

LandsimMoz Prototype

Technical Manual

version 1
September 2019

 **Anitidæ**
landscapes & value chains

 **cirad**

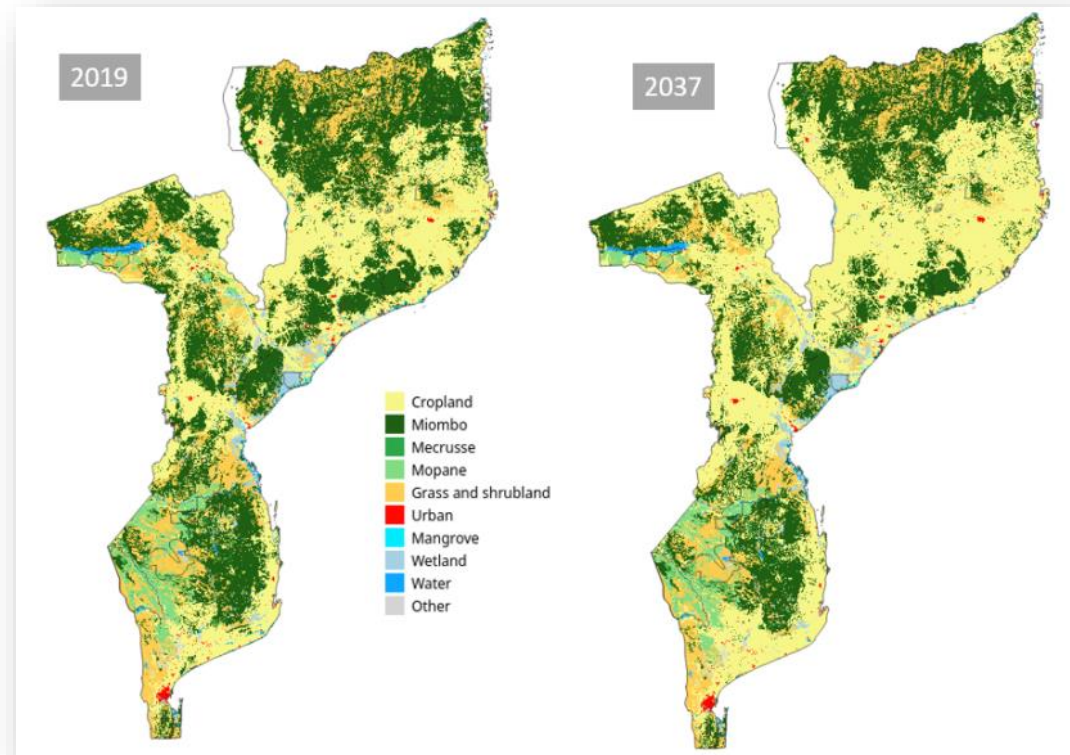
Summary

*This **technical manual** present the functionalities of LandsimMoz Prototype. After a brief presentation of the conceptual model every user panel are described with the specific requirements. A detail description of the various module is presented hereafter.*

The tool is constantly improving, this technical manual reflects the september version of the prototype.

Outline

- 1/ Basic characteristics of LandSIM-P
- 2/ Technical Manual
- 3/ Module description



Aknowledgments

This work is a product of the LAUREL project funded by the World Bank. The authors would like to thank all the people in Mozambique who have made the effort to help provide the data and expert opinion during the past two years. In particular, we would like to thank the researchers and technicians at FNDS, DINOTER and UEM, and many others, who have all provided invaluable commentary and input during this process.

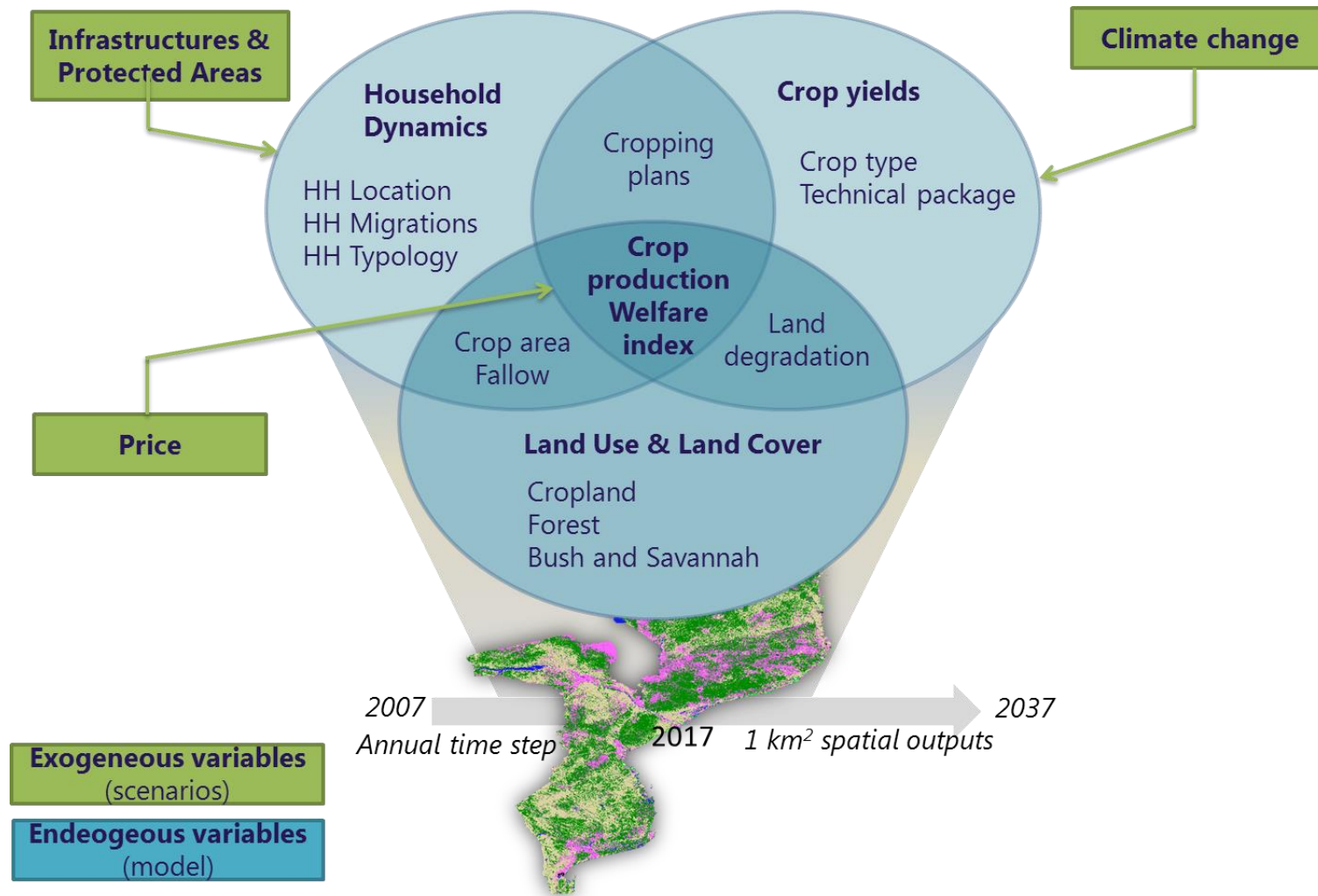
Basic characteristics of LANDSIM-P

- Developed for simulating and evaluating land use change processes at landscape scale over the entire country
- Built on a spatially-distributed household (HH) model
- Uses 4 groups (typologies) of rural households:
 - Subsistence
 - Some Cash Crop
 - Some Livestock
 - Small Emerging Farmers
- The country is discretized into spatial units of 1 km² (~ 800 000 cells)
- Each 1 km² cell contains a « population » of HH for each of the 4 types, with corresponding number of household members and cropped area
- Simulation period up to 2037 with 1 year time step

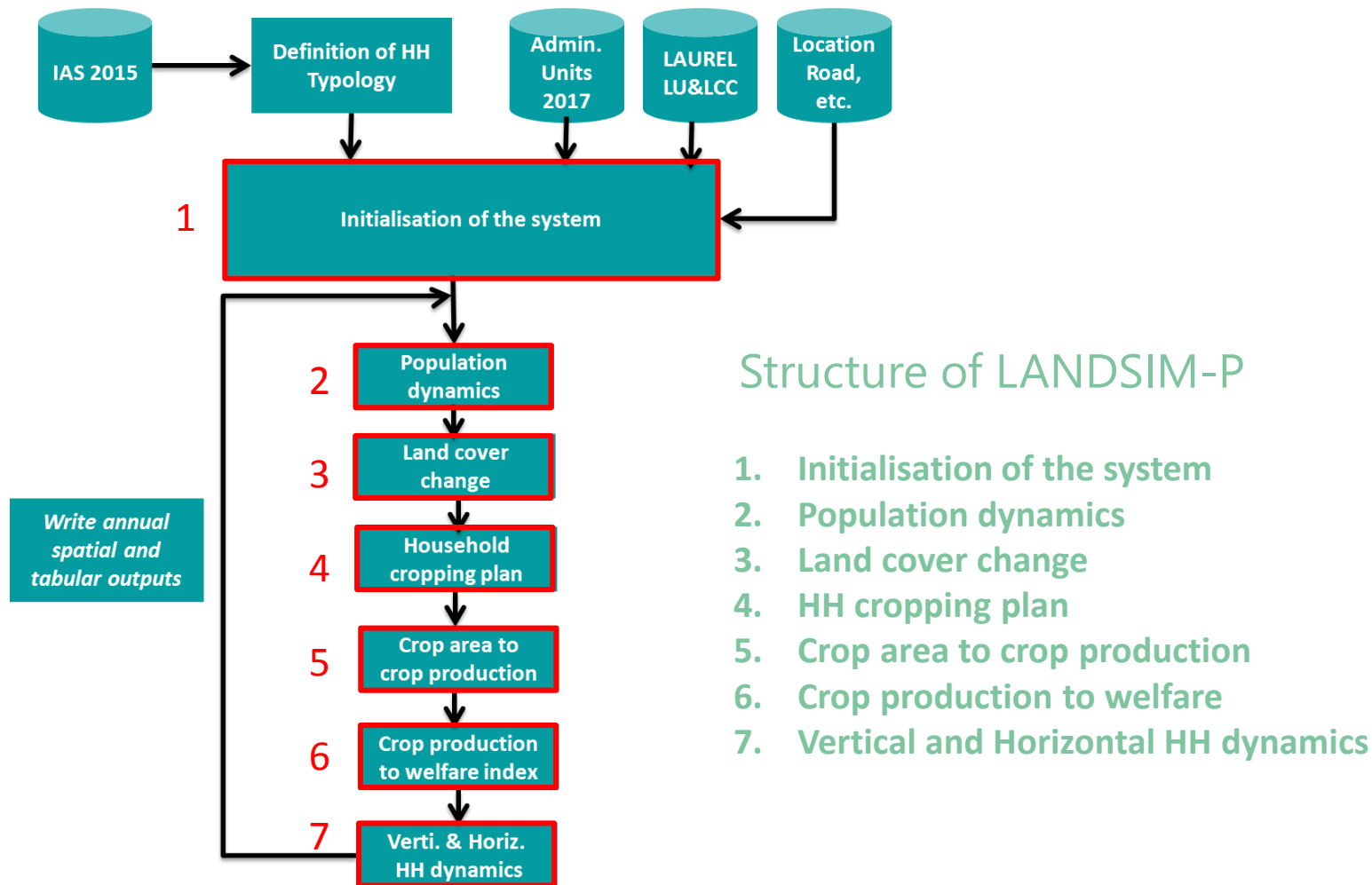
Highlights

- An ad-hoc spatially-explicit tool to simulate the impacts of interventions and policies at national scale and “fine” resolution (1 km²)
- Use to draw “visions” of stakeholders to facilitate concertation on land use planning options
- Integration of a large collection of national datasets (i.e. INE 2007, INE 2017, IAS, 2015, administrative data, LAUREL C1 products)
- Integrates various modules that have been specifically developed for Mozambique (e.g. population dynamics, household behaviors, land cover change, food production, welfare) and that provide a more sophisticated forecasting

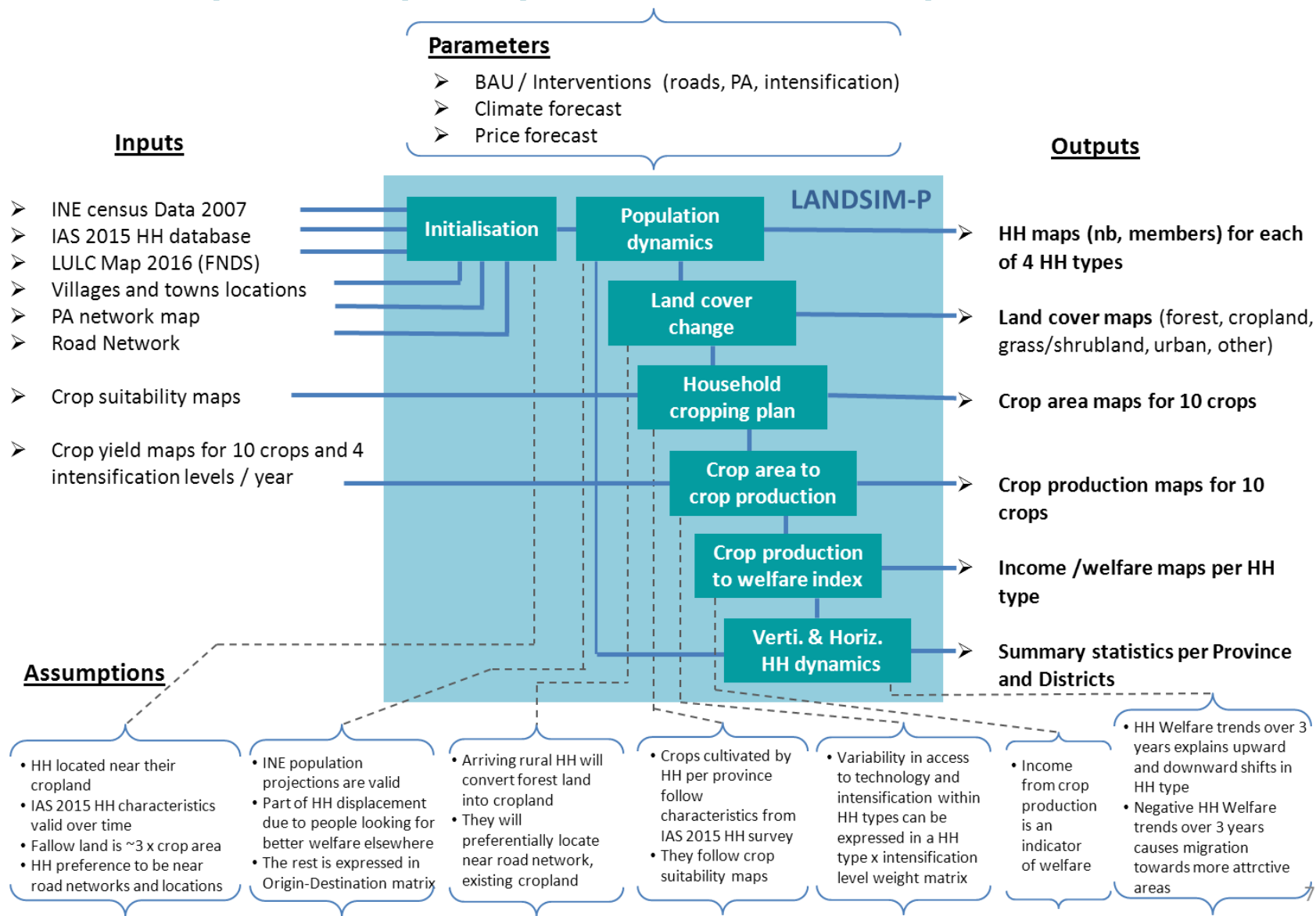
Conceptual framework



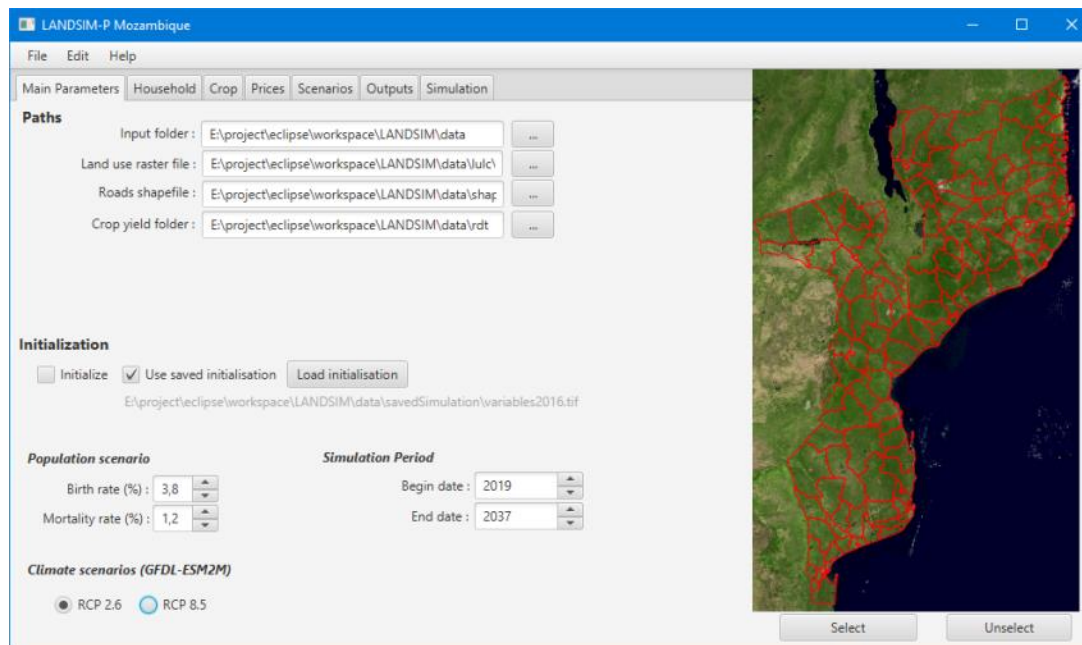
LANDSIM-P overview



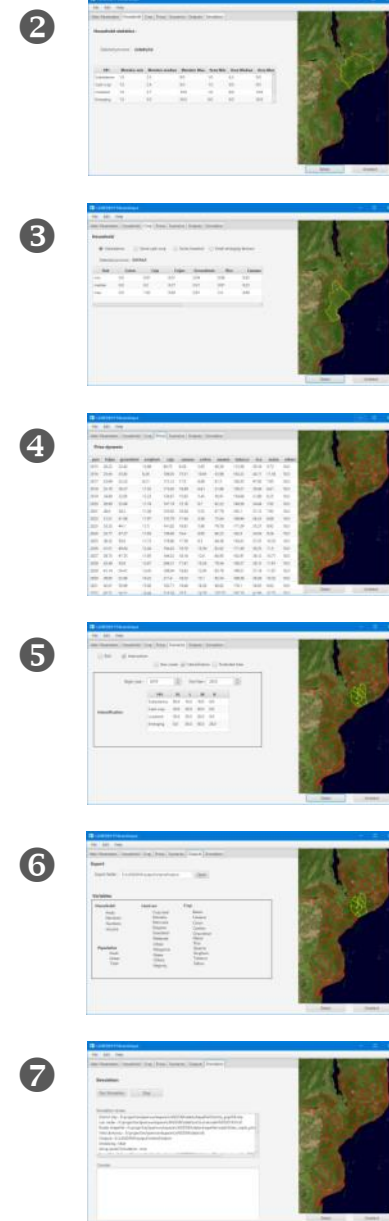
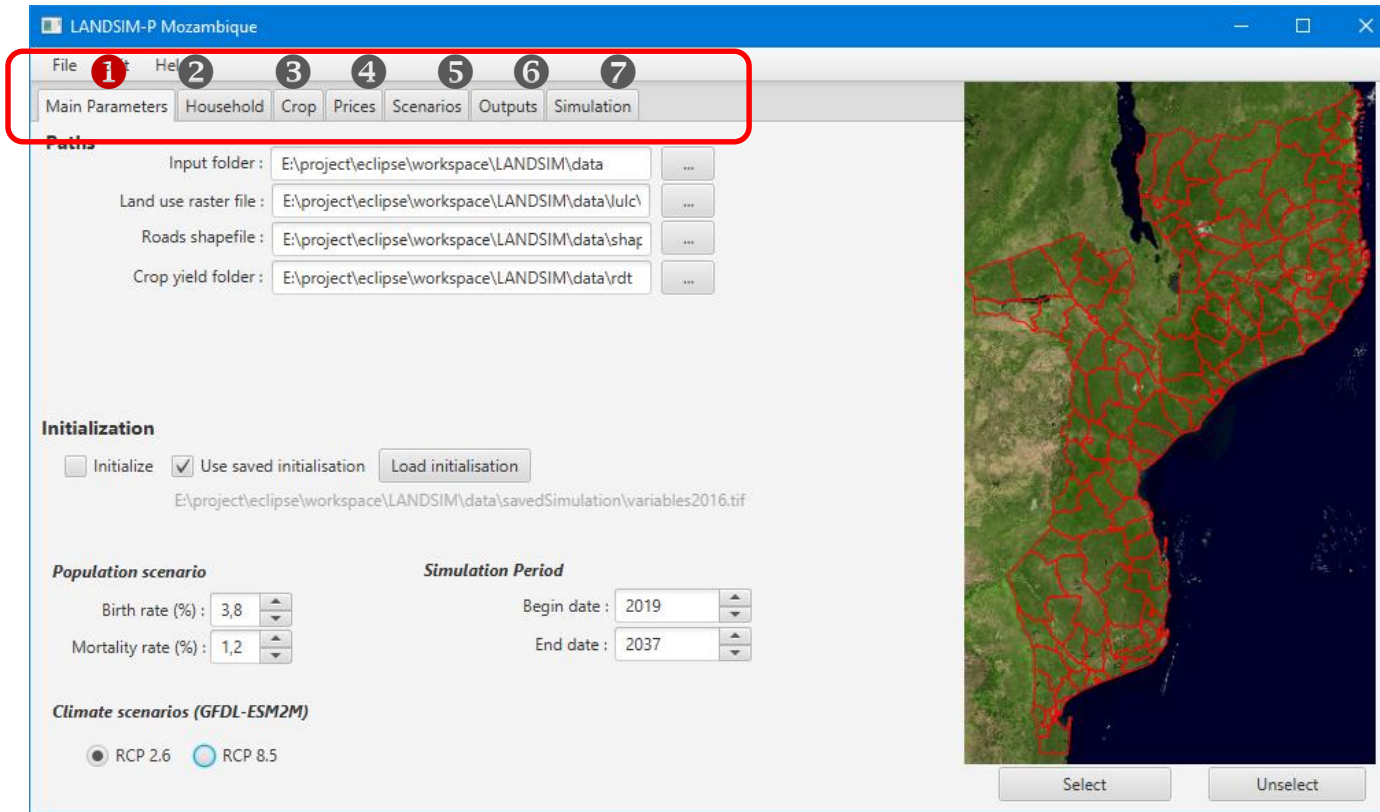
LANDSIM: inputs, outputs, parameters, assumptions



Software Interface



Software Interface




1. Main panel

The Main panel of LANDSIM-P gives access to the main settings that apply to the overall simulations. These settings are to specify: **i) the paths to the input data, ii) whether to re-compute the initial conditions, iii) the simulation period.**

This panel also allows to choose which **iv) population and v) climate scenarios to apply.**

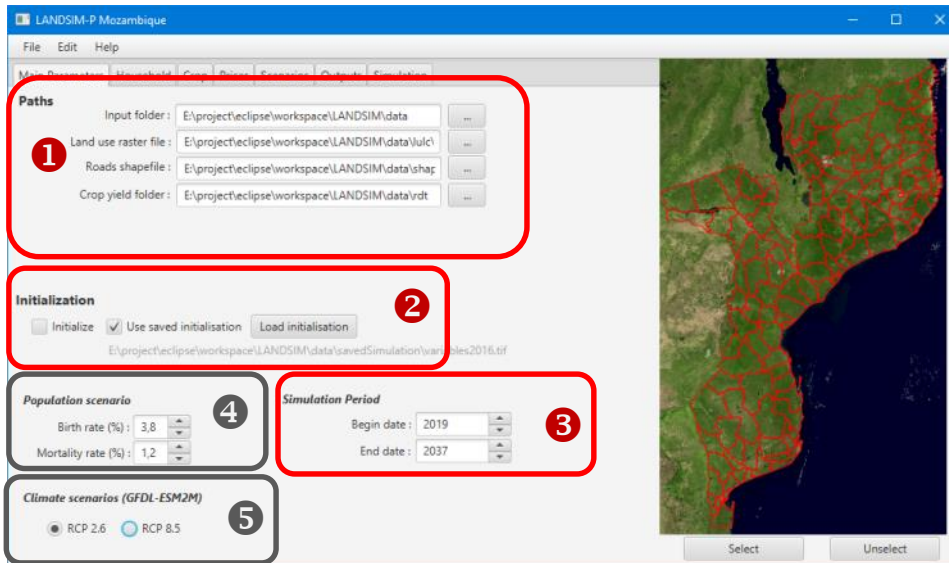
- 1 Set / check paths leading to input data folders:
 - Project root directory
 - Land Use Land Cover map
 - Roads shapefile
 - CropYield Maps

Use  button for navigating to required folder, or enter path directly in text window

E:\landsim\data

- 2 Decide whether to produce a new initialisation or to use a previously saved initialisation (thus saving computation time)

- 3 Select simulation period. Default value for Begin Year is set to now (2019) and EndYear to 2037



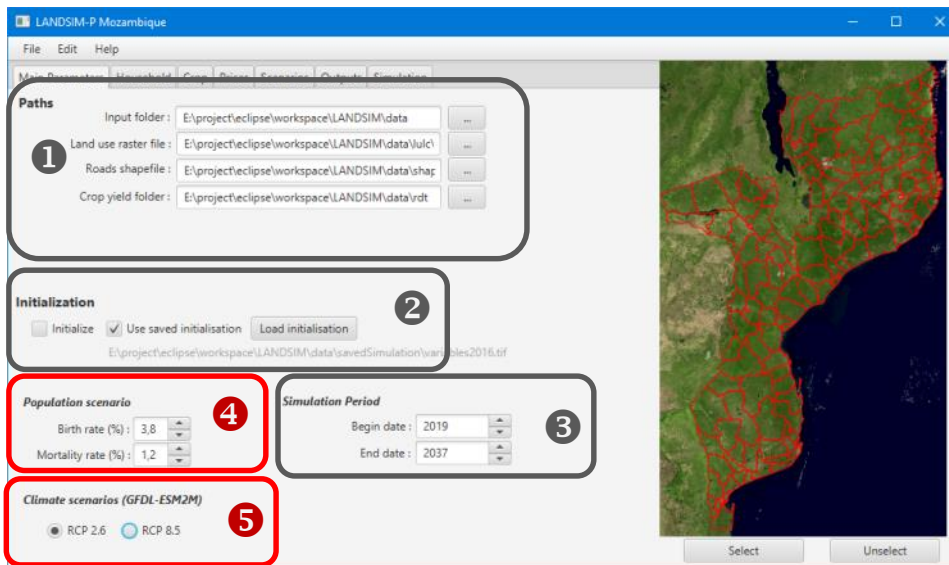
Main panel

The Main panel of LANDSIM-P gives access to the main settings that apply to the overall simulations. These settings are to specify: **i)** the paths to the input data, **ii)** whether to re-compute the initial conditions, **iii)** the simulation period.

This panel also allows to choose which **iv)** population and **v)** climate scenarios to apply.

4 Set population projection scenarios using birth and mortality rates. Preset rates are given for INE 2017 projections

5 Set climate change scenarios: RCP 2.6 corresponds to $< 2\text{ }^{\circ}\text{C}$, whereas RCP 8.5 is the worst case scenario projecting $> 5\text{ }^{\circ}\text{C}$ temperature rise during the century



Interface: Household

LANDSIM-P Mozambique

File Edit Help

Main Parameters Household Crop Prices Scenarios Outputs Simulation

Household statistics :

Selected province : ZAMBEZIA

HH	Member min	Member median	Member Max	Area Min	Area Median	Area Max
Subsistence	1.0	2.3	9.0	1.0	4.3	9.0
Cash crop	1.0	2.4	9.0	1.0	8.0	9.0
Livestock	1.0	2.7	10.0	1.0	8.0	10.0
Emerging	1.0	5.0	26.0	8.0	8.0	26.0

Select Unselect

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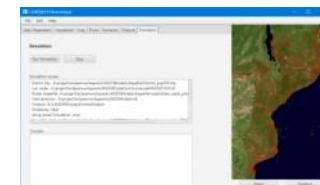
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Household panel

The Household panel of LANDSIM-P allows exploring input data on the characteristics of the different household types per province

Household statistics :

Selected province : ZAMBEZIA

HH	Member min	Member median	Member Max	Area Min	Area Median	Area Max
Subsistence	1.0	2.3	9.0	1.0	4.3	9.0
Cash crop	1.0	2.4	9.0	1.0	8.0	9.0
Livestock	1.0	2.7	10.0	1.0	8.0	10.0
Emerging	1.0	5.0	26.0	8.0	8.0	26.0

1 For the *Household* panel, the Map of Mozambique is clickable to select a province. The 'select' and 'unselect' button allows to select or unselect a province using the map. The selected province is outlined in yellow. The selected province is given in 2.

The household statistics of the selected province is displayed in the table in 3.

2 The selected province is given here.

3 This table gives the characteristics of the 4 types of households for the selected province.

- number of HH members (min, median, max)
- crop area owned in hectares (min, median, max)

HH1 Subsistence

HH2 Some cash crop

HH3 Some livestock

HH4 Small emerging farmers

Interface: Crop

LANDSIM-P Mozambique

File 1 Help 2 3 4 5 6 7

Main Parameters Household Crop Prices Scenarios Outputs Simulation

Household

Subsistence
 Some cash crop
 Some livestock
 Small emerging farmers

Selected province : SOFALA

Stat	Coton	Caju	Feijao	Groundnuts	Rice	Cassava
min	0.0	0.01	0.01	0.04	0.08	0.03
median	0.0	0.2	0.27	0.21	0.91	0.23
max	0.0	1.02	0.84	0.81	3.4	0.68

Select Unselect

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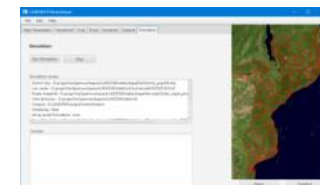
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Crop panel

The Crop panel of LANDSIM-P allows exploring input data on the different crops cultivated by households of the 4 types, per province

1

2

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4

Stat	Coton	Caju	Feijao	Groundnuts	Rice	Cassava
min	0.0	0.01	0.01	0.04	0.08	0.03
median	0.0	0.2	0.27	0.21	0.91	0.23
max	0.0	1.02	0.84	0.81	3.4	0.68

1 For the *Crop* panel, the Map of Mozambique is clickable to select a province. The 'select' and 'unselect' button allows to select or unselect a province using the map. The selected province is outlined in yellow.

The HH type is selected in 2.

The selected province is given in 3.

The different crops cultivated by each of the HH types of the selected province is displayed in the table in 3.

2 The HH type for which crop data is to be displayed is chosen here.

3 The selected province is given here.

4 This table gives the number of hectares cultivated by each of the 4 types of households for the selected province.
- area cultivated per crop type per HH type (min, median, max)

HH1 Subsistence

HH2 Some cash crop

HH3 Some livestock

HH4 Small emerging farmers

Interface: Prices

Price dynamic

year	feijao	groundnut	sorghum	caju	cassava	cotton	sesame	tobacco	rice	maize	others
2015	26.22	22.42	13.98	94.75	8.29	5.05	40.36	112.58	29.16	5.72	10.0
2016	25.65	33.83	6.26	106.03	15.51	10.65	53.98	162.22	44.11	11.54	10.0
2017	25.69	32.23	6.31	115.13	17.0	8.06	61.5	160.35	47.93	7.95	10.0
2018	25.18	30.37	11.53	115.65	16.09	6.61	51.86	138.21	29.46	6.61	10.0
2019	24.69	32.85	12.23	130.67	15.63	5.45	56.91	154.08	31.89	6.25	10.0
2020	26.69	35.46	11.74	147.19	15.18	6.7	62.22	146.56	34.44	7.05	10.0
2021	28.8	38.2	11.28	135.93	16.28	5.52	67.79	163.1	37.12	7.93	10.0
2022	31.01	41.08	11.97	125.79	17.44	4.58	73.64	180.96	36.23	8.88	10.0
2023	33.33	44.1	11.5	141.82	16.91	5.66	79.78	171.29	35.37	9.92	10.0
2024	35.77	47.27	11.05	159.46	16.4	6.95	86.23	162.4	34.56	9.26	10.0
2025	38.32	50.6	11.73	178.86	17.56	8.5	84.38	154.22	37.25	10.33	10.0
2026	41.01	49.04	12.44	164.43	18.78	10.36	82.62	171.36	36.35	11.5	10.0
2027	39.73	47.55	11.95	184.32	18.18	12.6	80.95	162.47	39.12	10.71	10.0
2028	42.49	50.9	12.67	206.21	17.61	10.24	79.36	180.27	38.12	11.91	10.0
2029	41.14	54.41	13.43	189.04	18.83	12.45	85.79	199.51	37.18	11.07	10.0
2030	39.85	52.66	14.23	211.4	18.23	15.1	92.54	188.36	36.28	10.32	10.0
2031	42.61	50.99	15.06	193.71	19.48	18.28	99.62	178.1	39.05	9.63	10.0
2032	45.51	54.51	14.44	216.54	20.8	14.78	107.07	197.16	41.96	10.73	10.0

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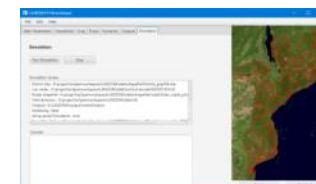
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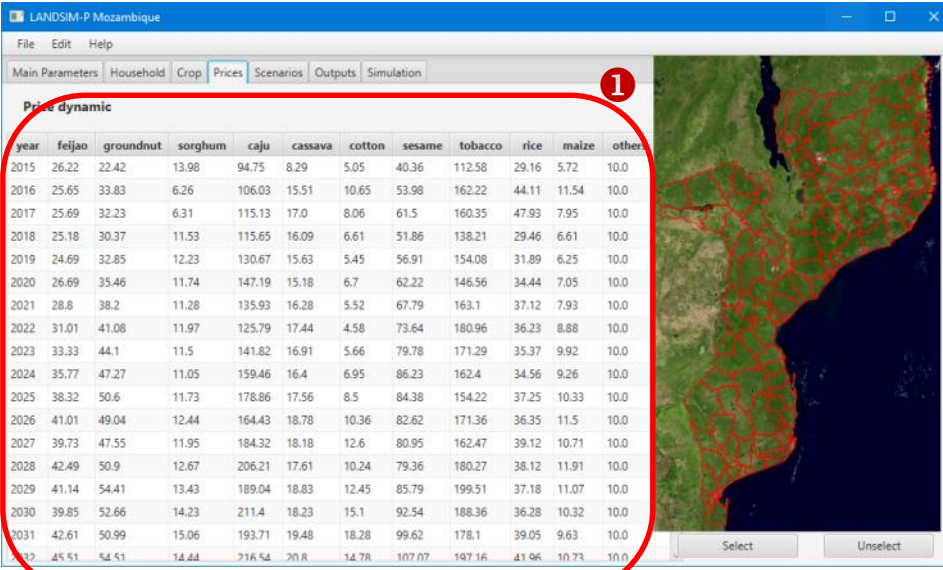
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Prices panel

The Prices panel of LANDSIM-P allows exploring input data on the price projections of 10 main crops cultivated by rural households in Mozambique

- The table shows the price projections for 10 main crop types cultivated by rural households (feijao, groundnut, sorghum, caju, cassava, cotton, sesame, tobacco, rice, maize). Prices are given in meticals per kg (MZN/kg). Each line in the table corresponds to a given year during the simulation period.



LANDSIM-P Mozambique

File Edit Help

Main Parameters Household Crop Prices Scenarios Outputs Simulation

Price dynamic

year	feijao	groundnut	sorghum	caju	cassava	cotton	sesame	tobacco	rice	maize	other
2015	26.22	22.42	13.98	94.75	8.29	5.05	40.36	112.58	29.16	5.72	10.0
2016	25.65	33.83	6.26	106.03	15.51	10.65	53.98	162.22	44.11	11.54	10.0
2017	25.69	32.23	6.31	115.13	17.0	8.06	61.5	160.35	47.93	7.95	10.0
2018	25.18	30.37	11.53	115.65	16.09	6.61	51.86	138.21	29.46	6.61	10.0
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2020	26.69	35.46	11.74	147.19	15.18	6.7	62.22	146.56	34.44	7.05	10.0
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2031	42.61	50.99	15.06	193.71	19.48	18.28	99.62	178.1	39.05	9.63	10.0
2032	45.51	54.51	14.44	216.54	20.8	14.78	107.07	197.16	41.96	10.73	10.0

Select Unselect

Interface: *Scenarios*

Protected Areas

Begin date : 2019

Shapefile :

Roads

Begin date : 2019

Shapefile :

Intensification

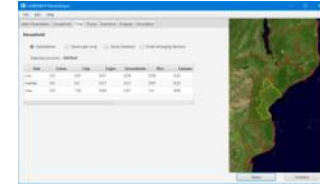
Begin year : 2019 End Year : 2019

	HH	VL	L	M	H
Subsistence	80.0	10.0	10.0	0.0	
Cash crop	50.0	30.0	20.0	0.0	
Livestock	50.0	30.0	20.0	0.0	
Emerging	0.0	30.0	50.0	20.0	

2



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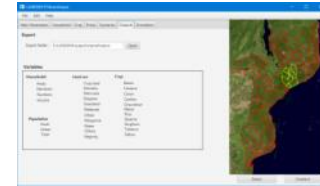
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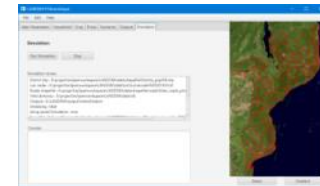
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Scenario settings

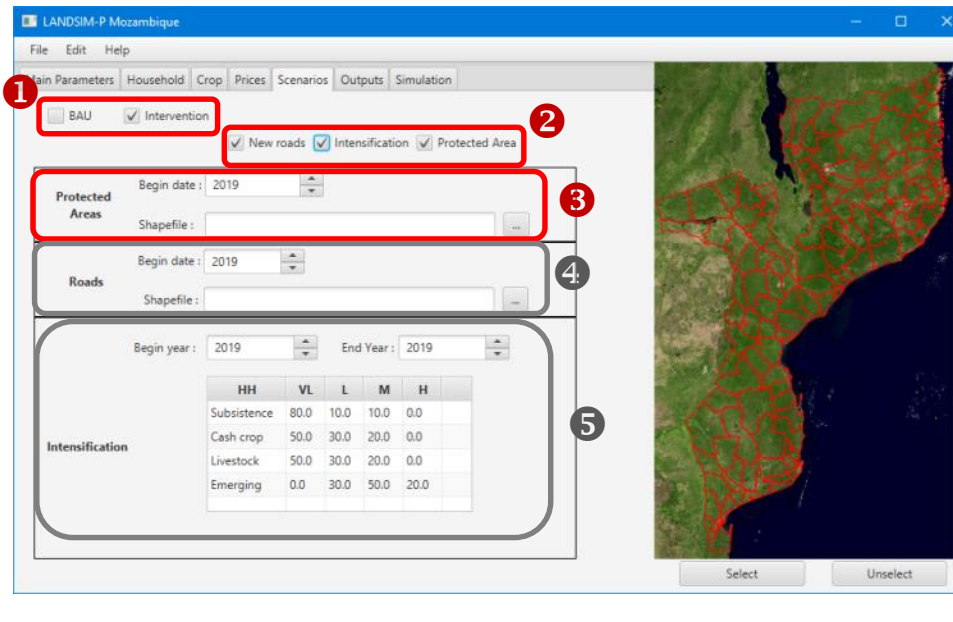
The Scenario panel of LANDSIM-P allows setting parameters to run simulations according to different BAU (Business As Usual) and Intervention scenarios.

1 Select either *BAU* or *Intervention*.

2 If *BAU* is selected, no further scenario parameters are required.

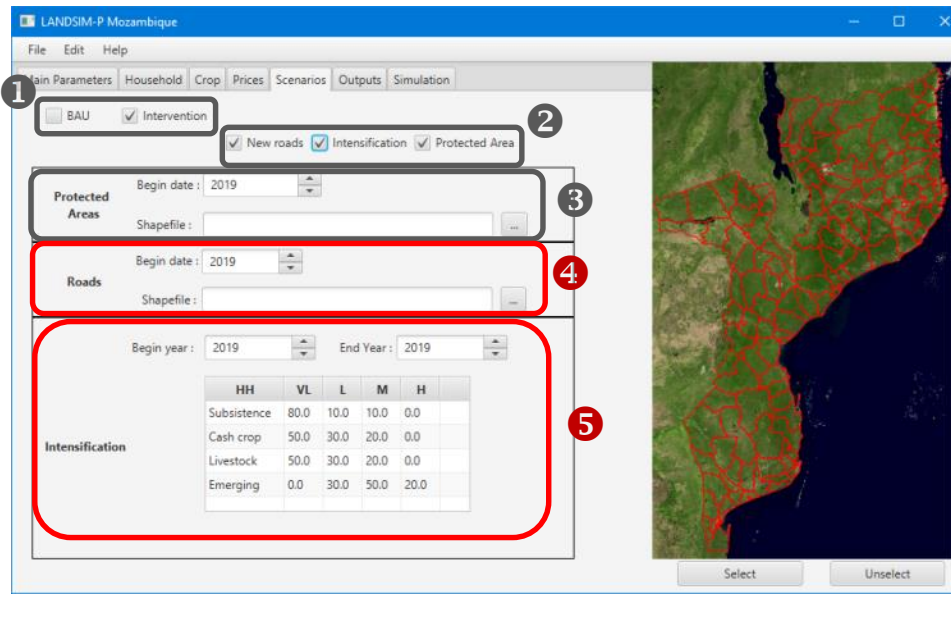
If *Intervention* is selected, up to 3 types of scenarios can be combined: *i*) new roads, *ii*) crop intensification and *iii*) protected areas. Once an intervention scenario type is ticked, a window (3, 4, 5) is opened to allow specifying the details of scenario.

3 To define a new road scenario, the path to a shapefile containing the new roads can be given, and the year when the new roads are put in service can be set.



Scenario settings

The Scenario panel of LANDSIM-P allows setting parameters to run simulations according to different BAU (Business As Usual) and Intervention scenarios.



4 To define a new Protected Area scenario, the path to a shapefile containing the Protected Area can be given, and the year when the Protected Area is created can be set.

5 To define a new Crop Intensification scenario, the clickable map on the right allows selecting the districts on which the intensification programme is carried out. The period during which the intensification programme is active can also be set. The level of intensification can be expressed by setting the values of the *HH type x intensification level* matrix applied during the programme.

Interface: *Outputs*

LANDSIM-P Mozambique

File Edit View Help

1 2 3 4 5 6 7

Main Parameters Household Crop Prices Scenarios **Outputs** Simulation

Export

Export folder: E:\LANDSIM\output\intensification

Variables

Households	Land use	Crop
Areas	Crop land	Beans
Members	Miombo	Cassava
Numbers	Mecrusse	Coton
Income	Mopane	Cashew
	Grassland	Groundnut
	Wetlands	Maize
	Urban	Rice
Population	Mangrove	Sesame
Rural	Water	Sorghum
Urban	Others	Tobacco
Total	Majority	Fallow

Select Unselect

2



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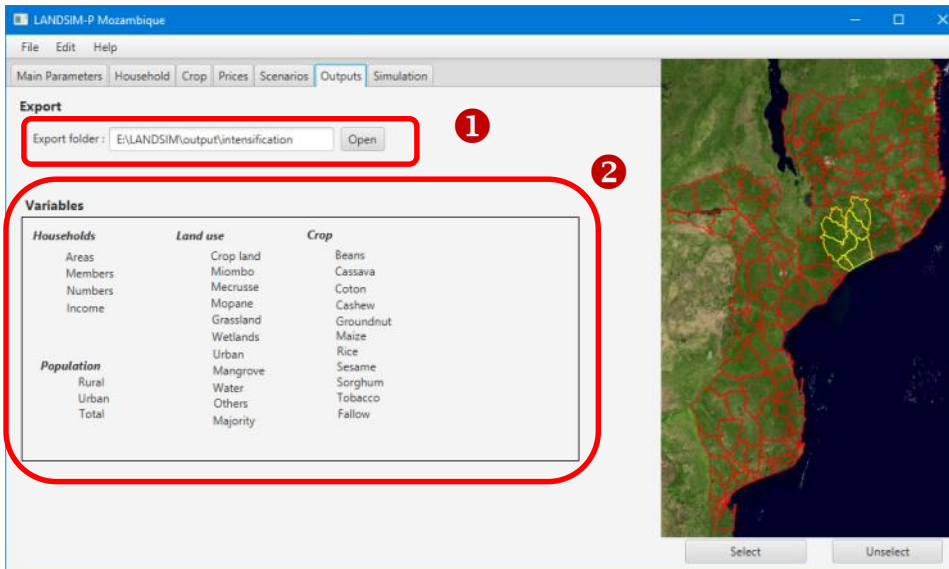
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Output panel

The Output panel of LANDSIM-P allows specifying the location of the output results and shows the types of variables that will be saved as results.

- 1 Select the folder where to save all the output results.
- 2 This pane lists the types of variables that will be saved in the output folder. The results are raster maps of 1 km pixel size. Each raster map correspond to one output variable for one given year. 55 raster maps will be saved for each simulation year.



Household maps (20 per year)

Number of households per HH type (4), total number of HH (1), HH members per HH type (4), total number of HH members (1), Crop area per HH type (4), total crop area for all HH types (1), Income per HH type (4), total income for all HH types (1)

Population maps (3 per year)

Rural population (1), urban population (1), total population (1)

Land Use maps (11 per year)

A land use map for each of: cropland, miombo, mecrusse, mopane, grassland, wetland, urban, mangrove, water, other (10), and a map showing the majority class for each 1 km² cell (1)

Crop maps (21 per year)

A crop area map for each of: beans, cassava, cotton, cashew, groundnut, maize, rice, sesame, sorghum, tobacco, fallow (11)
A crop production map for each of: beans, cassava, cotton, cashew, groundnut, maize, rice, sesame, sorghum, tobacco (10)

Interface: *Simulation*

Simulation

Run Simulation Stop

Simulation review

District shp : E:\project\ eclipse\workspace\LANDSIM\data\shapefile\Distrito_popINE.shp
 Lulc raster : E:\project\ eclipse\workspace\LANDSIM\data\lulc\lulcrecodeFNDS20161k.tif
 Roads shapefile : E:\project\ eclipse\workspace\LANDSIM\data\shapefile\roads\Main_roads_prio
 Yield directory : E:\project\ eclipse\workspace\LANDSIM\data\rdt
 Outputs : E:\LANDSIM\output\intensification
 Initializing : false
 Using saved Simulation : true

Console

Select Unselect

2



3



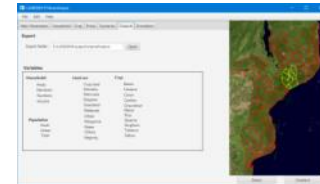
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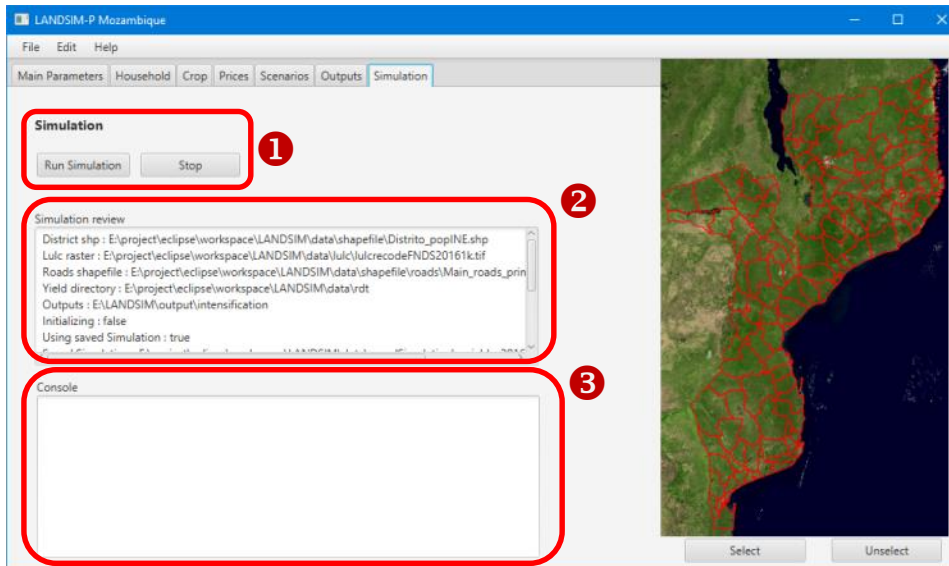
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Simulation panel

The Simulation panel of LANDSIM-P allows running a simulation once all other parameters and scenario definitions have been set. A summary of the parameters used for the simulation is also given.

- 1 Click on *Run Simulation* button to start the simulation.
Click on the *Stop* button to stop the simulation before it ends by itself.
- 2 This window gives a summary of the parameters set for the present simulation. It is used for checking purposes before running the simulation.
- 3 This window is the console window where messages are sent during the simulation. Error messages or normal simulation messages are displayed here.



Exploitations of the results

Once produced the results can be analyzed using Excel Spreadsheet and any Geographic Informations System (GIS), ArcGIS, QGIS, etc.

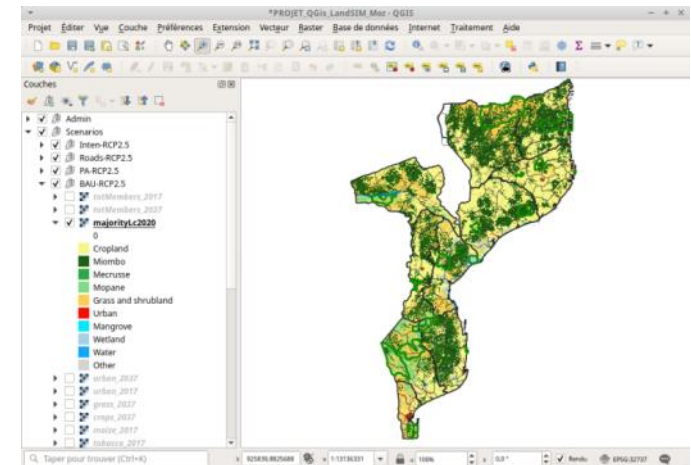
The results are located in the specified folder defined the interface (see « Output » panel).

The results are organised in 5 differents folders and according to type of outputs : 4 raw raster outputs 1 folder with aggregated statistics in text format.

Nom	Taille	Type	Modifié :
crop	32,8 ko	dossier	27/09/2019
households	32,8 ko	dossier	27/09/2019
income	32,8 ko	dossier	27/09/2019
production	32,8 ko	dossier	27/09/2019
stat	32,8 ko	dossier	27/09/2019

Nom	Taille	Type	Modifié :
miombo_2017.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2018.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2019.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2020.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2021.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2022.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2023.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2024.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2025.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2026.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2027.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2028.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2029.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2030.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2031.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2032.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2033.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2034.tif	19,1 Mo	image TIFF	26/09/2019

Nom	Taille	Type	Modifié :
stat_province_beansarea.txt	4,5 ko	document texte bri	26/09/2019
stat_province_beansprod.txt	4,2 ko	document texte bri	26/09/2019
stat_province_bodyWater.txt	97 octets	document texte bri	26/09/2019
stat_province_cashewarea.txt	4,5 ko	document texte bri	26/09/2019
stat_province_cashewprod.txt	3,8 ko	document texte bri	26/09/2019
stat_province_cassavaarea.txt	4,5 ko	document texte bri	26/09/2019
stat_province_cassavaprod.txt	3,6 ko	document texte bri	26/09/2019
stat_province_cotonarea.txt	3,9 ko	document texte bri	26/09/2019
stat_province_cotonprod.txt	2,4 ko	document texte bri	26/09/2019
stat_province_crop.txt	4,5 ko	document texte bri	26/09/2019
stat_province_fallow1area.txt	4,4 ko	document texte bri	26/09/2019
stat_province_fallow2area.txt	4,4 ko	document texte bri	26/09/2019
stat_province_fallow3area.txt	4,4 ko	document texte bri	26/09/2019
stat_province_forest.txt	4,5 ko	document texte bri	26/09/2019
stat_province_grass.txt	4,5 ko	document texte bri	26/09/2019
stat_province_hhfarmArea1.txt	4,5 ko	document texte bri	26/09/2019
stat_province_hhfarmArea2.txt	4,3 ko	document texte bri	26/09/2019
stat_province_hhfarmArea3.txt	4,4 ko	document texte bri	26/09/2019



Exploitations of the results

Exemple of access to raw raster outputs maps

Nom	Taille	Type	Modifié :
crop	32,8 ko	dossier	27/09/2019
households	32,8 ko	dossier	27/09/2019
income	32,8 ko	dossier	27/09/2019
production	32,8 ko	dossier	27/09/2019
stat	32,8 ko	dossier	27/09/2019

Nom	Taille	Type	Modifié :
member2	32,8 ko	dossier	27/09/2019
member3	32,8 ko	dossier	27/09/2019
member4	32,8 ko	dossier	27/09/2019
miombo	32,8 ko	dossier	28/09/2019
mopane	32,8 ko	dossier	27/09/2019
number1	32,8 ko	dossier	27/09/2019
number2	32,8 ko	dossier	27/09/2019
number3	32,8 ko	dossier	27/09/2019
number4	32,8 ko	dossier	27/09/2019
totalLandCover	32,8 ko	dossier	27/09/2019
totalPop	32,8 ko	dossier	27/09/2019
totArea	32,8 ko	dossier	27/09/2019
totMembers	32,8 ko	dossier	27/09/2019
totNumbers	32,8 ko	dossier	27/09/2019
urban	32,8 ko	dossier	27/09/2019
urbanPop	32,8 ko	dossier	27/09/2019
variable	32,8 ko	dossier	27/09/2019
water	32,8 ko	dossier	27/09/2019

Nom	Taille	Type	Modifié :
miombo_2017.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2018.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2019.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2020.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2021.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2022.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2023.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2024.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2025.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2026.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2027.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2028.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2029.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2030.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2031.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2032.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2033.tif	19,1 Mo	image TIFF	26/09/2019
miombo_2034.tif	19,1 Mo	image TIFF	26/09/2019

Exploitations of the results

Exemple of access to aggregated statistics

Nom	Taille	Type	Modifié :
crop	32,8 ko	dossier	27/09/2019
households	32,8 ko	dossier	27/09/2019
income	32,8 ko	dossier	27/09/2019
production	32,8 ko	dossier	27/09/2019
stat	32,8 ko	dossier	27/09/2019

Nom	Taille	Type	Modifié :
districtStat	32,8 ko	dossier	27/09/2019
nationalStat	32,8 ko	dossier	27/09/2019
provinceStat	32,8 ko	dossier	27/09/2019

Nom	Taille	Type	Modifié :
stat_province_beansarea.txt	4,5 ko	document texte bru	26/09/2019
stat_province_beansprod.txt	4,2 ko	document texte bru	26/09/2019
stat_province_bodyWater.txt	97 octets	document texte bru	26/09/2019
stat_province_cashewarea.txt	4,5 ko	document texte bru	26/09/2019
stat_province_cashewprod.txt	3,8 ko	document texte bru	26/09/2019
stat_province_cassavaarea.txt	4,5 ko	document texte bru	26/09/2019
stat_province_cassavaprod.txt	3,6 ko	document texte bru	26/09/2019
stat_province_cotonarea.txt	3,9 ko	document texte bru	26/09/2019
stat_province_cotonprod.txt	2,4 ko	document texte bru	26/09/2019
stat_province_crop.txt	4,5 ko	document texte bru	26/09/2019
stat_province_fallow1area.txt	4,4 ko	document texte bru	26/09/2019
stat_province_fallow2area.txt	4,4 ko	document texte bru	26/09/2019
stat_province_fallow3area.txt	4,4 ko	document texte bru	26/09/2019
stat_province_forest.txt	4,5 ko	document texte bru	26/09/2019
stat_province_grass.txt	4,5 ko	document texte bru	26/09/2019
stat_province_hhfarmArea1.txt	4,5 ko	document texte bru	26/09/2019
stat_province_hhfarmArea2.txt	4,3 ko	document texte bru	26/09/2019
stat_province_hhfarmArea3.txt	4,4 ko	document texte bru	26/09/2019

Exploitations of the results

The different Outputs Variable are described here

Household and Land Cover

Name of the folder	Description
area1	Annual maps of total farm area for HH1 in ha/km2
area2	Annual maps of total farm area for HH1 in ha/km2
area3	Annual maps of total farm area for HH1 in ha/km2
area4	Annual maps of total farm area for HH1 in ha/km2
crops	Annual maps of total farm area for HH1 in ha/km2
forest	Annual maps of forest area in ha/km2
grass	Annual maps of grassland area in ha/km2
majority	Annual maps of land cover majority in ha/km2
member1	Annual maps of number of HH1 members in #/km2
member2	Annual maps of number of HH2 members in #/km2
member3	Annual maps of number of HH3 members in #/km2
member4	Annual maps of number of HH4 members in #/km2
number1	Annual maps of number of HH1 in #/km2
number2	Annual maps of number of HH2 in #/km2
number3	Annual maps of number of HH3 in #/km2
number4	Annual maps of number of HH4 in #/km2
totalPop	Annual maps of total population in #/km2
totArea	Annual maps of total farm area in ha/km2
totMembers	Annual maps of total number of members in #/km2
totNumbers	Annual maps of total number of HH in #/km2
urban	Annual maps of total urban area in ha/km2
urbanPop	Annual maps of total urban population in #/km2
water	Annual maps of total area of water in ha/km2

Crop

Name of the folder	Description
caju	Annual maps of cajou area in ha/km2
cassava	Annual maps of caassava area in ha/km2
coton	Annual maps of caassava area in ha/km2
crops hh1	Annual maps of cropsarea for HH1 in ha/km2
crops hh2	Annual maps of cropsarea for HH2 in ha/km2
crops hh3	Annual maps of cropsarea for HH3 in ha/km2
crops hh4	Annual maps of cropsarea for HH4 in ha/km2
fallow1	Annual maps of fallow area of class 1 in ha/km2
fallow2	Annual maps of fallow area of class 2 in ha/km2
fallow3	Annual maps of fallow area of class 3 in ha/km2
feijao	Annual maps of feijao area in ha/km2
groundnut	Annual maps of groundnut area in ha/km2
maize	Annual maps of maize area in ha/km2
others	Annual maps of other crops area in ha/km2
rice	Annual maps of rice area in ha/km2
sesame	Annual maps of sesame area in ha/km2
sorghum	Annual maps of sorghum area in ha/km2
tobacco	Annual maps of tobacco area in ha/km2
totalCrop	Annual maps of total croparea in ha/km2
totalFallow	Annual maps of total fallow area in ha/km2
totalOs	Annual maps of total crop area + fallow in ha/km2

2



3



4



5



6



7



Exploitations of the results

The different Outputs Variable are described here

Crop Production

Name of the folder	Description
caju	Annual maps of caju production in tons/km2
cassava	Annual maps of cassava production in tons/km2
cotton	Annual maps of cotton production in tons/km2
feijao	Annual maps of feijao production in tons/km2
groundnut	Annual maps of groundnut production in tons/km2
maize	Annual maps of maize production in tons/km2
others	Annual maps of other crops production in tons/km2
rice	Annual maps of rice production in tons/km2
sesame	Annual maps of sesame production in tons/km2
sorghum	Annual maps of sorghum production in tons/km2
tobacco	Annual maps of tobacco production in tons/km2

Income

Name of the folder	Description
caju	Annual maps of income from caju production in MZN/km2
cassava	Annual maps of income from cassava production in MZN/km2
cotton	Annual maps of income from cotton production in MZN/km2
feijao	Annual maps of income from feijao production in MZN/km2
groundnut	Annual maps of income from groundnut production in MZN/km2
hh_hhtype1	Annual maps of income for HH1 in MZN/km2
hh_hhtype2	Annual maps of income for HH2 in MZN/km2
hh_hhtype3	Annual maps of income for HH3 in MZN/km2
hh_hhtype4	Annual maps of income for HH4 in MZN/km2
maize	Annual maps of income from maize production in MZN/km2
others	Annual maps of income from other crops production in MZN/km2
rice	Annual maps of income from rice production in MZN/km2
sesame	Annual maps of income from sesame production in MZN/km2
sorghum	Annual maps of income from sorghum production in MZN/km2
tobacco	Annual maps of income from tobacco production in MZN/km2

2



3



4



5



6



7



Exploitations of the results

The different Outputs Variable are described here

Aggregated statistics per pProvince

Name of the folder	Description
stat_province_beansarea.txt	Beans area in ha by province
stat_province_cashewarea.txt	Beans area in ha by province
stat_province_cassavaarea.txt	Cassava area in ha by province
stat_province_cotonarea.txt	Coton area in ha by province
stat_province_crop.txt	Total croparea in ha by province
stat_province_fallow1area.txt	Fallow area class1 area in ha by province
stat_province_fallow2area.txt	Fallow area class2 area in ha by province
stat_province_fallow3area.txt	Fallow area class3 area in ha by province
stat_province_forest.txt	Forest area in ha by province
stat_province_grass.txt	Grassland area in ha by province
stat_province_hhfarmArea1.txt	Total farm area of HH1 in ha by province
stat_province_hhfarmArea2.txt	Total farm area of HH2 in ha by province
stat_province_hhfarmArea3.txt	Total farm area of HH3 in ha by province
stat_province_hhfarmArea4.txt	Total farm area of HH4 in ha by province
stat_province_hhmember1.txt	Number of HH1 member in # by province
stat_province_hhmember2.txt	Number of HH2 member in # by province
stat_province_hhmember3.txt	Number of HH3 member in # by province
stat_province_hhmember4.txt	Number of HH4 member in # by province
stat_province_hhnumber1.txt	Number of HH1 in # by province
stat_province_hhnumber2.txt	Number of HH2 in # by province
stat_province_hhnumber3.txt	Number of HH3 in # by province
stat_province_hhnumber4.txt	Number of HH4 in # by province
stat_province_hhtotfarmArea.txt	Total farm area in ha by province
stat_province_hhtotnumber.txt	Total number of member in # by province
stat_province_hhtotpop.txt	Total population in # by province
stat_province_maizearea.txt	Maize area in ha by province
stat_province_othersarea.txt	Other crops area in ha by province
stat_province_peanutsarea.txt	Peanuts area in ha by province
stat_province_ricearea.txt	Rice area in ha by province
stat_province_sesamarea.txt	Sesame area in ha by province
stat_province_sorghumarea.txt	Sorghum area in ha by province
stat_province_tobaccoarea.txt	Tobacco area in ha by province
stat_province_totfallowarea.txt	Total fallow area in ha by province
stat_province_unforest.txt	
stat_province_ungrass.txt	
stat_province_urbanarea.txt	Urban area in ha by province
stat_province_urbanpop.txt	Total urban population in # by province

2



3



4



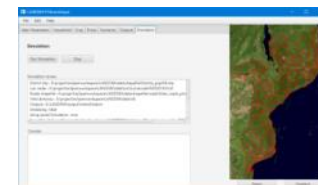
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6



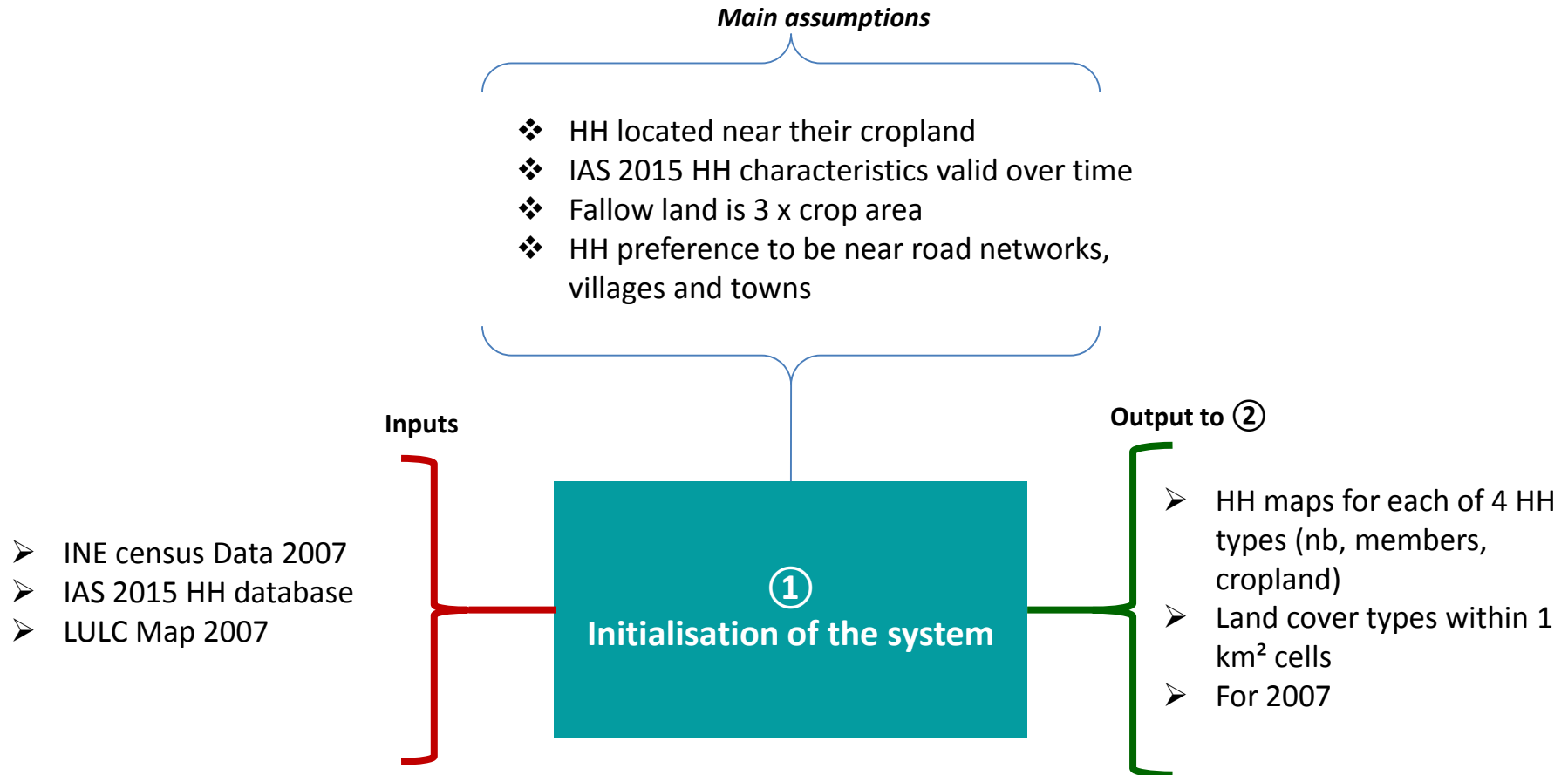
7



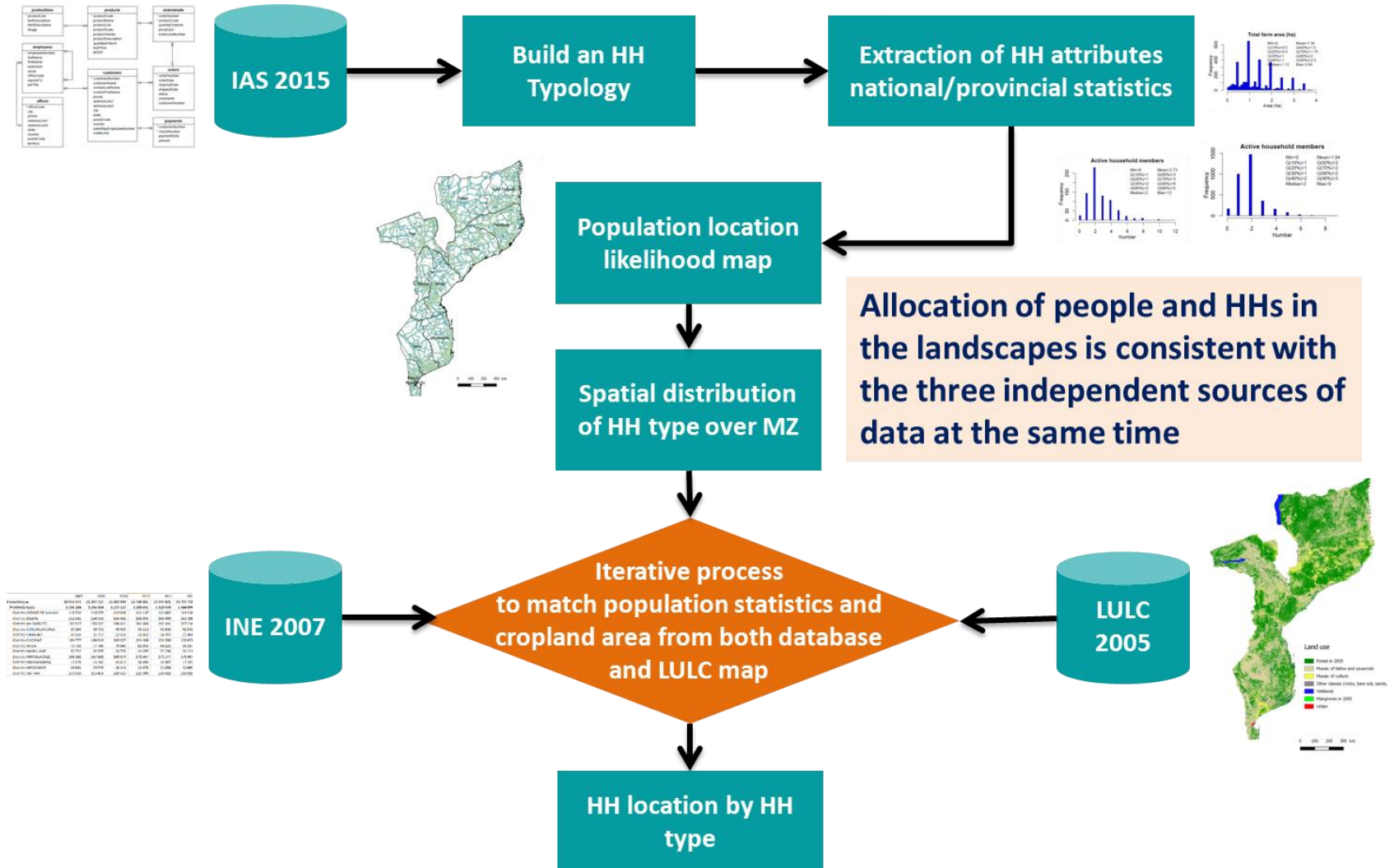
Technical Description

1. Initialization of the system

1. Initialization of the system



1. Initialization of the system



1. Initialisation of the system - Build the HH typology

Database and statistical analysis to define 4 household types with clear definition, farming strategies and resilience levels (climate change, price change, etc.)

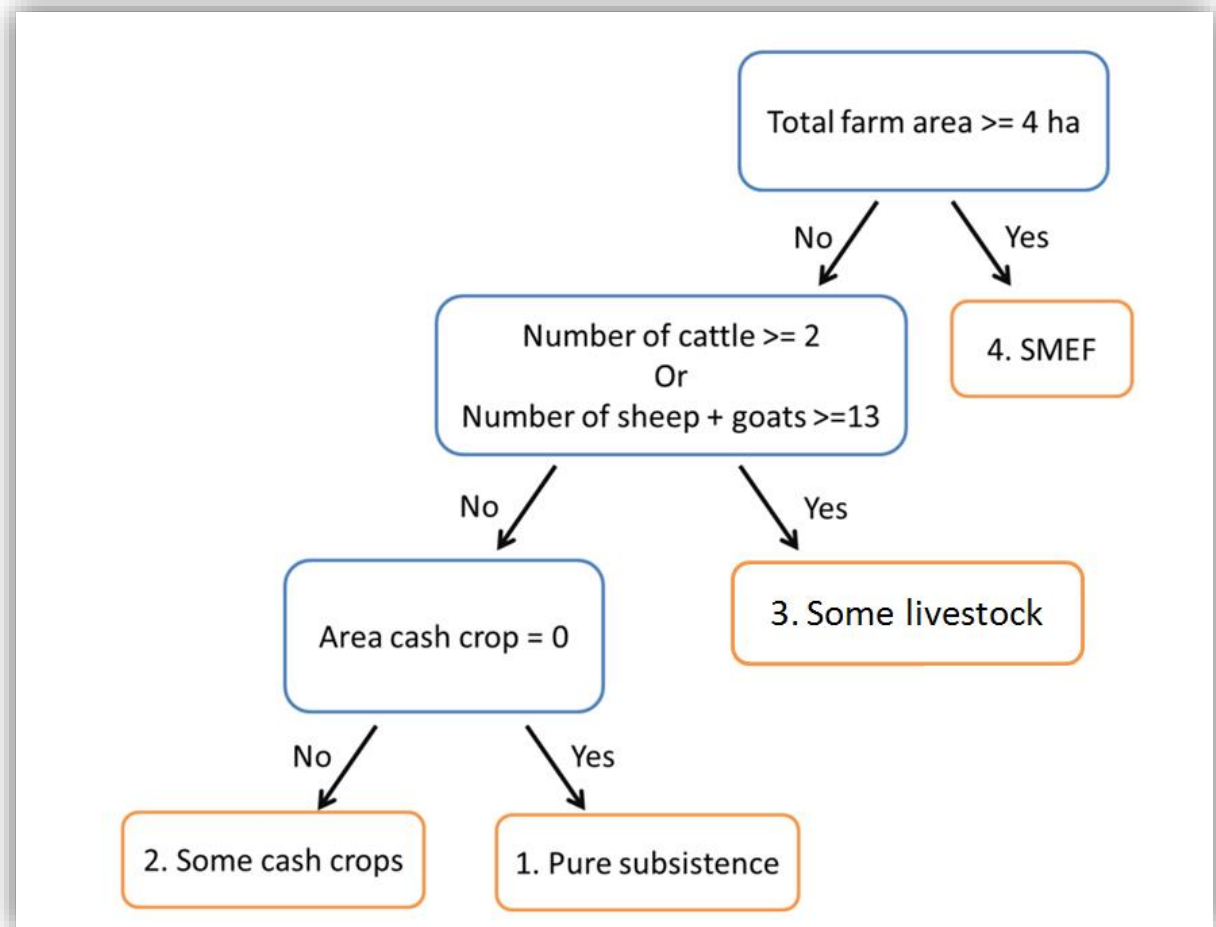
Type	Name	Farming and livelihood strategy
1	Pure subsistence	<p>INCOMES: Mainly staple crop for auto consumption. Not influenced by international agricultural products price.</p> <p>CLIMATE: High influence of climatic conditions on productivity.</p> <p>MIGRATION: Population very inclined to migration according to economical activity.</p>
2	Some cash crop	<p>INCOMES: If incomes increase, higher specialisation on cash crop. Investment remains low.</p> <p>CLIMATE: High influence of climatic conditions on productivity.</p> <p>MIGRATION: Population very inclined to migration according to economic activity but less than type 1.</p>
3	Some livestock	<p>INCOMES: Mainly breeding, no influence of prices.</p> <p>CLIMATE: Less impacted compared to type 1 and 2.</p> <p>MIGRATION: Population very inclined to migration according to economic activity but less than type 1.</p>
4	Small and Medium Emerging Farmers (SMEF)	<p>INCOMES: High influence of international agricultural products prices.</p> <p>CLIMATE: Less impacted compared to type 1, 2 and 3.</p> <p>MIGRATION: Create job demand for other HH types.</p>

1. Initialization of the system - Build the HH typology

Database and statistical analysis to define 4 household types with clear definition, farming strategies and resilience levels (climate change, price change, etc.)

Database
IAS 2015 and IOF
2015
(5810 HHs)

Variable family	Data available
Labour	Active household members Fulltime employees Parttime employees
Land	Total farm area Number of plots Area cultivated with annual crops Area cultivated with perennial crops Fallow Other land uses (garden, meadow)
Crop system	Land irrigated or border Crops cultivated during rainy season (season 1) Crops cultivated during dry season (season 2) Average per crop cultivated for the rainy season (staple and cash crops) Number of cashew trees
Stock	Number of other productive trees Number of head per type of breeding
Capital goods and input uses	Farm assets (barn, silo, processing tools) Animal traction or mechanized means for ploughing Use of tractor Use of fertilizer, pesticide and improved seeds for cash, staple and tree crops Breeding practices Access to veterinary services
Income	Credits Income from staple, cash crops and tree crops Income from animal product and breeding Non-farming incomes
Expenses	Input costs Non-farming expenses
Agricultural practices	Improved practices (irrigator, association, Fallow, Invo)



SMEF : Small and medium-size emerging farms

1. Initialization of the system - Build the HH typology

Distribution of agricultural households by group in each province :

Provinces	1. Pure subsistence	2. Some cash crops	3. Some livestock	4. SMEF
Niassa	58%	27%	3%	12%
Cabo Delgado	54%	25%	1%	21%
Nampula	75%	16%	1%	8%
Zambezia	80%	12%	1%	7%
Tete	35%	18%	21%	26%
Manica	46%	11%	23%	20%
Sofala	48%	28%	8%	16%
Inhambane	60%	1%	21%	18%
Gaza	47%	0%	34%	19%
Maputo province	57%	4%	24%	15%
Total	57%	13%	14%	16%

1 : Pure subsistence

2 : Some cash crops

3 : Some livestock

4 : SMEF

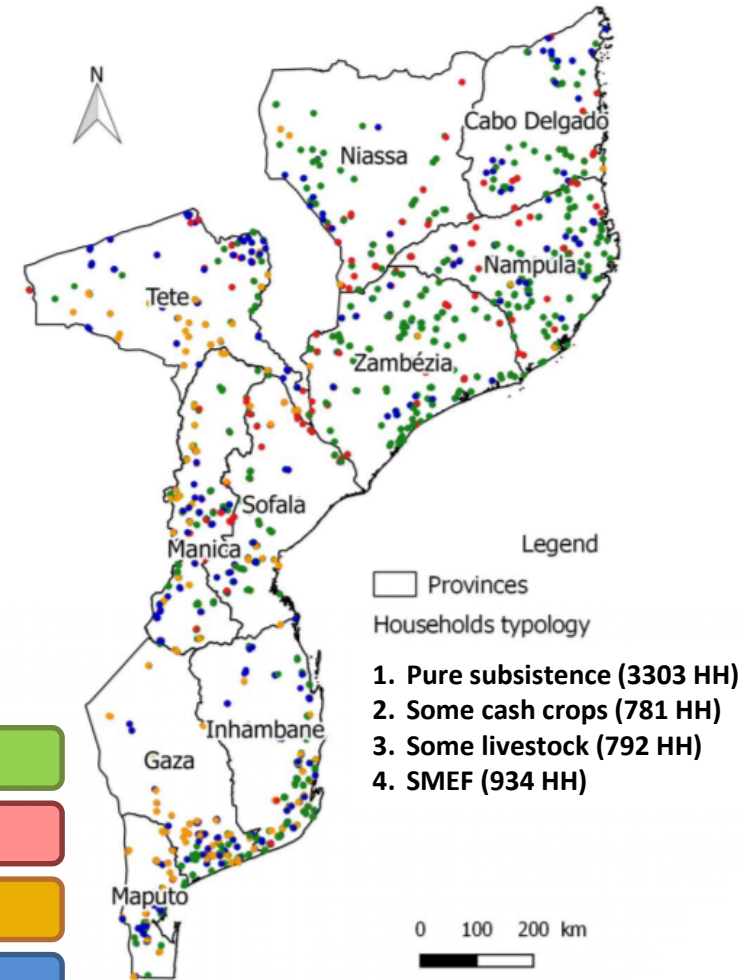
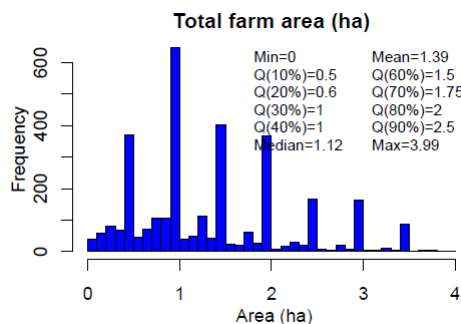
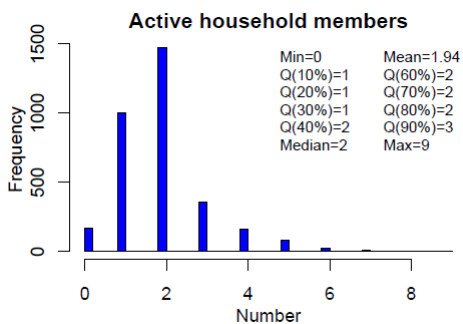


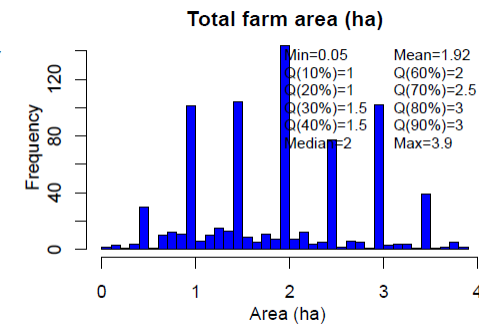
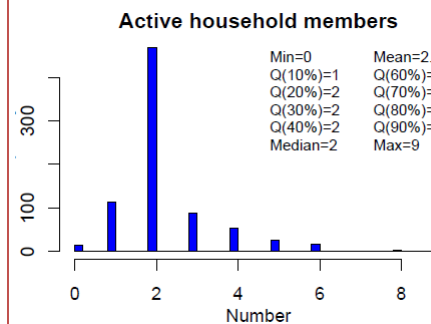
Figure 1 : Distribution of agricultural households by group

1. Initialization of the system - Build the HH typology

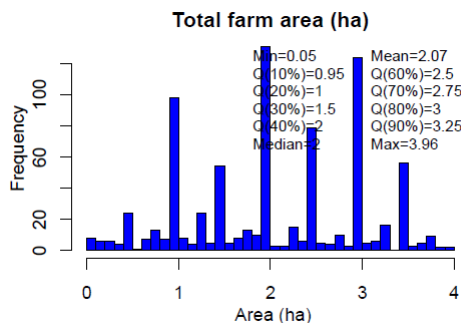
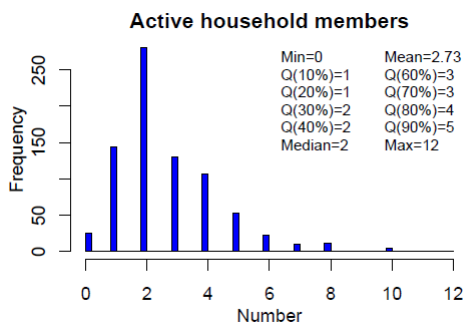
Extraction of household attributes statistics at provincial scale and by HH type



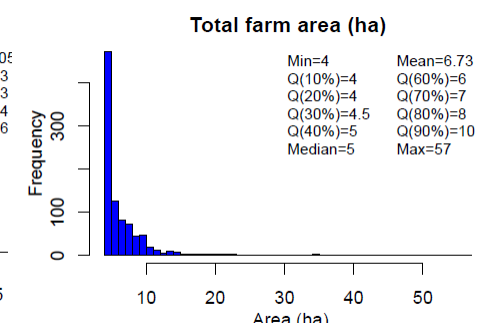
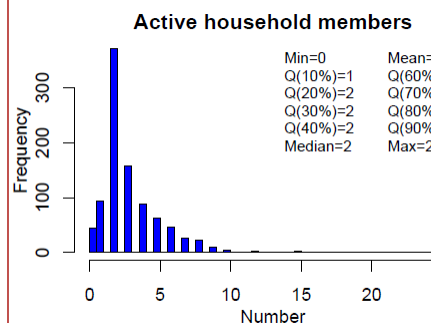
1 : Pure subsistence



2 : Some cash crops



3 : Some livestock



4 : SMEF

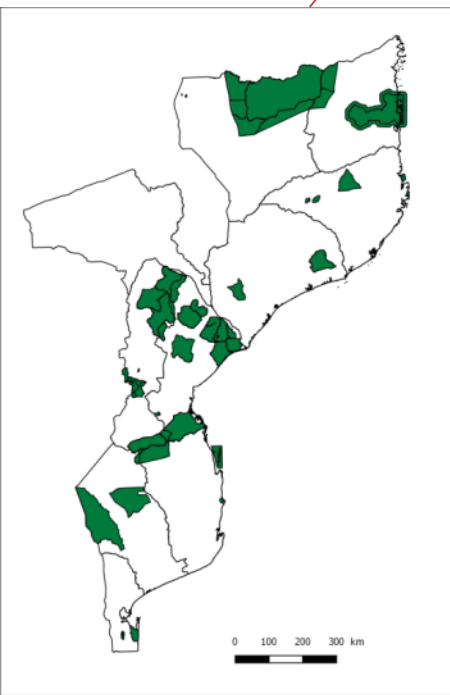
1. Initialization – Population likelihood location map

Spatial distribution of rural HH taking into account several factors

- population per province / district
- towns and villages
- land cover type
- communication routes
- protected areas

Census data 2007

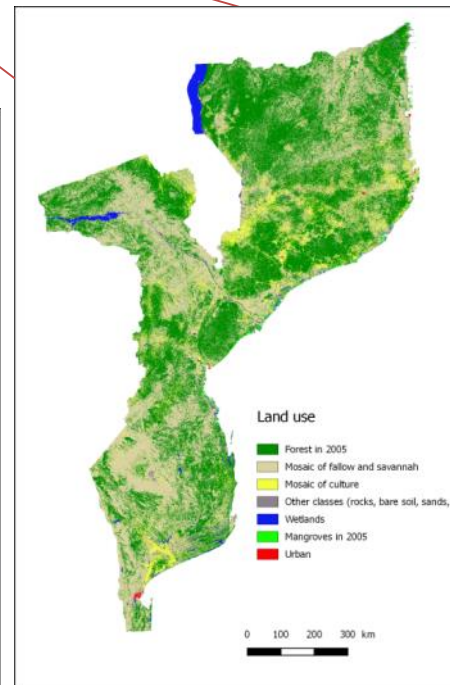
Data used



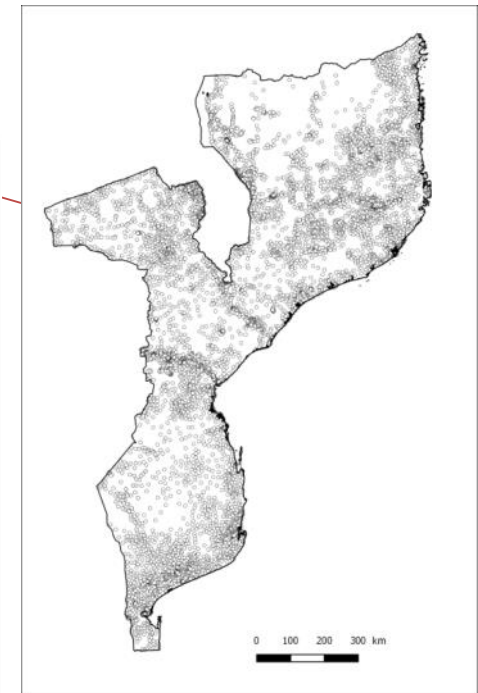
NITidae/Cirad



Road map



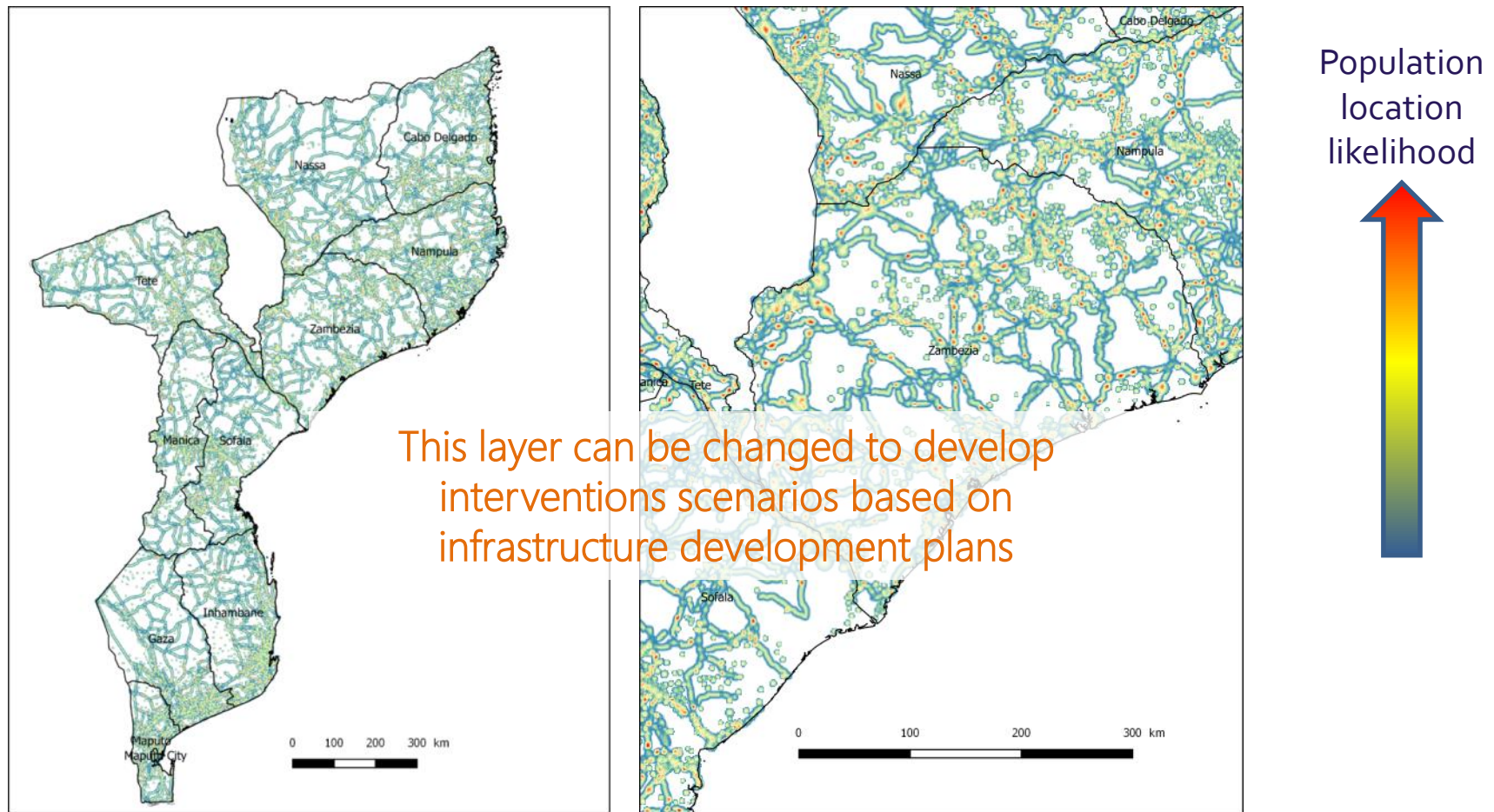
2005 LULC map
Laurel



Village location map

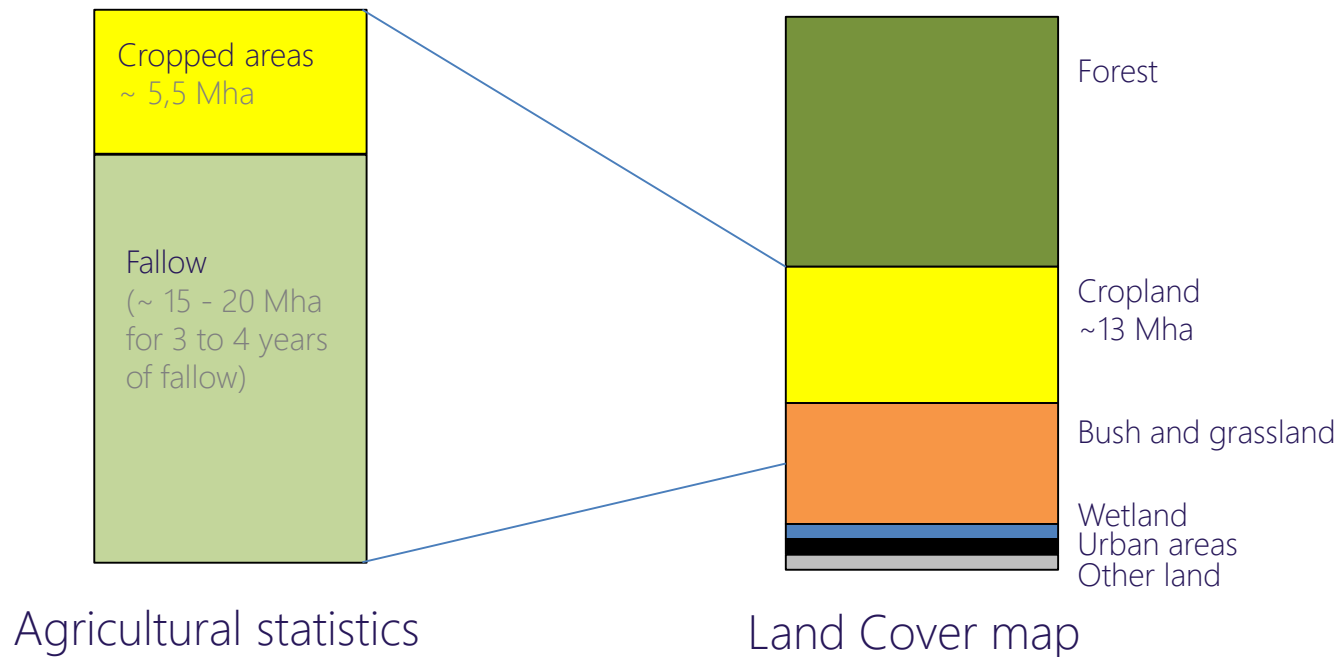
1. Initialization – Population likelihood location map

Exemple of factor maps: distance from roads and town/village locations



1. Initialization – Spatial distribution of household

Key issue: to match crop areas including fallow with land use and land cover map

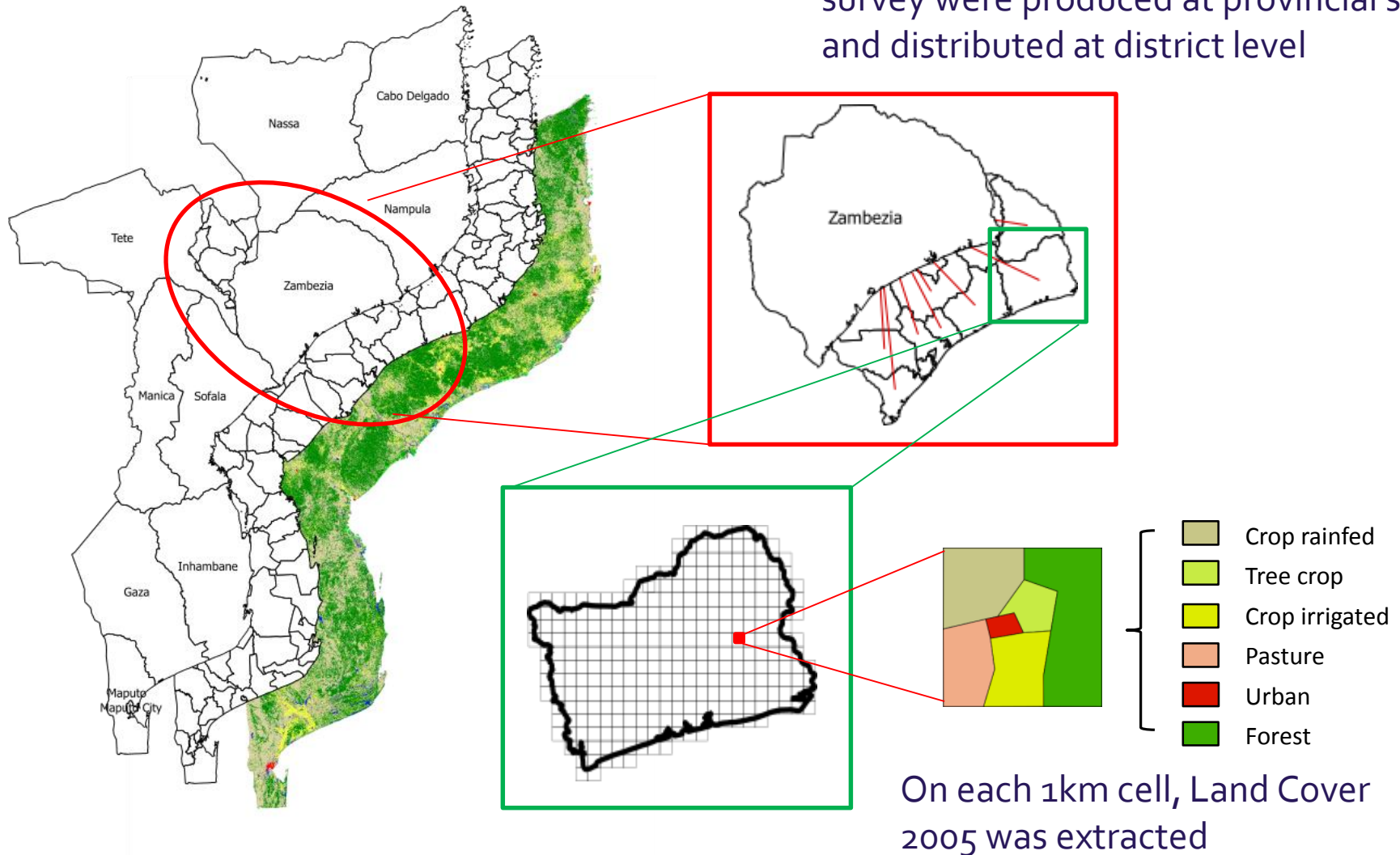


- Fallow extent is not reported in agricultural statistics
- Fallow in land cover map may be displayed in cropland and grassland categories
- Fallow is an important landscape feature (3 or 4 times more than cropped area) and provide many ecosystem services (food production, carbon sequestration, biodiversity connectivity, etc.)

1. Initialization – Spatial distribution of household

Combining multi scale datasets

HH attributes calculated from HH survey were produced at provincial scale and distributed at district level

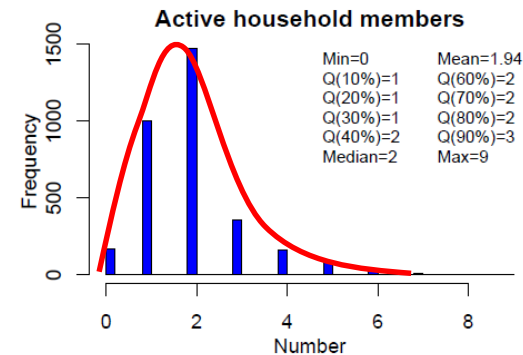
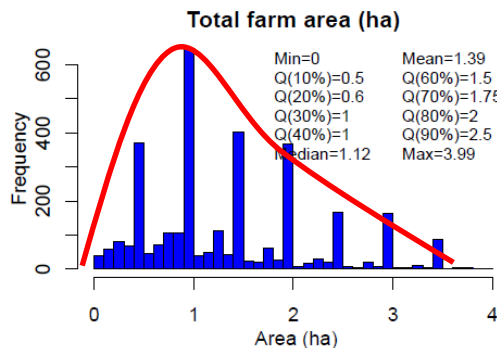


1. Initialization – Spatial distribution of household

On each district, HH type distribution is collected (e.g. Pebane in Zambesia)

% Household type	1: Pure subsistence	2: Some cash crops	3: Some livestock	4: SMEF
Pebane	80%	12%	1%	7%

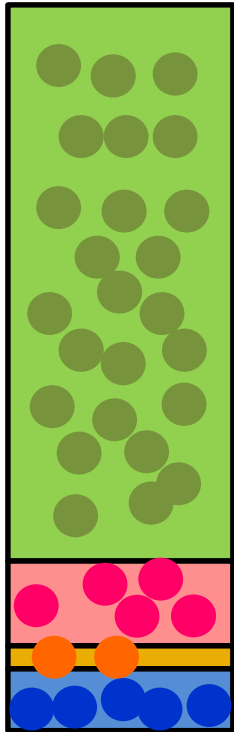
Each HH type has its own set of attributes, we used especially the **total crop area** and **number of household members**



In red: the probability distribution function (PDF) of the HH attributes according to HH type

1. Initialization – Spatial distribution of household

For each district, we draw 10 000 household candidates that match both the HH type proportion of the district and its related attributes according to the probability distribution function (PDF).



An iterative process is then triggered, that

- Draw household candidates into every modeling cell of the district
- Retain or reject HH candidate according to the population location likelihood map

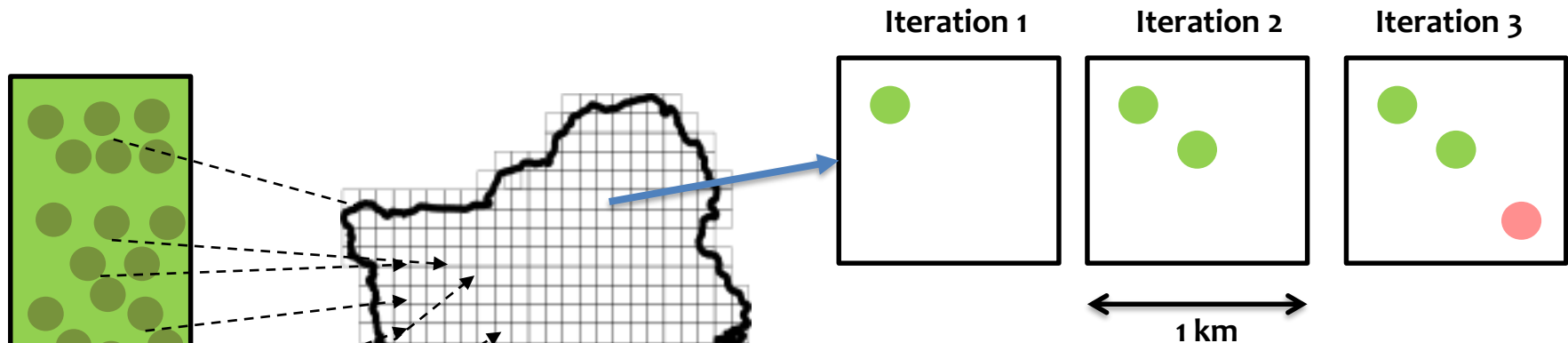
If the HH is retained :

- The crop area is subtracted from the initial cropland area collected from the LULC map
- The farm area is allocated to the cell
- The number of HH member is subtracted from the district population
- The number of HH member is allocated to the cell

1. Initialization – Spatial distribution of household

The process stops when all spatial units reach available crop area (from the LULC map) OR members reach population per district (from national statistics)

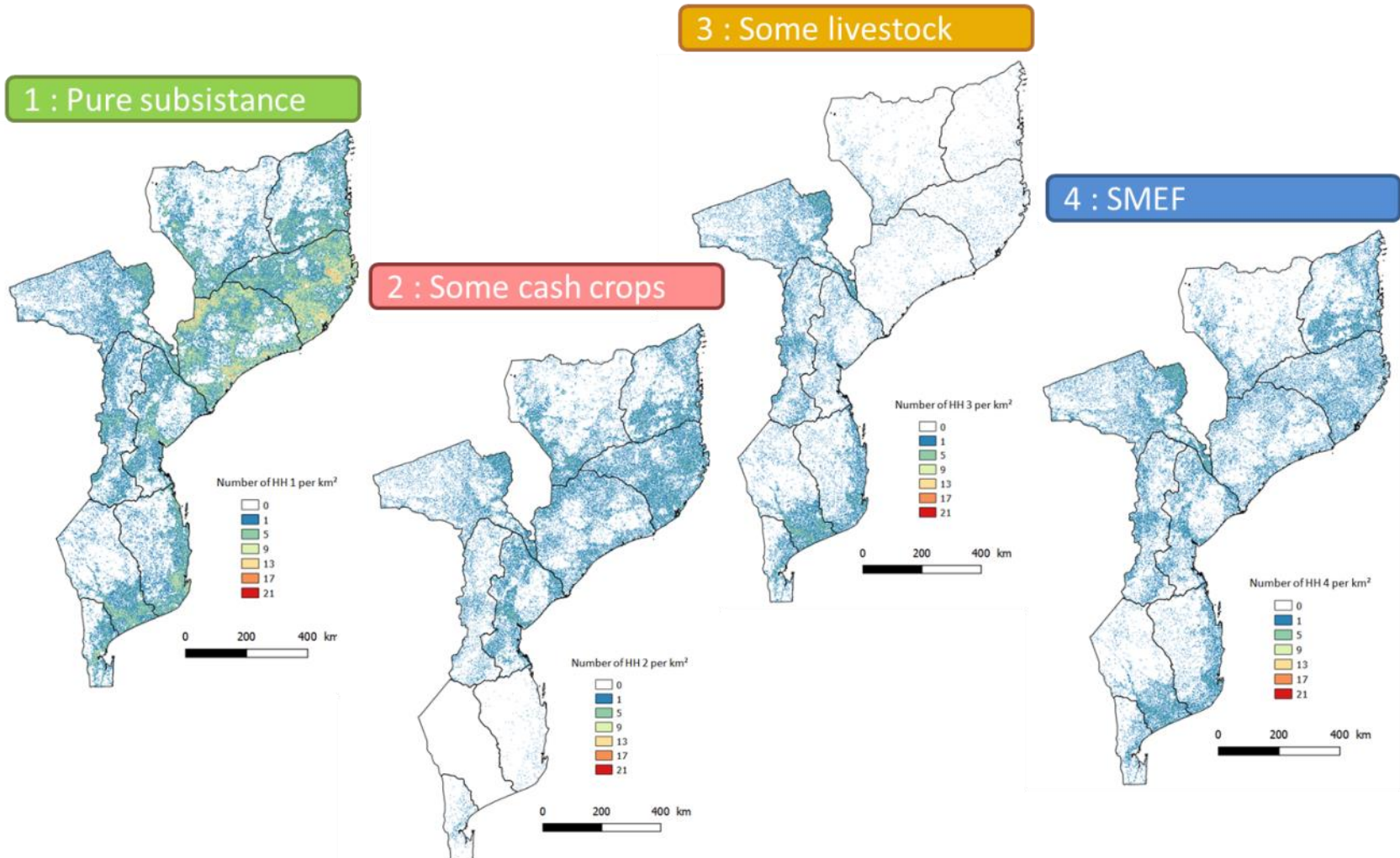
It corresponds to ~2500 iterations



This process allow to allocate HH on every cell matching the LULC map (cropland area), the HH type distribution, its related crop and members attributes, population census and according to population location likelihood.

1. Initialization of the system

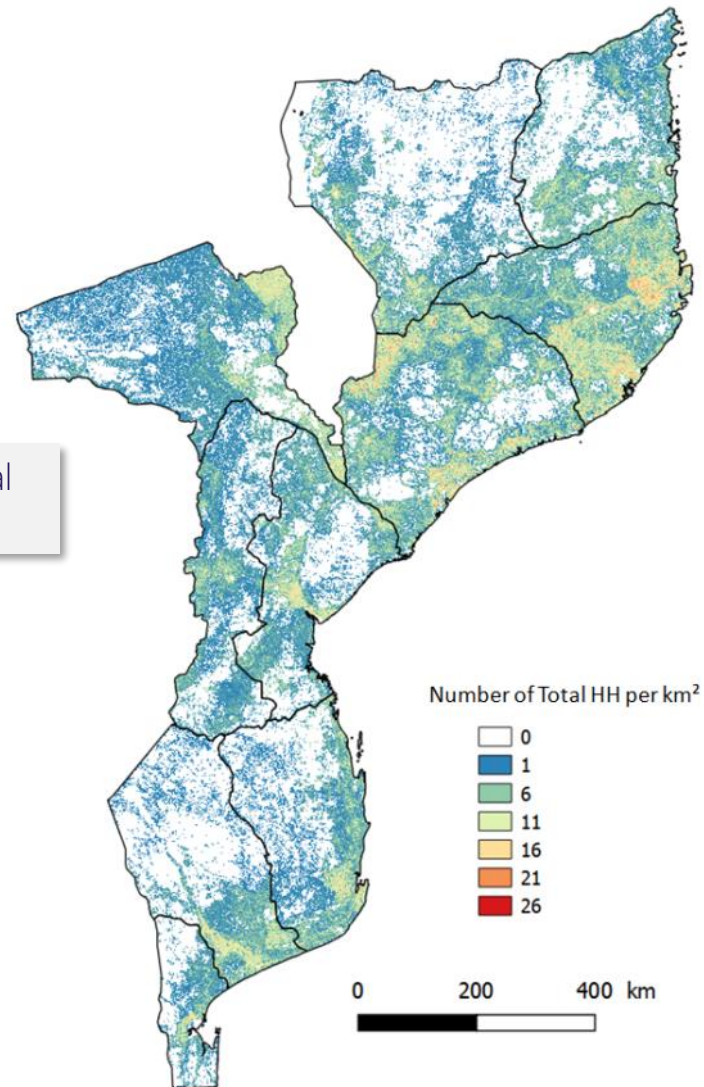
Exemple of HH Simulated distribution



1. Initialization of the system

Exemple of HH Simulated distribution

Total number of rural households per km²

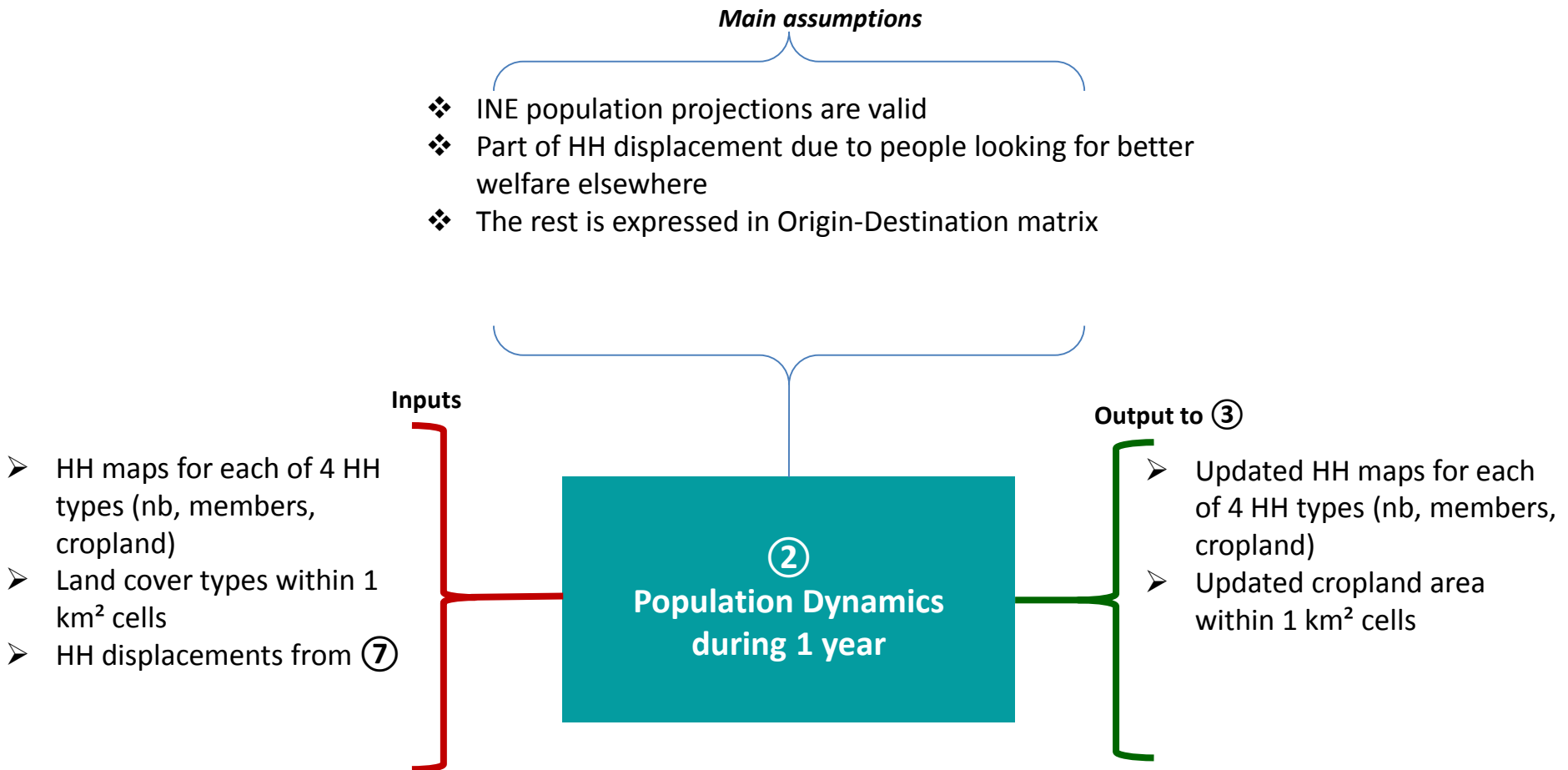


Technical Description

2. Population Dynamics



2. Population Dynamics



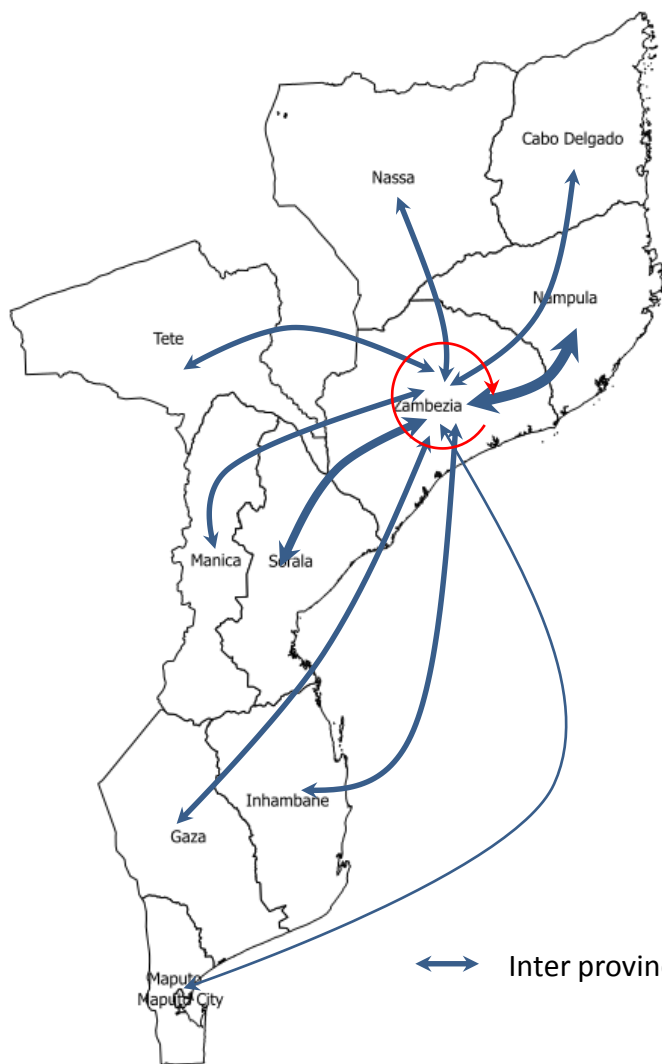
2. *Population Dynamics*

Population dynamics process

- Use of a growth and mortality factor applied on each spatial unit according to national statistics
- Migration occurs between Provinces (Origin-Destination matrix)
- After migration, population is redistributed between rural and urban population
- Rural population is then disaggregated to districts and redistributed as for 2007

2. Population Dynamics

The Origin-Destination matrix is an input to the model



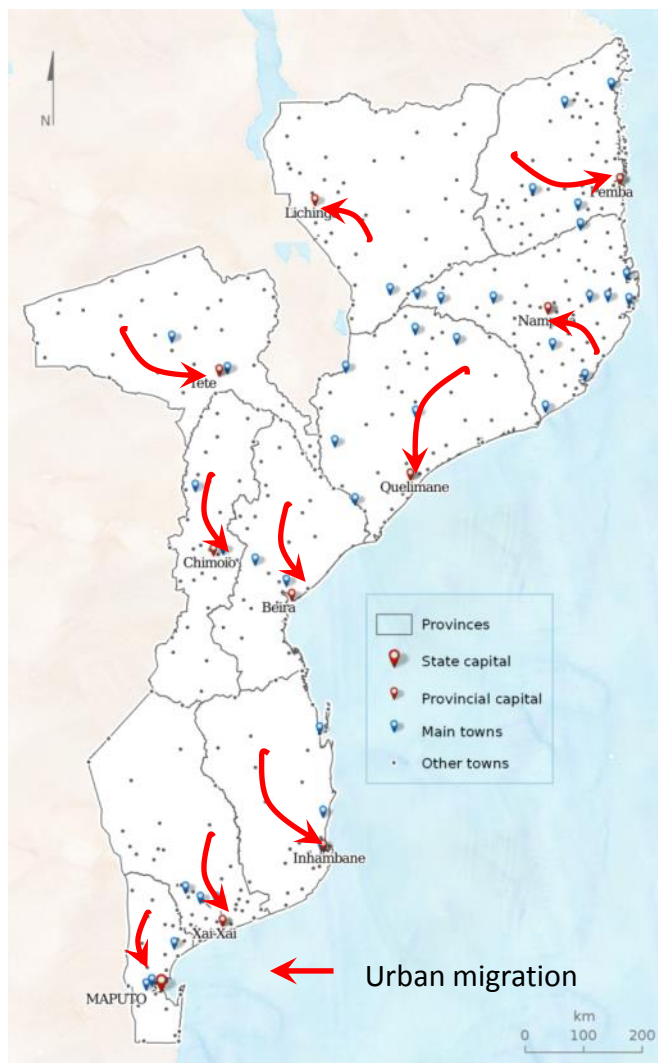
From Zambezia to ...

	Nassa	Cabo Delgado	Nampula	Zambézia	Tete	Manica	Sofala	Inhambane	Gaza	Maputo Província	Maputo Cidade
Nassa		8.7	16.8	12.2	4.4	0.8	1.1	0.5	0.5	0.4	1.1
Cabo Delgado	12.8		24.3	2.7	3.0	0.7	1.0	0.4	0.5	0.5	1.6
Nampula	42.9	65.2		27.2	4.3	1.9	3.3	1.0	1.7	1.5	5.3
Zambézia	21.4	5.2	31.9		12.4	10.1	42.1	0.9	2.1	4.0	12.5
Tete	3.4	4.0	3.9	12.3		16.0	12.8	1.1	0.9	0.8	2.0
Manica	1.8	1.6	3.8	4.5	28.5		20.9	2.6	2.2	0.9	2.2
Sofala	3.9	3.2	4.4	24.5	25.2	58.0		10.2	2.4	2.9	8.3
Inhambane	1.1	1.0	1.4	0.9	4.5	3.4	6.6		16.6	16.6	25.6
Gaza	0.9	0.6	0.9	0.8	1.3	2.7	1.0	8.7		12.2	22.5
Maputo Província	3.5	1.6	1.9	3.0	2.4	1.4	2.2	16.9	23.7		18.9
Maputo Cidade	8.4	8.9	10.9	11.9	13.8	5.1	9.0	57.6	49.4	60.1	

Dataset : inter-province migration percentages 1997-2007 (INE, 2017)

2. Population Dynamics

Integration of urban and rural population migration



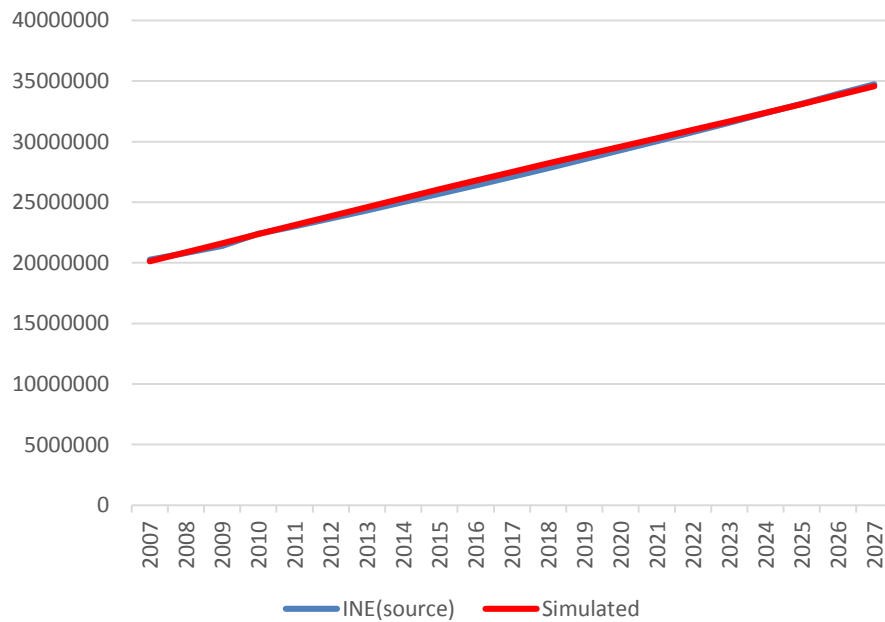
Província	Total		Urbana		Rural	
	N	%	N	%	N	%
Niassa	1 213 398	100	277 838	22,9	935 560	77,1
Cabo Delgado	1 634 162	100	340 707	20,8	1 293 455	79,2
Nampula	4 084 656	100	1 167 813	28,6	2 916 843	71,4
Zambézia	3 890 453	100	679 073	17,5	3 211 380	82,5
Tete	1 807 485	100	247 178	13,7	1 560 307	86,3
Manica	1 438 386	100	363 844	25,3	1 074 542	74,7
Sofala	1 685 663	100	645 413	38,3	1 040 250	61,7
Inhambane	1 304 820	100	289 458	22,2	1 015 362	77,8
Gaza	1 236 284	100	142 793	11,6	1 093 491	88,4
Maputo	1 225 489	100	832 188	67,9	393 301	32,1
Maputo Cidade	1 111 638	100	1 111 638	100	-----	-----

Dataset : INE, 2017

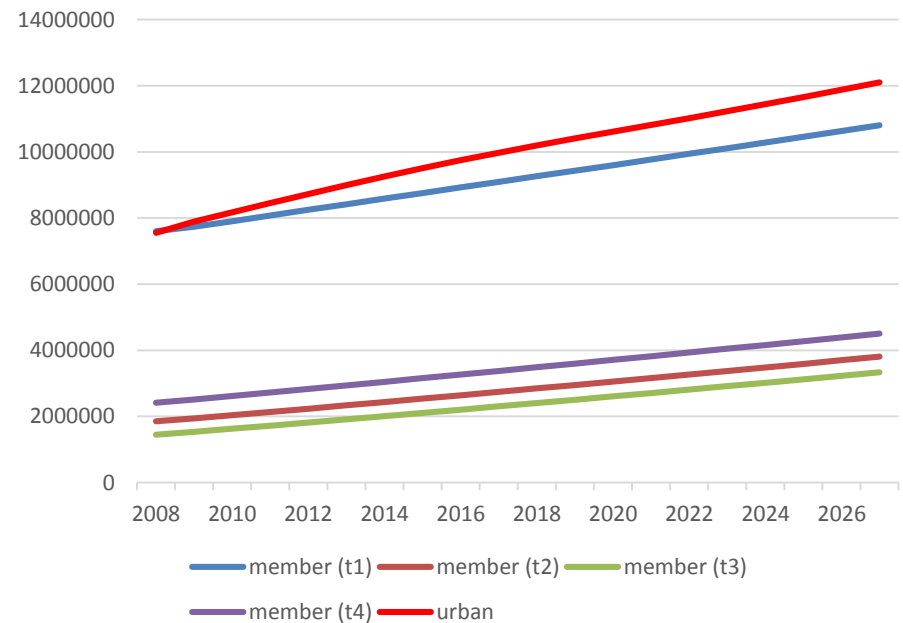
2. Population Dynamics

Exemple of Population dynamics simulation results

Total population dynamics



Urban and household population dynamics



Technical Description

3. Land Cover Change



3. Land Cover Change

Main assumptions

- ❖ Arriving rural HH will convert forest land into cropland
- ❖ They will preferentially locate near road network, existing cropland
- ❖ Slopes and altitude higher than a given threshold are avoided



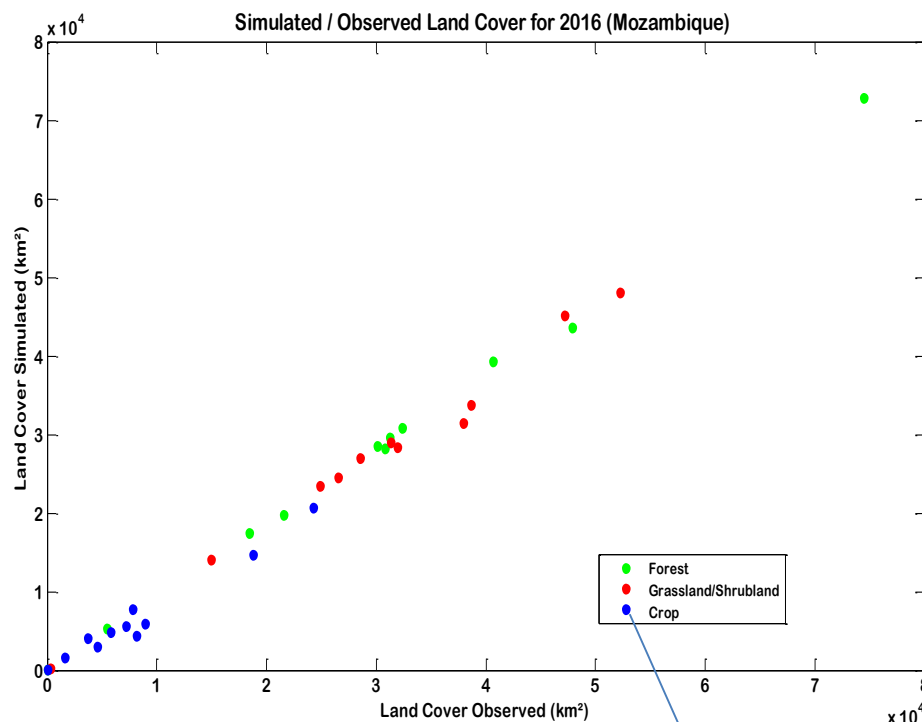
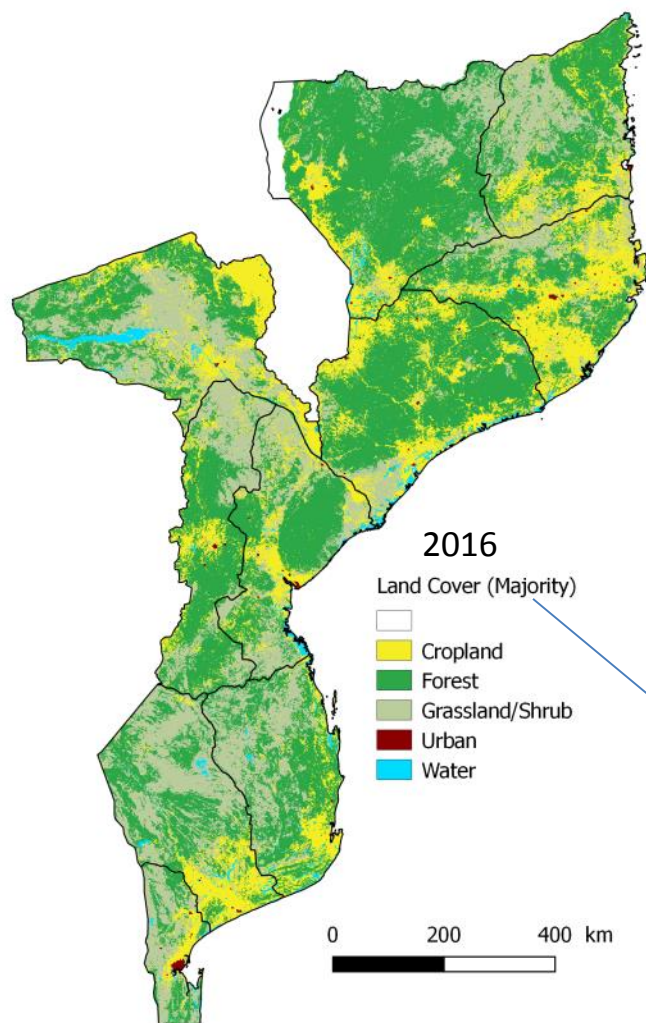
3. Land Cover Change

Land cover change process

- Displacement of people and households in space is the main driver of land cover change
- New households allocated in rural areas will seek for land to cultivate, and will prospect available grassland and forest land to convert into cropland
- People moving to urban areas contribute to increase urban population density, which, in turn, creates urban sprawl

3. Land Cover Change

Calibration of LCC model between 2007-2016



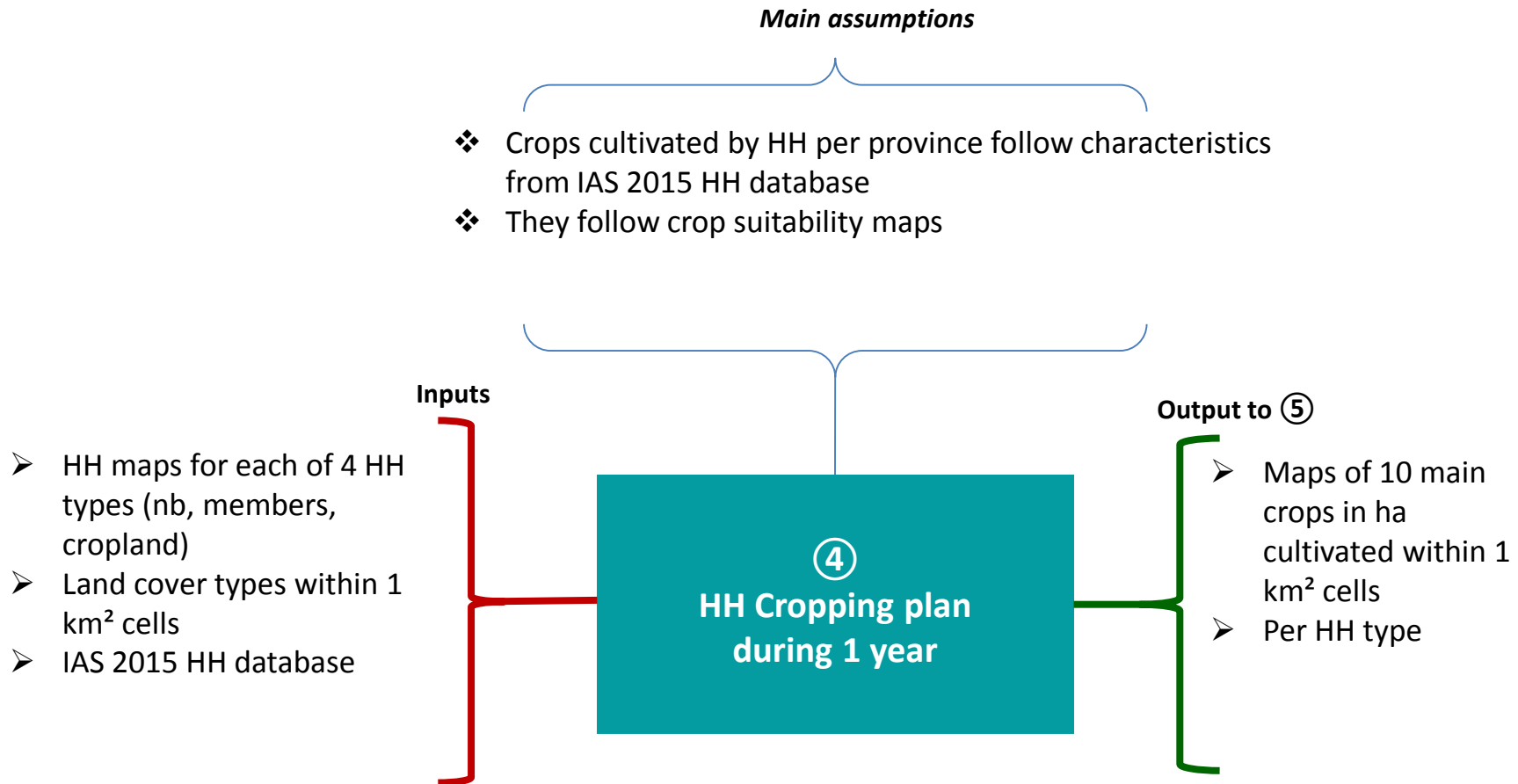
Each 1km x 1km cell may contain several LC types. This map gives the majority in surface area for each cell.

Each point is the total land cover area for a province.

Technical Description

4. HH Cropping Plan

4. HH Cropping Plan



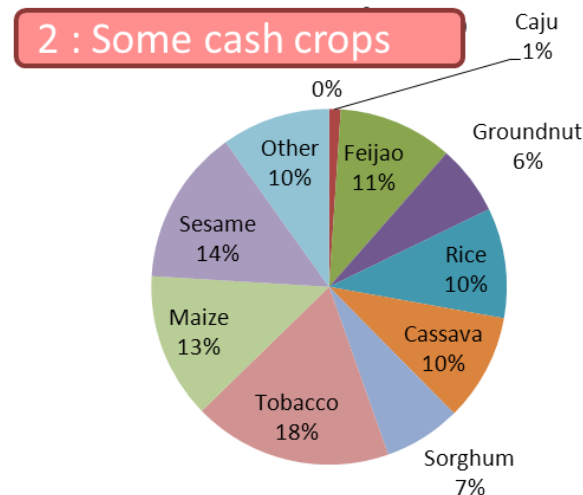
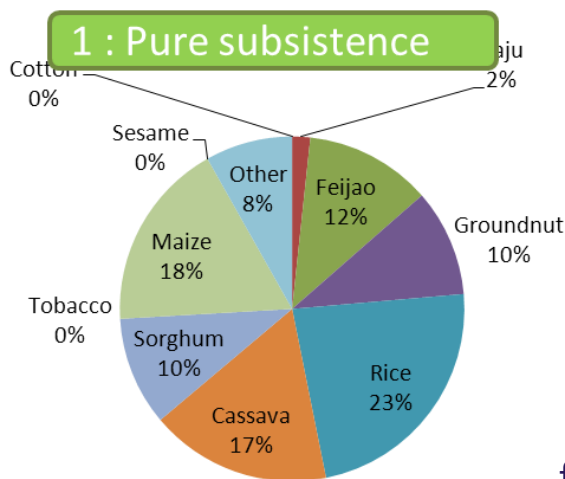
4. HH Cropping Plan

Selection of 10 dominant crops in Mozambique

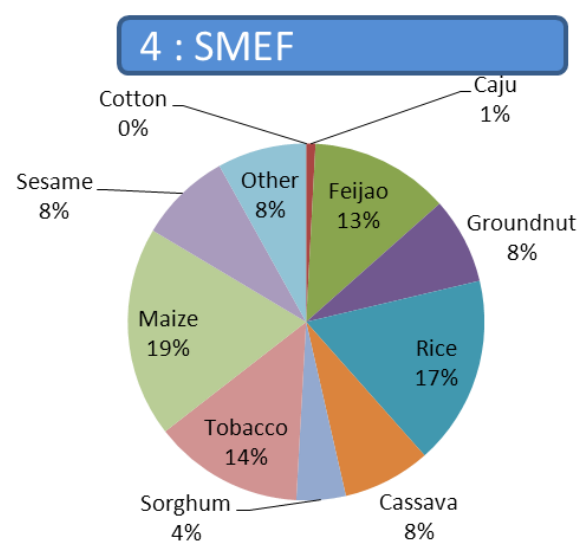
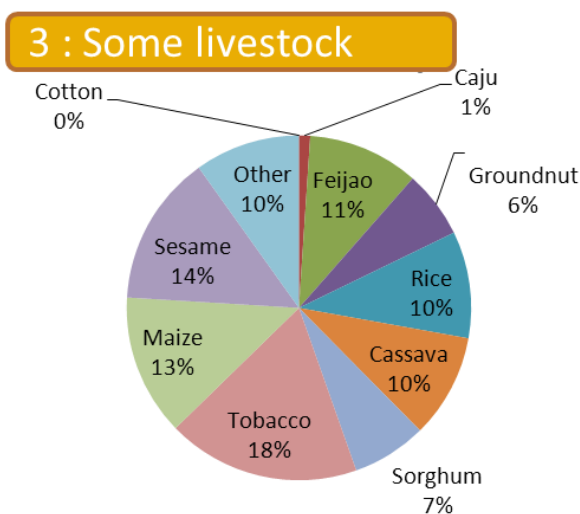
- Pure cash crops: **tobacco, sesame, cotton, cashew**
- Mix cash and staple crops: **feijao, peanut**
- Pure staple crops: **maize, cassava, sorghum, rice**

4. HH Cropping Plan

Extraction of cropping plan from the database (TIA 2015)



Cropping pattern for HH types in Zambezia



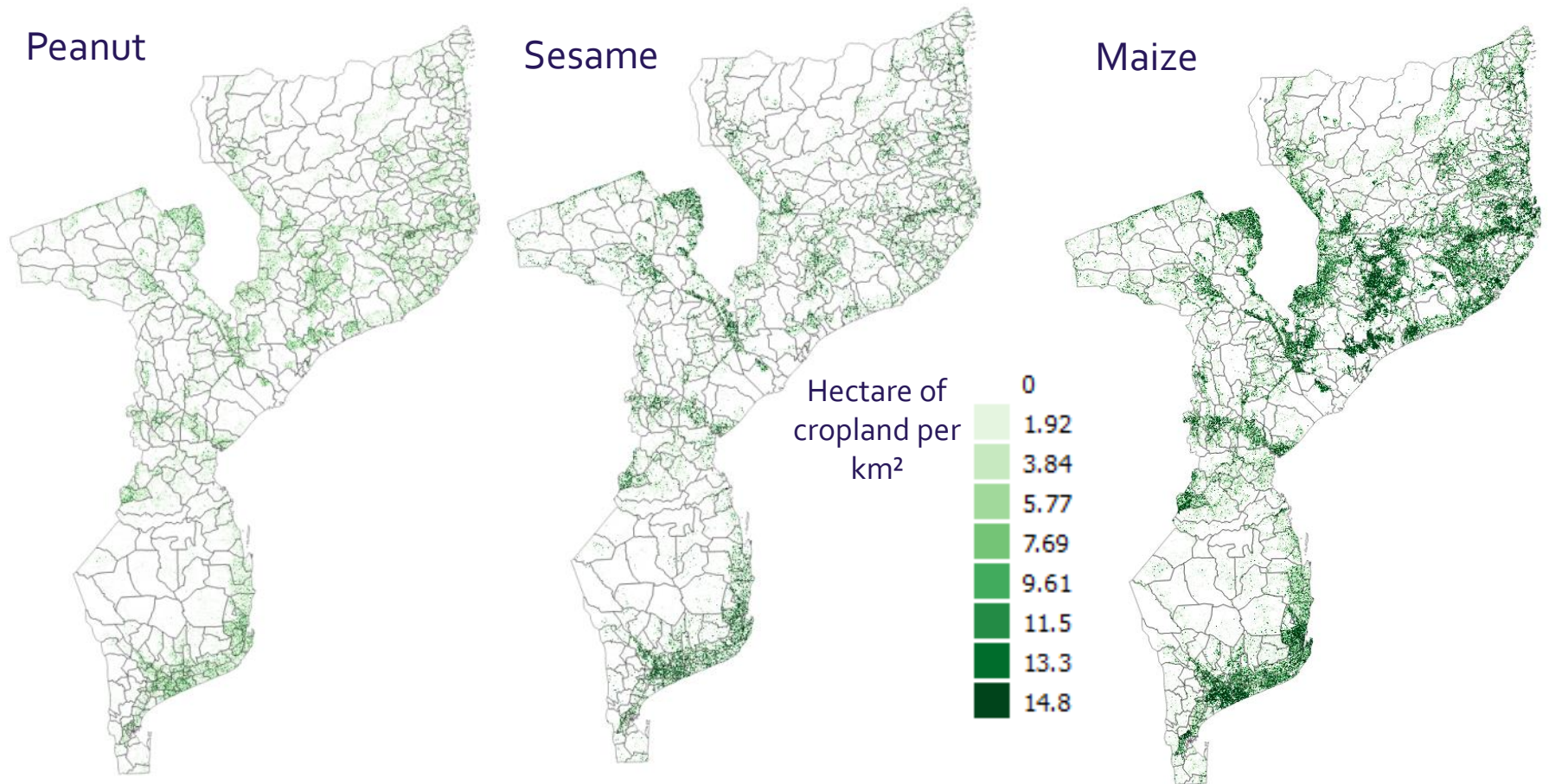
4. HH Cropping Plan

Use of the cropping plan in the model

- For each spatial unit, crop area is redistributed among 12 classes (10 crop types + fallow + other)
- The consistency is checked between the cropping patterns per HH type and per province (distribution of crop surface per crop type x HH type; HH dataset 2015)
- Each year for each HH, random draw of which crops and which surface area per crop type, according to probability distribution function.
- Subtract from total crop area of spatial unit until all surfaces allocated

4. HH Cropping Plan

Production of Crop area (ha) maps for 10 crops and simulation over time



Technical Description

5. Crop Area to Crop Production



5. Crop area to Crop Production

Main assumptions

- ❖ Variability in access to technology and intensification within HH types can be expressed in a HH type x intensification level weight matrix

Inputs

- HH maps for each of 4 HH types (nb, members, cropland, 10 crops)
- Crop yield maps for 10 crops and 4 intensification levels

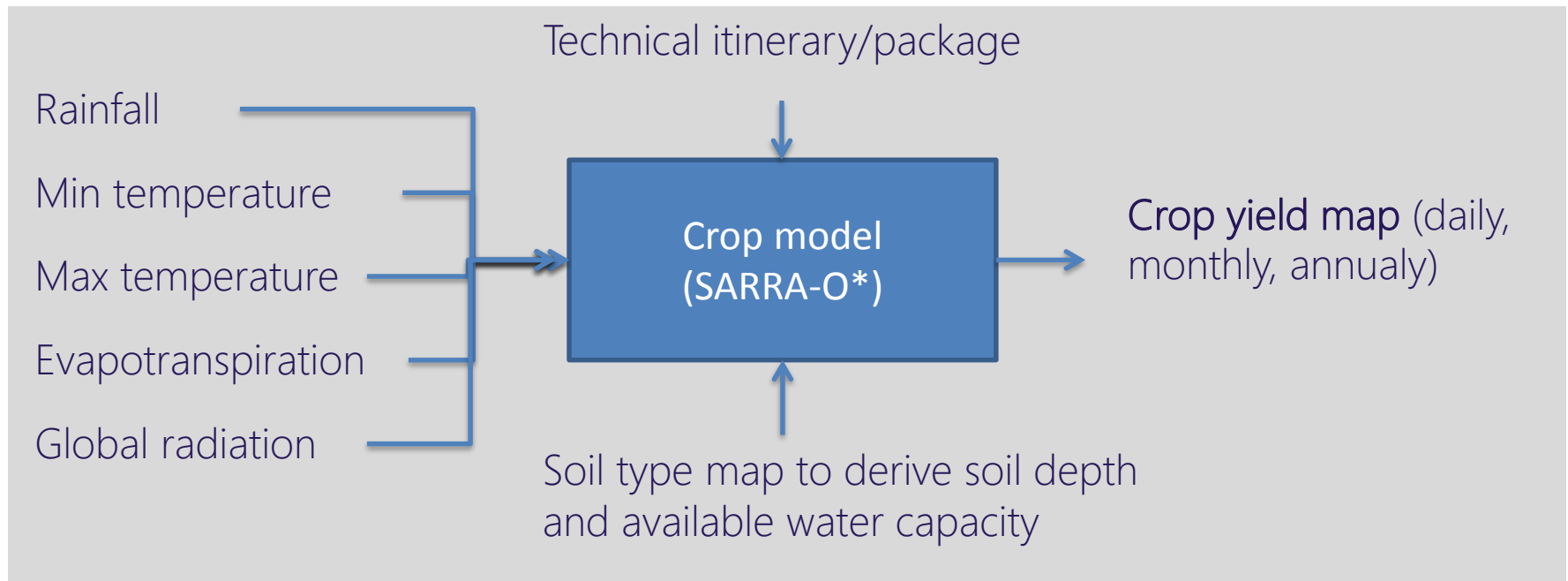
⑤
**Crop area to
crop production
during 1 year**

Output to ⑥

- Maps of crop production for 10 main crops in kg within 1 km² cells
- Per HH type

5. Crop area to Crop Production

Use of a crop model to provide spatially-explicit crop yields maps for 2017 to 2037 period using climate scenarios.

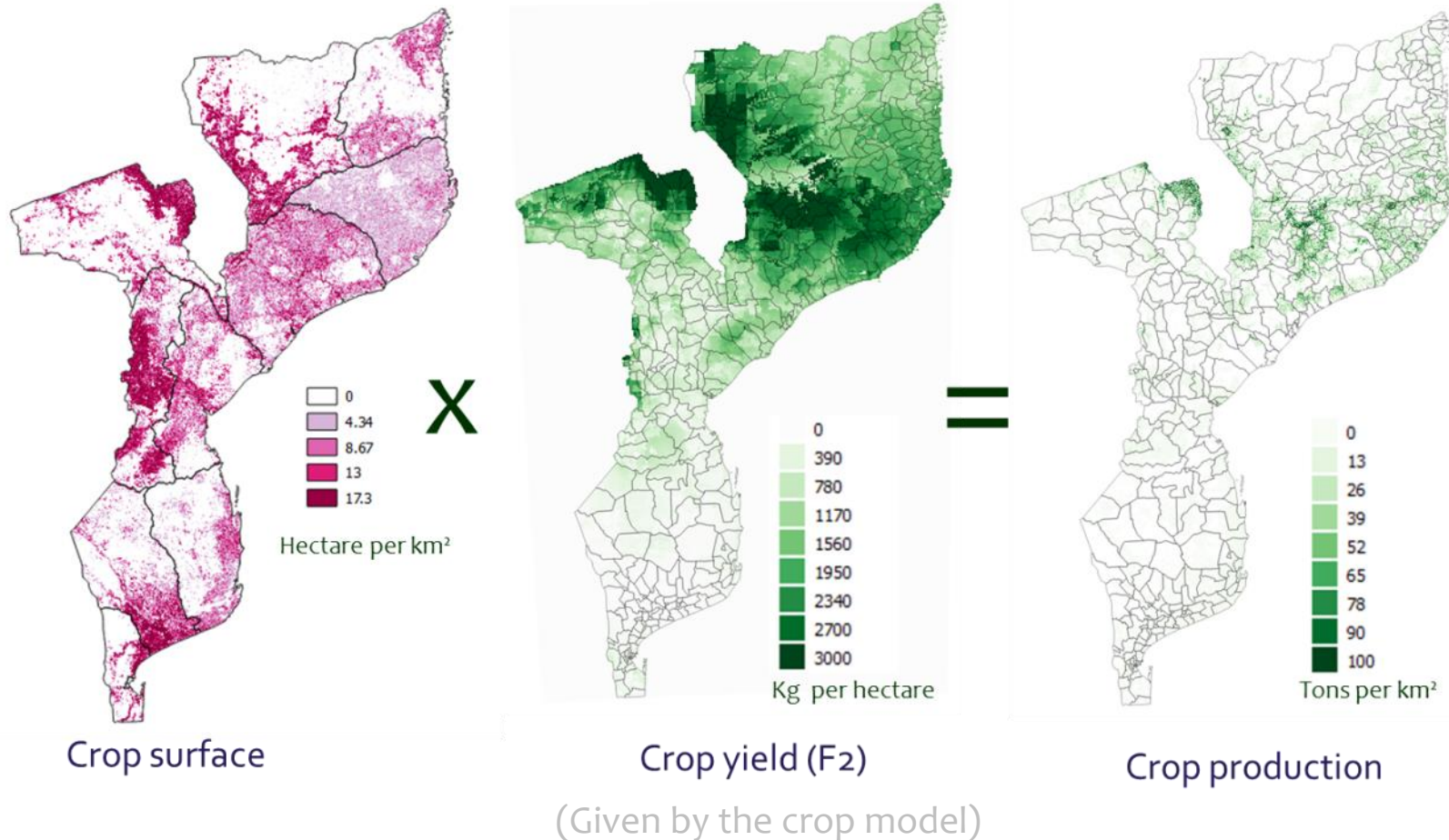


**SARRA-O : A spatially-explicit process-based crop model that uses input meteo or climate information for estimating yields.*

http://sarra-h.teledetection.fr/SARRAH_Home_Br.html

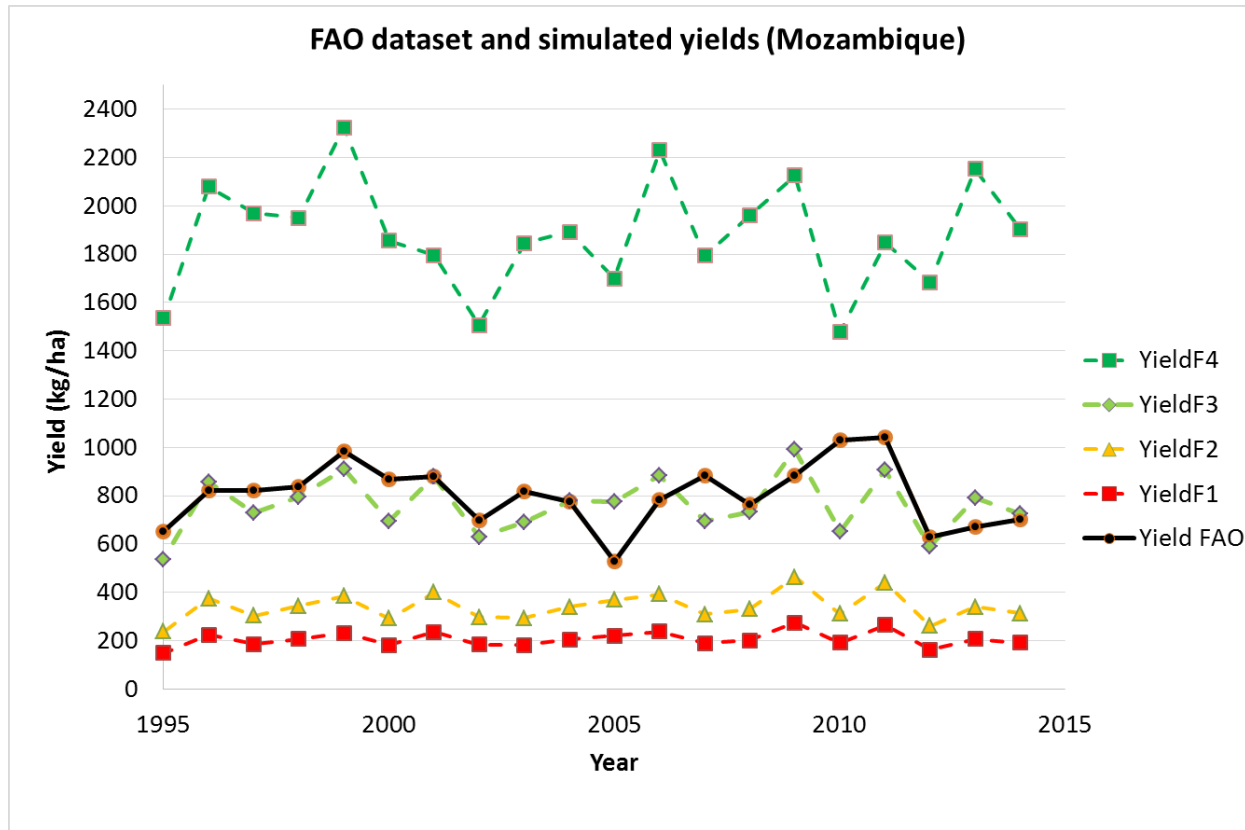
5. Crop area to Crop Production

From cropping plan to crop production 2015 : e.g. Maize



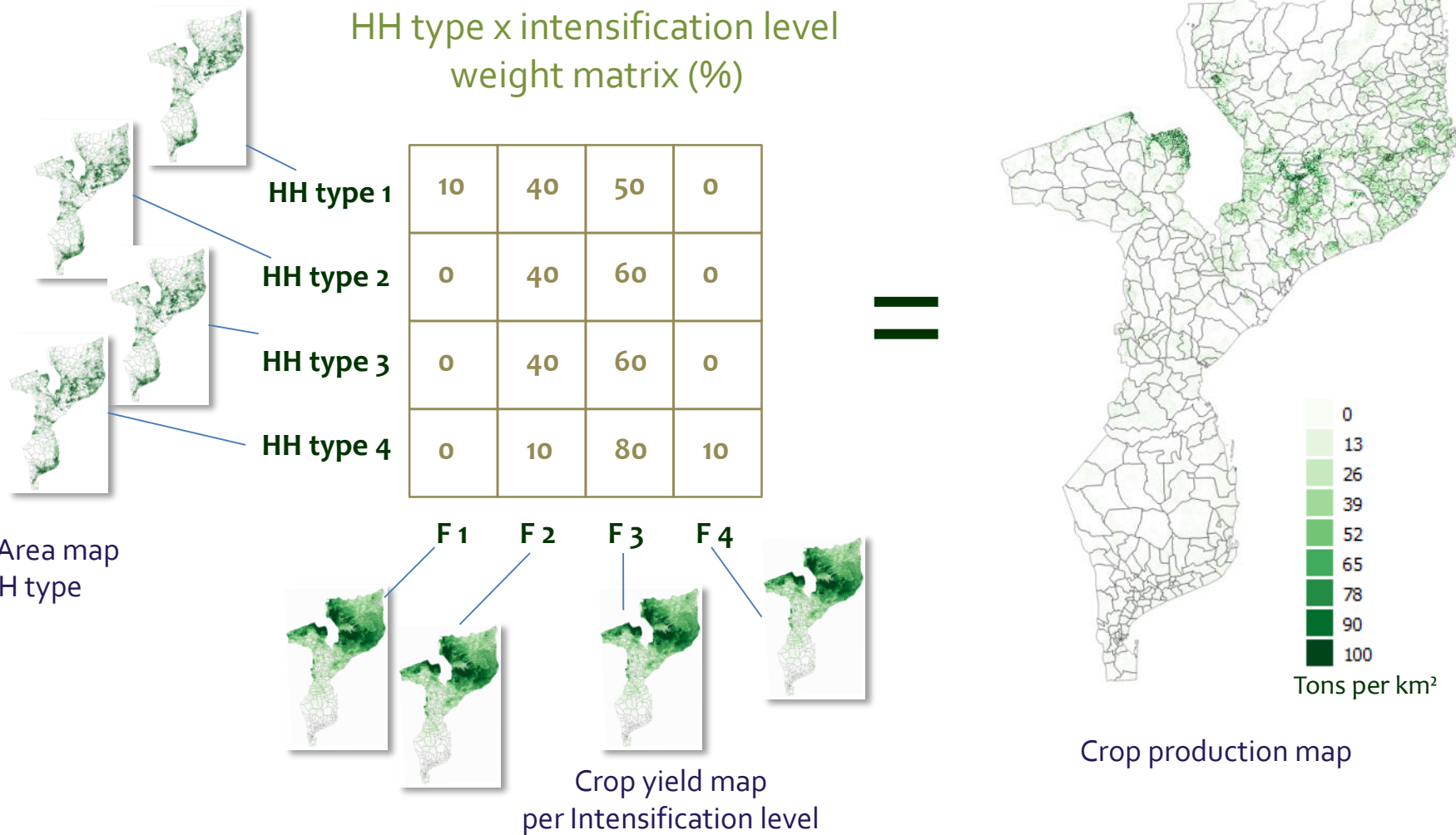
5. Crop area to Crop Production

The crop model produce four potential maps corresponding to four intensity levels



5. Crop area to Crop Production

Production a crop production map using a weighted average of crop area x crop yield for a given crop and a given year



5. Crop area to Crop Production

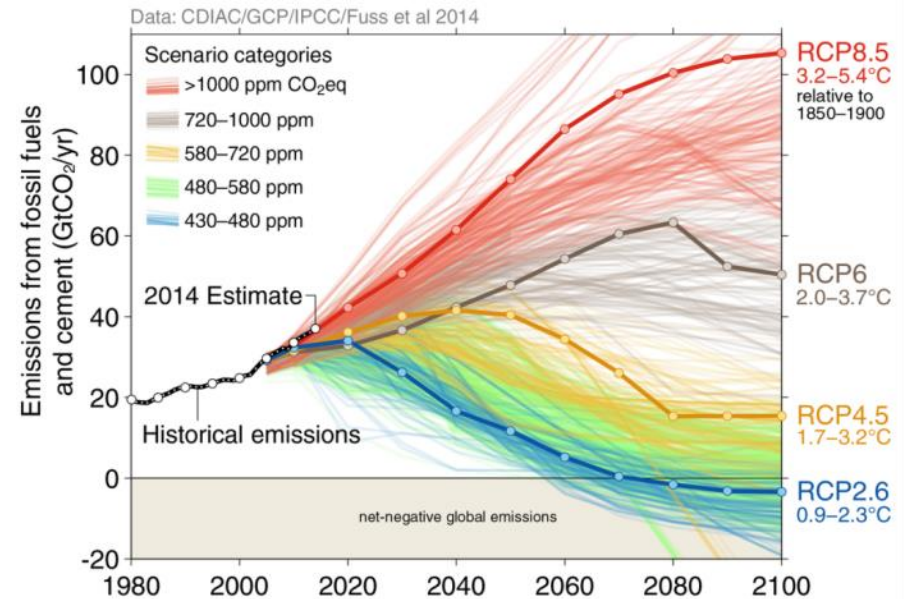
Climate scenarios

The crop model enable to use various climate inputs data from IPCC climate projections.

On the baseline scenarios we used:

RCP 2.6 scenario

GFDL-ESM2M climate model



Other future climate data were collected and processed to provide large set of crop yields dataset to be used as climate scenarios into the SD-HH model and for the 10 crops:

Climate scenarios:

RCP 2.6 (paris agreement)

RCP 8.5 (worst-case scenario)

Climate models:

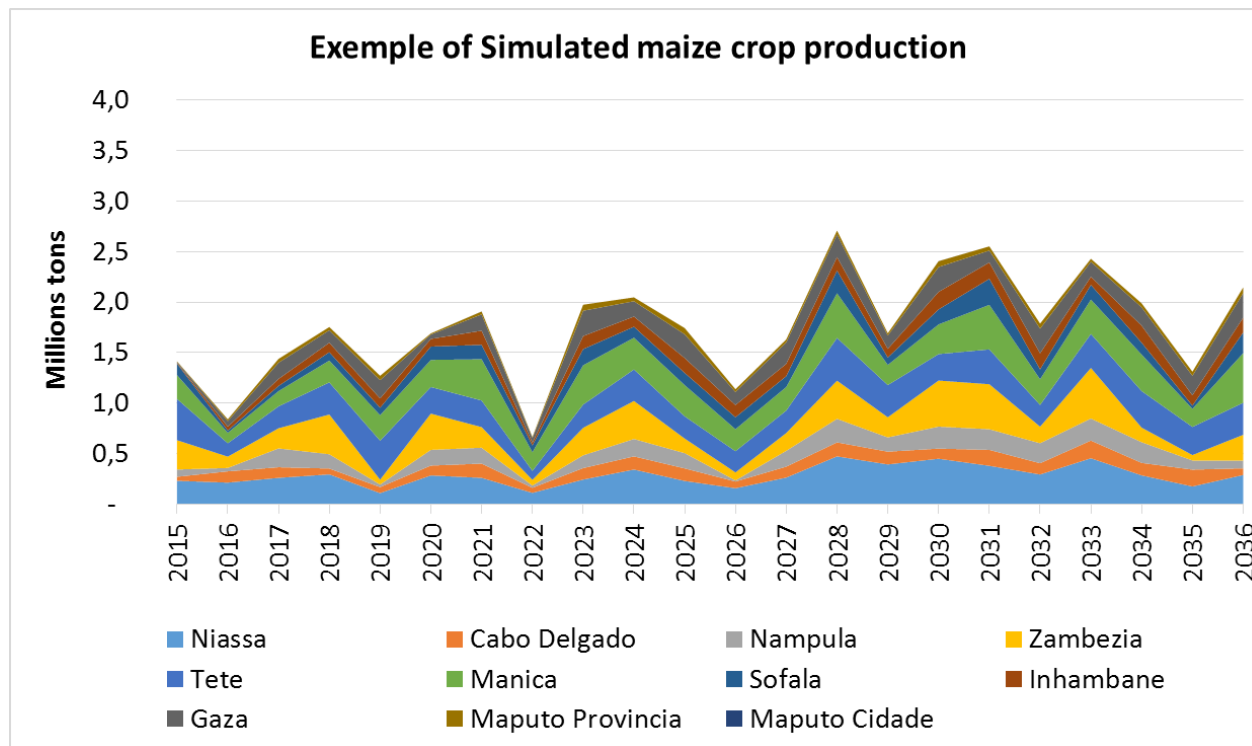
HadGEM2-ES

IPSL-CM5A-LR

MIROC5

5. Crop area to Crop Production

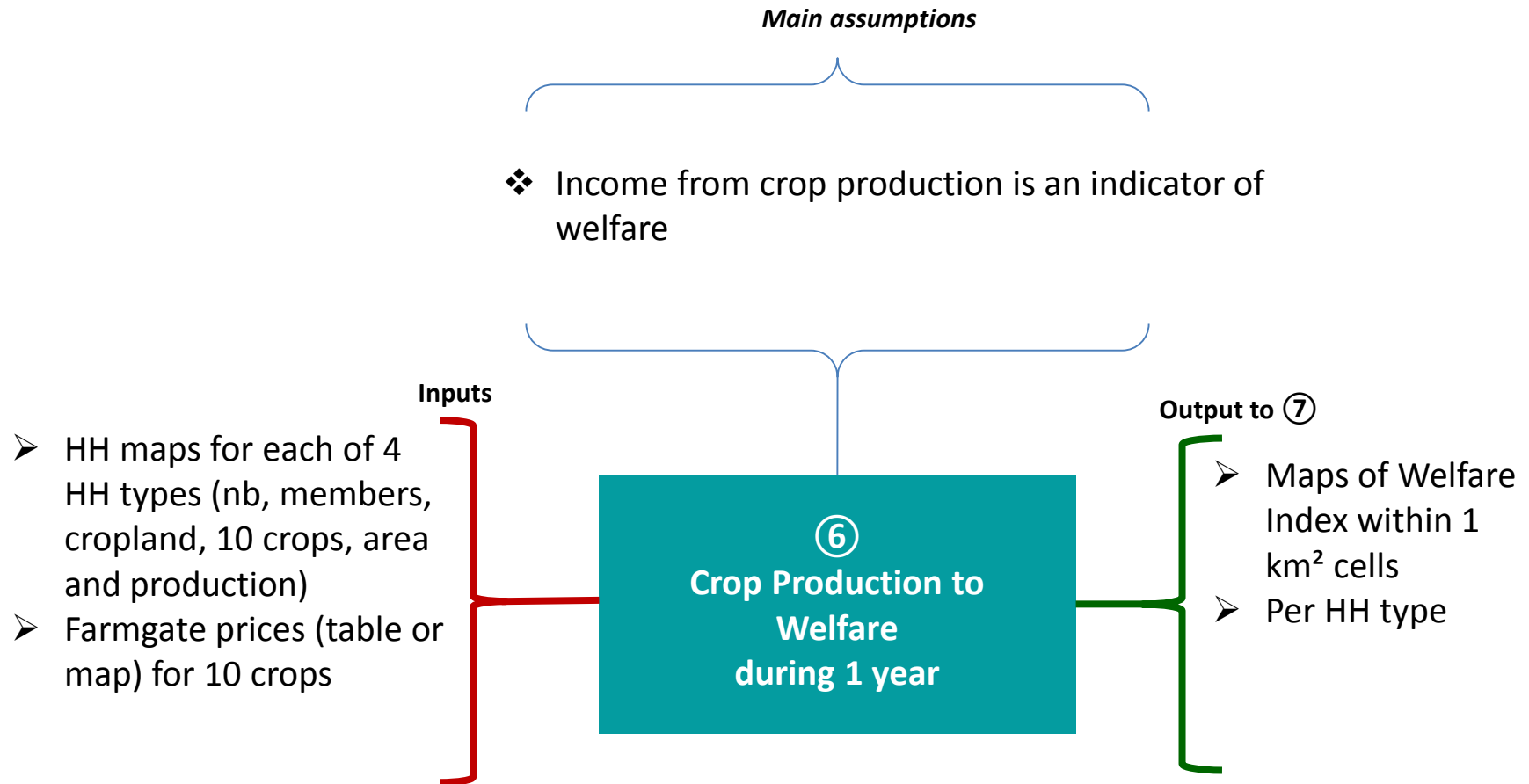
Exemple of simulation of maize crop production over the 2017 – 2037 period using the GFDL-ESM2M climate model and RCP 2.6 scenario



Technical Description

6. Crop Production to Welfare

6. Crop production to welfare



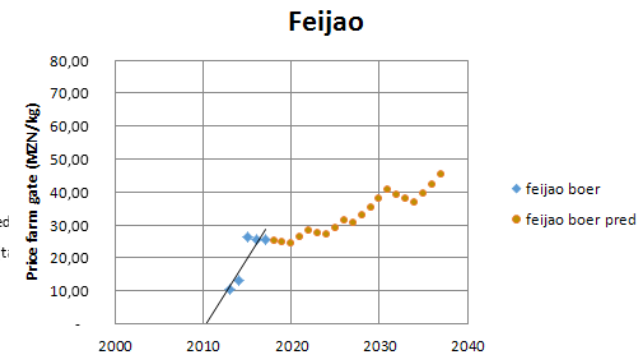
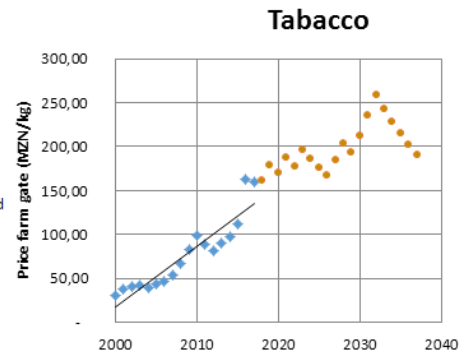
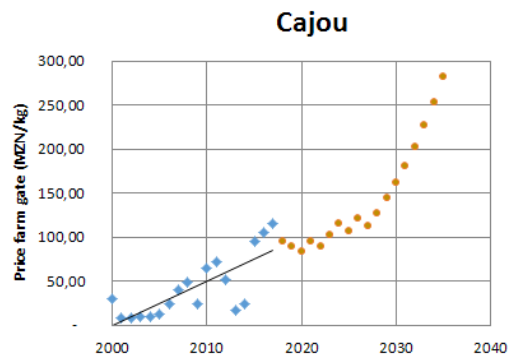
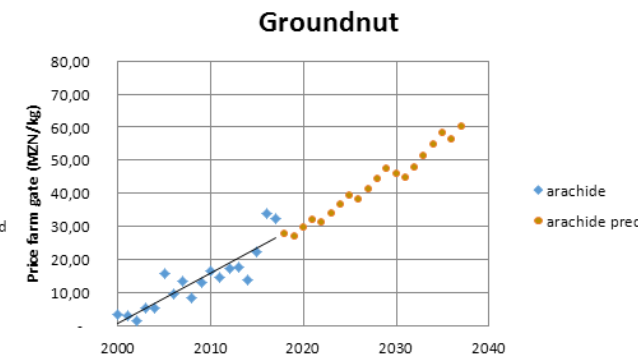
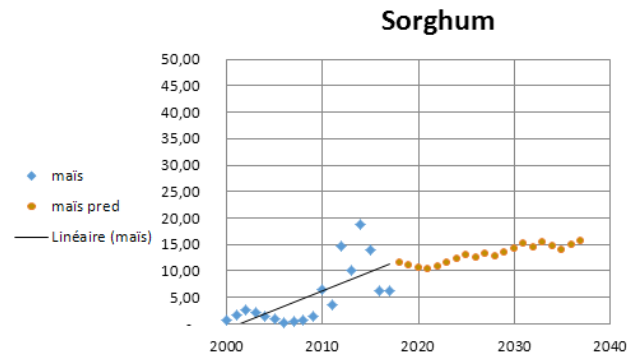
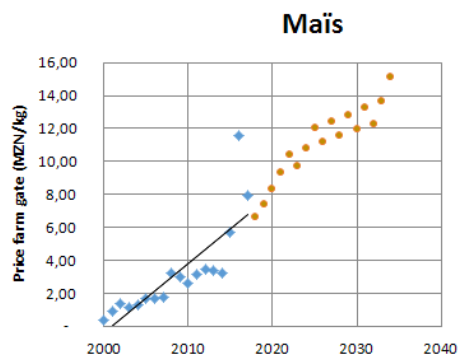
6. Crop production to welfare

- Welfare is expressed in terms of income generated from the agricultural production
- HH strategy regarding welfare index depends on HH type. SHH minimize risks, SMEF maximize their income
- Use price forecast (price scenarios) per product
- Convert crop production at household level into income

6. Crop production to welfare

- Price scenarios for the baseline scenario

Project historical price trend and volatility using a random function

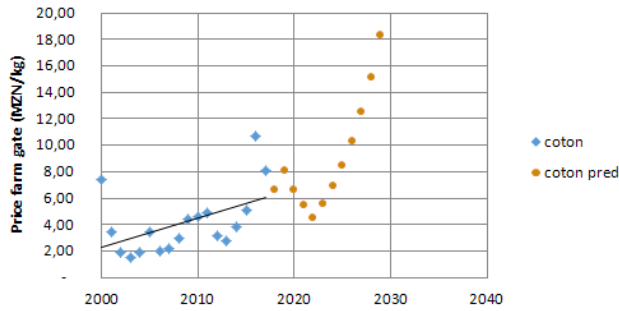


6. Crop production to welfare

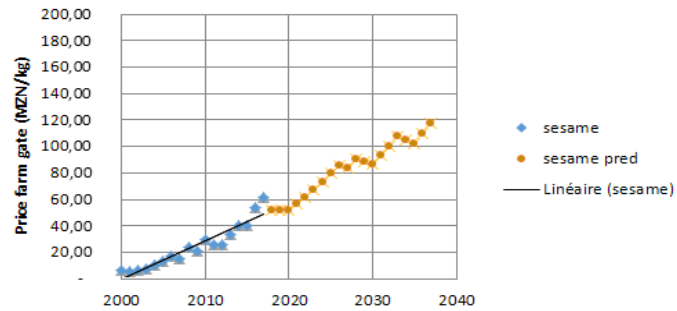
- Price scenarios on the baseline scenario

Use of historical price trend and volatility

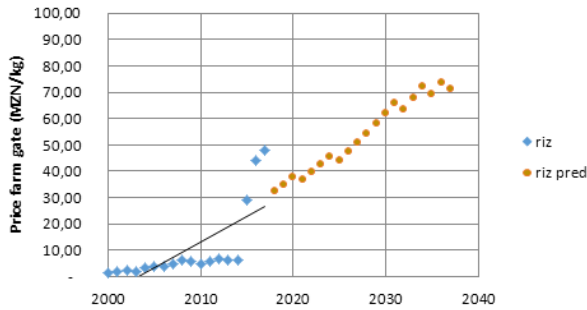
Coton



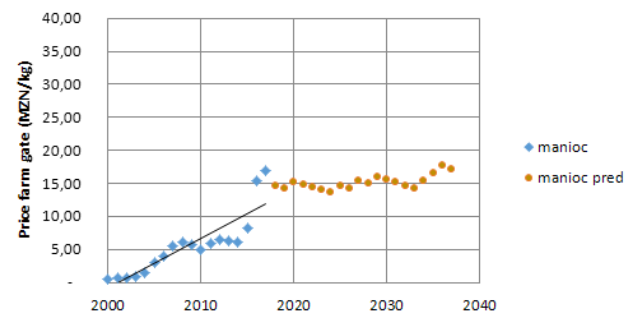
Sesame



Rice



Cassava

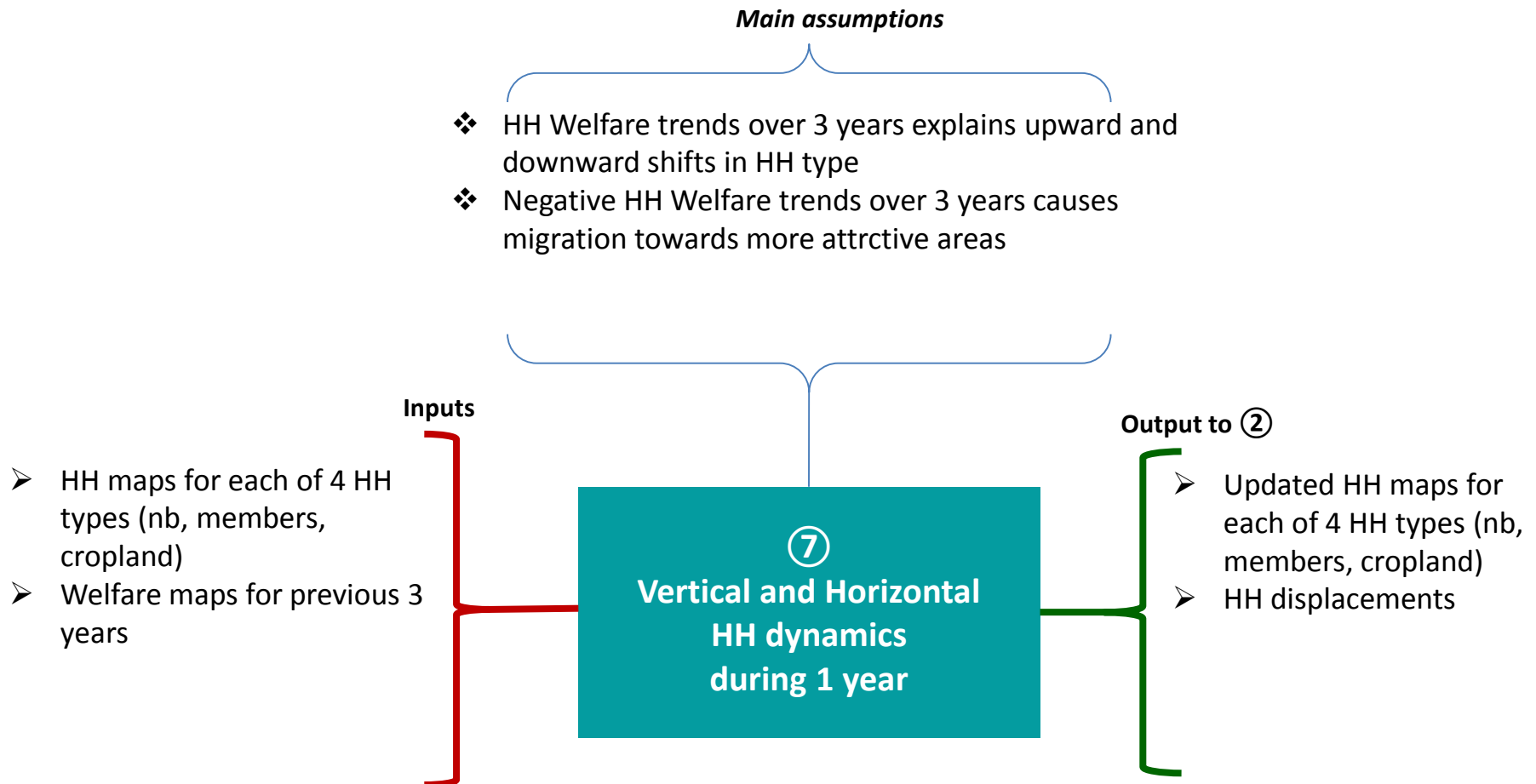


Technical Description

7. Vertical and Horizontal household dynamics



7. Vertical and Horizontal household dynamics

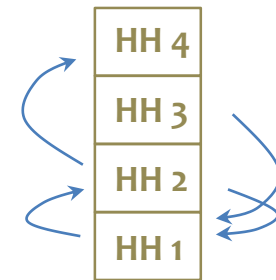


7. Vertical and Horizontal household dynamics

Integration of vertical and horizontal household dynamics to account for change in household situations following change in welfare

Vertical dynamics:

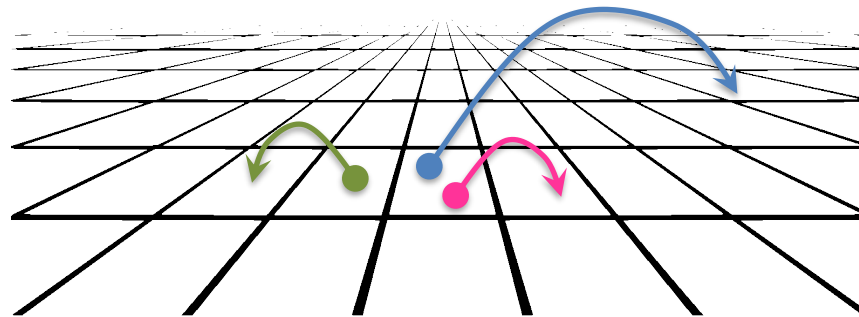
- HH may transition from one type to another depending on the variation of their welfare index
- Change in HH type results in change in strategy, crop area cultivated, cropping pattern



7. Vertical and Horizontal household dynamics

Horizontal dynamics: Displacement of HH in space, intra- and inter-province migrations

- Increase or decrease of welfare over time act on the propensity of HH to migrate
- Need of cultivable space drives HH displacements
- Push (reduced welfare, increased population density) and Pull (off-farm labor in economically dynamic regions) factors influence migrations





LandsimMoz Prototype

Technical Manual

version 1

September 2019

Anitidæ
landscapes & value chains

cirad