



# Introduction to CLEWs

## Hands-on lecture 6: Introduction to the land system

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### V1.2.0

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### V1.3.0

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**Tags:** CLEWs; Climate; Land; Energy; Water; Systems Modelling; Integrated; Policy Coherence; Land system; 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 5



# Learning outcomes

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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

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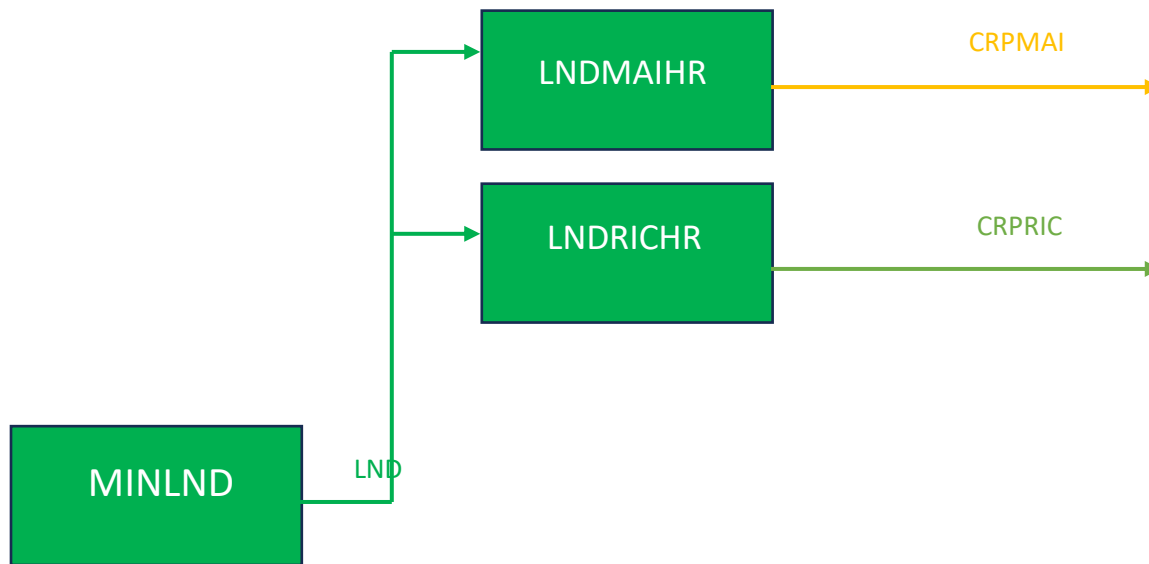
Until now, you have been building the aspects of an energy system into the model. From this hands-on exercise, you will create commodities and technologies to represent land-cover and land-use in the CLEWs model. Additionally, you will learn how to differentiate between the rainfed and irrigated land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

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 left panel and click on 'Configure model'.
4. Update the model name and description and save the changes by clicking in 'Update model data'.

# Activity 1 – Introducing rainfed landcover types

This activity will introduce the following structure to the existing model that includes only the power system, as shown in the image below.



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.
LNDRICHR	An accounting technology that keeps a tab on the land used for rainfed Rice cultivation.

You will also add the following **Commodities**

CRPMAI	Commodity that represents the Maize crop
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CRPRIC	Commodity that represents the Rice (Paddy) crop
LND	Central land resource

You will introduce two types of rainfed crops: Maize and Rice. This is the first step in introducing land cover. Similar to the energy systems, you will have to add the technologies and commodities for the land system using the **“Define model configuration”** in the newly cloned model.

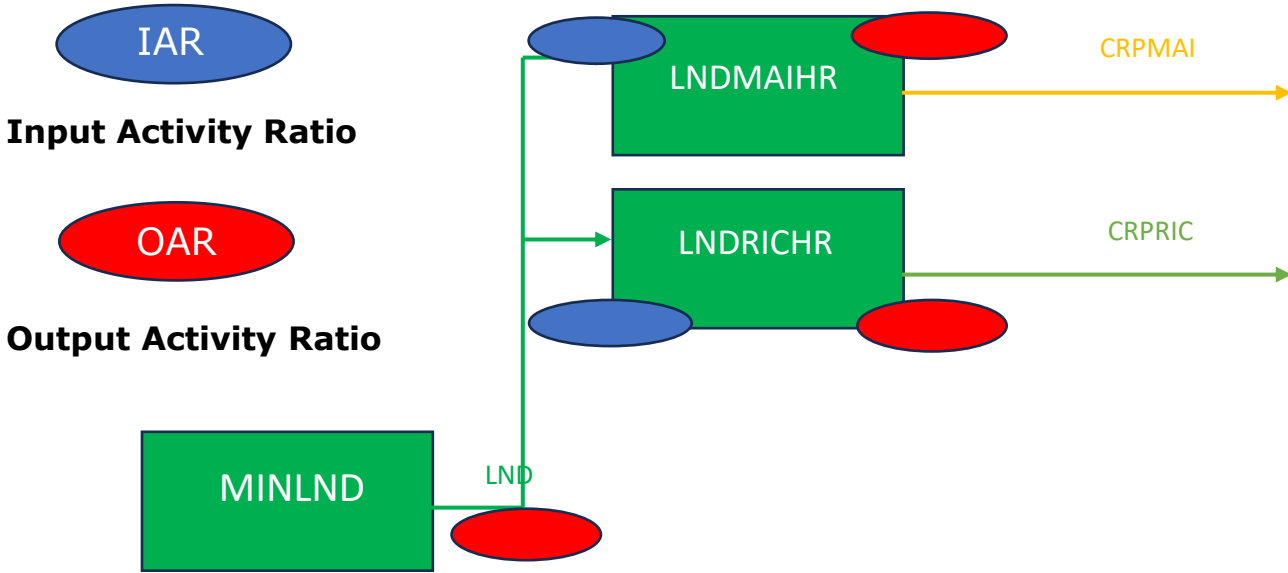
After you have added the new technologies and commodities. Save the changes by clicking in ‘Update model data’.

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	Value	Parameter
MINLND	LND	1 1000sq.km/1000sq.km	OutputActivityRatio
LNDMAIHR	LND	1 1000sq.km/1000sq.km	InputActivityRatio
LNDRICHR	LND	1 1000sq.km/1000sq.km	InputActivityRatio
LNDMAIHR	CRPMAI	0.8 Mt/1000sq.km	OutputActivityRatio
LNDRICHR	CRPRIC	0.2 Mt/1000sq.km	OutputActivityRatio

It must be noted that the default mode of operation is "1". In previous iterations of this course, modes of operation made an important part of the model. **You do not need to worry about this**, as the connections between technologies and commodities are now made without them.

**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 LNDMAIHR takes 1 unit of land allocated for rainfed maize (as input) and produces 0.8 million tonnes of CRPMAI (Maize).

**Now, generate a Case for this model, download the data file and run it (if you do not recall how, kindly go back to Activity 3 of Hands-on lecture 3).**

## Own reflection

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### **Optional (no deliverable needed)**

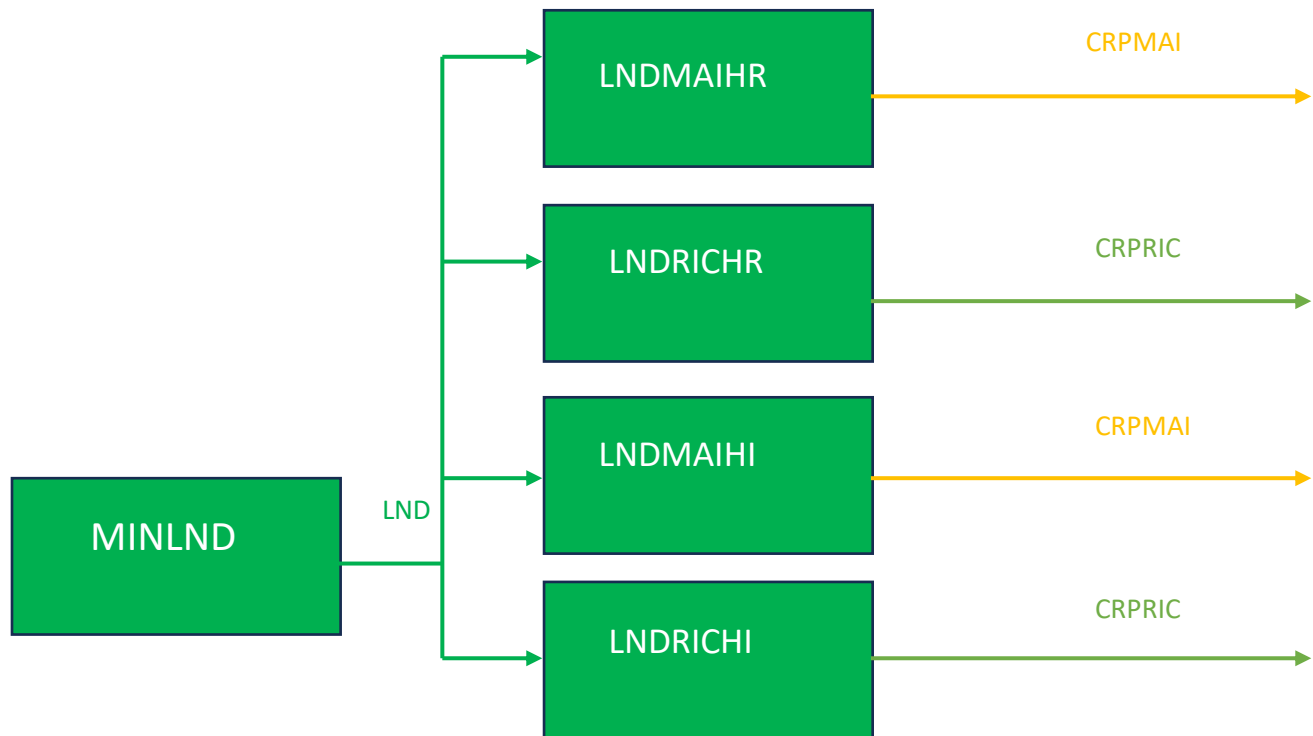
- Reflect on the potential and limitations of such representation of land uses and whether there are other possible approaches.
- What demands are driving the land uses? Which input parameters you gave represented the link between land use and crop production?

## Activity 2– Introducing irrigated land cover types

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**Before you start with the Activity, copy the model from the previous Activity. Make sure you do this every time you start a new activity (and name accordingly).**

In this activity, you will add two irrigated land cover types. In addition to the rainfed land cover types, you will now include the irrigated alternatives for Maize and Rice crop, as shown in the following figure.



You will first need to add the two new land cover types in the same way you did for activity 1, adding two technologies to account for the land allocated to the irrigated land cover types, **as you have already added the necessary commodities.**

**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.

These **accounting** technologies are introduced to allow the user to specify capital and fixed costs for each land use type.

Please note that the outputs for both the rainfed and irrigated Maize crop 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	Value	Parameter
LNDMAIHI	LND	1 1000sq.km/1000sq.km	InputActivityRatio
LNDRICHI	LND	1 1000sq.km/1000sq.km	InputActivityRatio
LNDMAIHI	CRPMAI	1 Mt/1000 sq.km	OutputActivityRatio
LNDRICHI	CRPRIC	0.4 Mt/1000 sq.km	OutputActivityRatio

**Now, generate a Case for this model, download the data file and run it (if you do not recall how, kindly go back to Activity 3 of Hands-on lecture 3).**

## Own reflection

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### Optional (no deliverable needed)

- Elaborate on the differences between irrigated and rainfed crops, regarding water use and yield.
- Elaborate more on the structure of the land model you are creating: why do you think the land technologies (e.g. LNDMAIHR) are represented in the model the way they are? Do you think anything is missing in the inputs you gave so far? Is there a way you are accounting for potential limits in available land for different uses?





# Activity 3– Introducing costs for crop types

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***Firstly, copy your previous model and name it accordingly.***

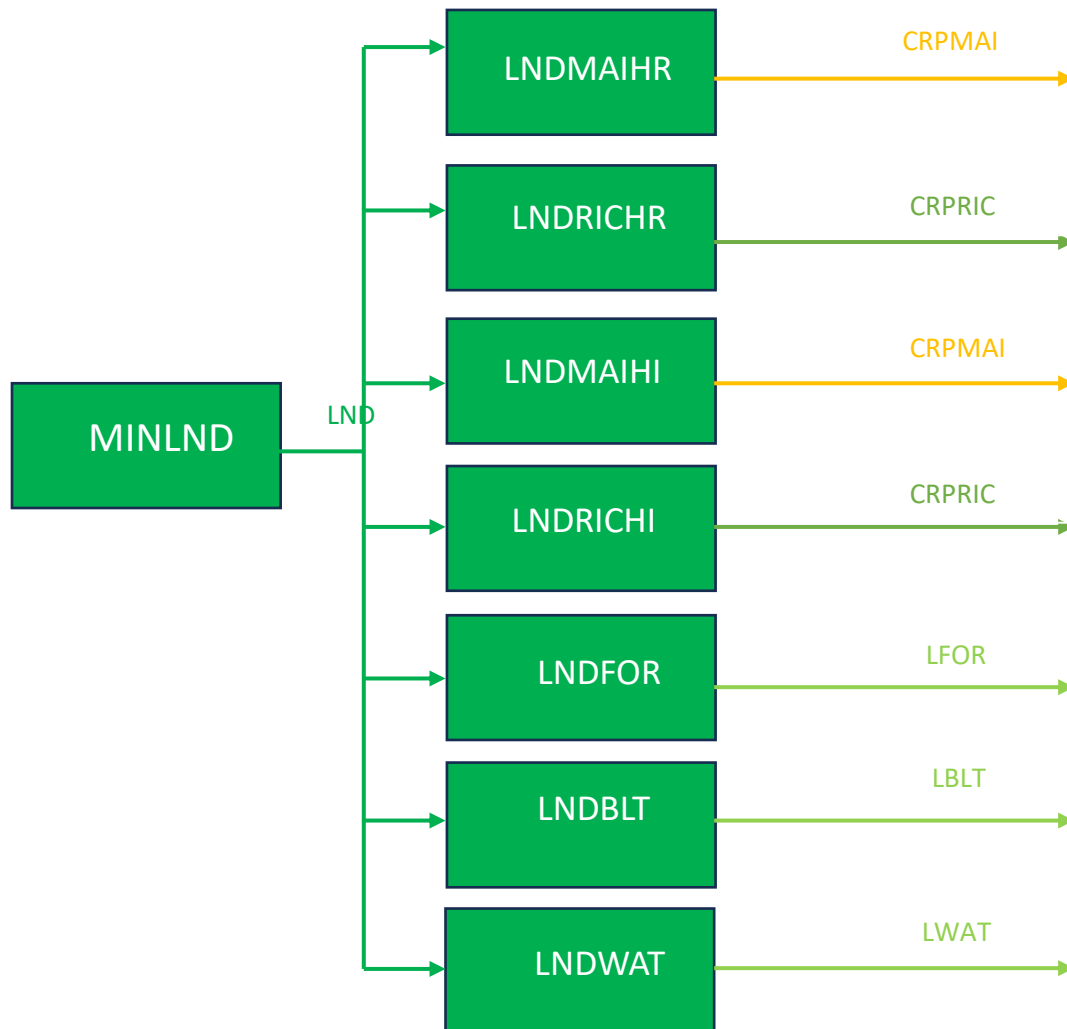
In this exercise, you will add **capital costs** for both rainfed and irrigated crops. This will simply represent the cost differences between each crop type. Add the following data below to your model.

	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>
<b>Rainfed Crops</b>	10	10	10	10
<b>Irrigated Crops</b>	20	20	20	20

***Now run your model again as you have done previously. Have your results for area by crop type changed?***

# Activity 4– Introducing non-agricultural land cover types

In this exercise, you will add three (other) non-agricultural land cover types like forests, built-up land and water bodies.



Firstly, you need to introduce the necessary connections, as illustrated in the RCD 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, introduce a cost (**variable cost**) for the commodity LNDFOR. 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, you will also include a value to signify the total land available for allocation. This value is set to 300 units each year and is added to the technology representing the total land available, that is, MINLND. You will have to use the "TotalTechnologyAnnualActivityUpperLimit" parameter to specify the limit for the total land available. All the inputs you need to give are summarised in the below table



Technology	Commodity	Value	Parameter
LNDFOR	LND	1	InputActivityRatio
LNDBLT	LND	1	InputActivityRatio
LNDWAT	LND	1	InputActivityRatio
LNDFOR	LFOR	1	OutputActivityRatio
LNDBLT	LBLT	1	OutputActivityRatio
LNDWAT	LWAT	1	OutputActivityRatio
LNDFOR	-	-2 Million USD/1000 sq.km	VariableCost
MINLND	-	300 (1000 sq.km)	TotalTechnologyAnnual ActivityUpperLimit

**Now, generate a Case for this model, download the data file and run it (if you do not recall how, kindly go back to Activity 3 of Hands-on lecture 3).**

## Own reflection

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### Optional (no deliverable needed)

- What types of dynamics in land uses (e.g. changes in land uses, conflicts in land uses, or anything else) is one able to see with this model structure?
- You may reflect on the benefits and drawbacks of this type of simplified representation.