Land Use Planning for Enhanced Resilience of Landscapes (LAUREL) Mozambique

Project Results

Outline

1) Project overview
2) Land use change and land degradation analysis
3) LANDSIM Prototype overview
4) Some LANDSIM-P Results
5) LANDSIM-P User interface

Project overview

Key objectives

To support decision making for landscape management in Mozambique through :

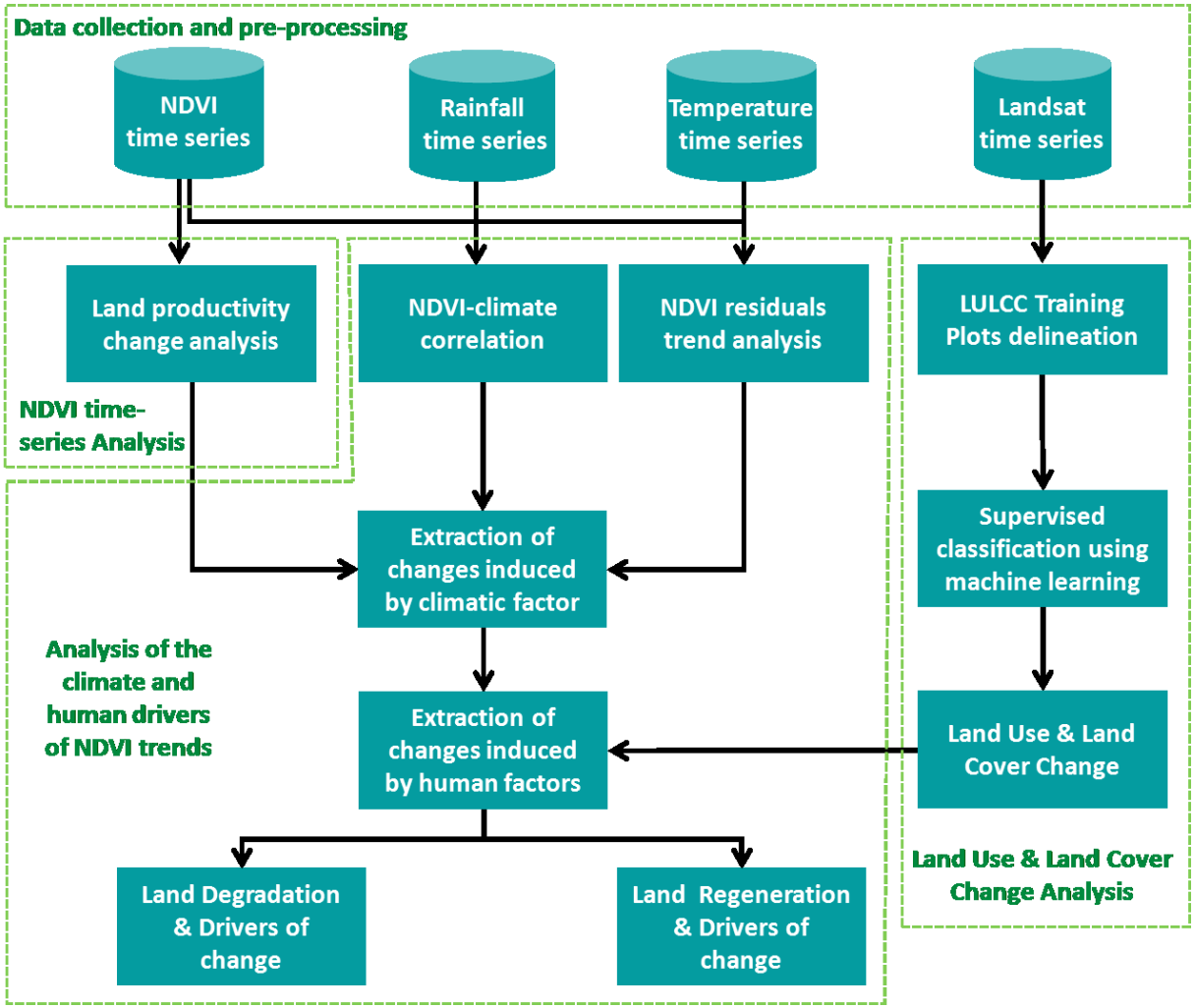
1. Improved spatial data and analysis on land degradation

2. A prototype model and platform for simulating and evaluating land use and land use change processes.

Land Use Change and Land Degradation Analysis

Component I: Land Degradation

General Approach



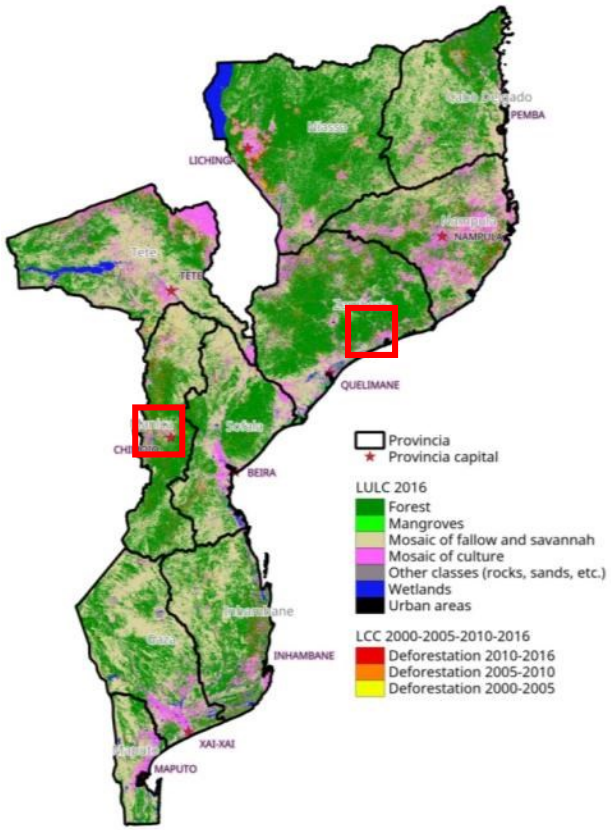
Key results

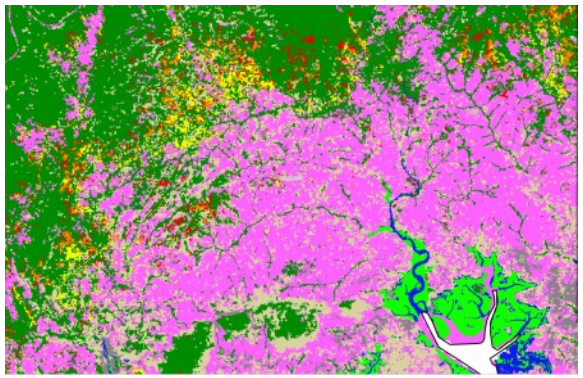
- ✓ Wall to wall Land Use – Land Cover Change map
- ✓ Land productivity change map
- ✓ Land productivity change analysis

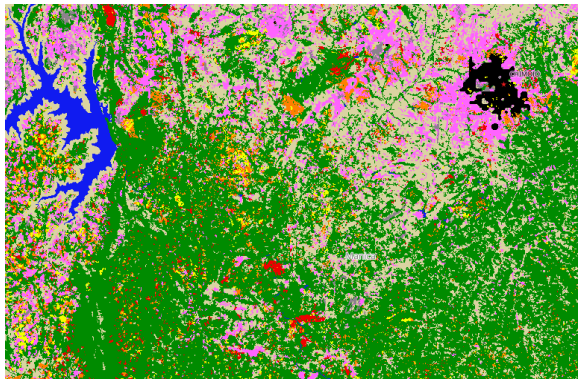
Key results (cont.)

Land use land cover change map

- Consistent with national estimates (FNDS)
- First Land Cover Change map in Mozambique

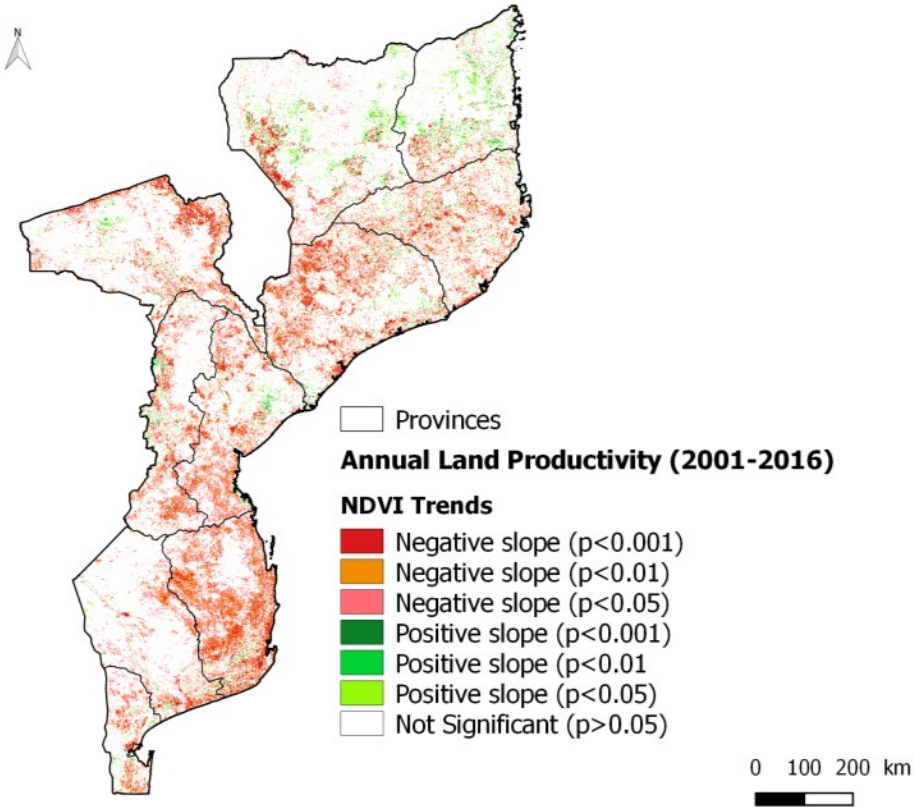






Key results (cont.)

Land productivity change map



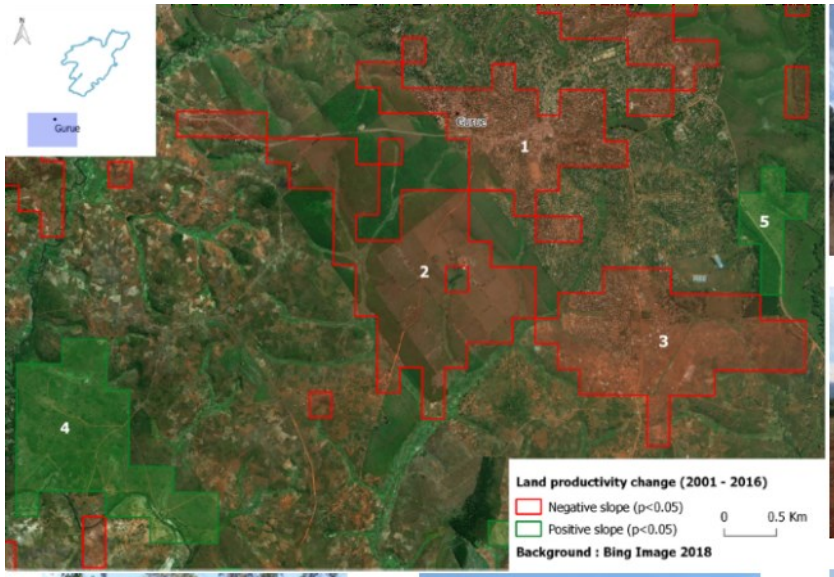
✓A large proportion of the country (**77%**) is characterized by an overall **stable trend**, meaning there is no significant change in terms of vegetation productivity over the period 2001-2016.

✓**19%** of the total area is characterized by a **negative NDVI trend**, concentrated in the Provinces of Inhambane, Zambezia and Nampula.

✓Only **3%** of the country displayed **increasing productivity** trends

Key results (cont.)

Ground-truthing land productivity estimates

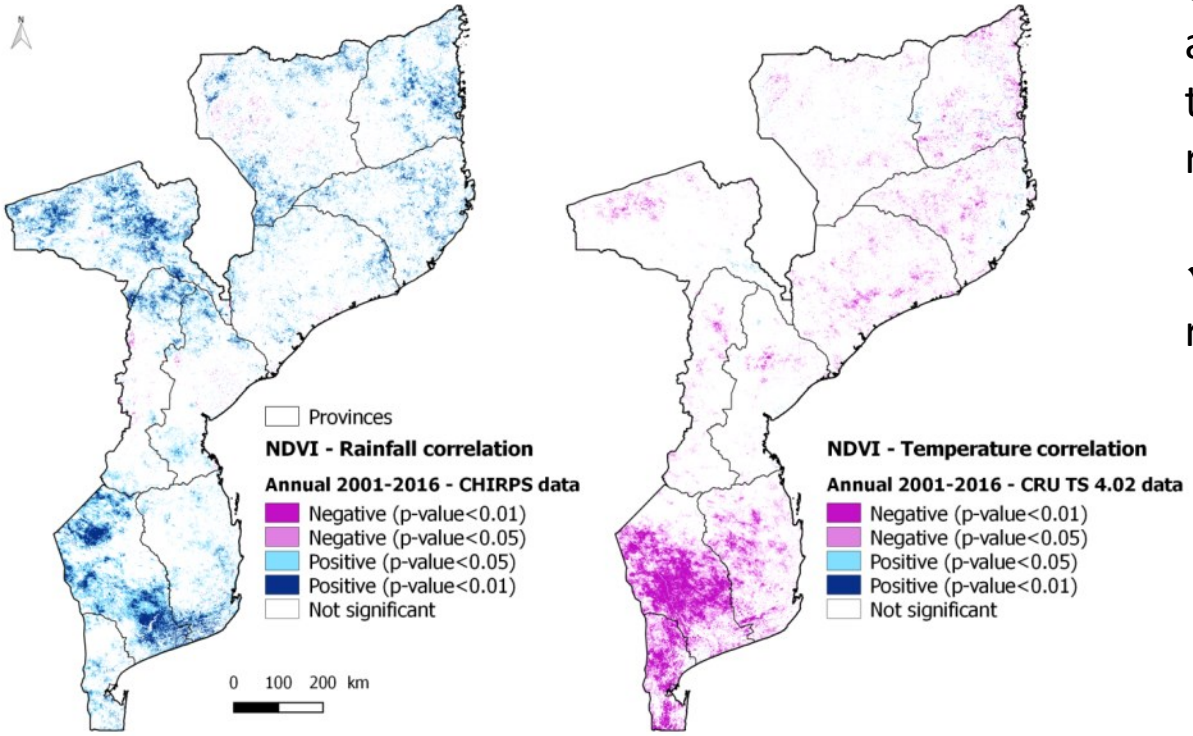


Areas of significant vegetation productivity change:

1) Urban growth in Gurué city
2) Old tea plantation
3) Settlement
4) Post-agriculture forest regeneration
5) Eucalyptus plantation.

Key results (cont.)

Land use change driver's analysis



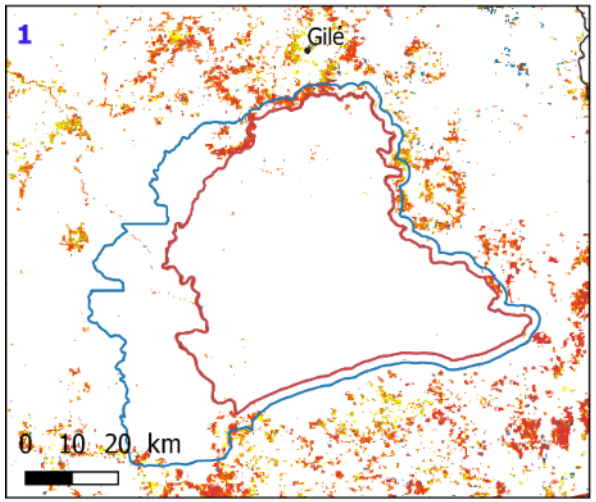
✓ More stable productivity trends (84 to 80%) when accounting for temperature and rainfall, respectively

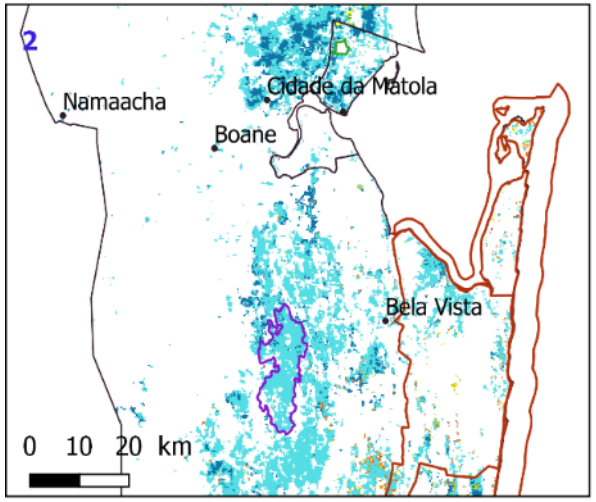
✓Positive trends are rainfall dependent

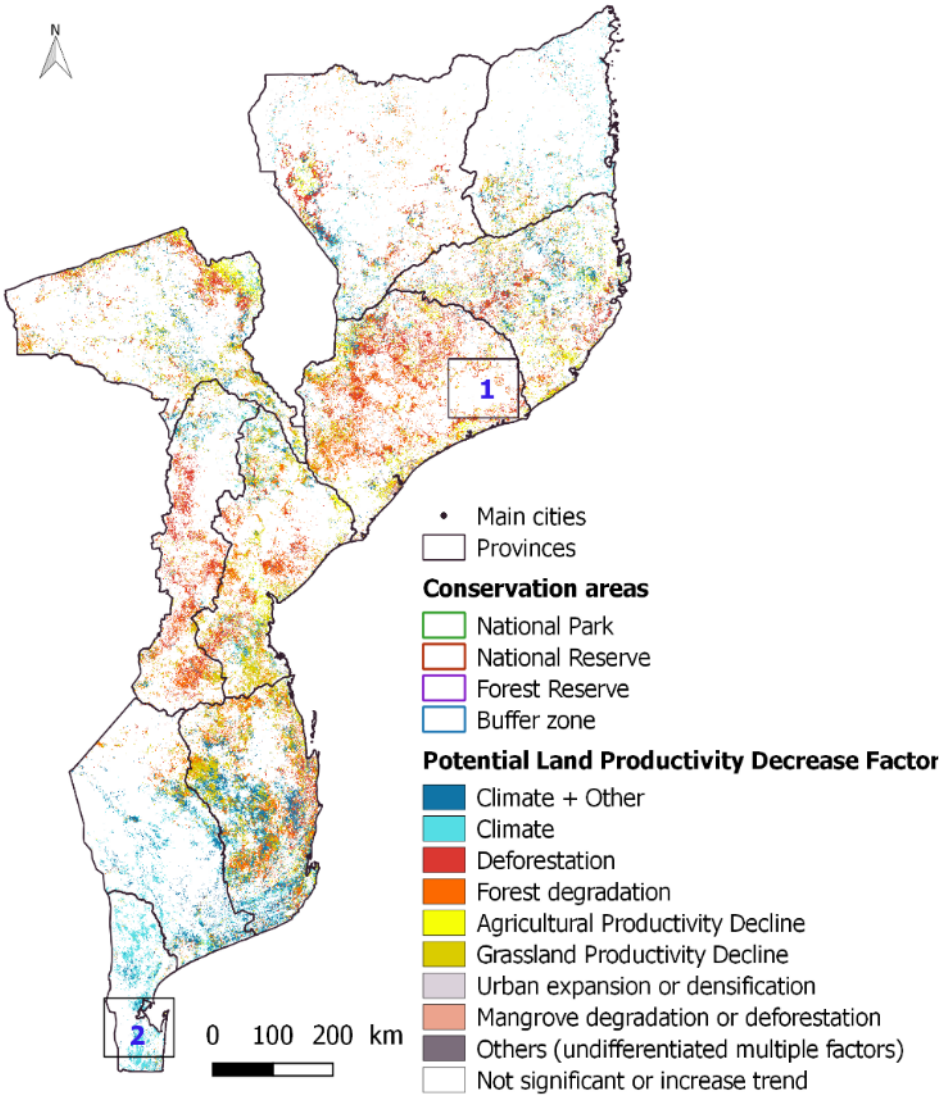
	NDVI-Temperature correlation		NDVI-Rainfall correlation	
	Area (ha)	% total area	Area (ha)	% total area
Negative (p<0.05)	11 360 573	14.42	289 418	0.37
Positive (p<0.05)	34 186	0.04	14 555 363	18.48
No correlation	66 468 162	84.37	63 347 776	80.41

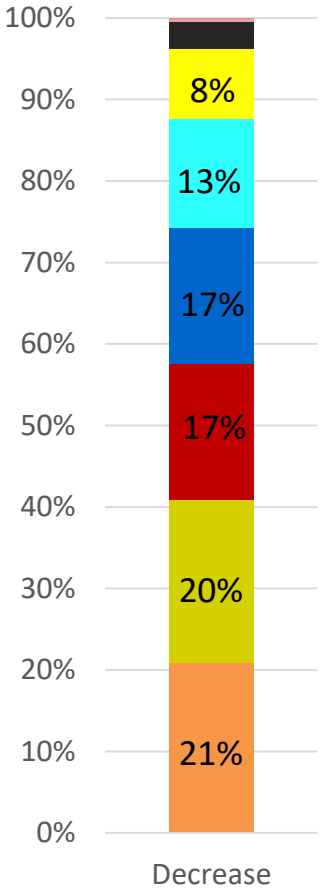
Key results (cont.)

Mapping the human drivers of decrease trends









Deliverables and dissemination

- 1 report outlining the methodology and results

- 1 Training session at UEM on Land Degradation assessment (may 2018, 25 participants)

- 1 paper in preparation

Estimating land degradation : effects of climate, human factors and definition

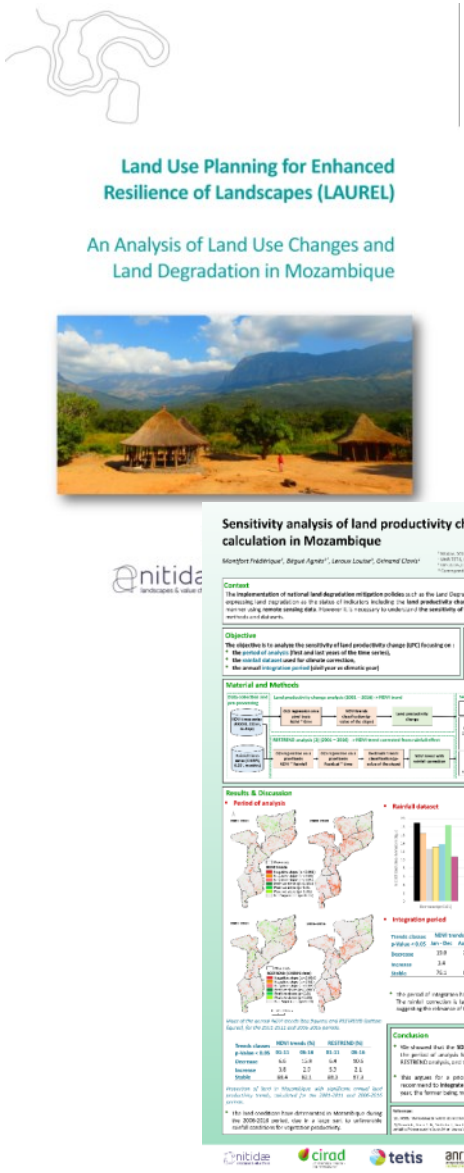
Montfort Frédérique[1,2,3,6,7], Bégué Agnès[2,3], Leroux Louise[4,5], Lilian Blanc[6,7], Valery Gond[6,7], Cambule Armindo[8], Remane Ivan[8], Grinand Clovis[1]

- 1 communication in international conference

IEEE International Geoscience & Remote Sensing Symposium (sept 2019)

Sensitivity analysis of land productivity change calculation in Mozambique

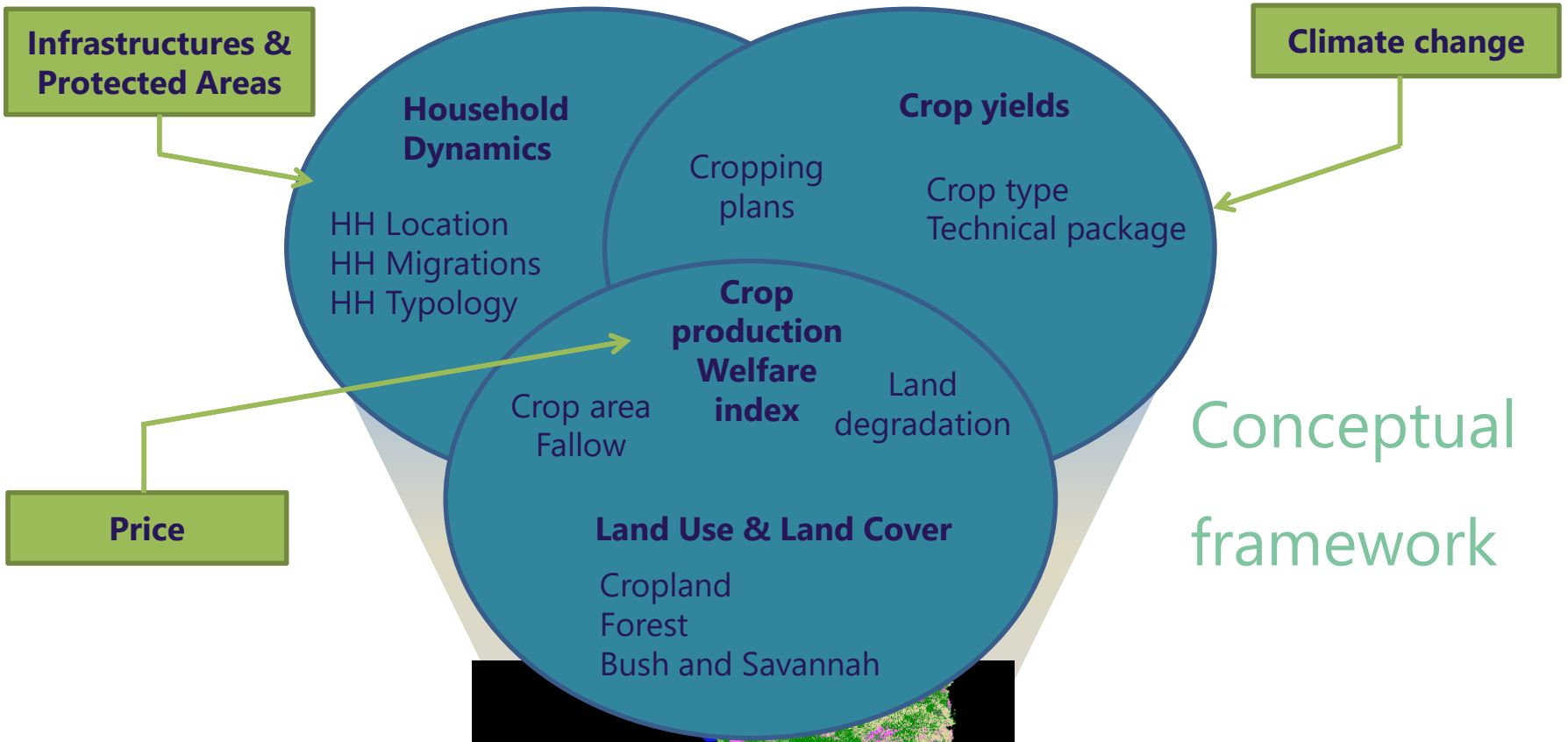
Montfort Frédérique[1], Bégué Agnès[2], Leroux Louise[3], Grinand Clovis[1]



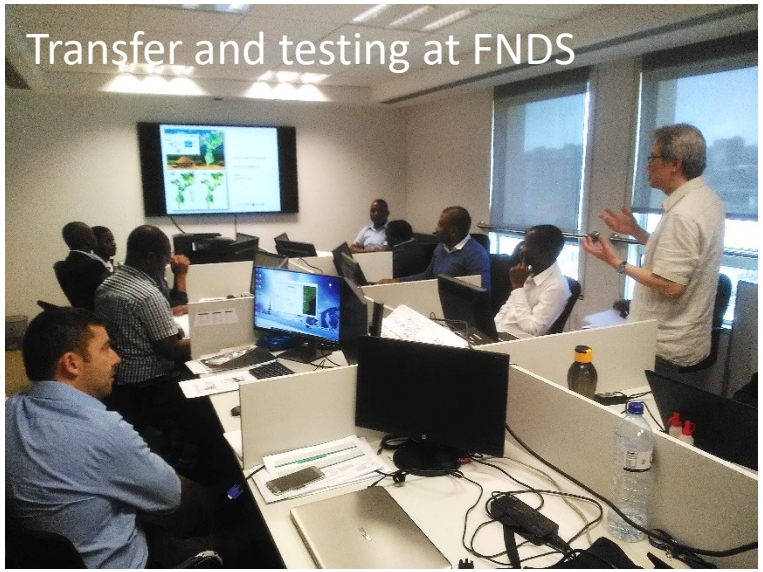
LANDSIM

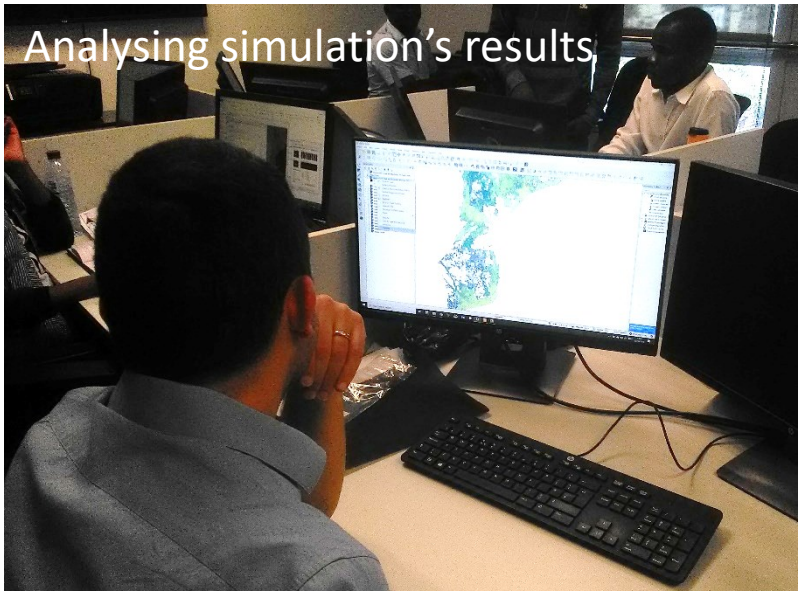
Prototype overview

LANDSIM-P overview



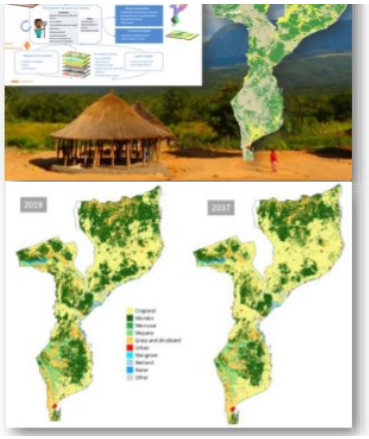
Prototype development, transfer and testing





Simulating impacts of projects

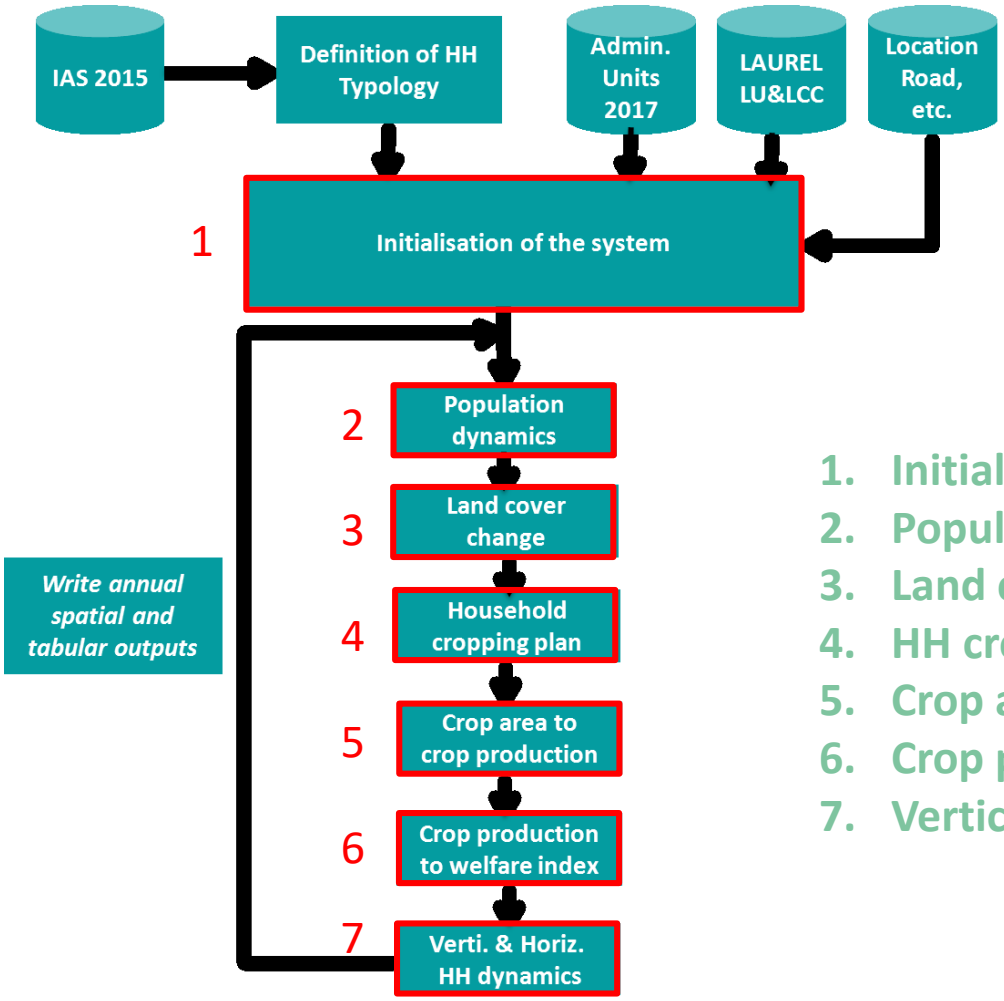
Production of a technical manual



LANDSIM-P overview

- Developed for simulating and evaluating land use and land use change processes at landscape scale over the entire country
- Flexibility in terms of scale and scope of analysis – national, regional, project level by interventions (e.g. infrastructure, protected areas, etc).
- Uses 4 groups (typologies) of rural households (spatial):
  - Subsistence
  - Some Cash Crop
  - Some Livestock
  - Small Emerging Farmers
- Spatial units of 1 km^2 (~ 800 000 cells)
- Simulation period: annual up to 2037

LANDSIM-P overview

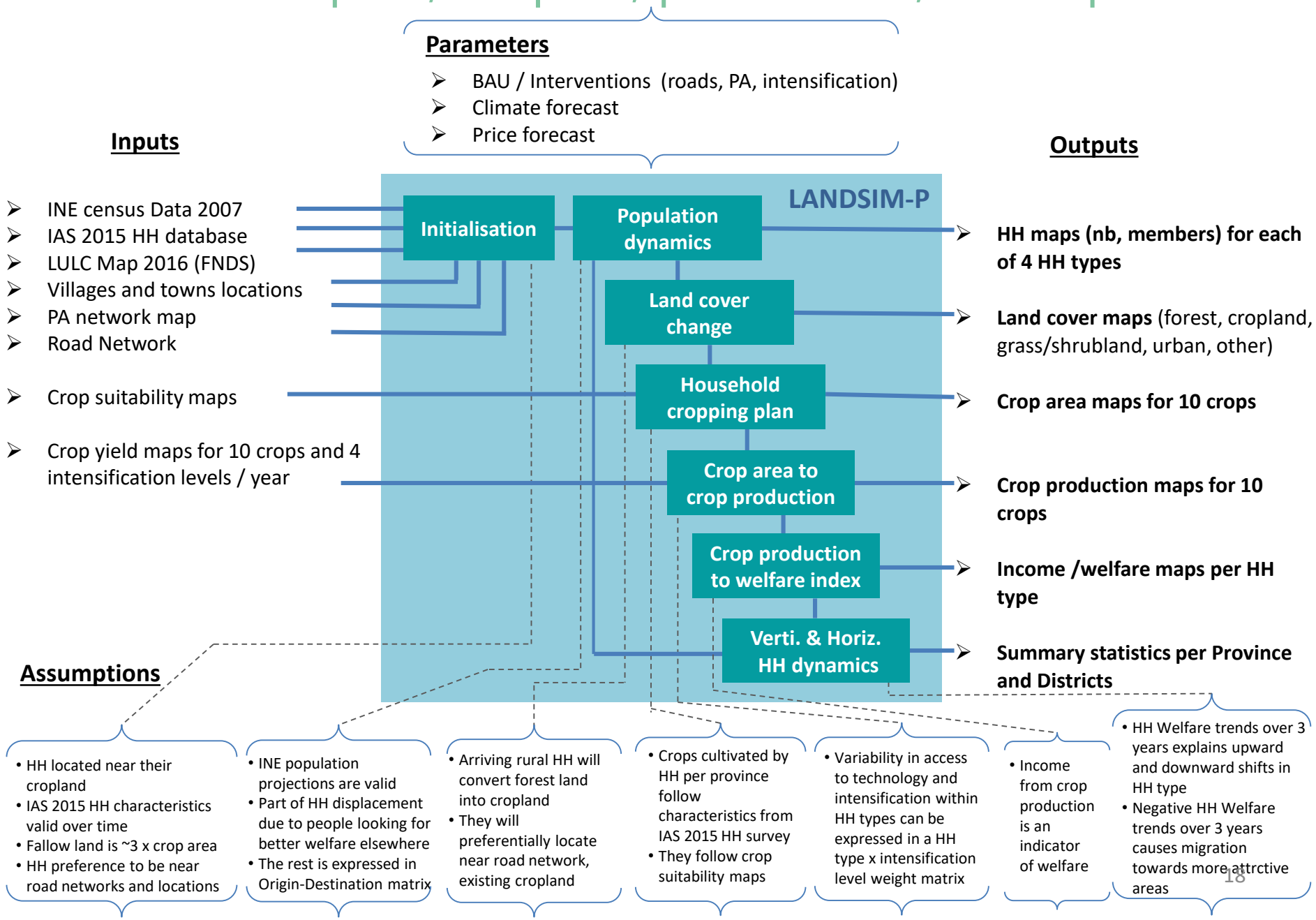


cture of LANDSIM-P

1. Initialisation of the system
2. Population dynamics
3. Land cover change
4. HH cropping plan
5. Crop area to crop production
6. Crop production to welfare
7. Vertical and Horizontal HH dynamics

IAS: Household survey 2015
LULCC: Land Use and Land Cover change map 2000-2005-2010-2016

LANDSIM: inputs, outputs, parameters, assumptions

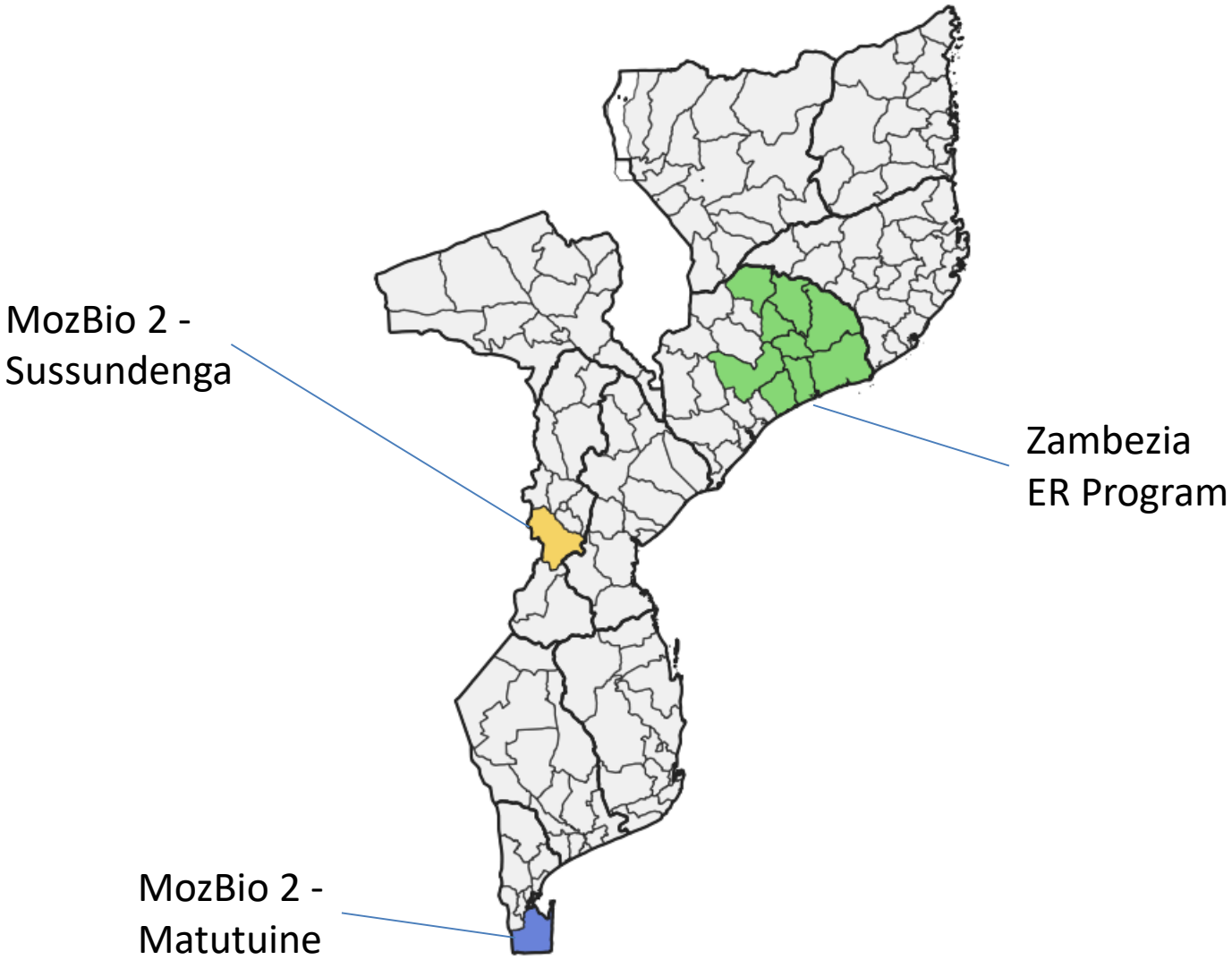


Some LANDSIM-P Results

Application of LANDSIM-P to FNDS projects

Project/ Initiatives	Area	Objectives
MOZbio II	National Reserve of Chimanimani *(District Sussendenga) and* Special Reserve of Maputo *(District Matutuine)*	To predict the impact without interventions and quantify the impacts of interventions in road rehabilitation combined with strengthening of conservation interventions
Mozbio I, Sustenta and REDD+ Zambezia	Zambezia Province *(9 Districts)*	Predict the impacts without interventions and quantify the impacts of interventions on crop intensification Estimate the CO2 emissions in each scenario and the risks of non performance of the ZILMP.

Application of LANDSIM-P to FNDS projects



Applied intervention scenarios

Scenario	Study area / FNDS projects	Key parameter changed in the model	Link to policy
BAU	National		
Roads	Districts of Matutiune and Susendenga	With of without roads construction or rehabilitation (date and type)	Roads investments
Protected areas	Districts of Matutiune and Susendenga	Probability of human presence	Land tenure policy
Intensification	Zambezia Province	HH type intensification matrix	Agricultural sector investments

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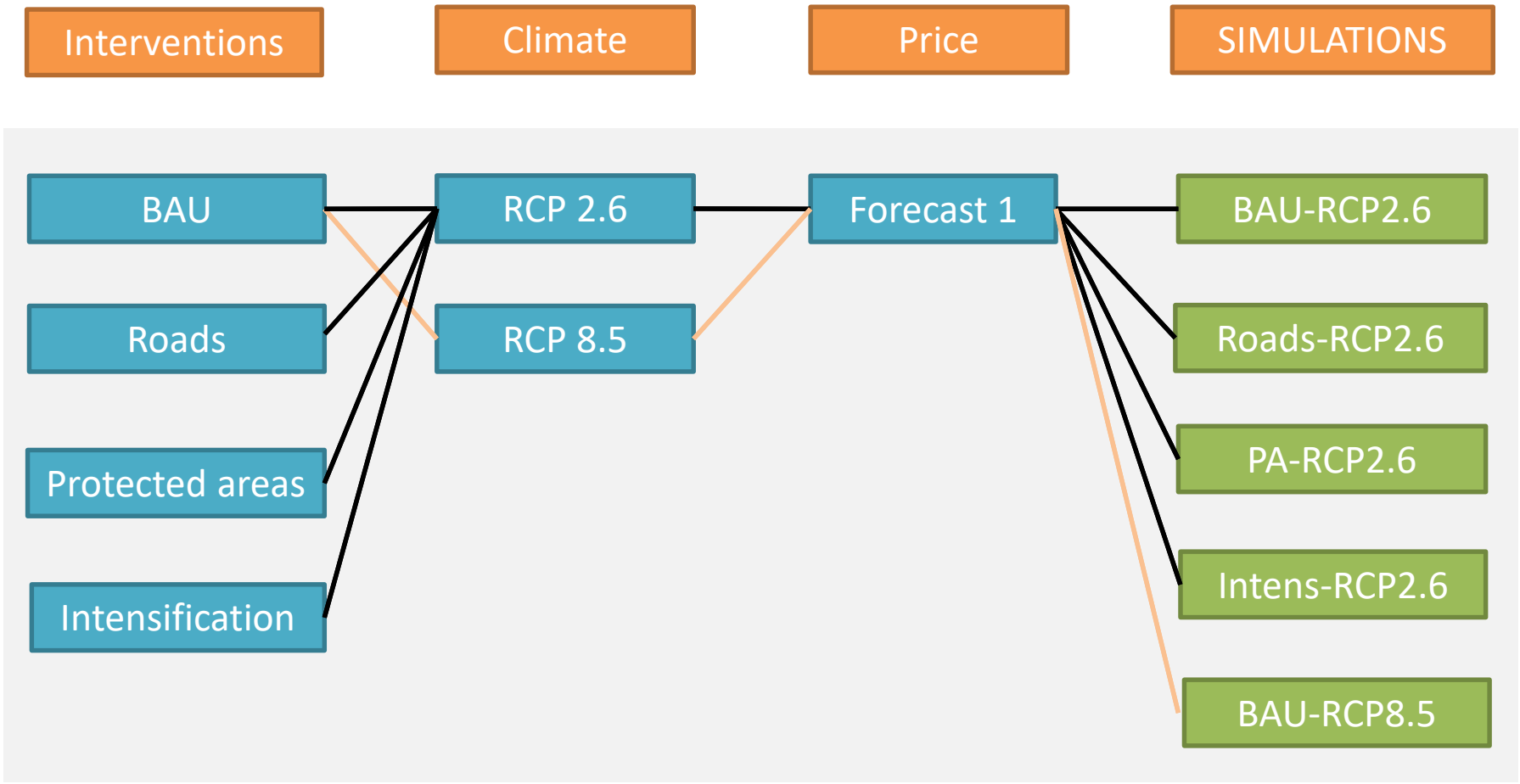
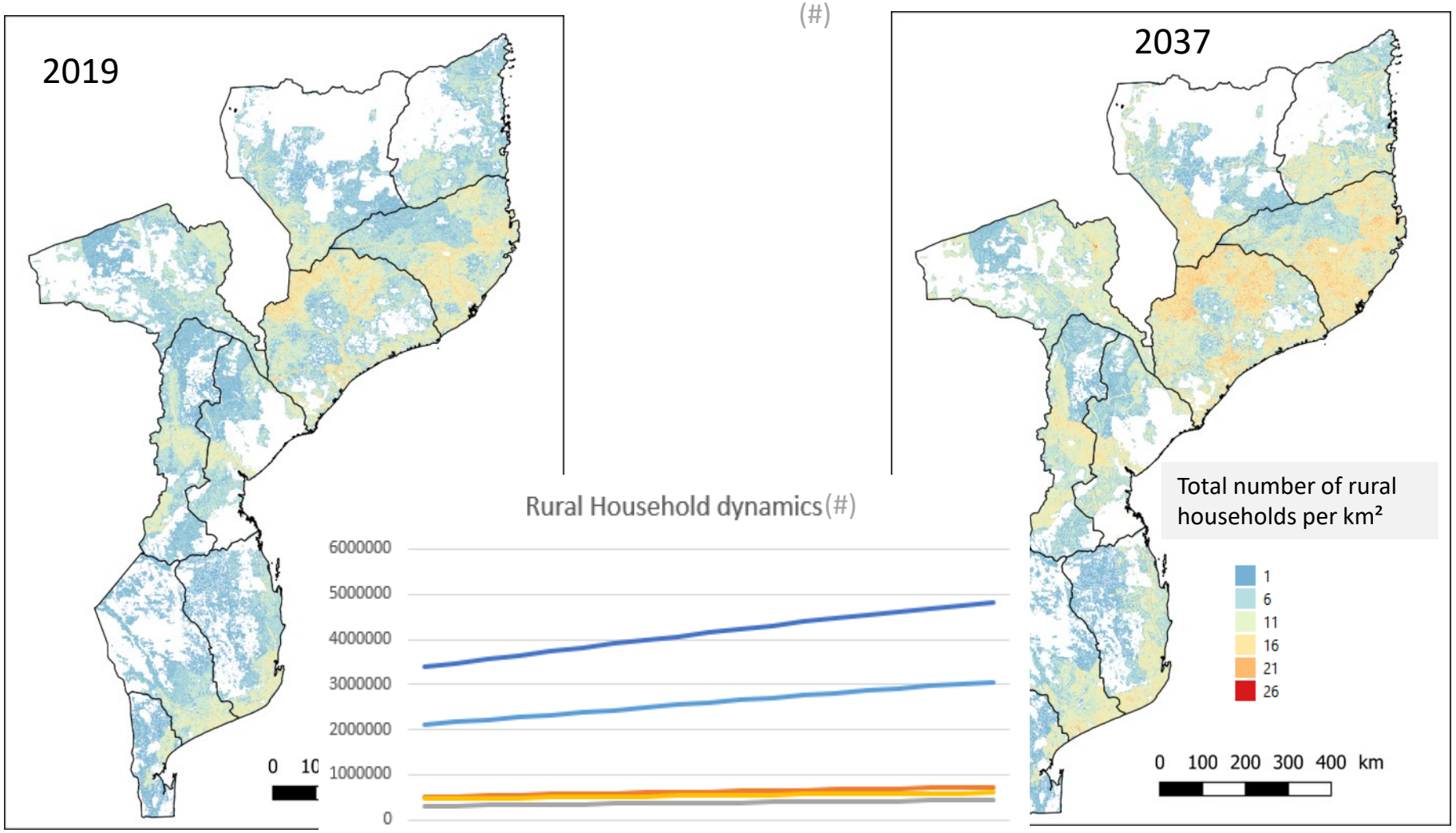
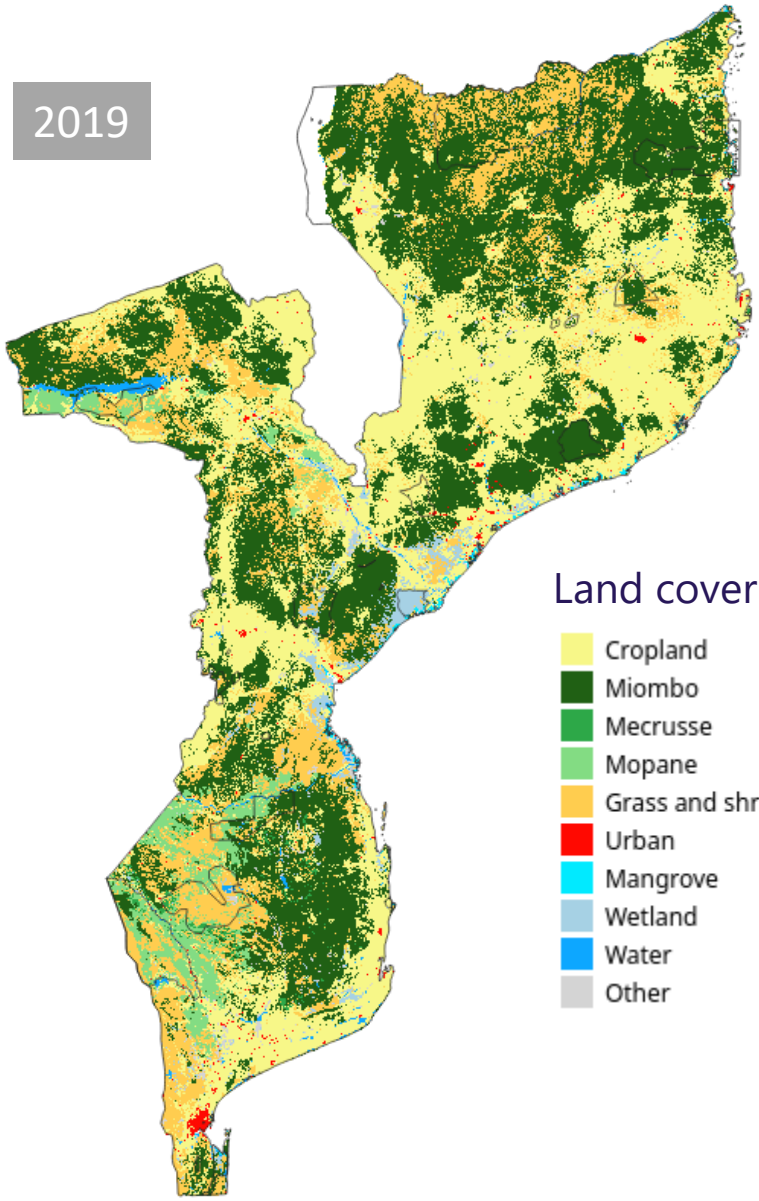
LandSIM Simulations

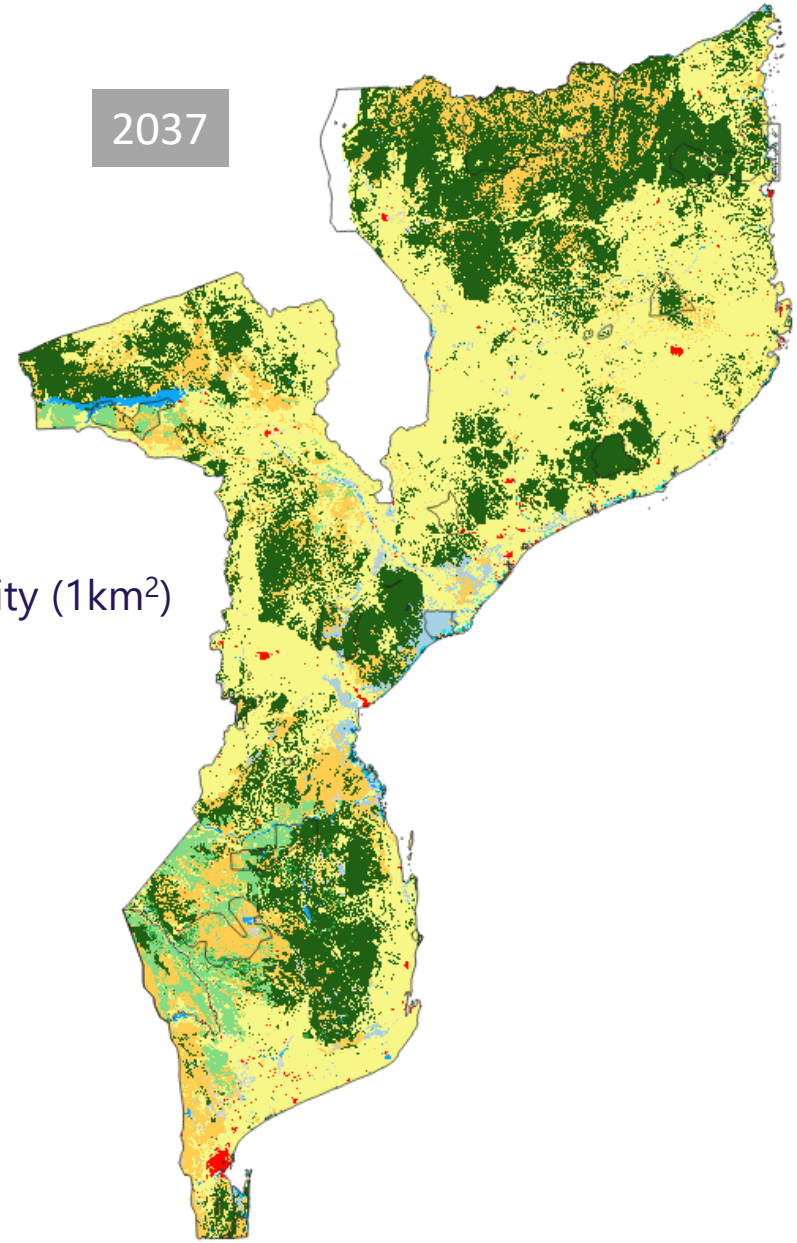



2019
2037
Total number of rural households per km²
1
6
11
16
21
26
0 100 200 300 400 km
Rural Household dynamics(#)
6000000
5000000
4000000
3000000
2000000
1000000
0
Year
2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036
totHHnumber1
totHHnumber2
totHHnumber3
totHHnumber4
totHHtotnumber

2019

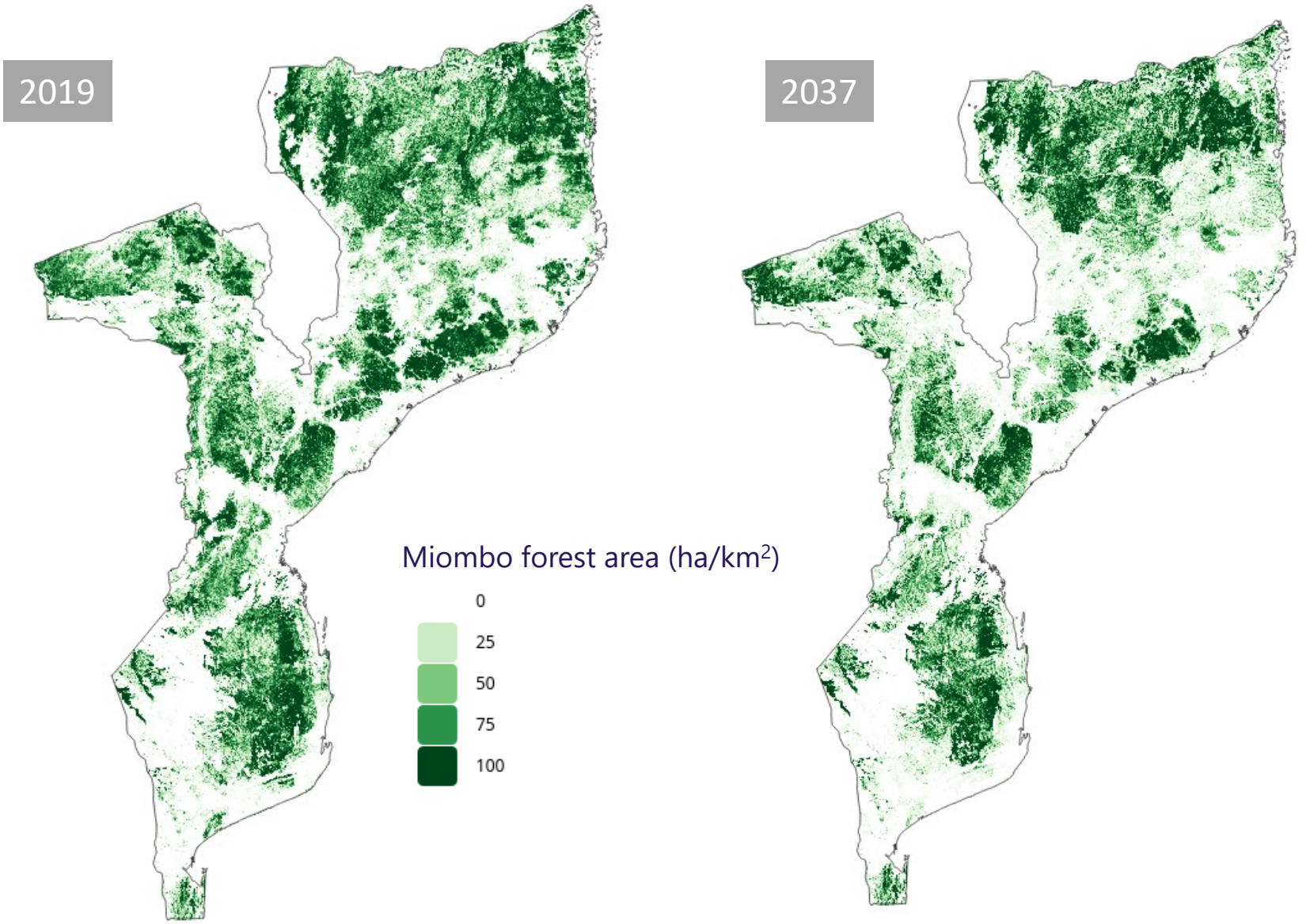


2037

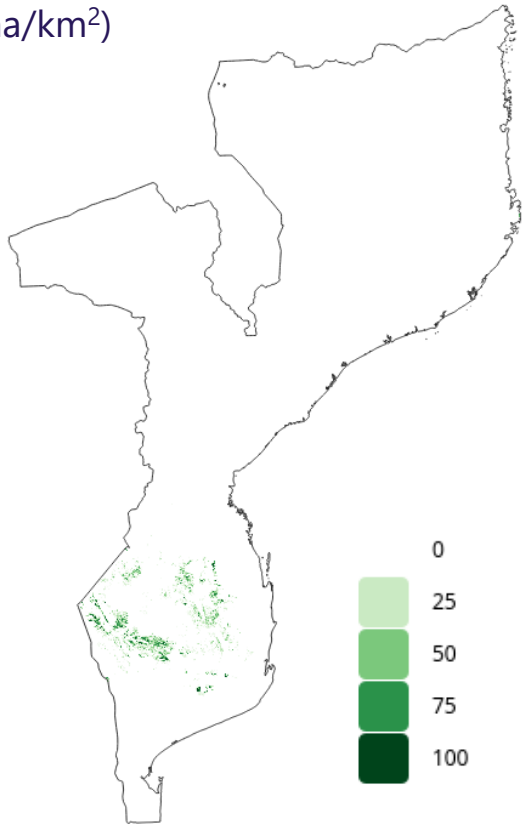


Land cover majority (1km^2)

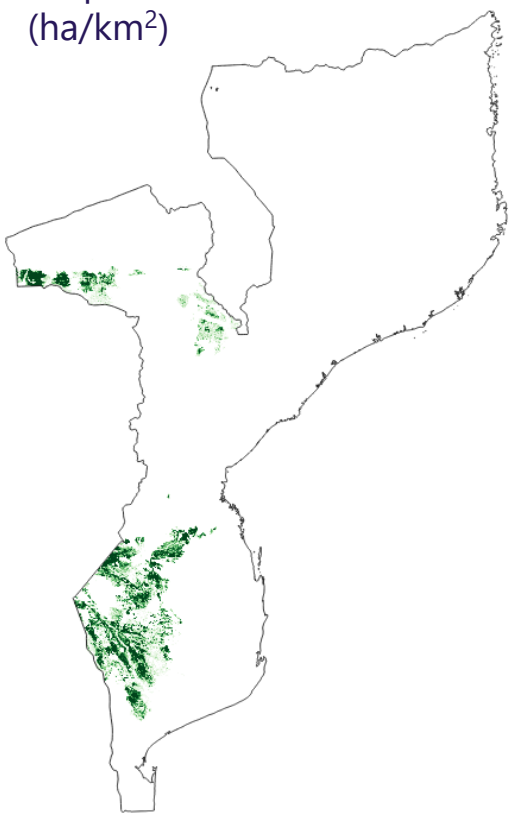
- Cropland
- Miombo
- Mecrusse
- Mopane
- Grass and shrubland
- Urban
- Mangrove
- Wetland
- Water
- Other


2019
2037
Miombo forest area (ha/km2)
0
25
50
75
100

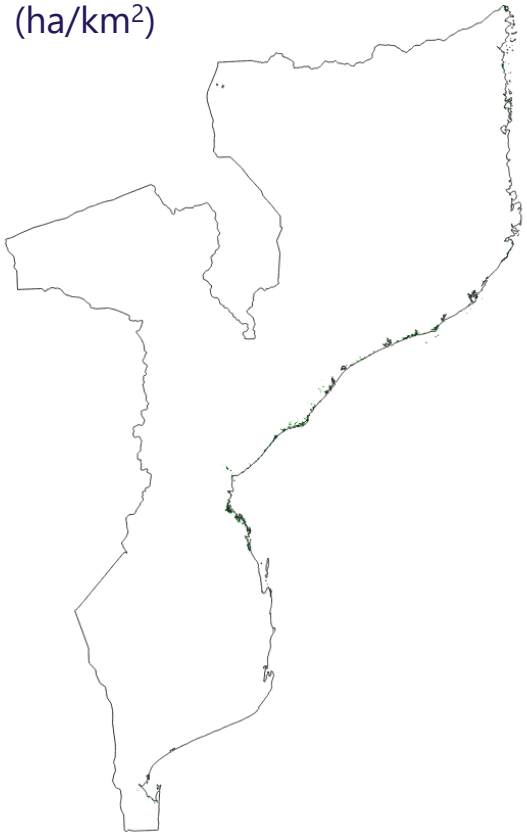
Mecrusse forest area in 2037 (ha/km^2)



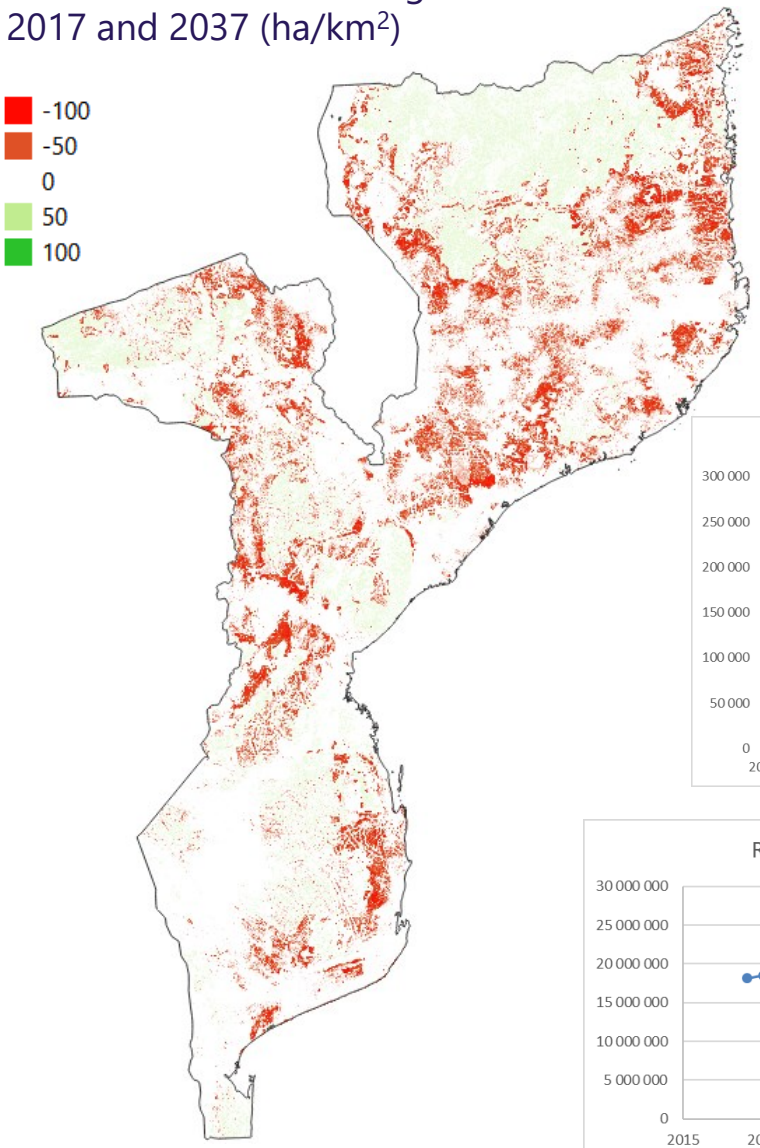
Mopane forest area in 2037 (ha/km^2)

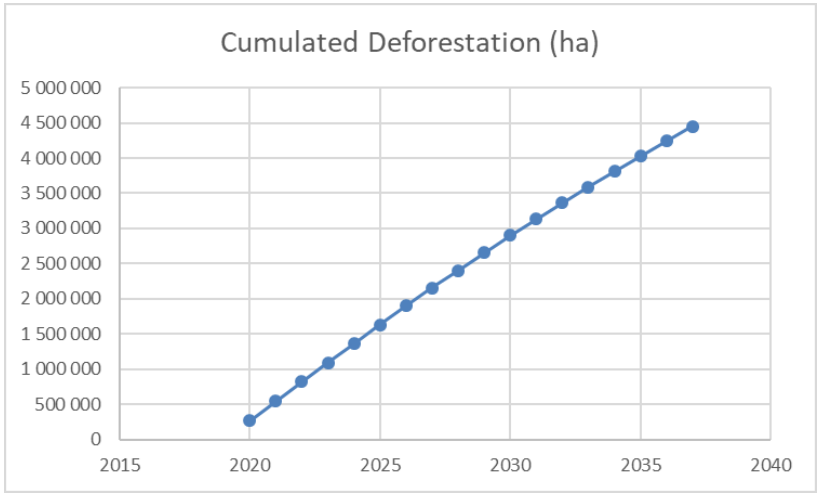


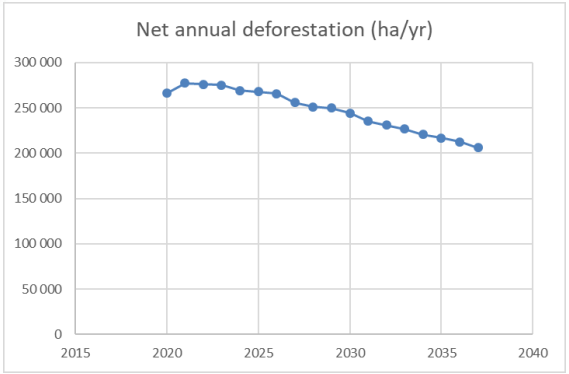
Mangrove forest area in 2037 (ha/km^2)

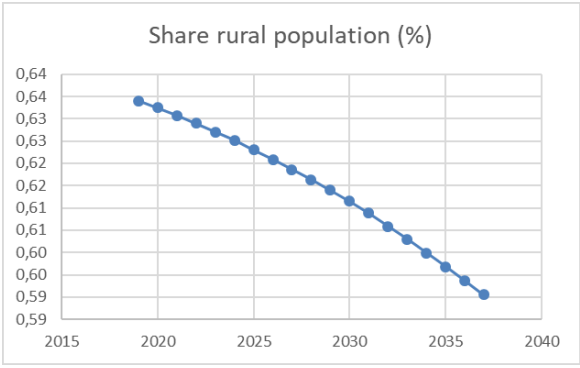


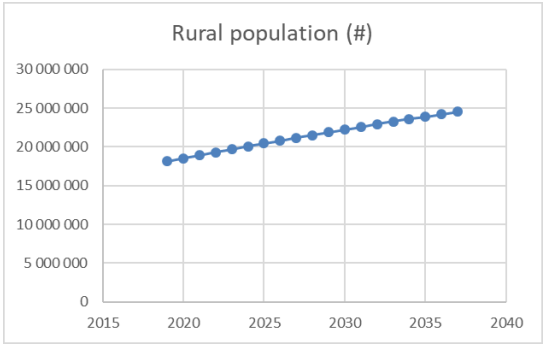
Miombo net forest change between 2017 and 2037 (ha/km^2)

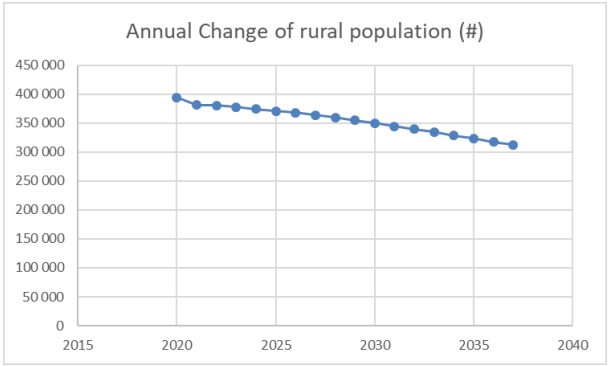




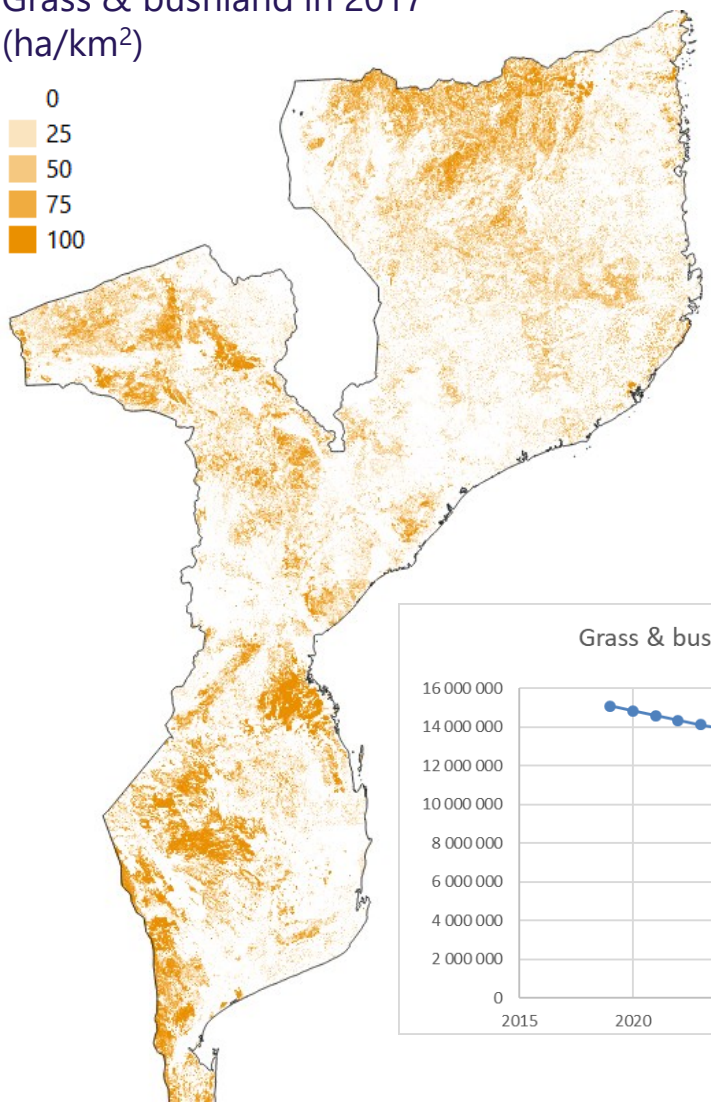


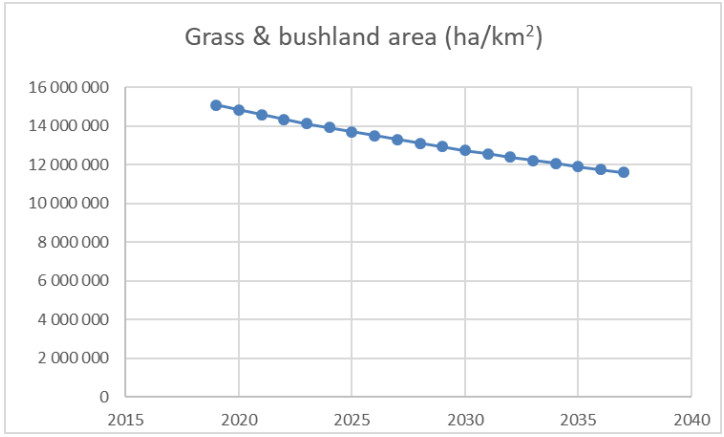




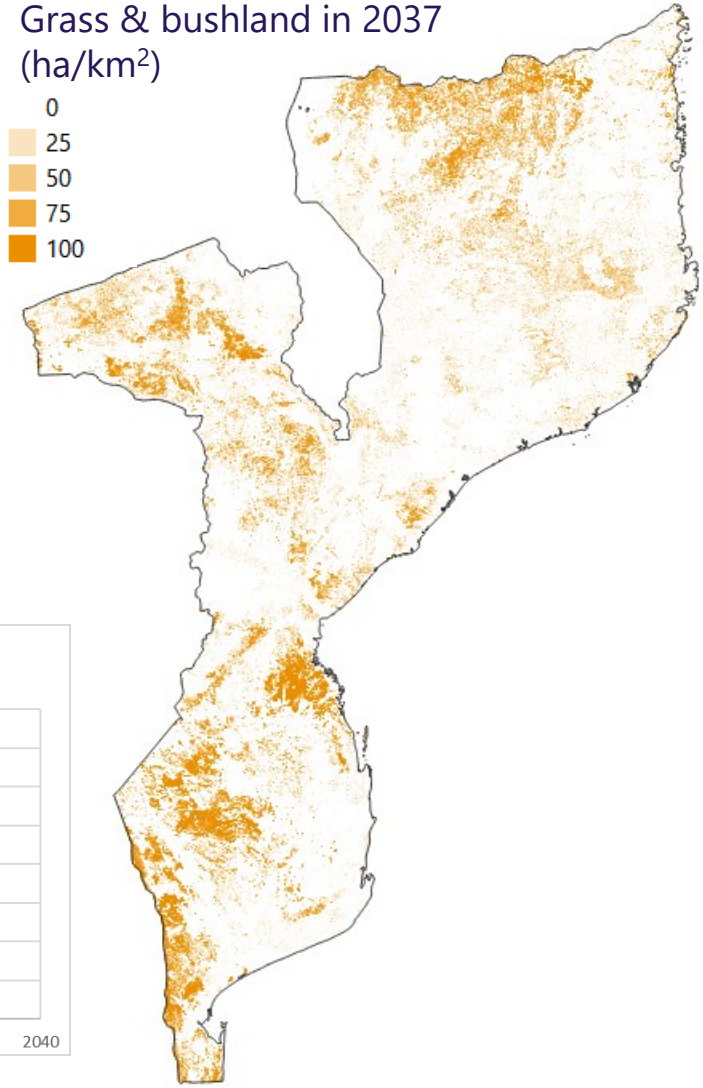


Grass & bushland in 2017 (ha/km²)

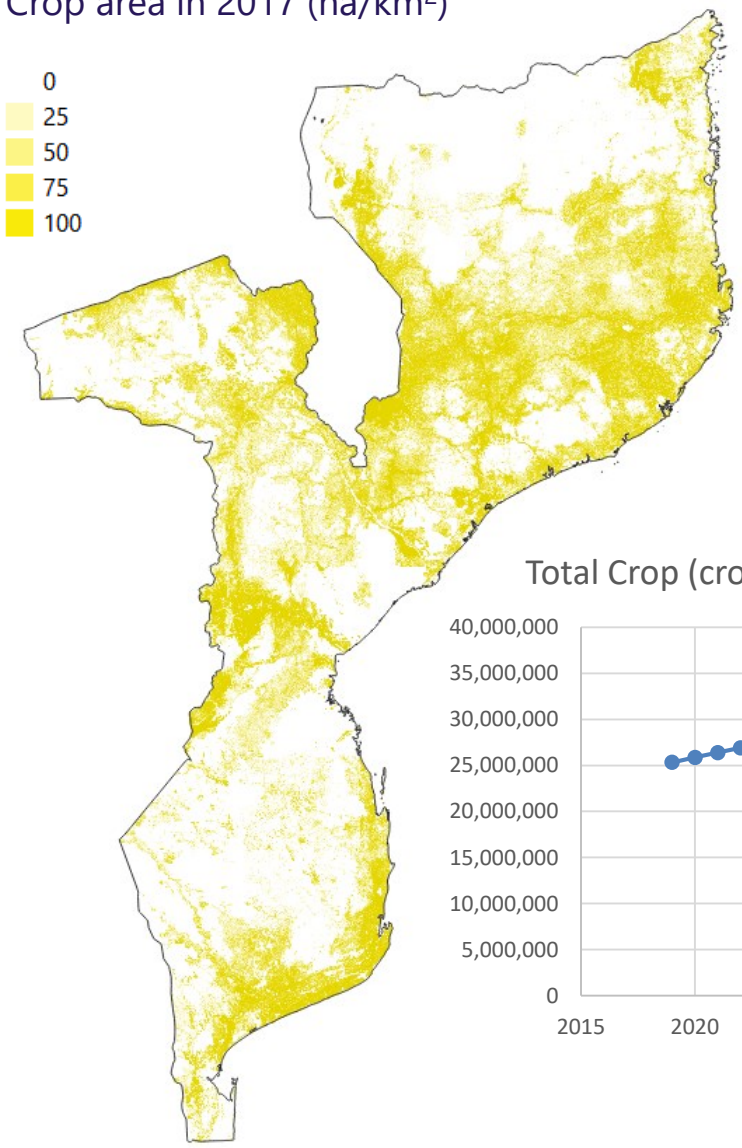




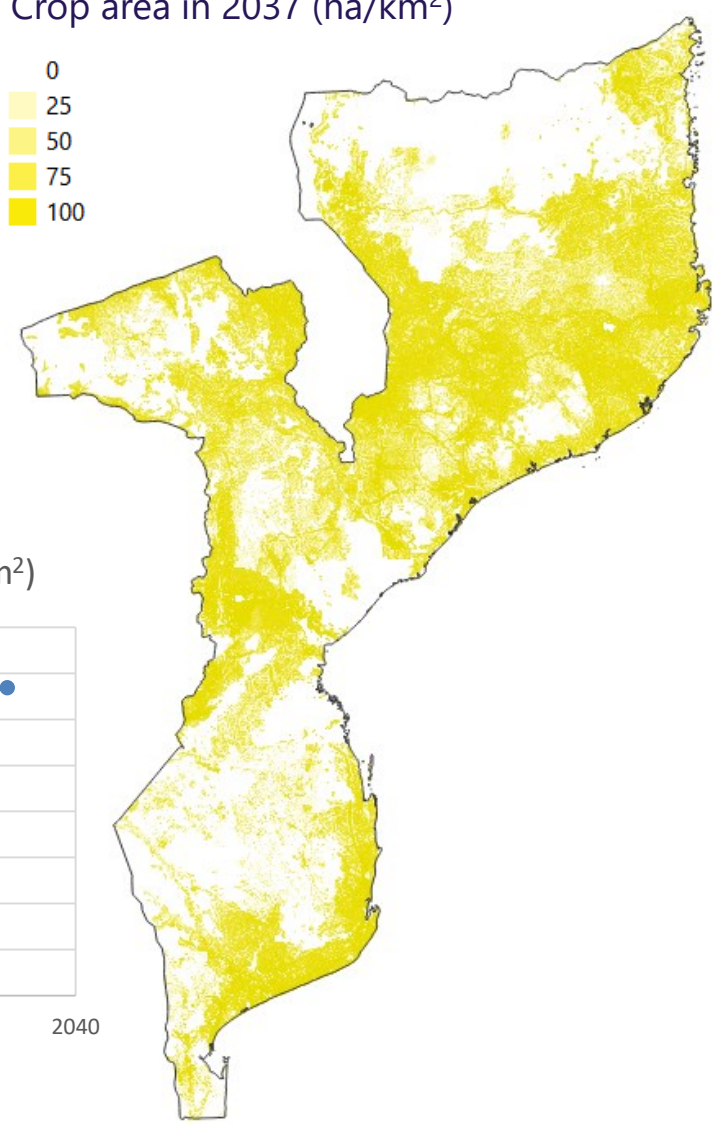
Grass & bushland in 2037 (ha/km²)



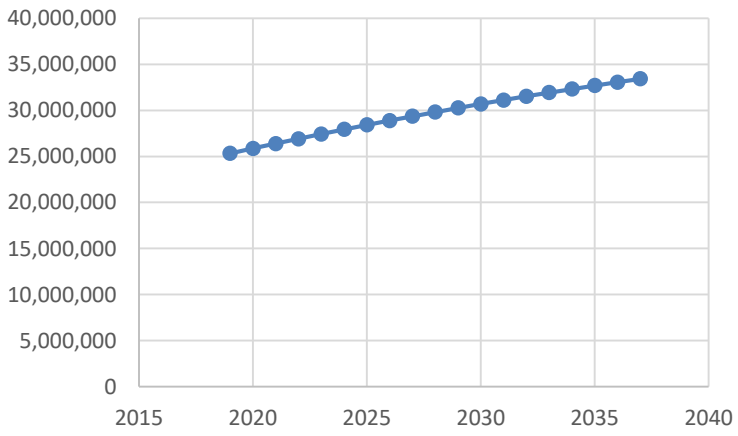
Crop area in 2017 (ha/km^2)



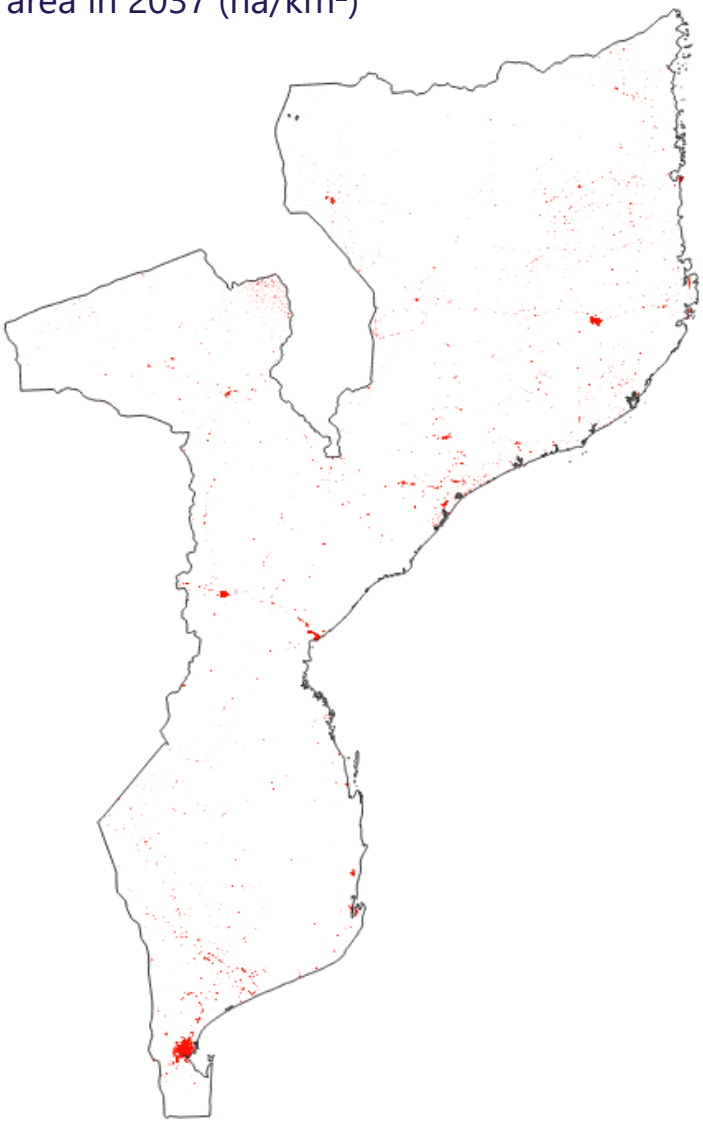
Crop area in 2037 (ha/km^2)

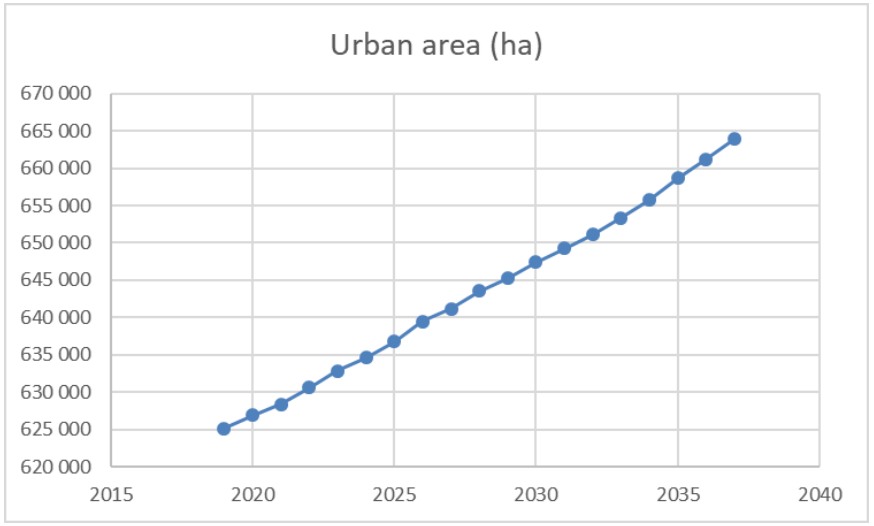


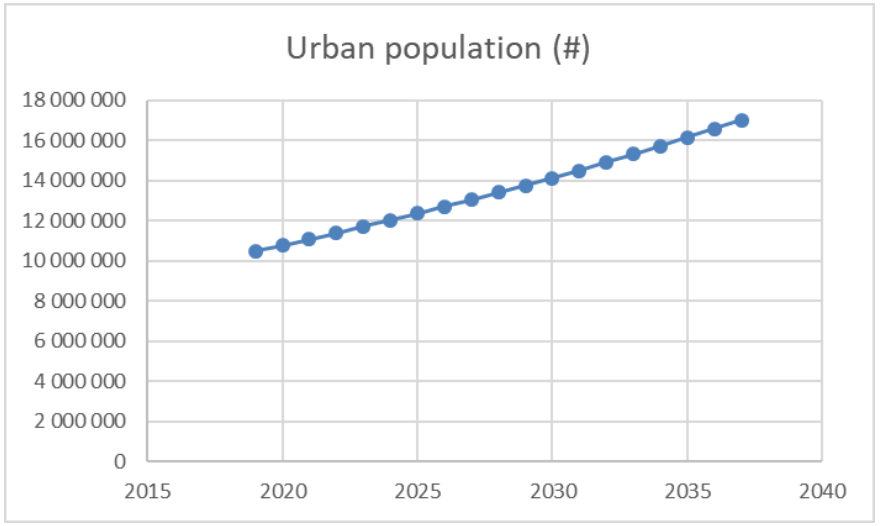
Total Crop (crop+Fallow) area (ha/km^2)



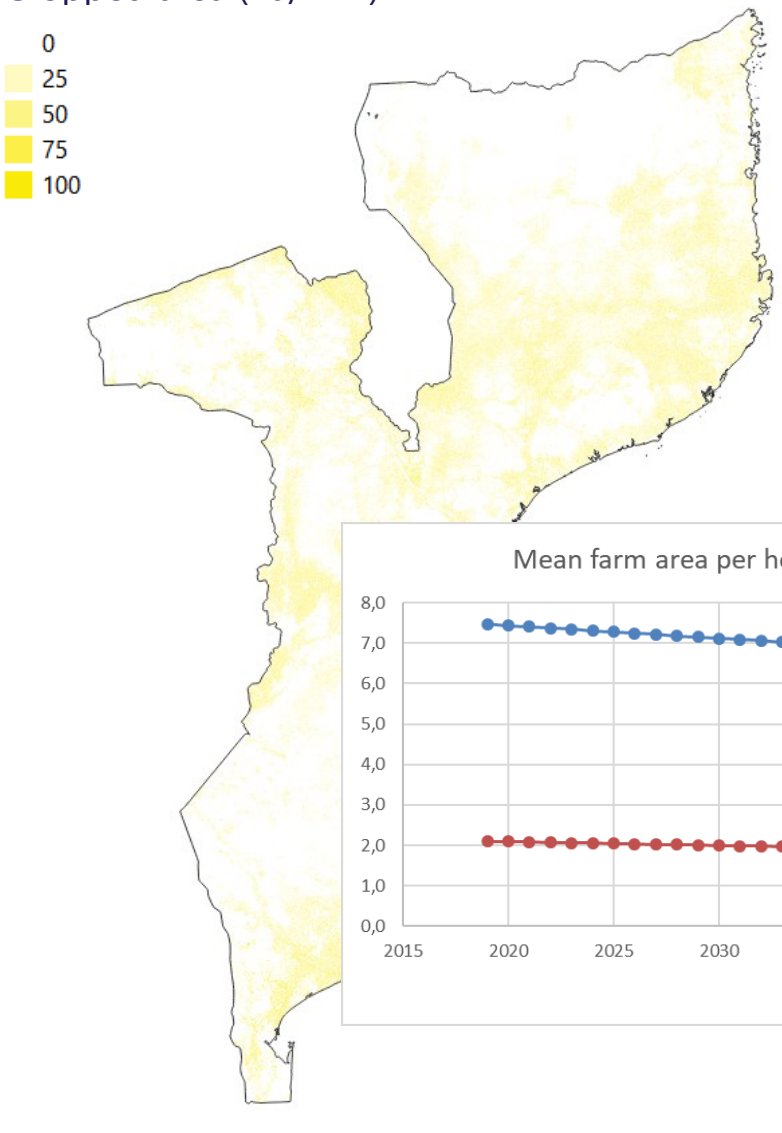
Urban area in 2037 (ha/km^2)



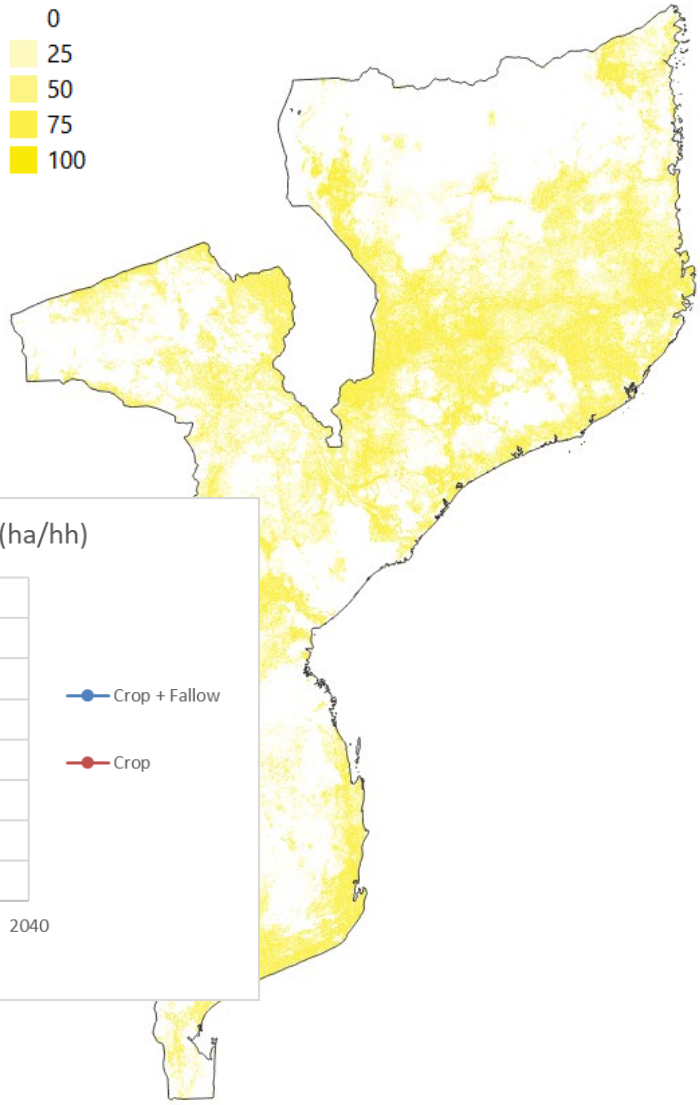




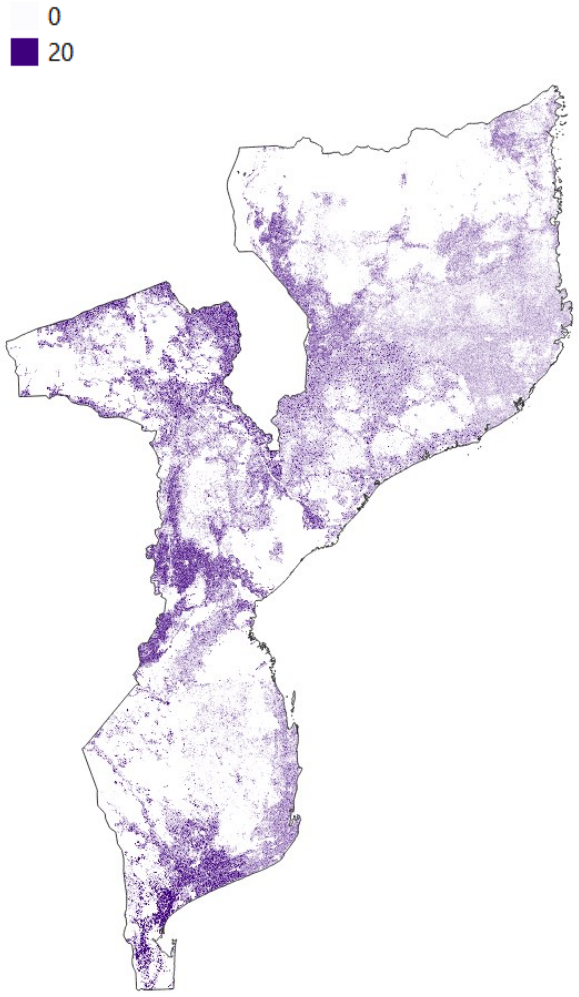
Cropped area (ha/km^2)



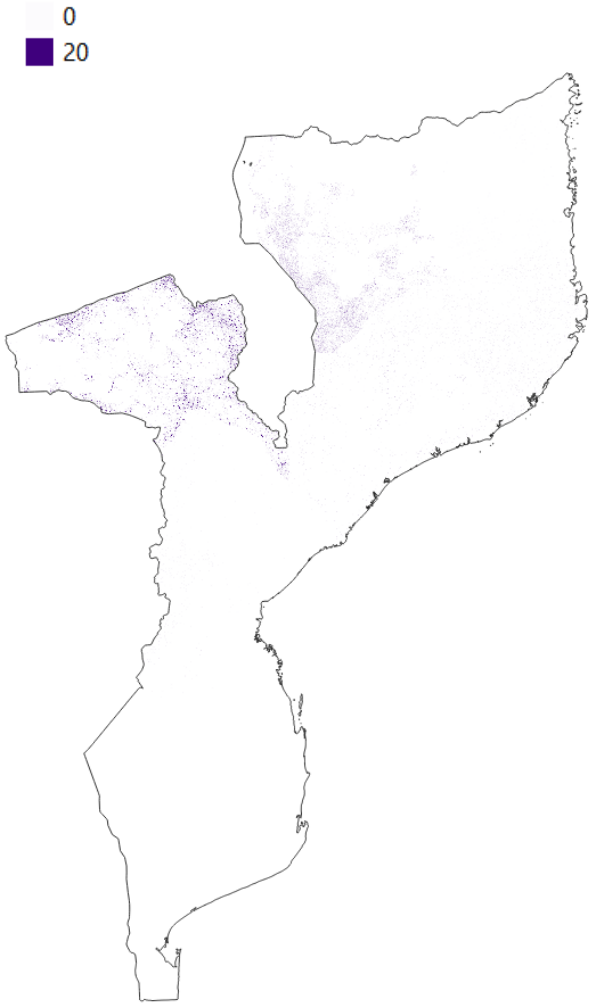
Fallow area (ha/km^2)



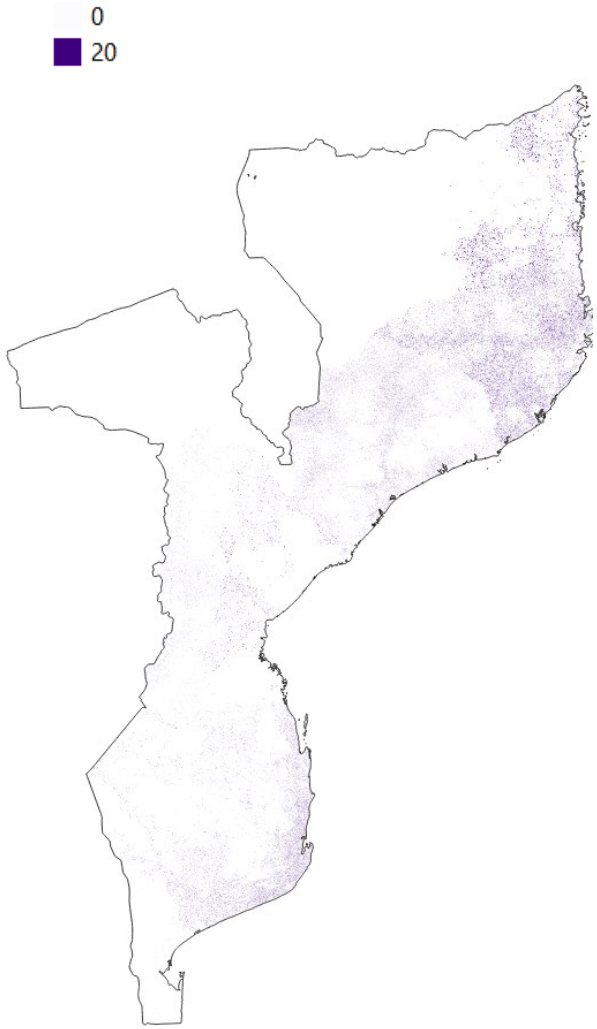
Maize area in 2017 (ha/km^2)

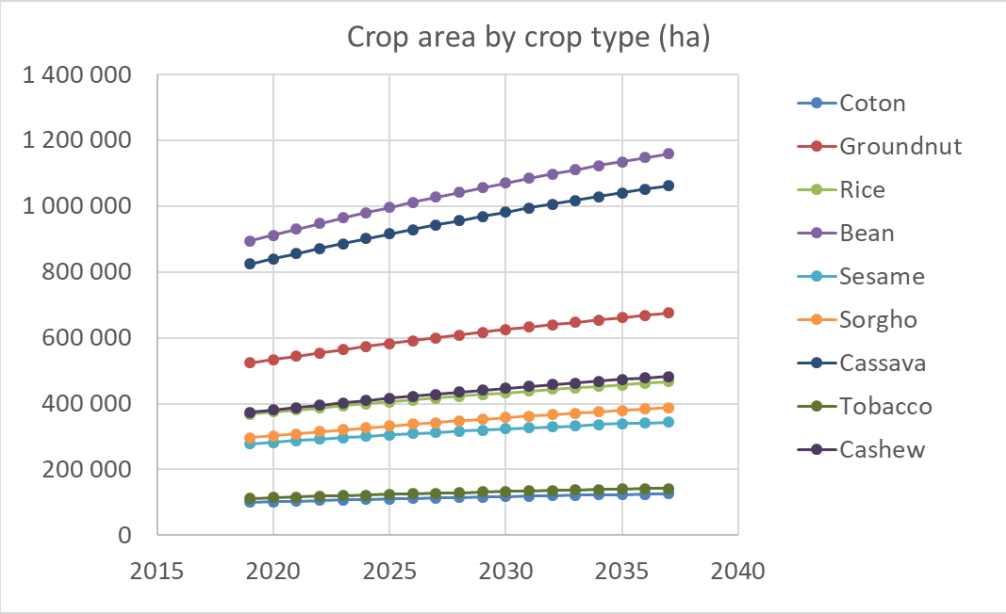


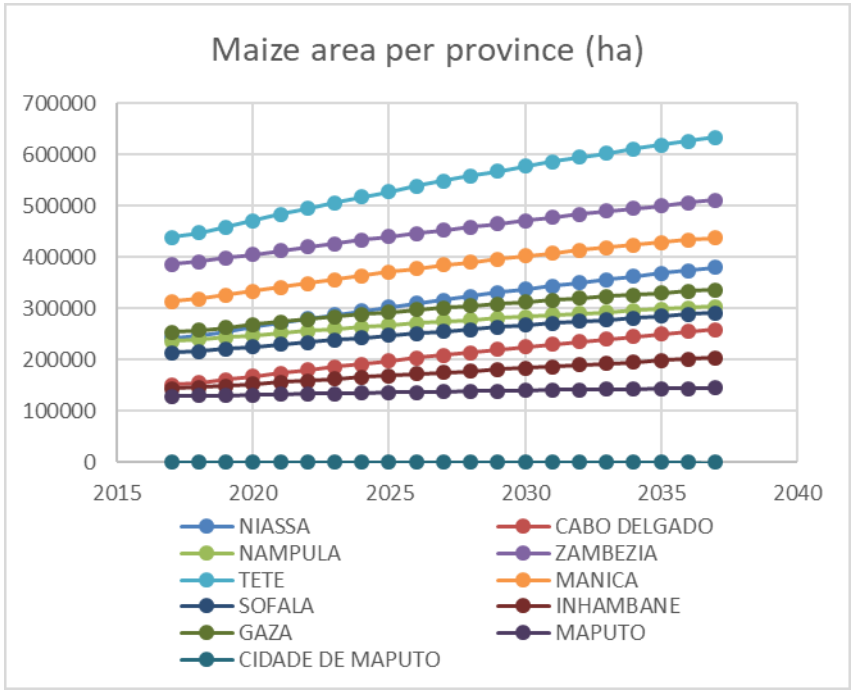
Tobacco area in 2017 (ha/km^2)



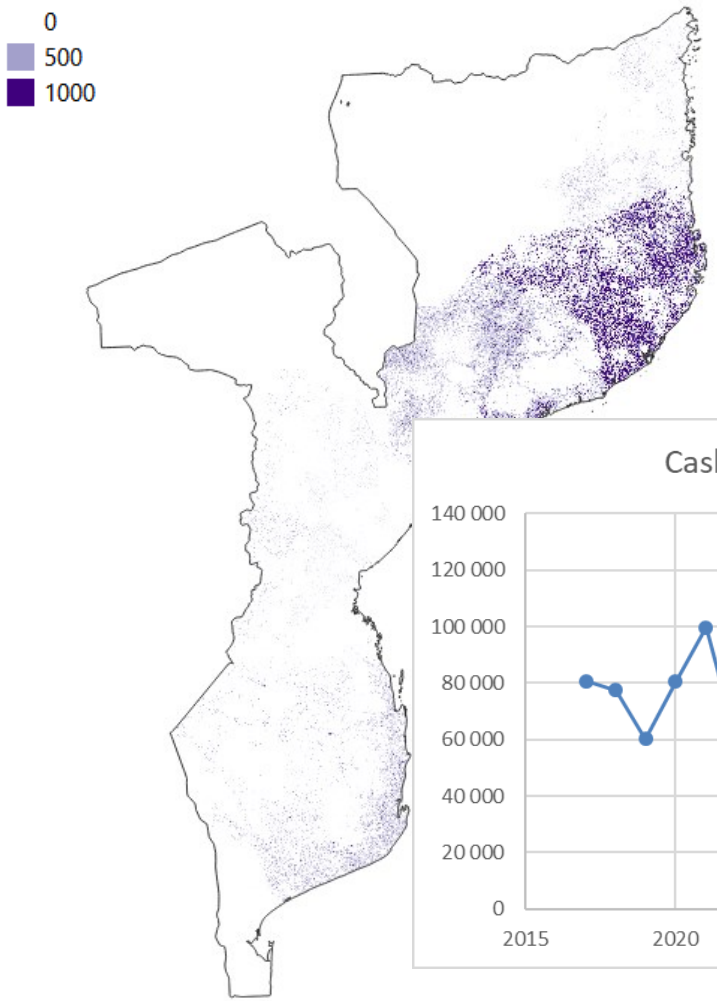
Cashew area in 2017 (ha/km^2)



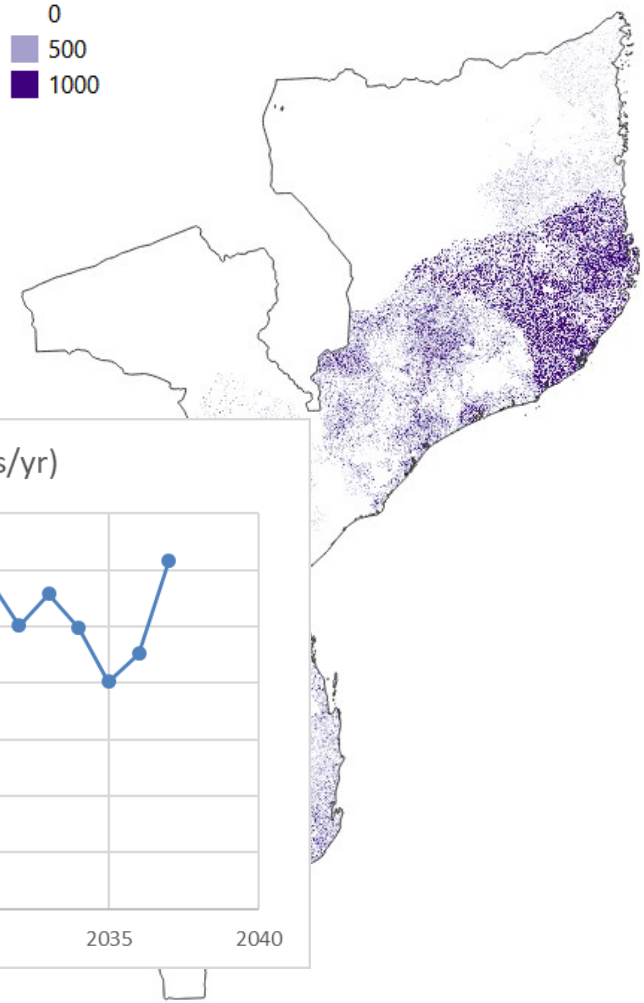

Crop area by crop type (ha)
1 400 000
1 200 000
1 000 000
800 000
600 000
400 000
200 000
0
2015
2020
2025
2030
2035
2040
Coton
Groundnut
Rice
Bean
Sesame
Sorgho
Cassava
Tobacco
Cashew

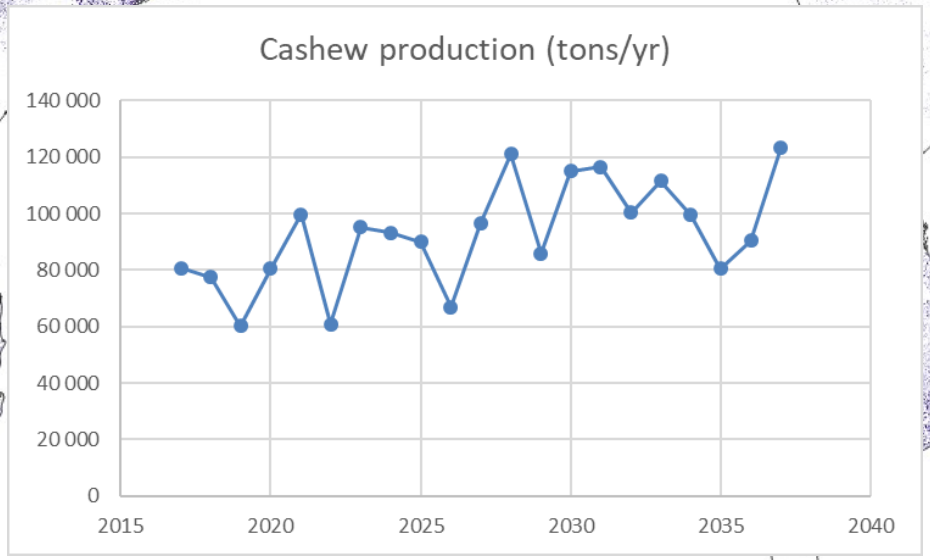

Maize area per province (ha)
700000
600000
500000
400000
300000
200000
100000
0
2015
2020
2025
2030
2035
2040
NIASSA
CABO DELGADO
NAMPULA
ZAMBEZIA
TETE
MANICA
SOFALA
INHAMBANE
GAZA
MAPUTO
CIDADE DE MAPUTO

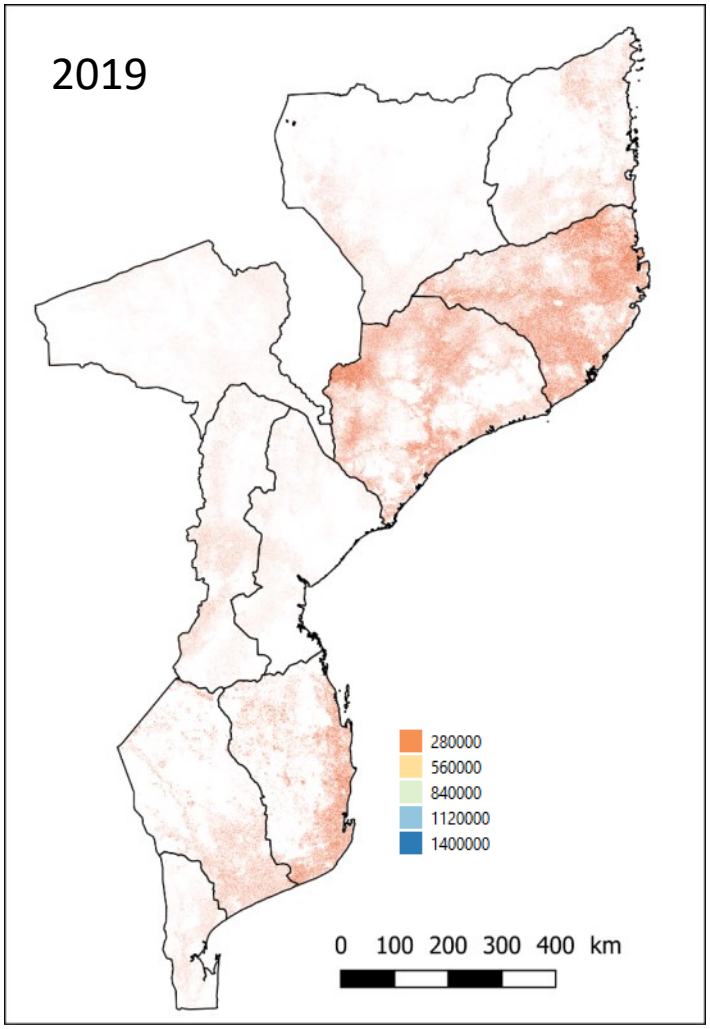
Cashew production for HH type 1 in 2017 (kg/km^2)

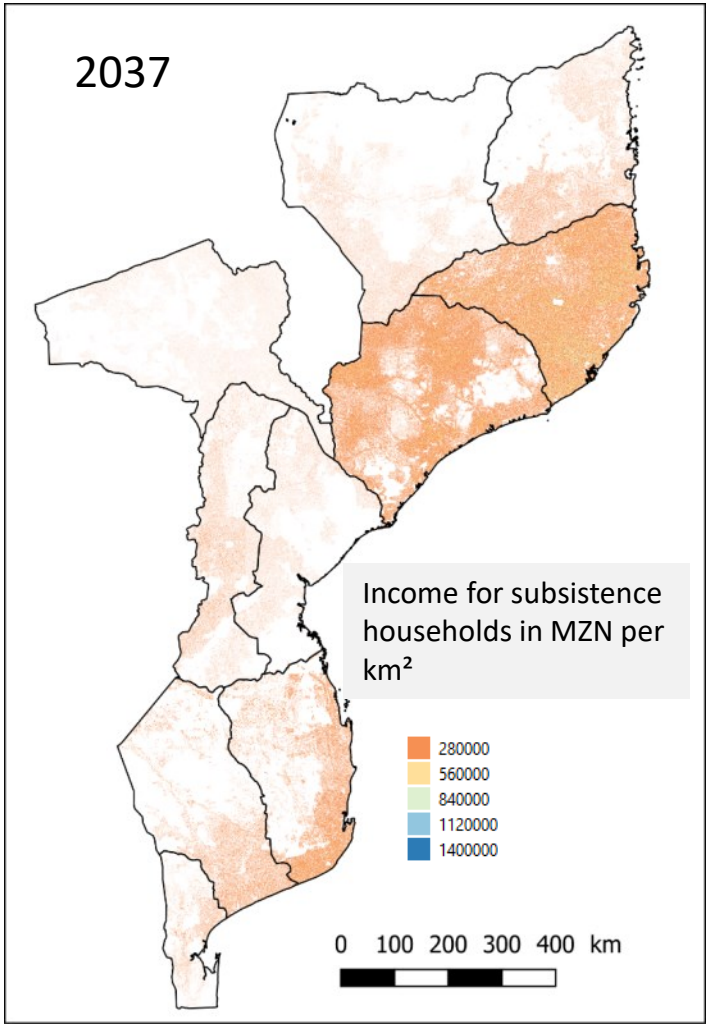


Cashew production for HH type 1 in 2037 (kg/km^2)






2019
280000
560000
840000
1120000
1400000
0 100 200 300 400 km

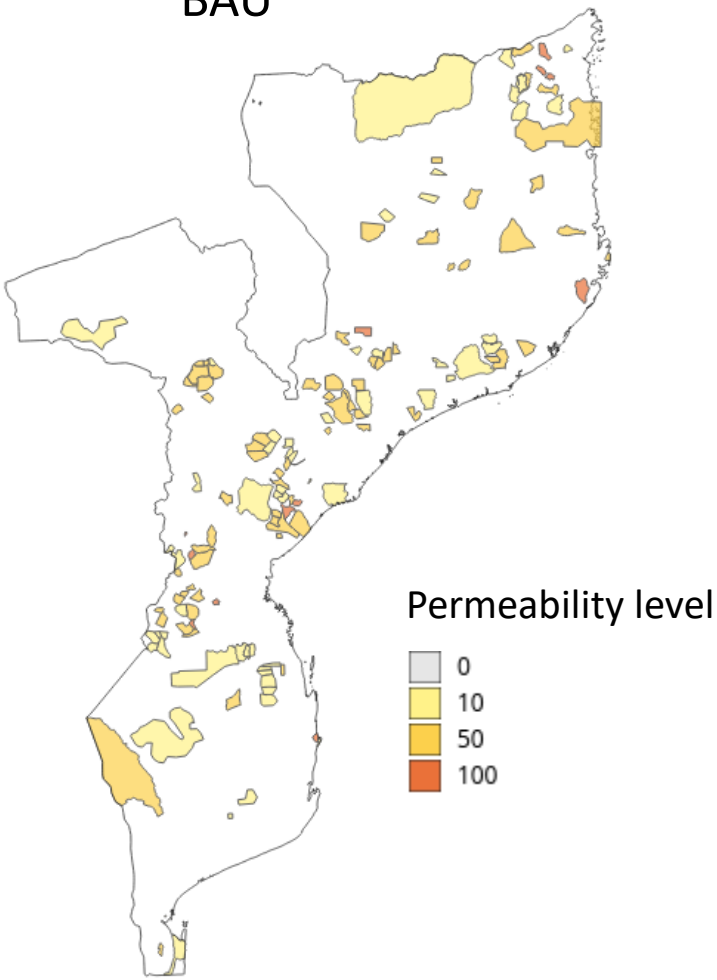

2037
Income for subsistence households in MZN per km²
280000
560000
840000
1120000
1400000
0 100 200 300 400 km

Applied intervention scenarios

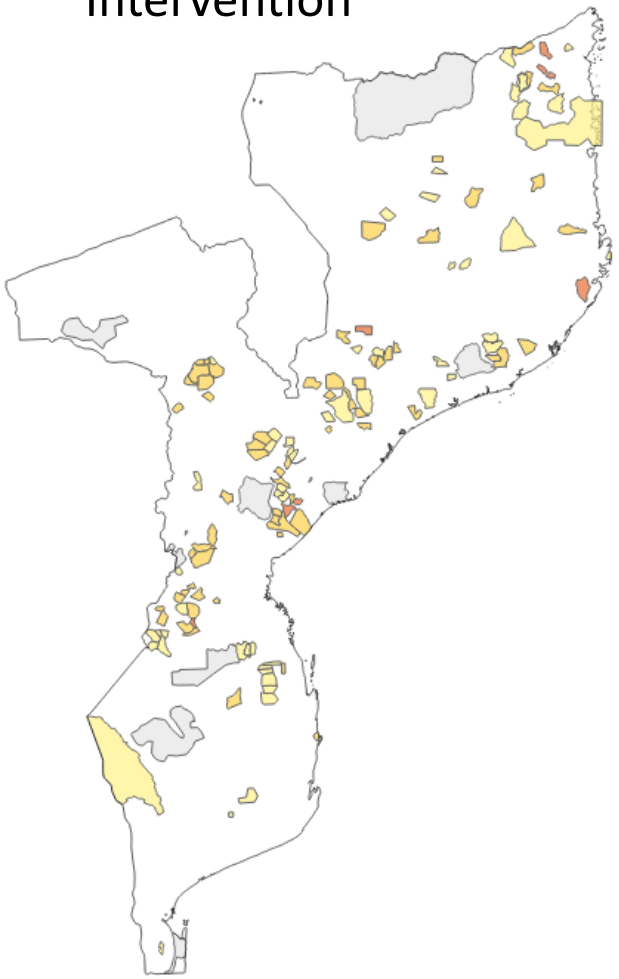
Scenario	Study area / FNDS projects	Key parameter changed in the model	Link to policy
BAU	National		
Roads	Districts of Matutiune and Susendenga	With of without roads construction or rehabilitation (date and type)	Roads investments
Protected areas	Districts of Matutiune and Susendenga	Probability of human presence	Land tenure policy
Intensification	Zambezia Province	HH type intensification matrix	Agricultural sector investments

“Protected Area” intervention scenario

BAU*



Intervention**



* based on the historical deforestation identified in each protected area and forest concessions

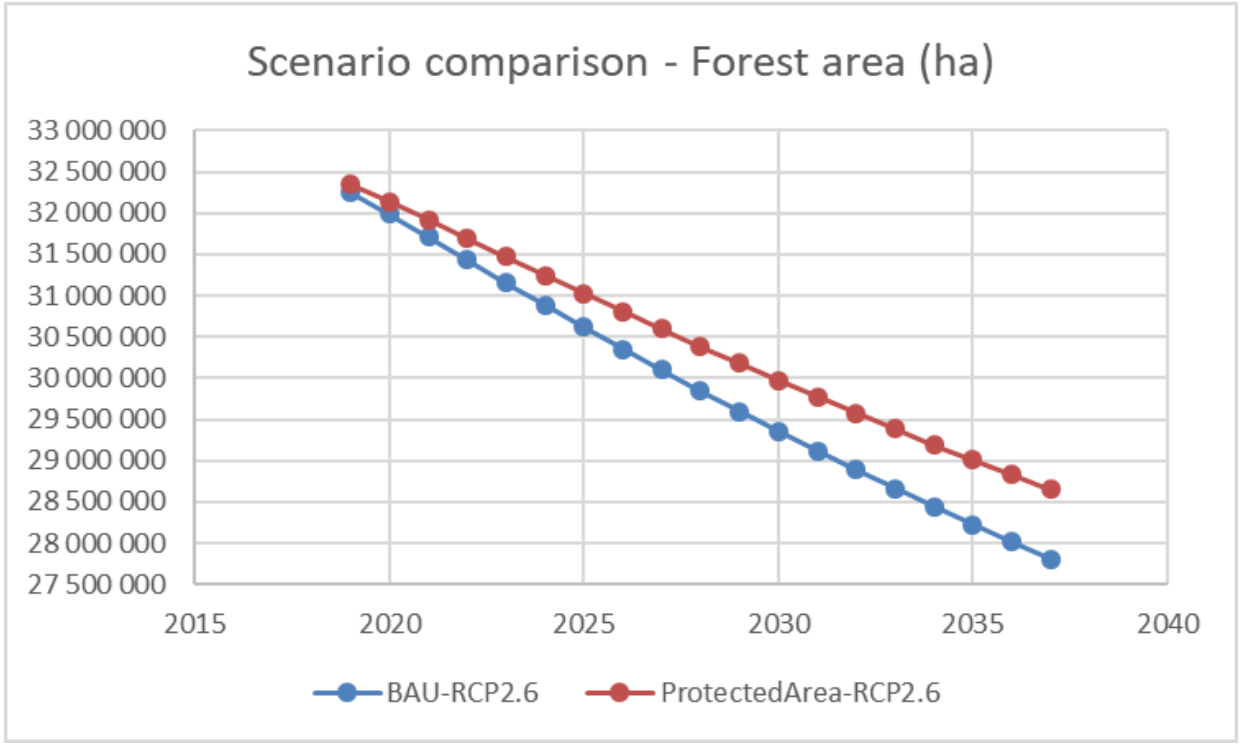
** based on expert judgements

BAU-RCP2.6

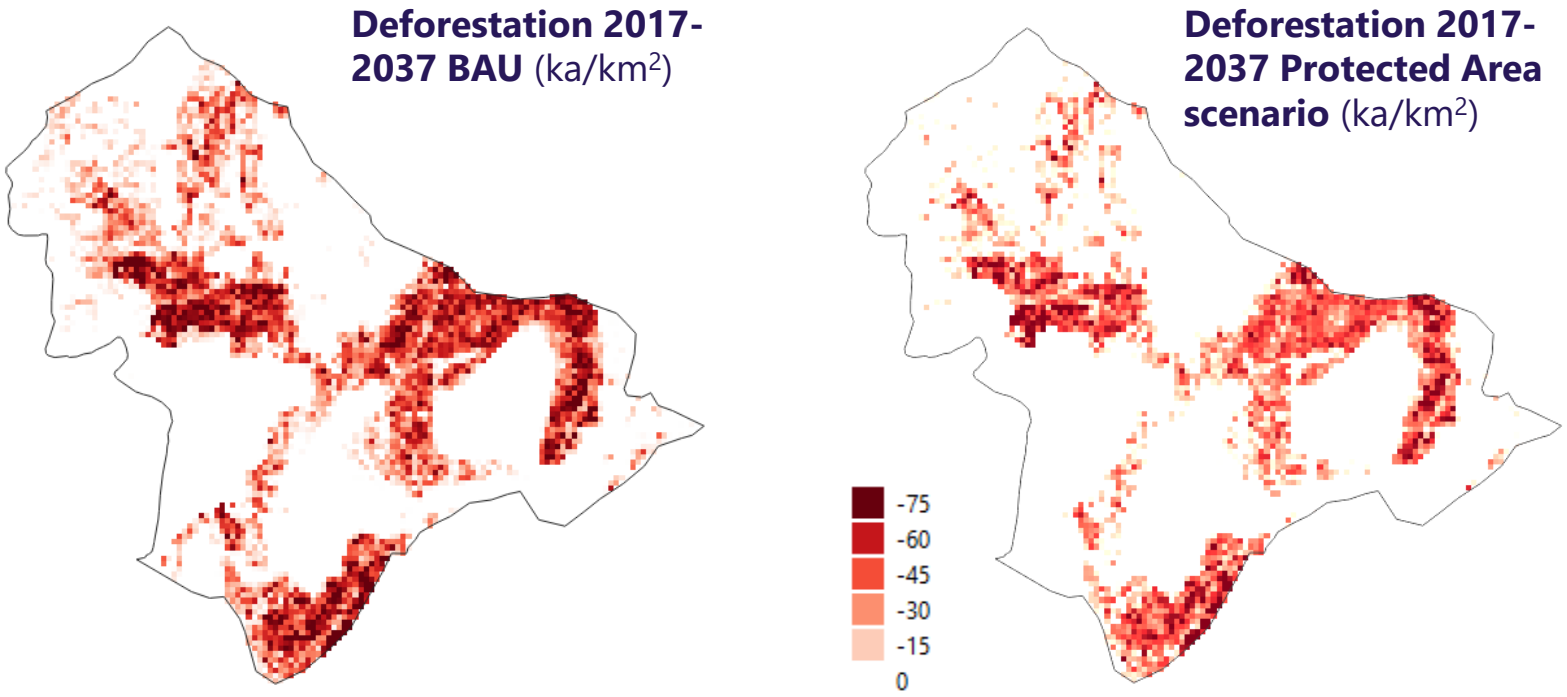
PA-RCP2.6

Household | Land use | Crop | Production | Income

- Comparison of scenarios **BAU-RCP2.6** Vs **ProtectedArea-RCP2.6**



- Simulating impacts of improved of protected area management at district level (district of Sussendenga)



Applied intervention scenarios

Scenario	Study area / FNDS projects	Key parameter changed in the model	Link to policy
BAU	National		
Roads	Districts of Matutiune and Susendenga	With of without roads construction or rehabilitation (date and type)	Roads investments
Protected areas	Districts of Matutiune and Susendenga	Probability of human presence	Land tenure policy
Intensification	Zambezia Province	HH type intensification matrix	Agricultural sector investments

"Intensification" Scenario (Zambezia)

- BAU (Baseline)*

% of HH type / technical package	Very Low	Low	Middle (national average yield)	High (full technology/yield potential)
HH1 (subsistence)	40	50	10	0
HH2 (some cash c.)	10	60	30	0
HH3 (some livest.)	10	60	30	0
HH4 (PACE)	0	20	60	20

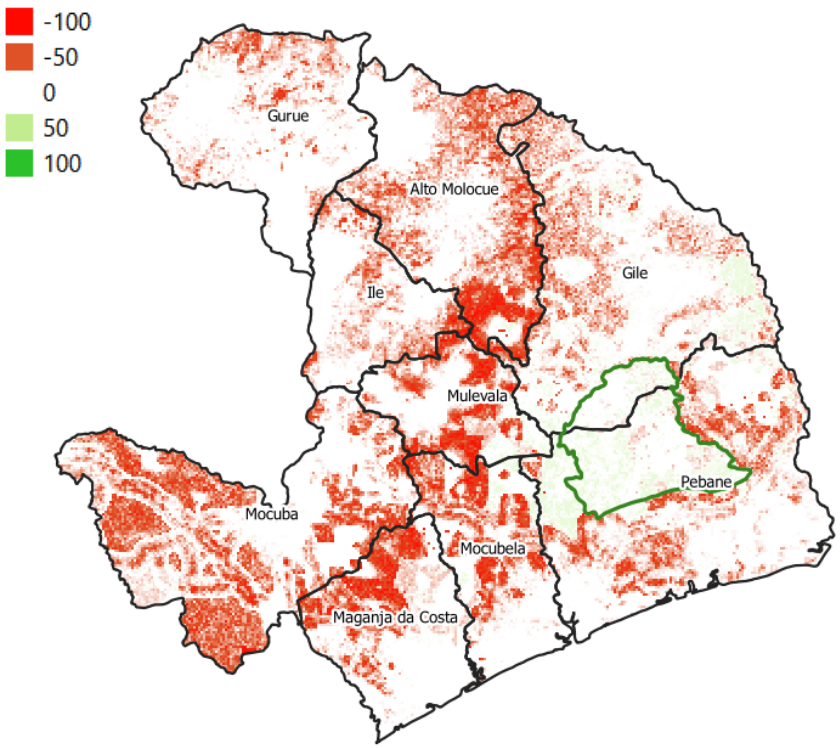
- Interventions simulation* : SUSTENTA [2017 – 2024]

	Very Low	Low	Middle	High
HH1 (subsistence)	40	50	10	0
HH2 (some cash c.)	0	40	40	20
HH3 (some livest.)	0	40	40	20
HH4 (PACE)	0	0	20	80

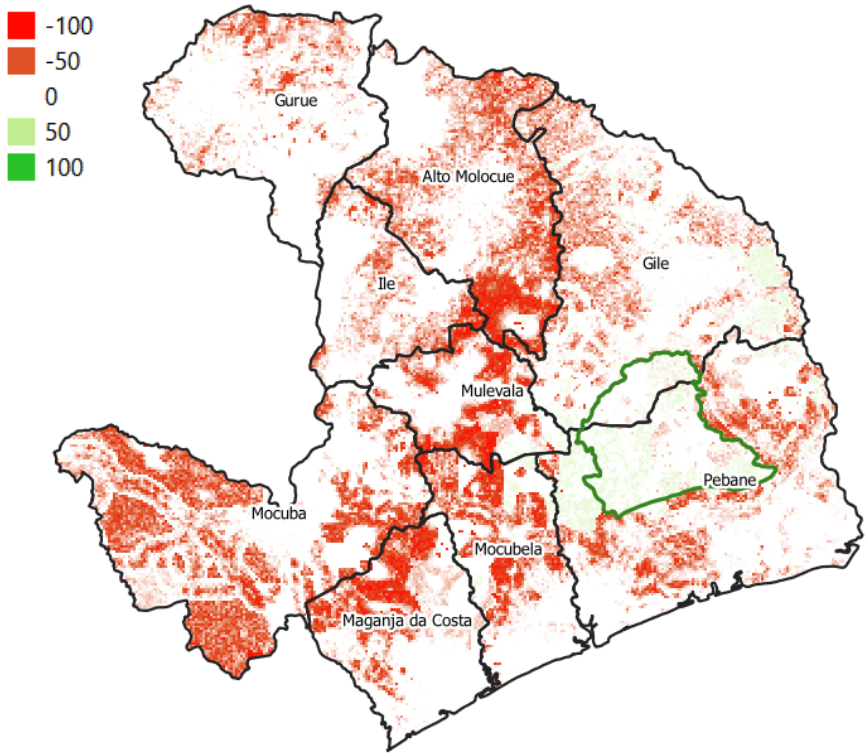
* based on FNDS discussions reprensenting sustenta objectives

- Comparison of scenarios **BAU-RCP2.6** Vs **Intensification-RCP2.6** in the ER Program

Miombo net forest change between 2017 and 2037 (ha/km^2) under **BAU**



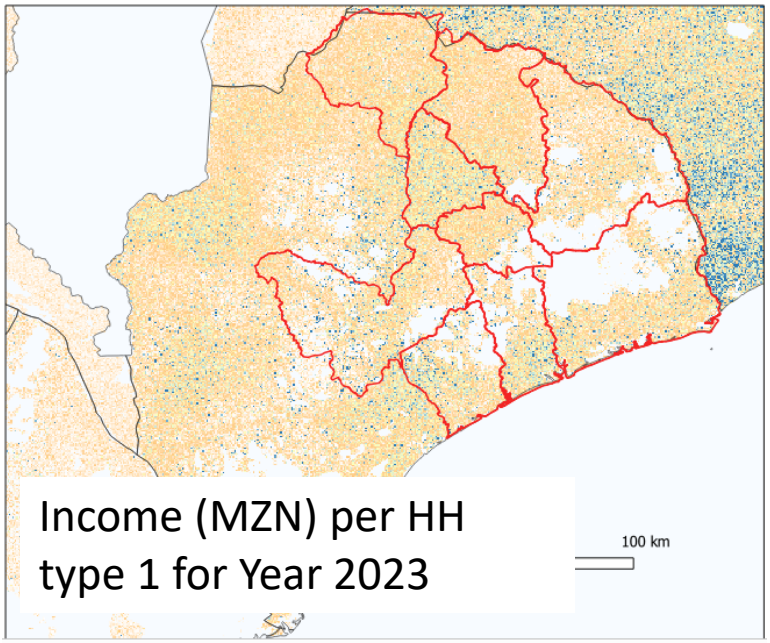
Miombo net forest change between 2017 and 2037 (ha/km^2) under **Intensification scenario**



- Simulating impacts of diffusion of improved access to extension services and diffusion technical package for increasing yields (intensification)

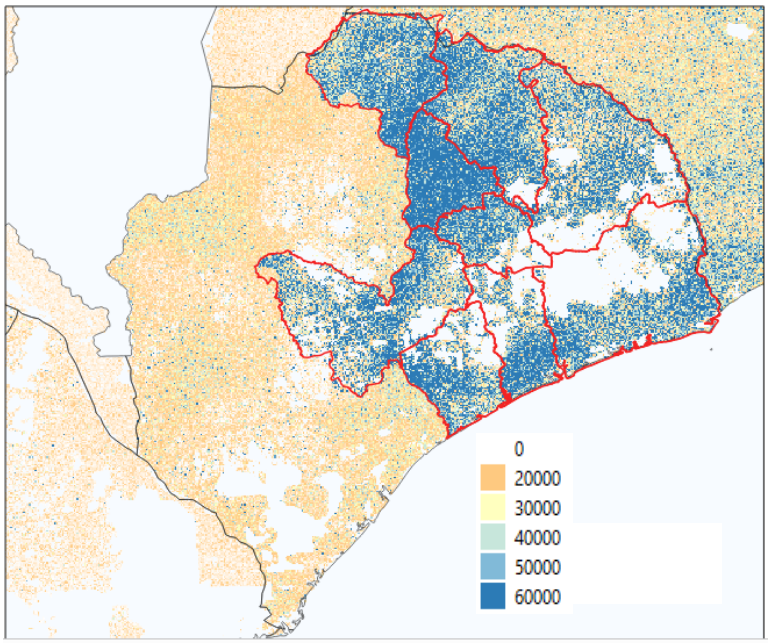
Baseline

(40% very low; 50% low; 10% medium)



Intervention

(10% very low; 10% low; 40% medium; 40% high)



→ Increase in average income per type 1 HH for Zambezia in 2023 (BAU : 19 kMZN per HH ; Intensification : 38 kMZN)

Applied intervention scenarios

Scenario	Study area / FNDS projects	Key parameter changed in the model	Link to policy
BAU	National		
Roads	Districts of Matutiune and Susendenga	With of without roads construction or rehabilitation (date and type)	Roads investments
Protected areas	Districts of Matutiune and Susendenga	Probability of human presence	Land tenure policy
Intensification	Zambezia Province	HH type intensification matrix	Agricultural sector investments

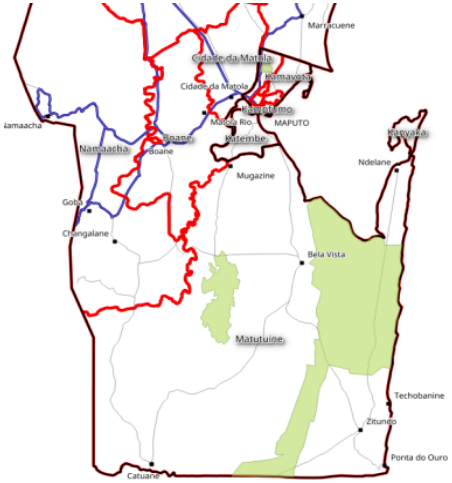
“Roads” intervention scenario

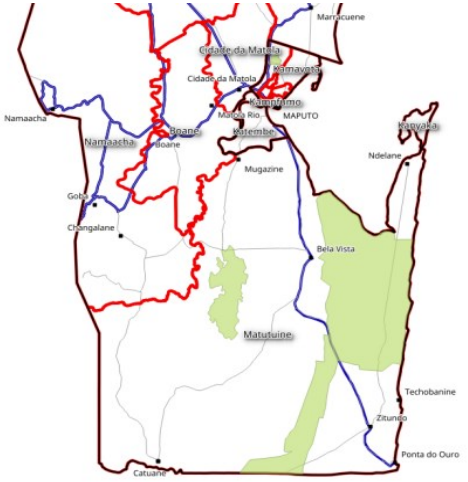
Baseline

Intervention*

Manica Province

Maputo Province





* based known roads investments

BAU-RCP2.6

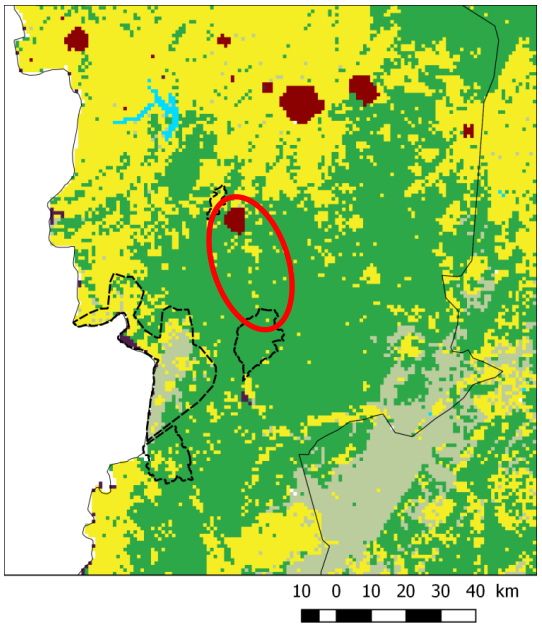
ROADS-RCP2.6

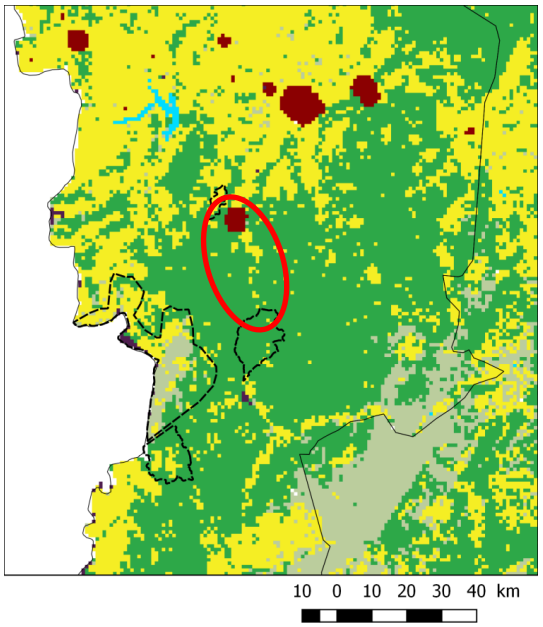
Household | Land use | Crop | Production | Income

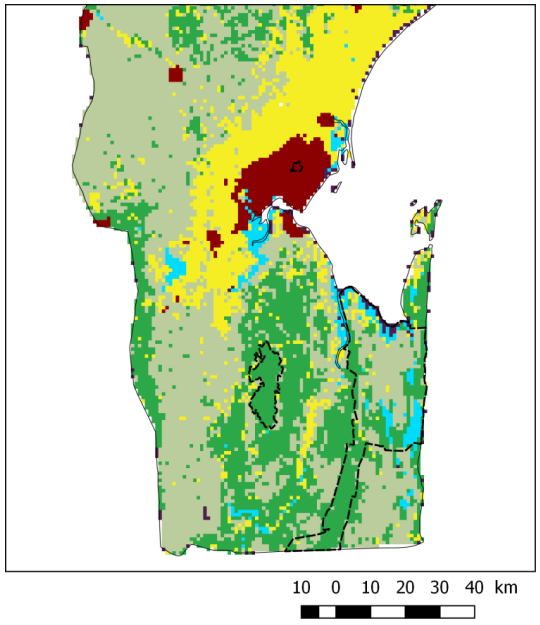
Cropland
Forest
Grassland/Shrub
Urban
Water

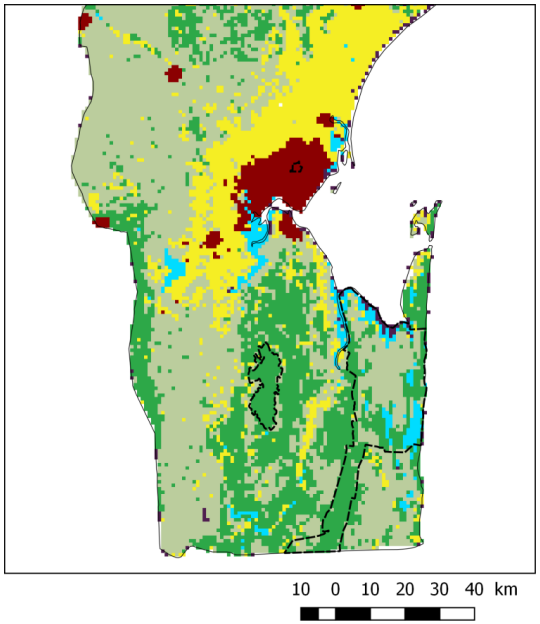
Baseline

Intervention





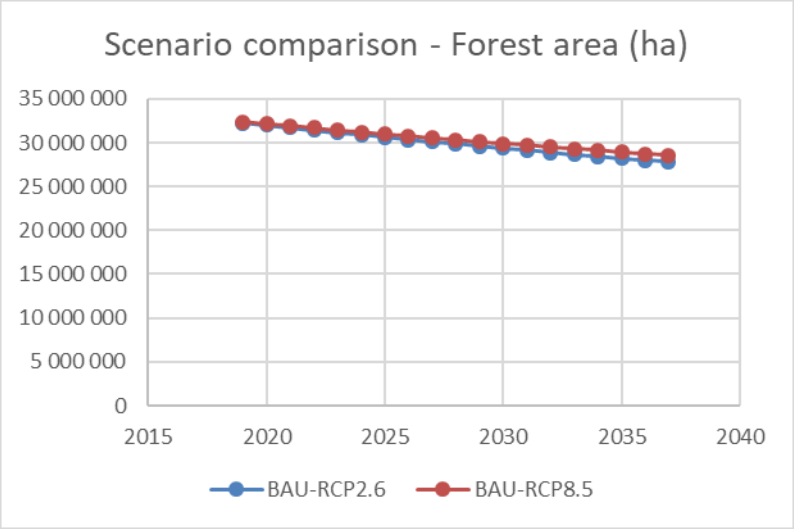


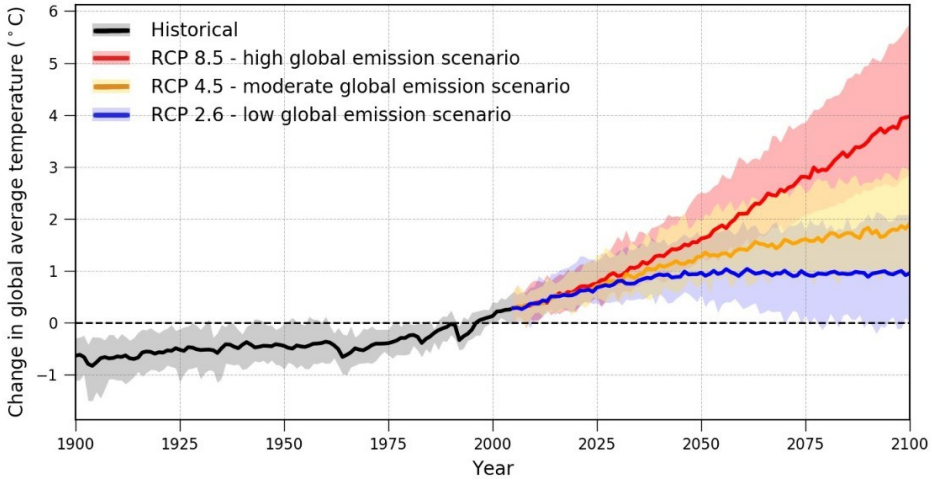


- Simulating impacts of rehabilitated or new road construction in Sussendenga and Matutuine district thought increasing likelihood of settlement

- Only slight effect observed on forest cover in both are due limited local migrations

- Climate change scenarios (RCP2.6 and RCP8.5) for baseline (BAU) scenario





Remarks:

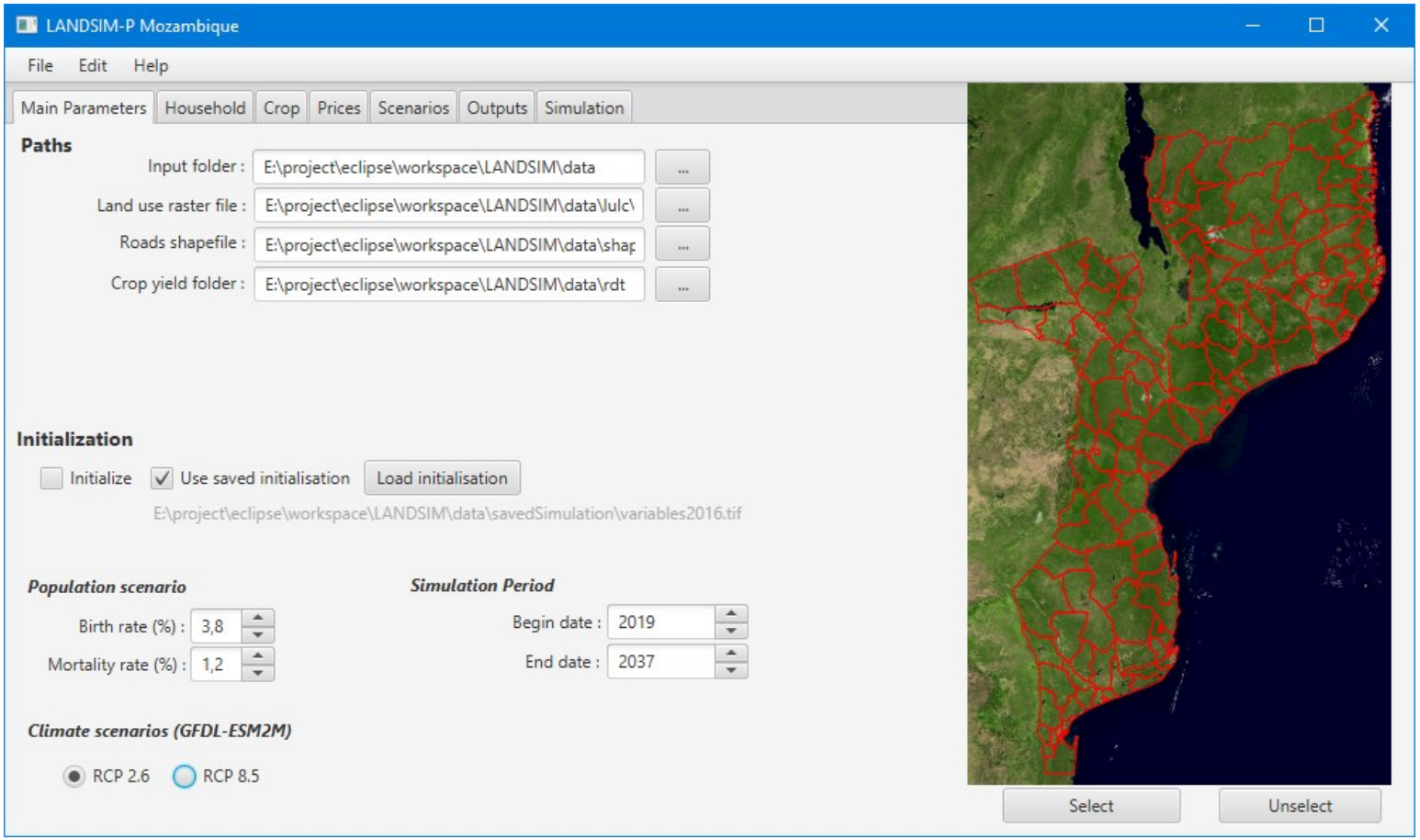
- The time frame (20 years) is not sufficient to capture significant climate change patterns
- The high variations of climate change models (models projection uncertainties)
- The coarse spatial resolution of Global Climate Models

Suggestions for future development :

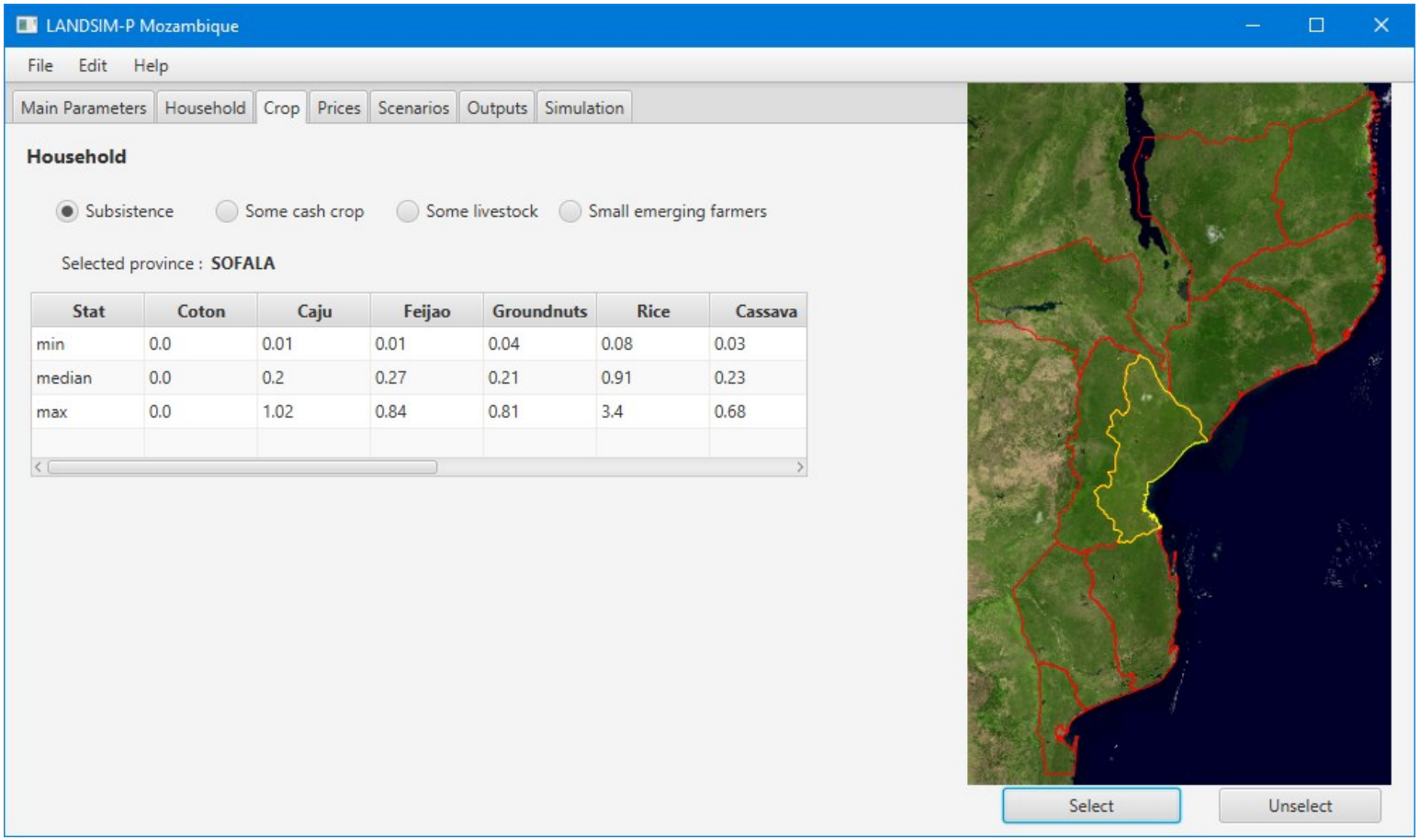
-> integrate extreme events (drought and flood) spatial pattern and frequency

LANDSIM-P User interface

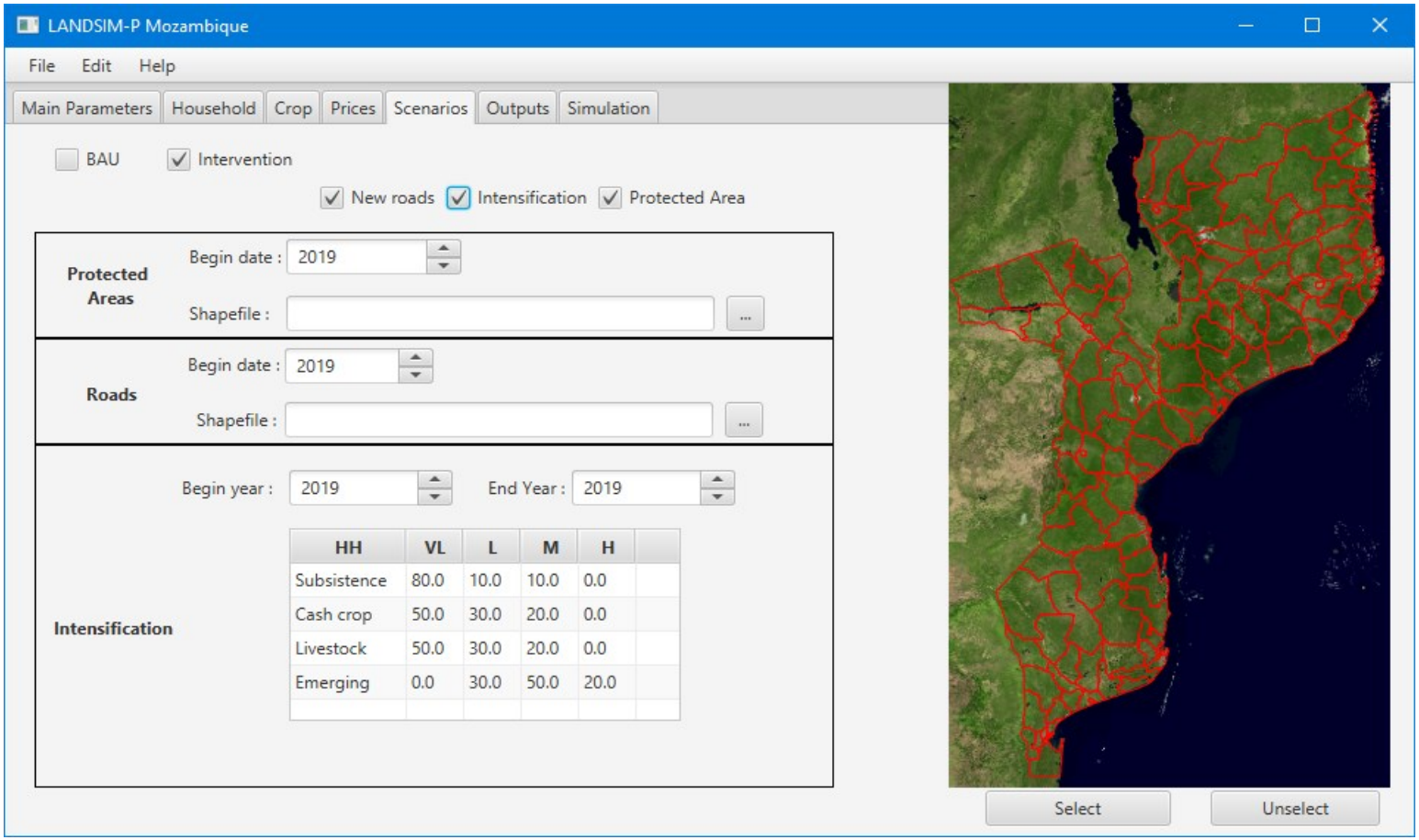
LANDSIM-P user interface



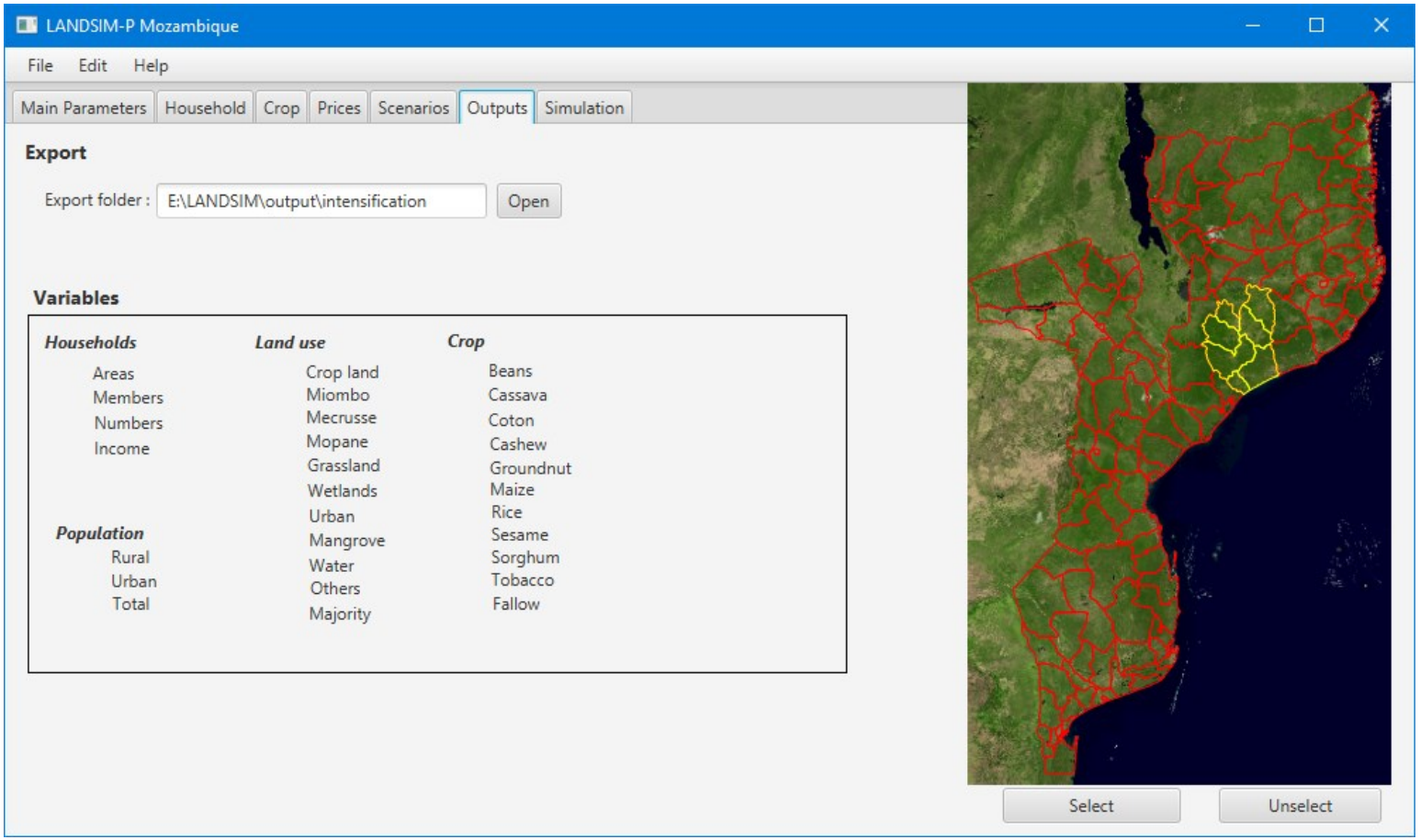
LANDSIM-P user interface



LANDSIM-P user interface



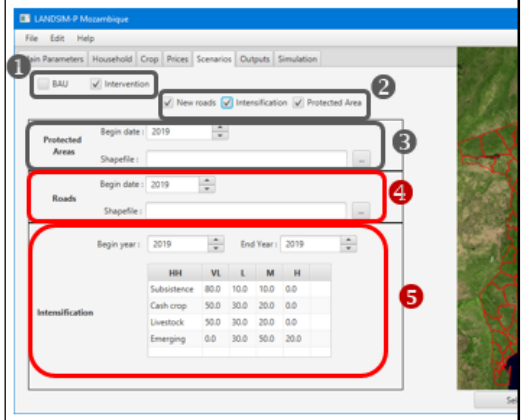
LANDSIM-P user interface



Technical Manual

Scenario settings

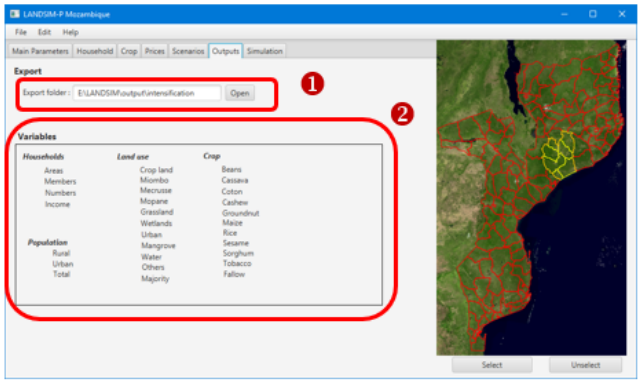
The Scenario panel of LANDSIM-P allows setting parameters to run simulations according to different BAU (Business As Usual) and Intervention scenarios.



❹ 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.

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.



❶ Select the folder where to save all the output results.

❷ 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)

Next steps

LandSIM-P: Some caveats

- The model is a **brand new solution created *ad-hoc***. It was developed using national databases, statistics and local knowledge on Mozambican rural economy and livelihood strategies.

- The model incorporates sufficient processes and feedbacks to qualify as a complex system. This means that **significant efforts are required to conduct a sensibility analysis**, except where very specific examples where high quality data is available. Validation will be only possible in a certain numbers of years (observed Vs predicted)

- The results demonstrate the ability to incorporate different interventions. It is **possible to mix interventions in the current version, yet this has not been tested**.

- The model was designed to **easily incorporate new and updated data or knowledge**. Current results could be improved with better quality of input data and knowledge such as INE census 2017 (disaggregated at district level), roads infrastructure, and precise information on cropland and fallow.

LandSIM-P: Limitations and improvements needed

1. **Population increase and rural migration**. Demography is the main driver development. The model is very sensitive to population dynamics with endogenous processes. It provides complementary and downscaled projections compared to INE projections. Fine tuning these parameters is important as it may dwarf the impact of most of local interventions.

2. **Agricultural intensification**. The model shows that the current interventions (SUSTENTA) are not having an impact on subsistence drivers (interventions are mostly concentrated on emerging farmers) so the impact on deforestation, etc. is limited. It requires to look at the fallow sizes; the model is very sensitive to this → Future improvement.

3. **Climate change.** Integration of extreme events would be more relevant. It could be possible to use a frequency of extreme droughts in the model and the resulting impacts on HH but a background study on historical events and impacts would be required to create this functionality → Future improvement.

Discussed improvements on stories

5. **Infrastructure**. This factor impacts household settlement likelihood (*attractivity*) influencing migrations at local scale. Large scale migrations processes need to be added to "see" more potential impacts. The influence on price and the value chain is currently not modeled. This would require complex modeling of commodity prices and expert knowledge by value chain → Future improvement.

Other functionalities:

- **Charcoal and livestock activities.** Those two rural activities are currently not implemented yet they are important factors for rural households. A background study on charcoal rural activities, value chain (supply and demand) would be required to add processes and eventually a new household type to simulate the impacts on the landscape (focus on Maputo and Gaza province?) → Future improvement.

Next steps - Dissemination

- Running of “business cases” to show the importance of integrated landscape management
- Separate presentation to MAT and MADER

Next steps – From prototype to operationalization

- FNDS and UEM interest in improving geospatial analysis and coding capabilities
- Addition of functionalities to prototype
- Planting a seed of long term capacity building in land use and welfare analysis (potentially covered by AFD project)

Obrigado