| LNDMAIHI | LND | 1 | 1 1000sq.km/1000sq.km | InputActivityRatio |
| LNDRICHI | LND | 1 | 1 1000sq.km/1000sq.km | InputActivityRatio |
| LNDMAIHI | LMAIHI | 1 | 1 1000sq.km/1000sq.km | OutputActivityRatio |
| LNDRICHI | LRICHI | 1 | 1 1000sq.km/1000sq.km | OutputActivityRatio |
| LNDAGR001 | LMAIHI | 3 | 1 1000sq.km/1000sq.km | InputActivityRatio |
| LNDAGR001 | LRICHI | 4 | 1 1000sq.km/1000sq.km | InputActivityRatio |
| LNDAGR001 | CRPMAI | 3 | 1 Mt/1000 sq.km | OutputActivityRatio |
| LNDAGR001 | CRPRIC | 4 | 0.4 Mt/1000 sq.km | OutputActivityRatio |

Now that you have input all the data for the two new modes let us rerun the model through the [OSeMOSYS online platform](#). Follow the same procedure as in the last activity to set up a new optimization run and analyze the model results.

Activity 3– Introducing non-agricultural land cover types

In this activity, you will add three more modes of operation to include other non-agricultural land cover types like forests, built-up land and water bodies. The three new types will be in modes 5, 6 and 7, respectively.



Similar to **“Activity 1 & 2”**, you will have to add three new modes of operation using the **“Edit set data”** tab. After the modes are defined, the next step is to introduce the necessary connections, as illustrated in the figure above. In this setup, there are no expected outputs from the forests, built-up lands and water bodies. Therefore, only the technologies and commodities used for accounting have to be created and connected.

Technologies to be added:

- LNDFOR: An accounting technology that keeps a tab on the forest land cover.
- LNDBLT: An accounting technology that keeps a tab on the built-up land.
- LNDWAT: An accounting technology that keeps a tab on the area covered by water bodies.

Commodities to be added:

- LFOR: Land representing forests
- LBLT: Land representing built-up areas
- LWAT: Land representing areas of water bodies



Additionally, we will introduce a cost (**variable cost**) for the Forest mode. This value will be equal to USD -2 Million per unit of land. A negative value is provided to tell the model that it is beneficial to have land allocated to the forest category. Additionally, we will also include a value to signify the total land available for allocation. This value is set to 300 units each year. You will have to use the **“TotalTechnologyAnnualActivityUpperLimit”** parameter to specify the limit for the total land available.

| Technology | Commodity | Mode Of Operation | Value | Parameter |
|------------|-----------|-------------------|------------------------|---|
| LNDFOR | LND | 1 | 1 | InputActivityRatio |
| LNDBLT | LND | 1 | 1 | InputActivityRatio |
| LNDWAT | LND | 1 | 1 | InputActivityRatio |
| LNDFOR | LFOR | 1 | 1 | OutputActivityRatio |
| LNDBLT | LBLT | 1 | 1 | OutputActivityRatio |
| LNDWAT | LWAT | 1 | 1 | OutputActivityRatio |
| LNDAGR001 | LFOR | 5 | 1 | InputActivityRatio |
| LNDAGR001 | LBLT | 6 | 1 | InputActivityRatio |
| LNDAGR001 | LWAT | 7 | 1 | InputActivityRatio |
| LNDAGR001 | - | 5 | -2 MUSD/ 1000 sq.km | VariableCost |
| MINLND | - | - | 300 (1000 sq.km) | TotalTechnologyAnnual ActivityUpperLimit |

After the above data is inside the model, save it and rerun it on the cloud platform to visualize the results.