LandSIM developments using Ocelet Modeling Platform (OMP)

LAUREL Project

Progress report July 2018

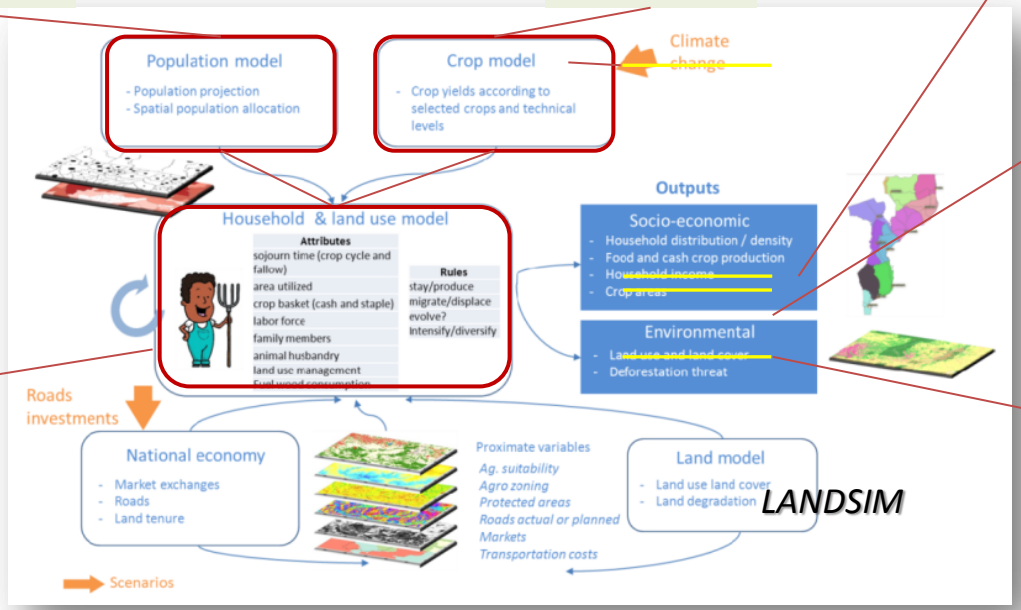
Methodological development for LANDSIM

- **Development of 3 modules**
- **Production of 5 SOV under baseline scenario**

Population model

Crop model

Household model



Outputs:
HH density and distribution map

Outputs:
Crop production & Crop area maps

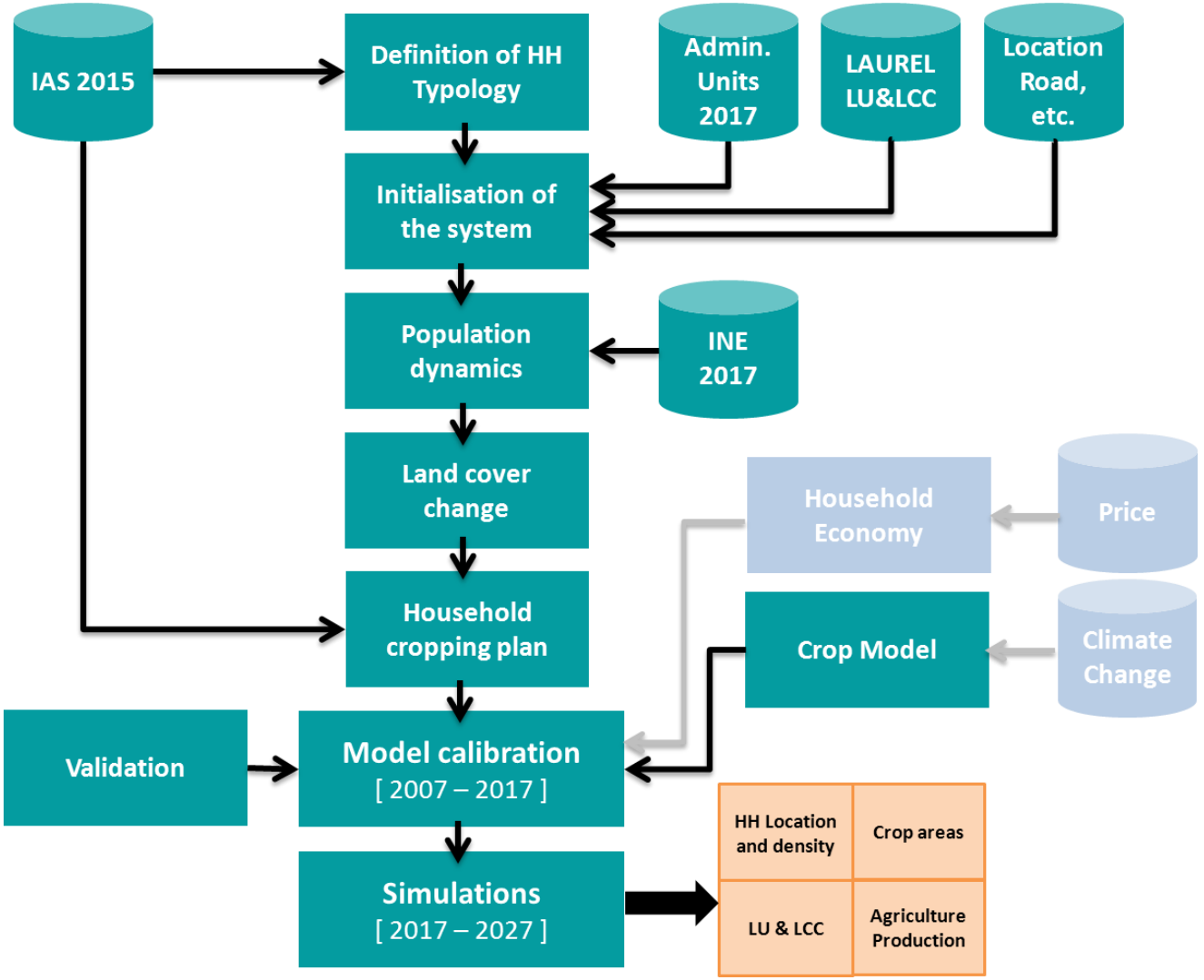
Outputs:
Land Cover Change Simulations 2007-2027

Methodological development for LANDSIM

Develop a land use simulation model driven by rural household (HH) dynamics

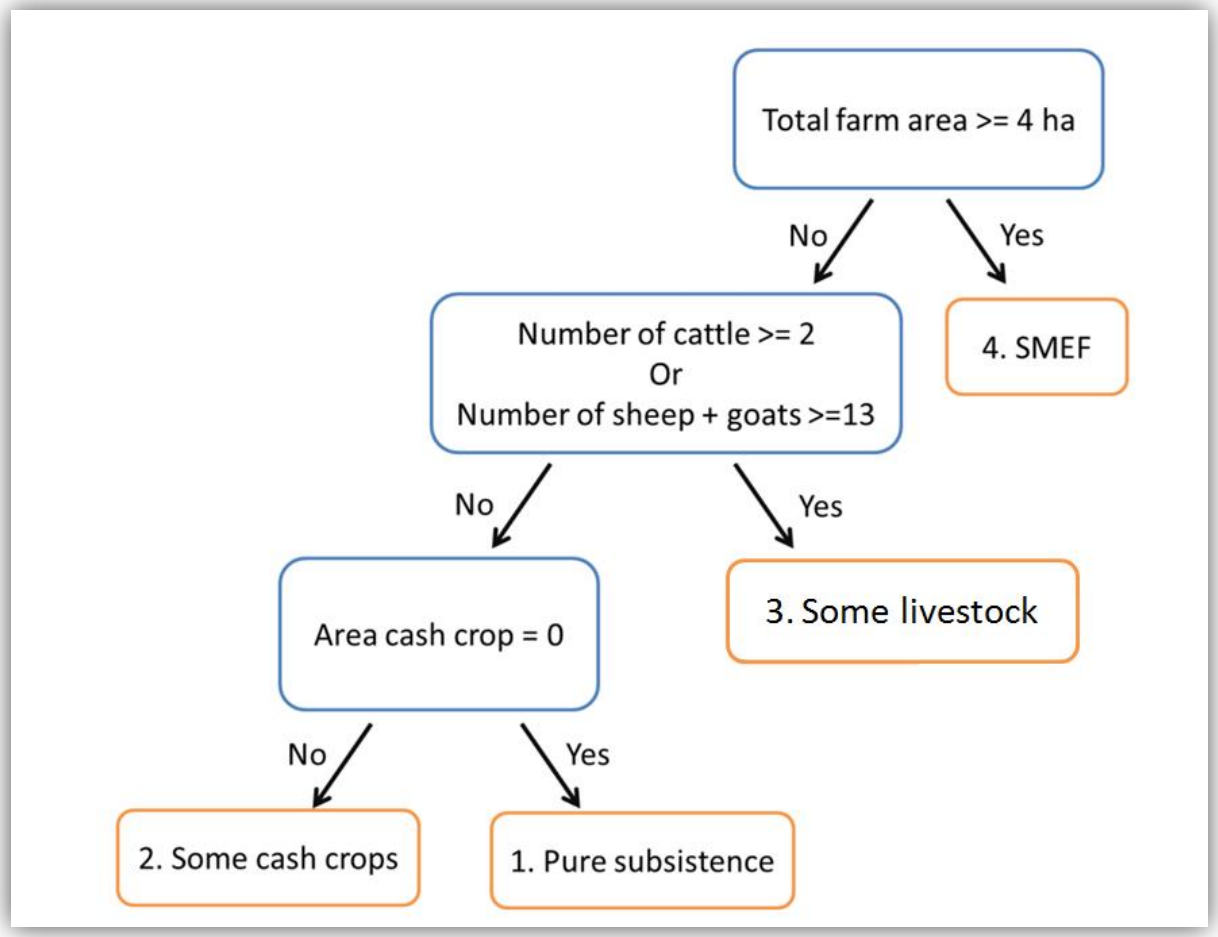
- **(i) Definition of HH types**
- **(ii) Spatial distribution of HH over Mozambique : 2007**
- **(iii) Population dynamics and migration**
- **(iv) Land cover change model : 2007-2027**
- **(v) HH cropping plan**
- **(vi) Crop model: link with HH model**

Methodological development for LANDSIM



Household model - Step (i) *Build HH typology*

Database
IAS 2015 and
IOF 2015
(5810 HHs)



SMEF : Small and medium-size emerging farms

Household model - Step (i) *Build 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 subsistance

2 : Some cash crops

3 : Some livestock

4 : SMEF

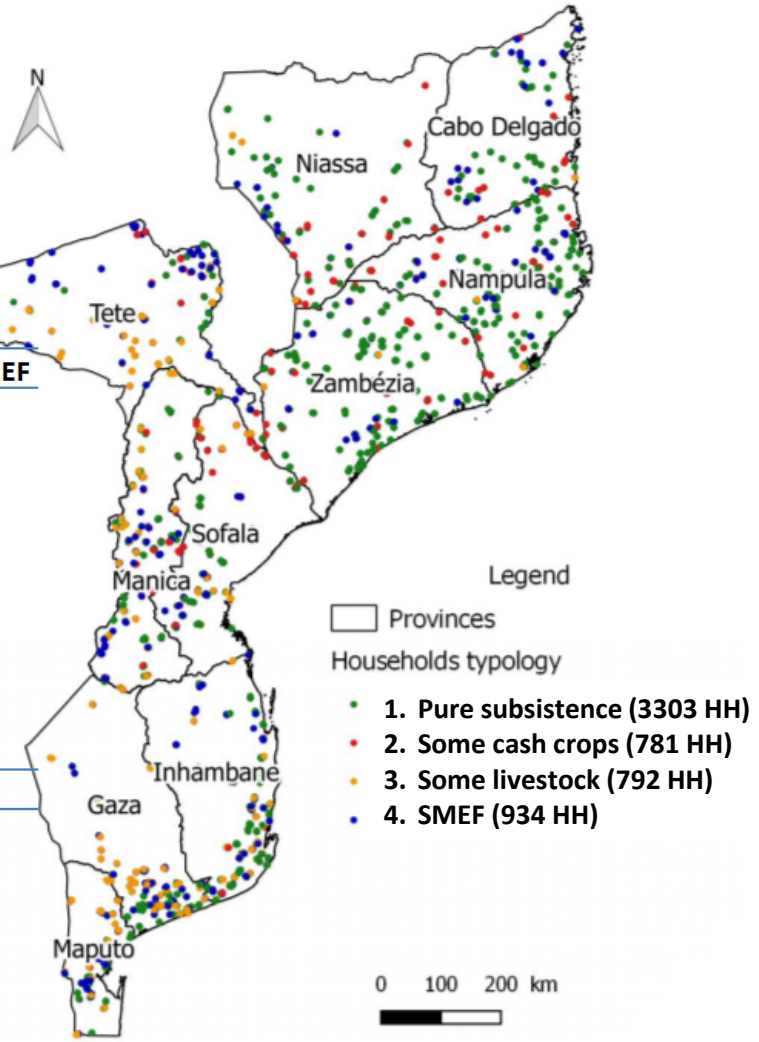
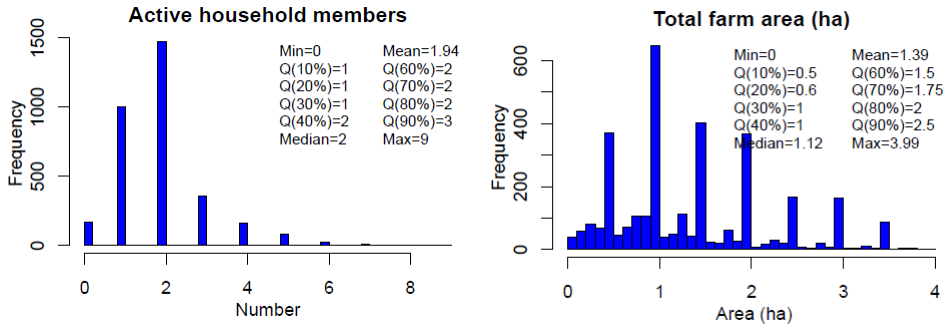
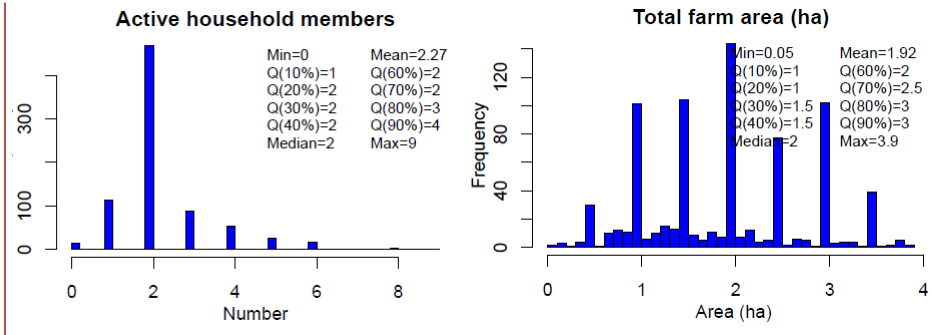


Figure 1 : Distribution of agricultural households by group

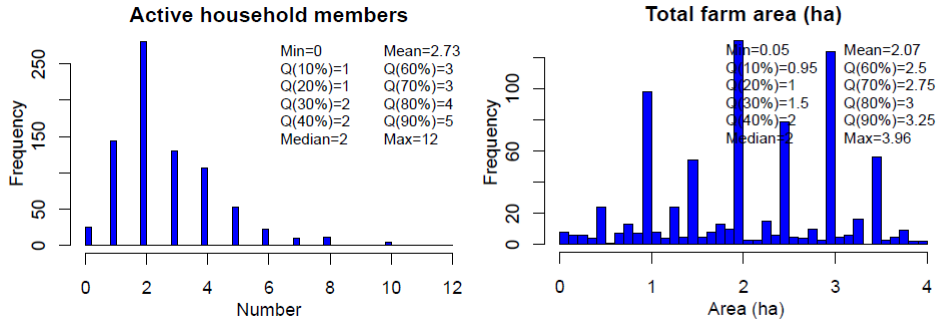
Household model - Step (i) *Build HH typology*



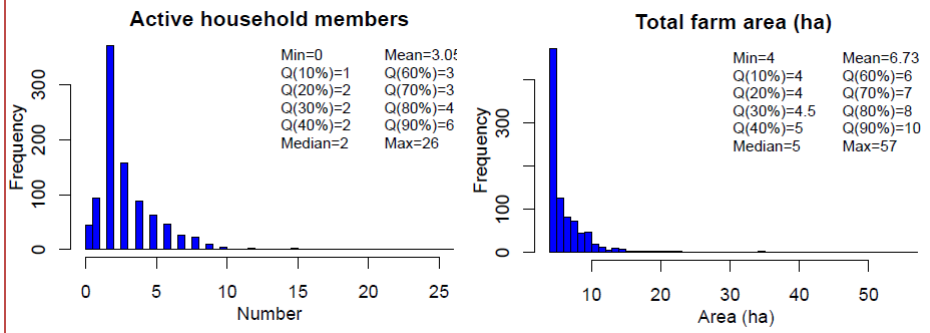
1 : Pure subsistance



2 : Some cash crops



3 : Some livestock



4 : SMEF

Household model - Step (ii)

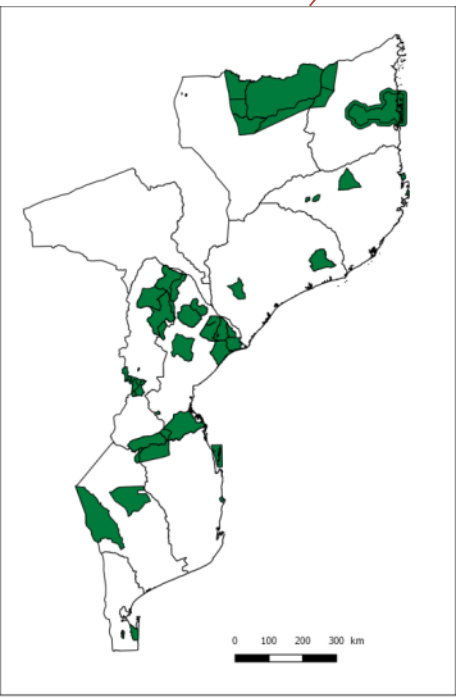
Spatially distribute HH over Mozambique

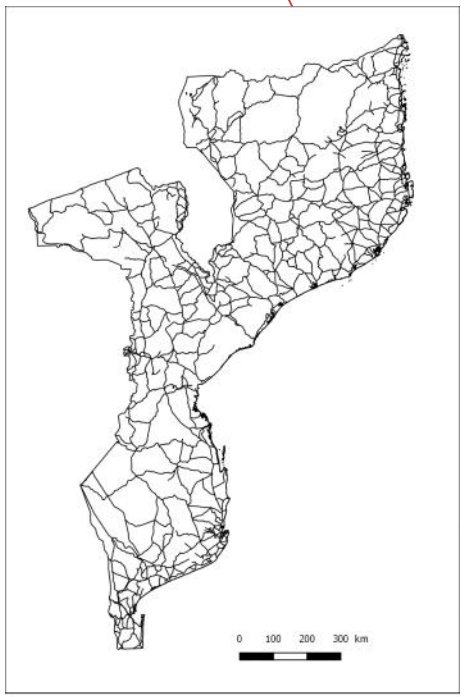
Spatially distribute rural HH taking into account :

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

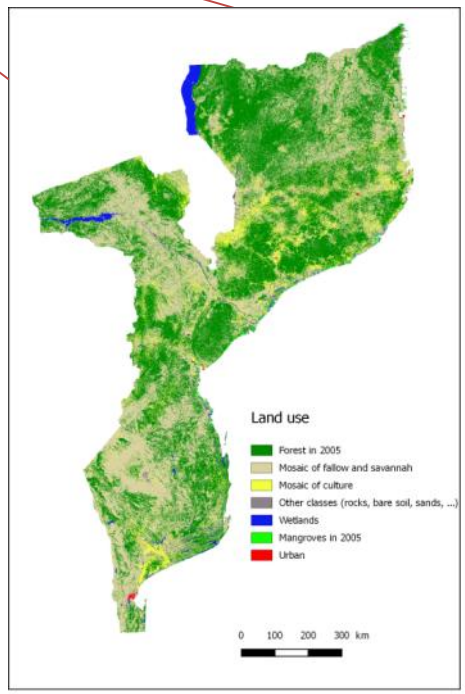
Data used

Census data 2007





Road map



2005 LULC map
Laurel

Village location map

Household model - Step (ii)

Spatially distribute HH over Mozambique

Managing millions of individual and geographically localised rural HH : not desirable *(computer intensive, lack of fine data)*

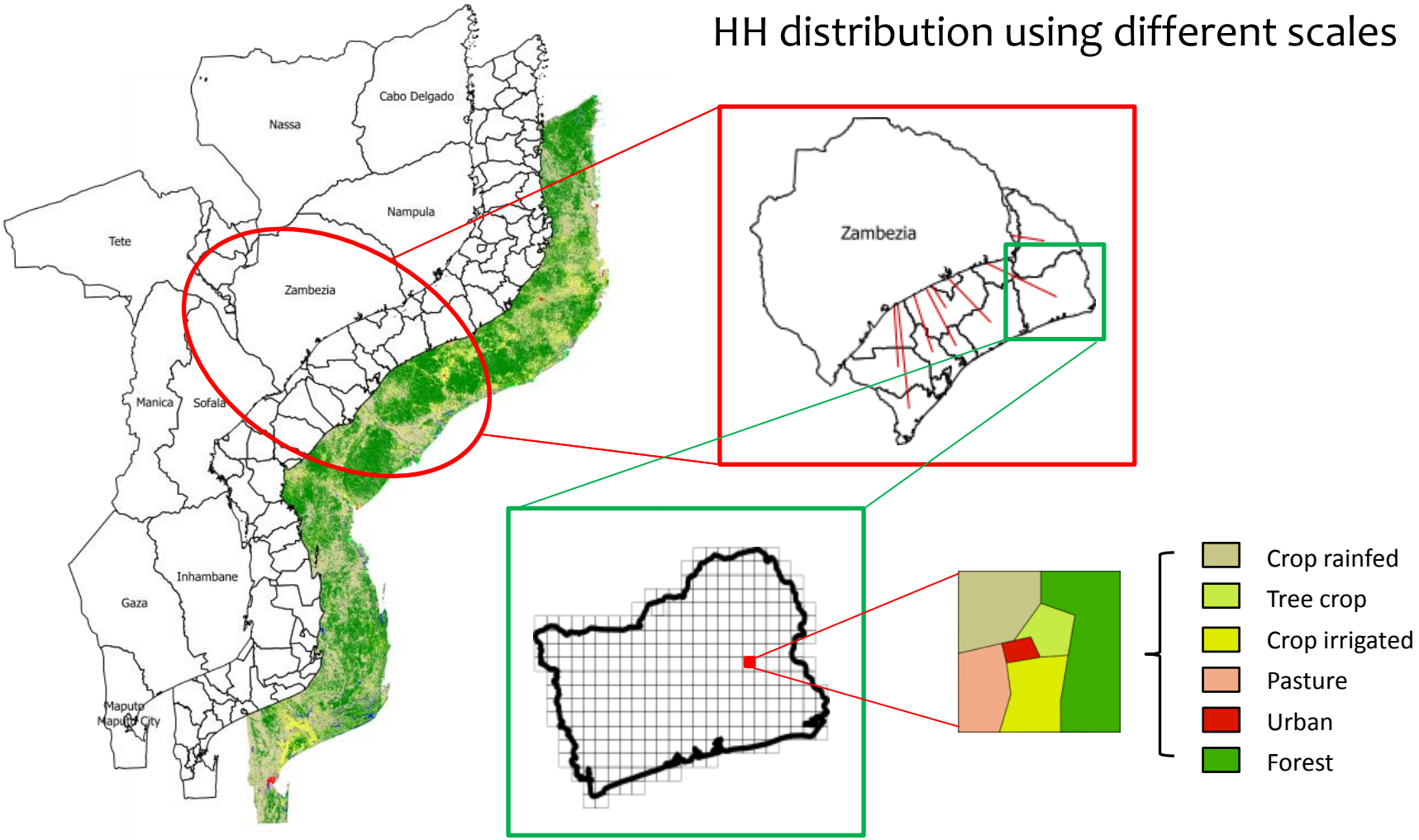
Proposed solution :

- discretize the country into **spatial units** of **1 km²**
- each 1 km² cell contains a « population » of HH for each of 4 types, with corresponding # members and cropped surface area
- for each cell we know the land cover types present
- HH will use cropland, and will locate preferably in villages , near roads,
- HH will avoid protected areas (strictly or partially)

Household model - Step (ii)

Spatially distribute HH over Mozambique

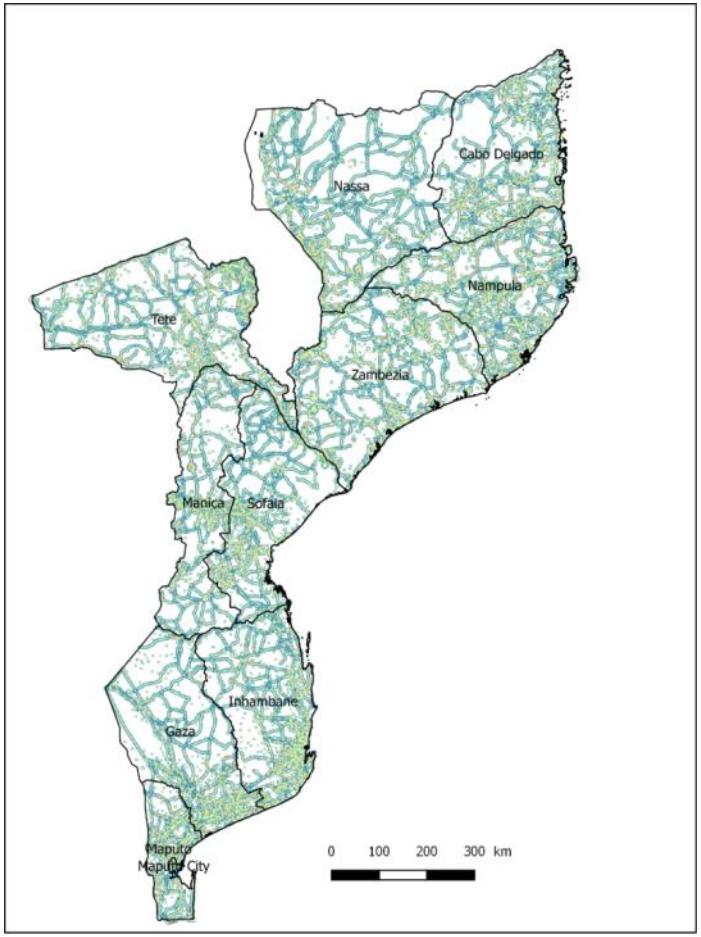
HH distribution using different scales

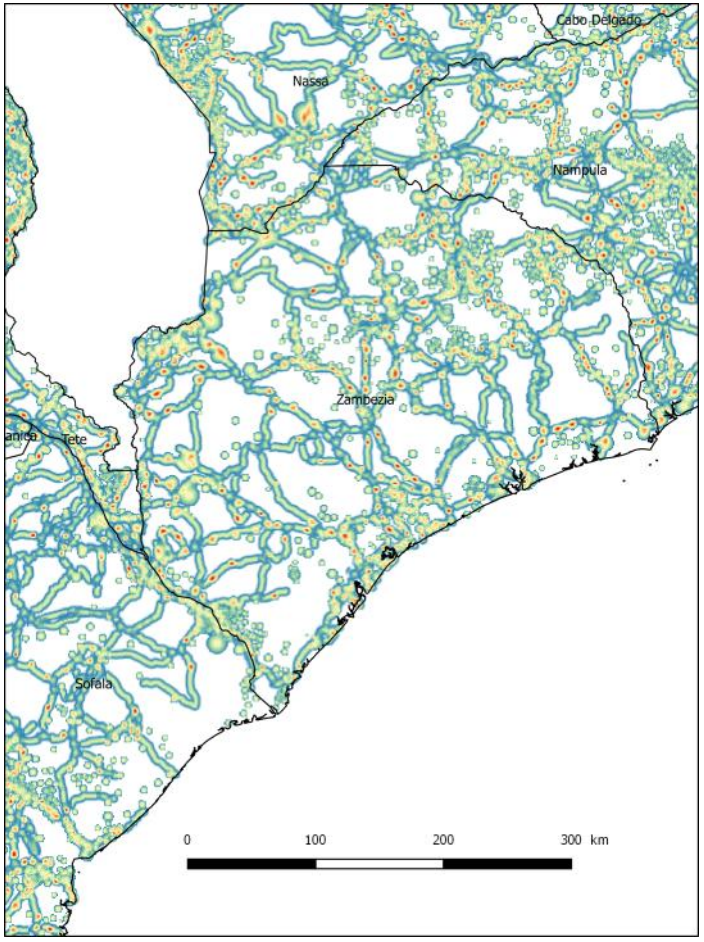


Household model - Step 2

Spatially distribute HH over Mozambique

Attractivity levels : distance from roads and town/village locations





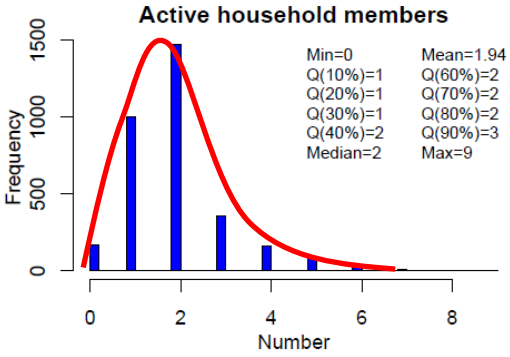
Attractivity levels

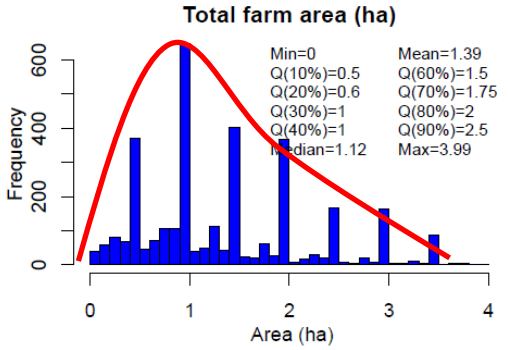
Household model - Step (ii)

Spatially distribute HH over Mozambique

Distribution process : Example for one district in Zambezia (Pebane)

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

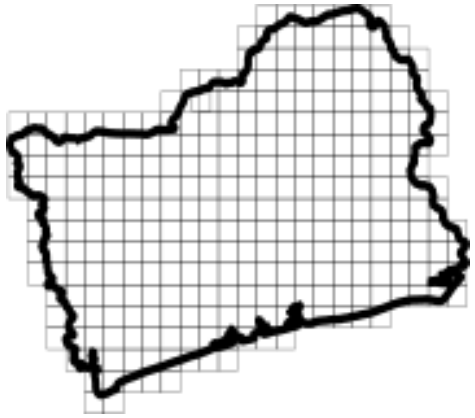




Resampling to 10000 objects that match HH types per district

Each object:
- Area
- Members

Attribution of HH sample area and members to spatial units per district

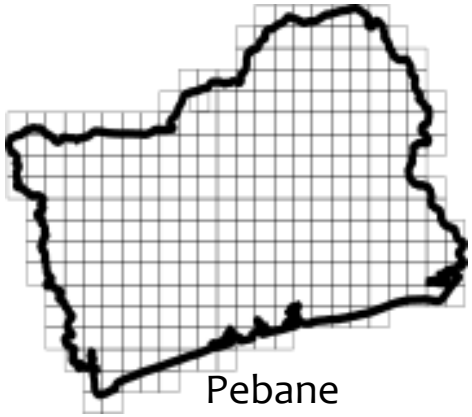


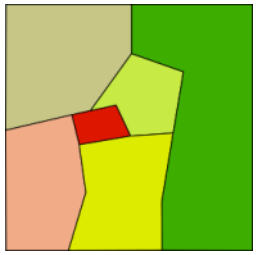
New samples

Household model - Step (ii)

Spatially distribute HH over Mozambique

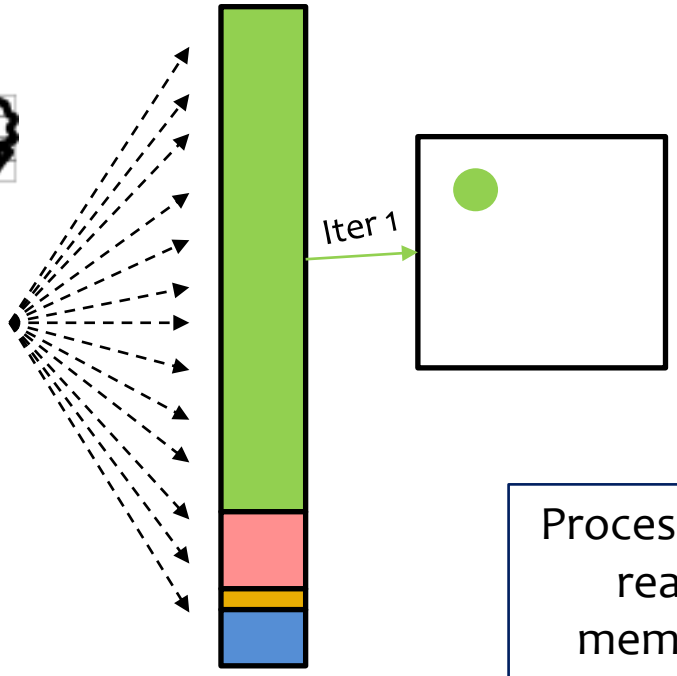
Distribution process : detailed for Zambezia (Pebane)





Spatial unit with areas from land cover and attractivity level

Iteration : for each spatial unit



Per iteration :

- Retrieve available crop area
- Add Farm area
- Substract Members from district population
- Add Members to spatial unit

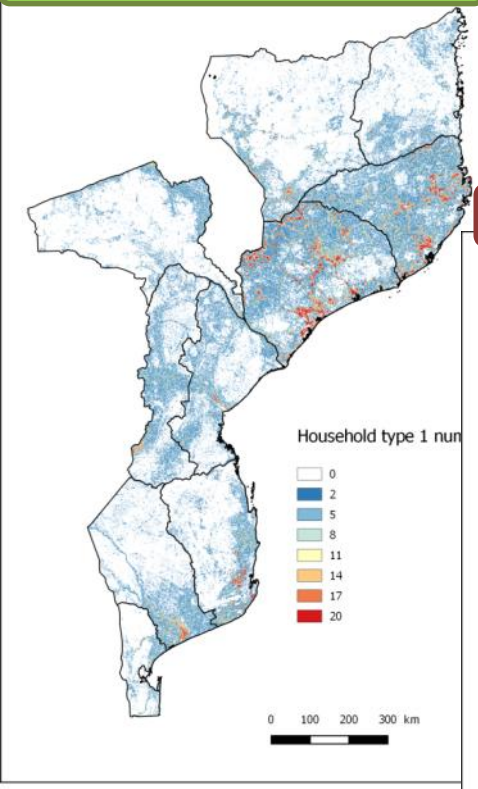
Process stops when all spatial units reach available crop area or members reach population per district
(~2500 iterations)

Household model - Step (ii)

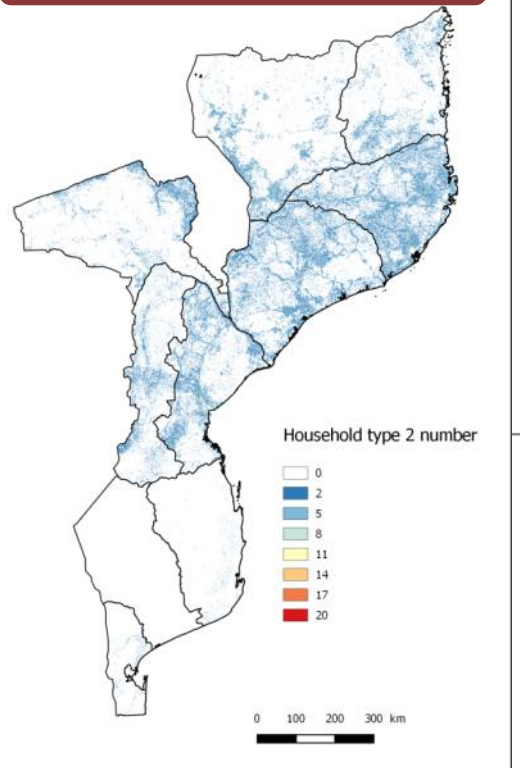
Spatially distribute HH over Mozambique

HH Simulated distribution for 2007

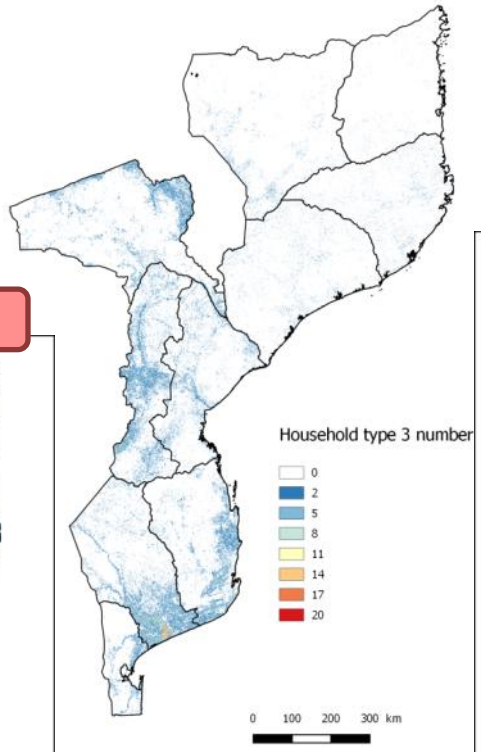
1 : Pure subsistance



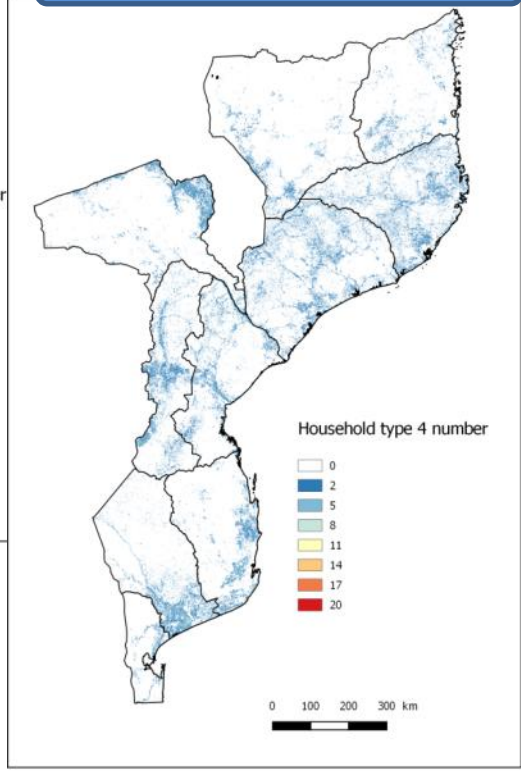
2 : Some cash crops



3 : Some livestock



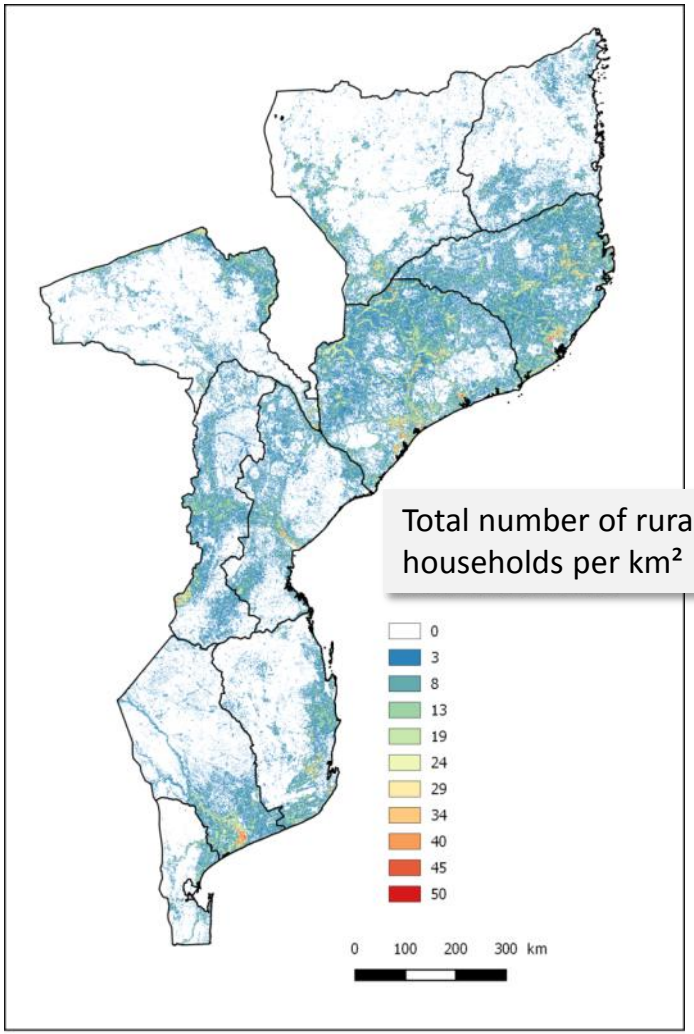
4 : SMEF

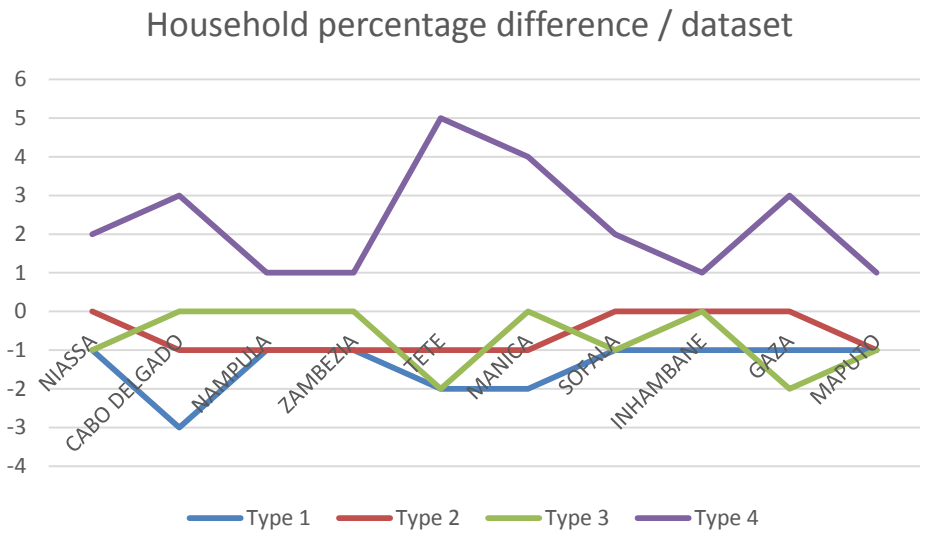


Household model - Step (ii)

Spatially distribute HH over Mozambique

HH Simulated distribution for 2007





2007

~ 13 M inhabitants

~ 2.4 M *rural households*

Household model - Step (iii)

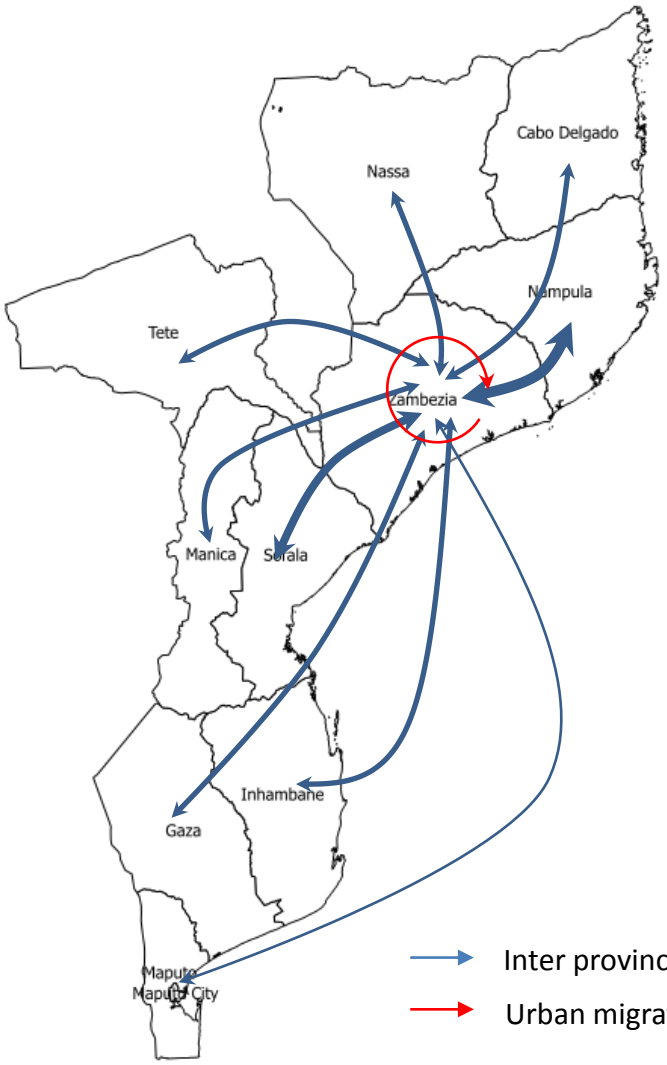
Link to population dynamics model – Test 2007-2027

Population dynamics towards 2027

- Apply a growth and mortality factor on each spatial unit to members and urban population
- Extra population above a threshold (~10) is lumped at Province level
- Migration occurs between Provinces
- After migration Province Population is redistributed between rural and urban population
- Rural population disaggregated to district and redistributed as for 2007

Household model - Step (iii)

Link to population dynamics model – Test 2007-2027



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

From Zambezia to …

	Niassa	Cabo Delgado	Nampula	Zambézia	Tete	Manica	Sofala	Inhambane	Gaza	Maputo Província	Maputo Cidade
Niassa		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	

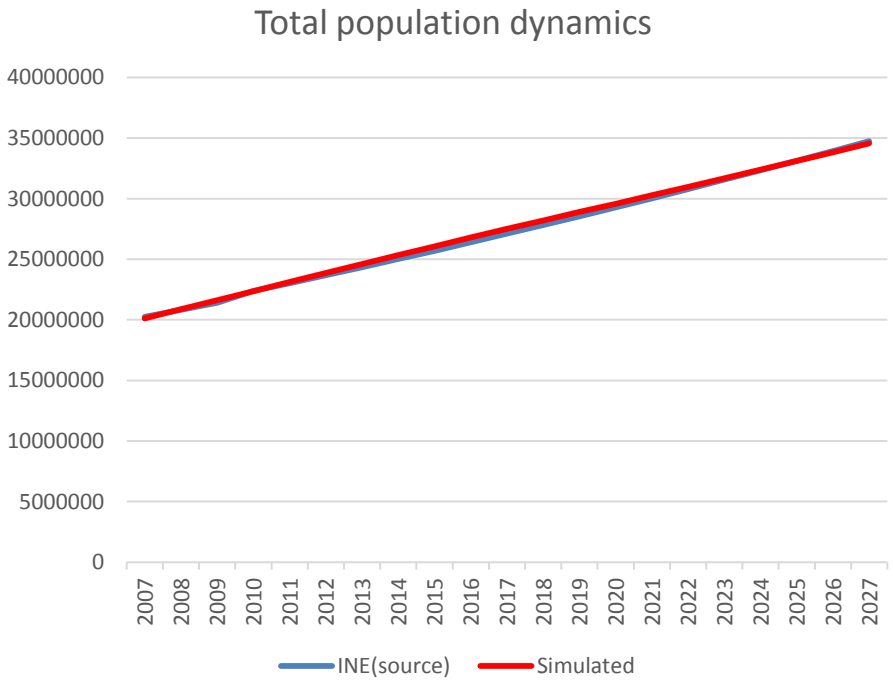
Urban and rural population migration

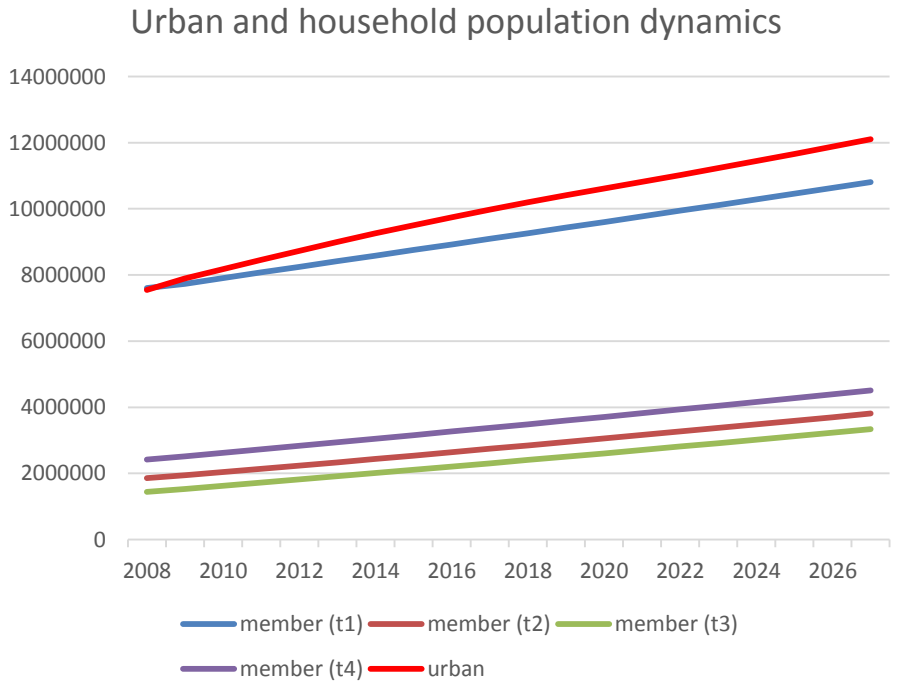
Província	Total		Urbana		Rural	
	N	%	N	%	N	%
Niassa	1 213 398	100	277 838	22,9	935 560	77,1
Cabo Delgado	1 634 162	100	340 707	20,8	1 293 455	79,2
Nampula	4 084 656	100	1 167 813	28,6	2 916 843	71,4
Zambézia	3 890 453	100	679 073	17,5	3 211 380	82,5
Tete	1 807 485	100	247 178	13,7	1 560 307	86,3
Manica	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	------	-----

Household model - Step (iii)

Link to population dynamics model – Test 2007-2027

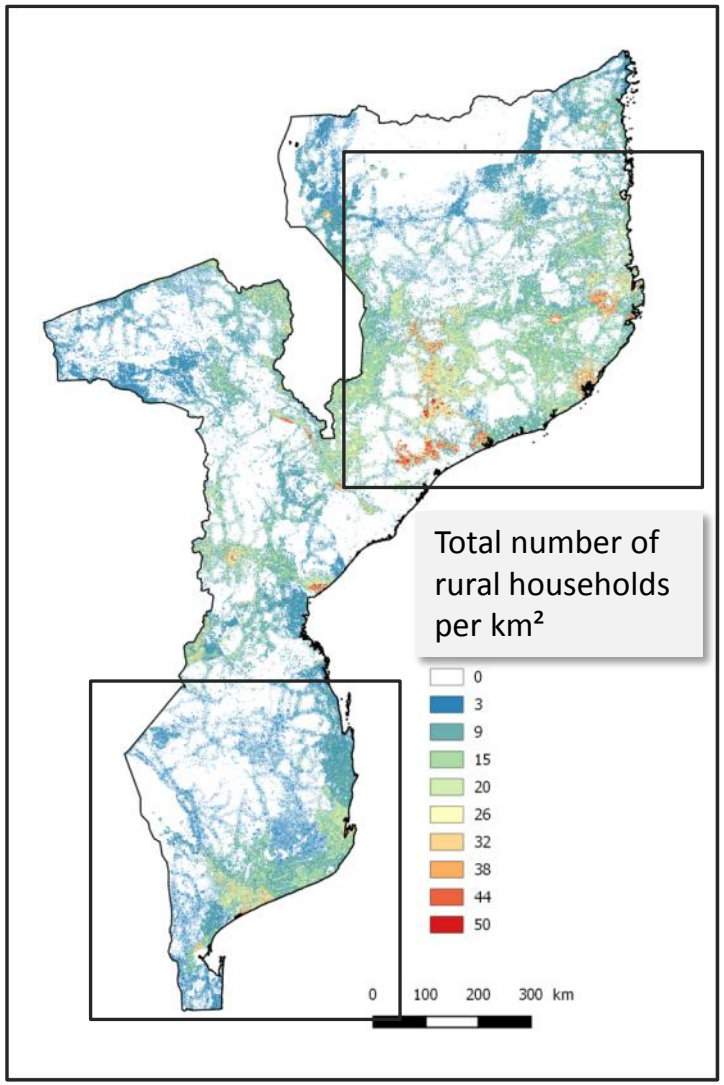
Population dynamics simulation results

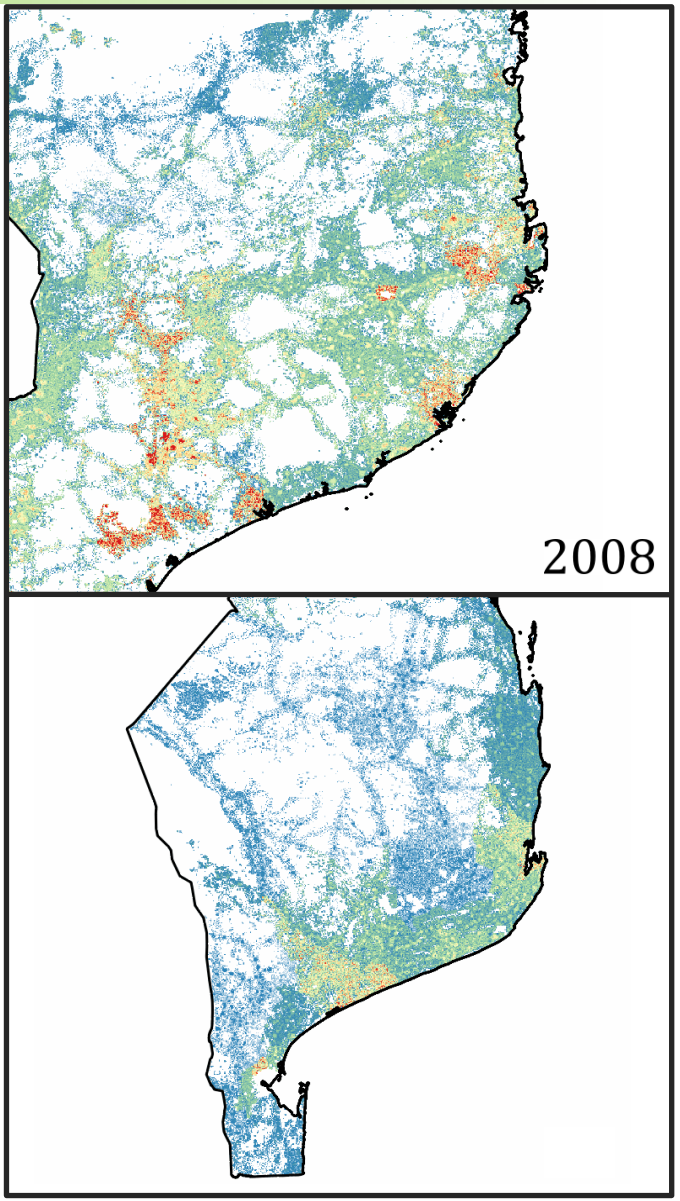




Household model - Step (iii)

Link to population dynamics model – Test 2007-2027





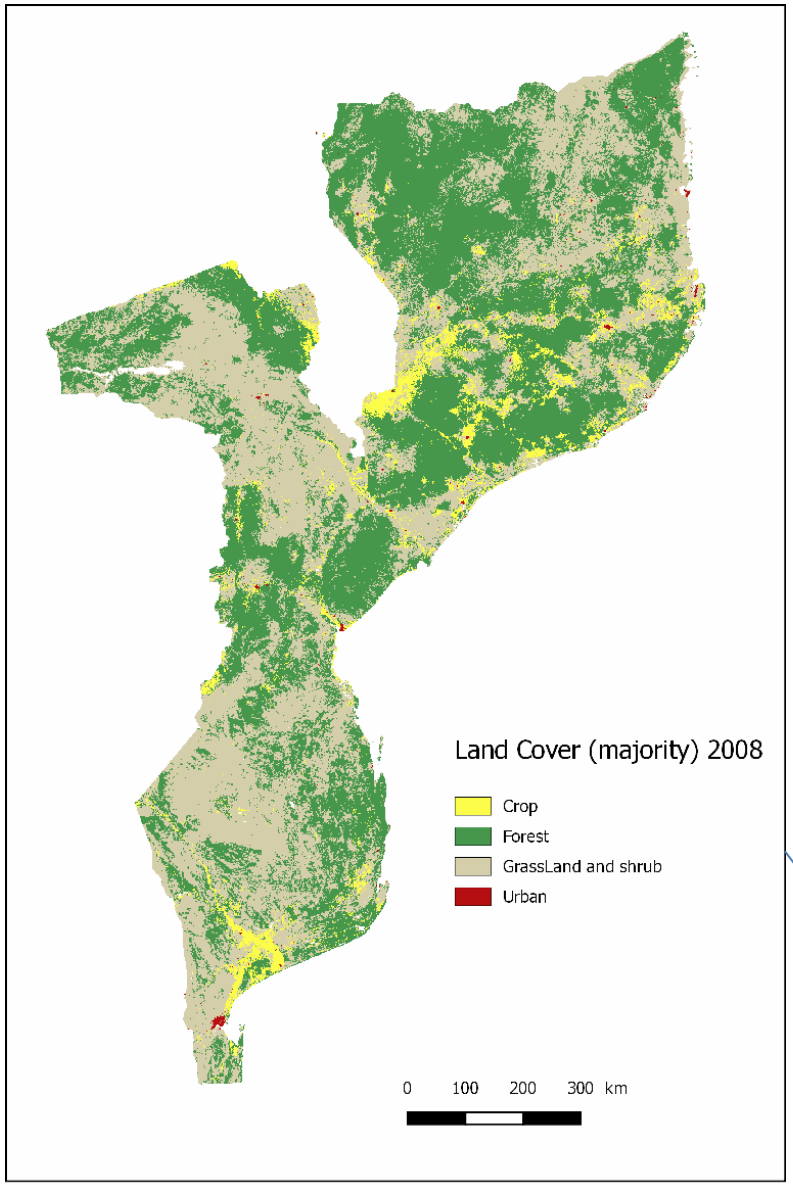
Land Cover Change model - Step (iv)

Land cover dynamics towards 2027

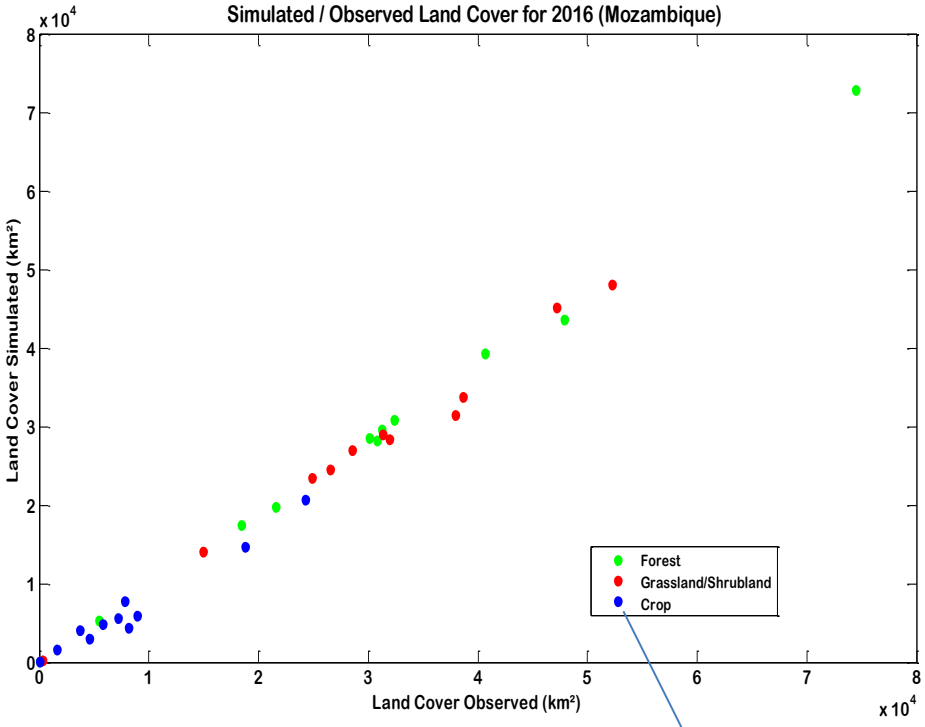
Calibrate LCC model between 2007-2017

- Deforestation process occurs (within spatial unit or neighbours) when there is no crop area available in the spatial unit
- HH number of members and surfaces cultivated may increase
- New HH are created and new crop areas are created from forest areas
- Urban population increase result in densification and urban sprawl
- Simulate LCC between 2007-2027, calibrate between 2007-2017

Land Cover Change model - Step (iv)



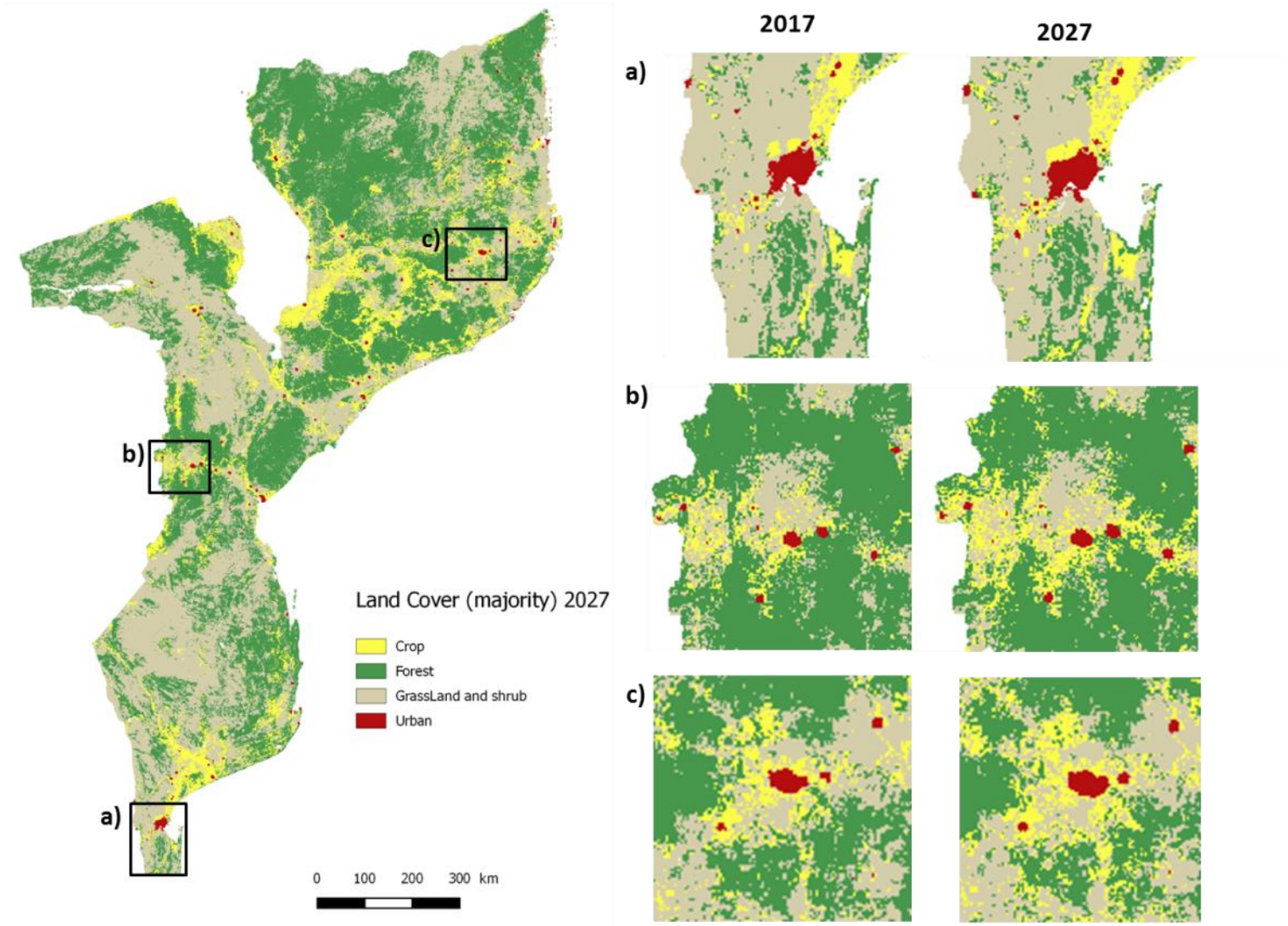
Calibrate LCC model between 2007-2017



Animated gif.
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.

Land Cover Change model - Step (iv)



Household model - Step (v)

Set Household cropping plan

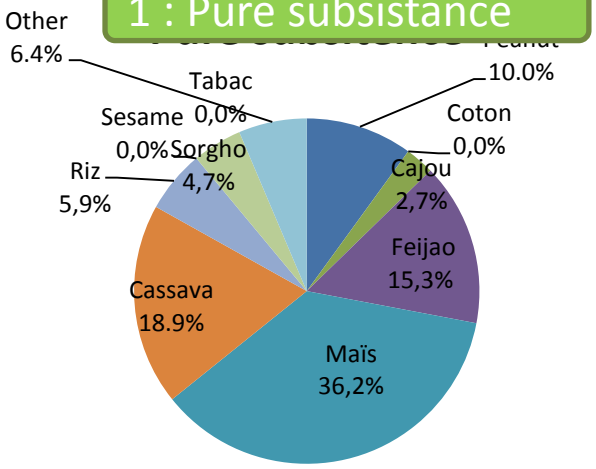
Products typology according to price influence

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

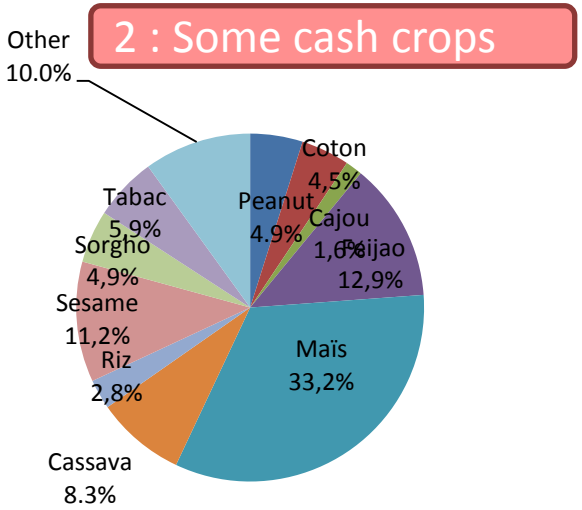
Household model - Step (v)

Set Household cropping plan

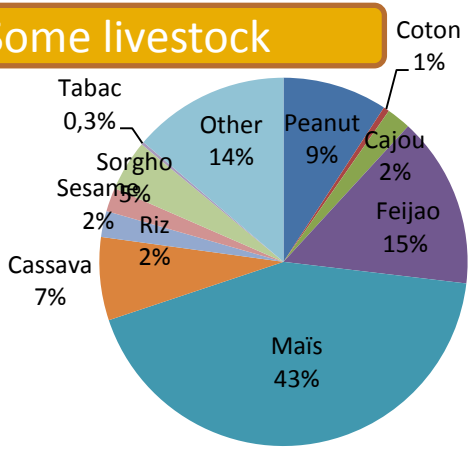
1 : Pure subsistance



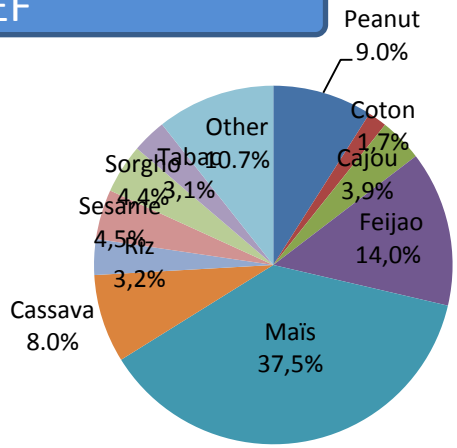
2 : Some cash crops



3 : Some livestock



4 : SMEF



Household model - Step (v)

Set Household cropping plan

Cropping plan to include 10 crop types + other

- For each spatial unit, crop area is redistributed among 11 classes (10 crop types + other)

- Keep consistency with cropping plans per HH type (distribution of crop surface per crop type x HH type; HH dataset 2015)

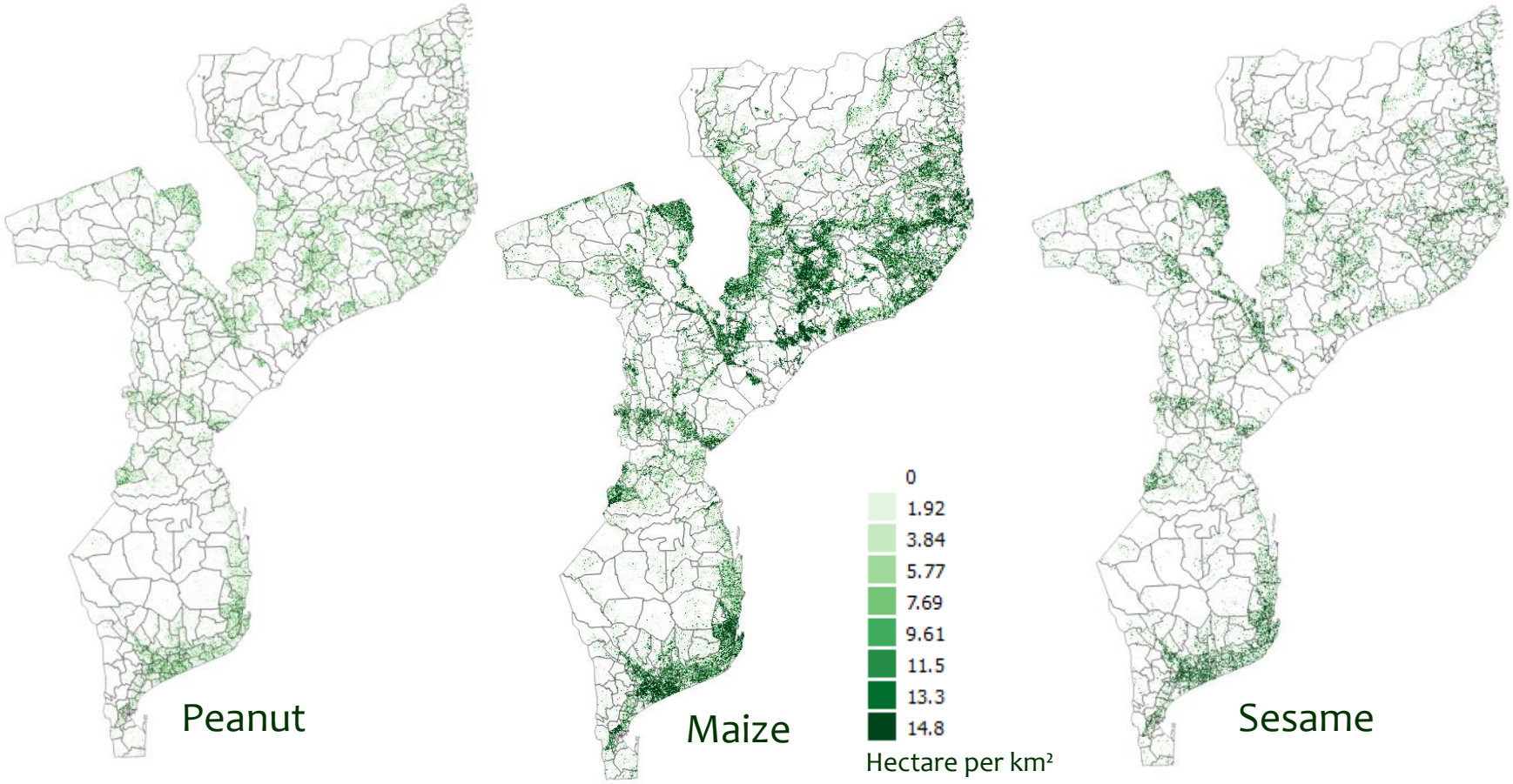
- Each year for each HH, random draw of surface area per crop type, substract from total crop area of spatial unit until all surface allocated

- Need to take into account suitability areas

Household model - Step (v)

Set Household cropping plan

Results : Crop area maps for 10 crops

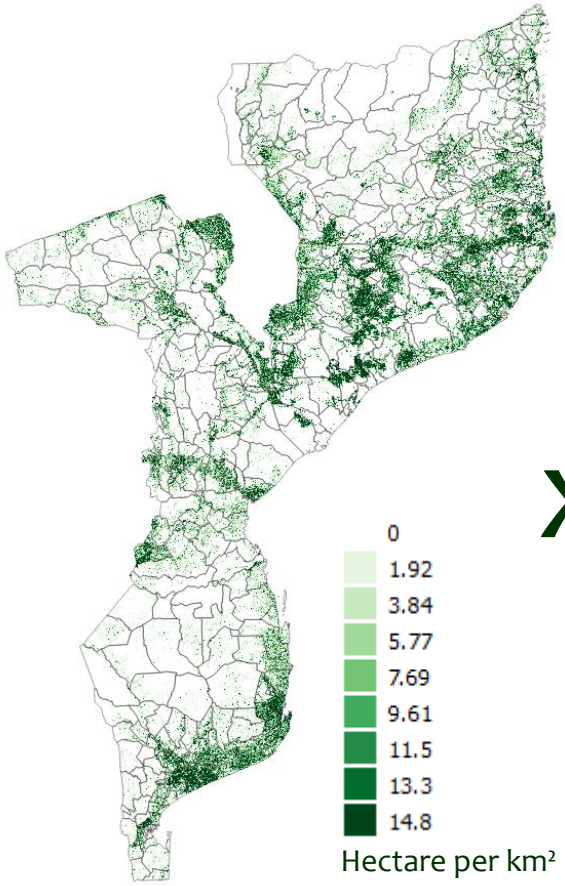


.. and also for tobacco, cotton, cashew, feijao, cassava, sorghum, rice, other

Household model - Step (v)

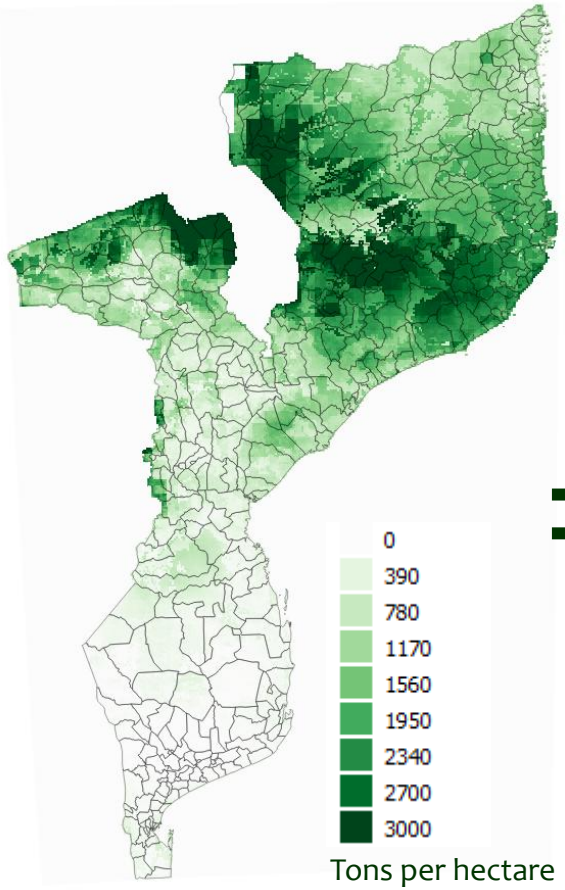
Set Household cropping plan

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



Crop surface

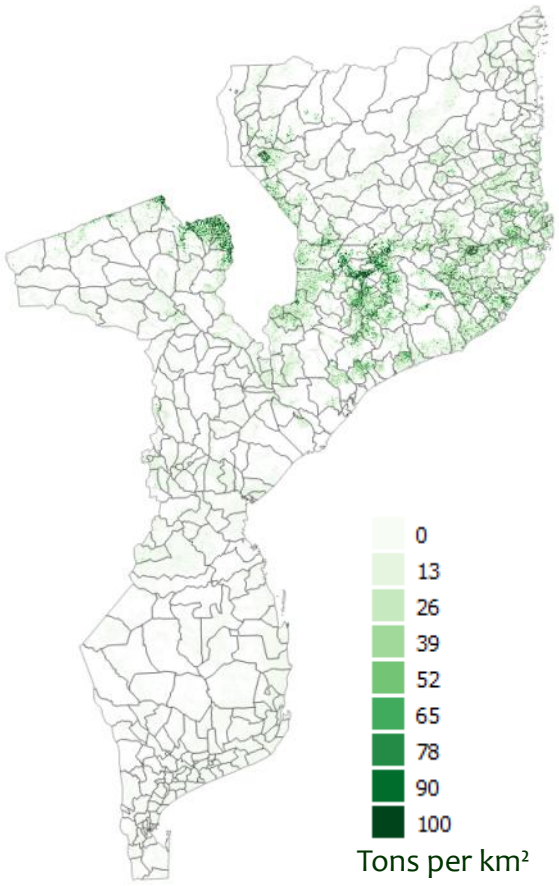
X



Crop yield

Given by crop model

=



Crop production

Crop model - Step (vi)

Link HH model to SARRA-O crop model

A spatially-explicit process-based crop model that uses input meteo or climate information for estimating yields

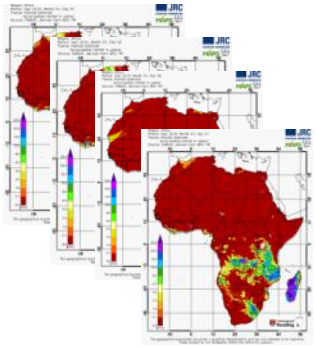
It is used by partners for:

- Food Security Early Warning Monthly Bulletins in West Africa (AGRHYMET Regional Center, Niger)
- Near Real Time crop monitoring during crop season
- Within season Yield forecast (2 months before harvest)
- Long term climate change impact on yield

Crop model - Step (vi)

Link HH model to SARRA-O crop model

A spatially-explicit process-based crop model that uses input meteo or climate information for estimating yields



Rainfall

Global Radiation

Min Temp.

Max Temp.

Evapotranspiration

Soil type map to derive soil depth and available water capacity

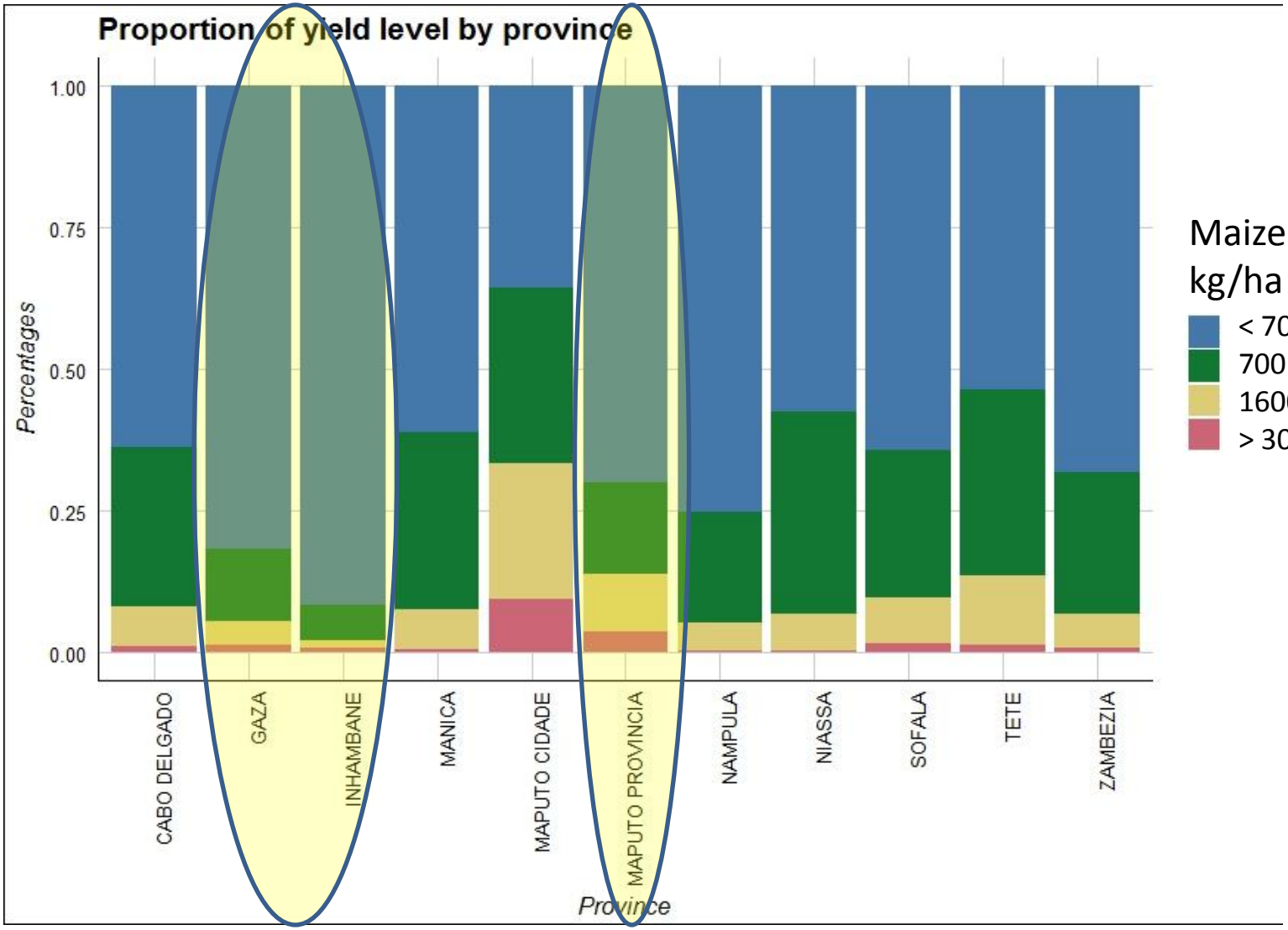
Input parameters (non spatial)

- Species, varieties
- Sowing date (strategies)
- Sowing density
- Irrigation
- Fertility/Technical package including soil degradation (F1 to F4)

Crop model - Step (vi)

Link HH model to SARRA-O crop model

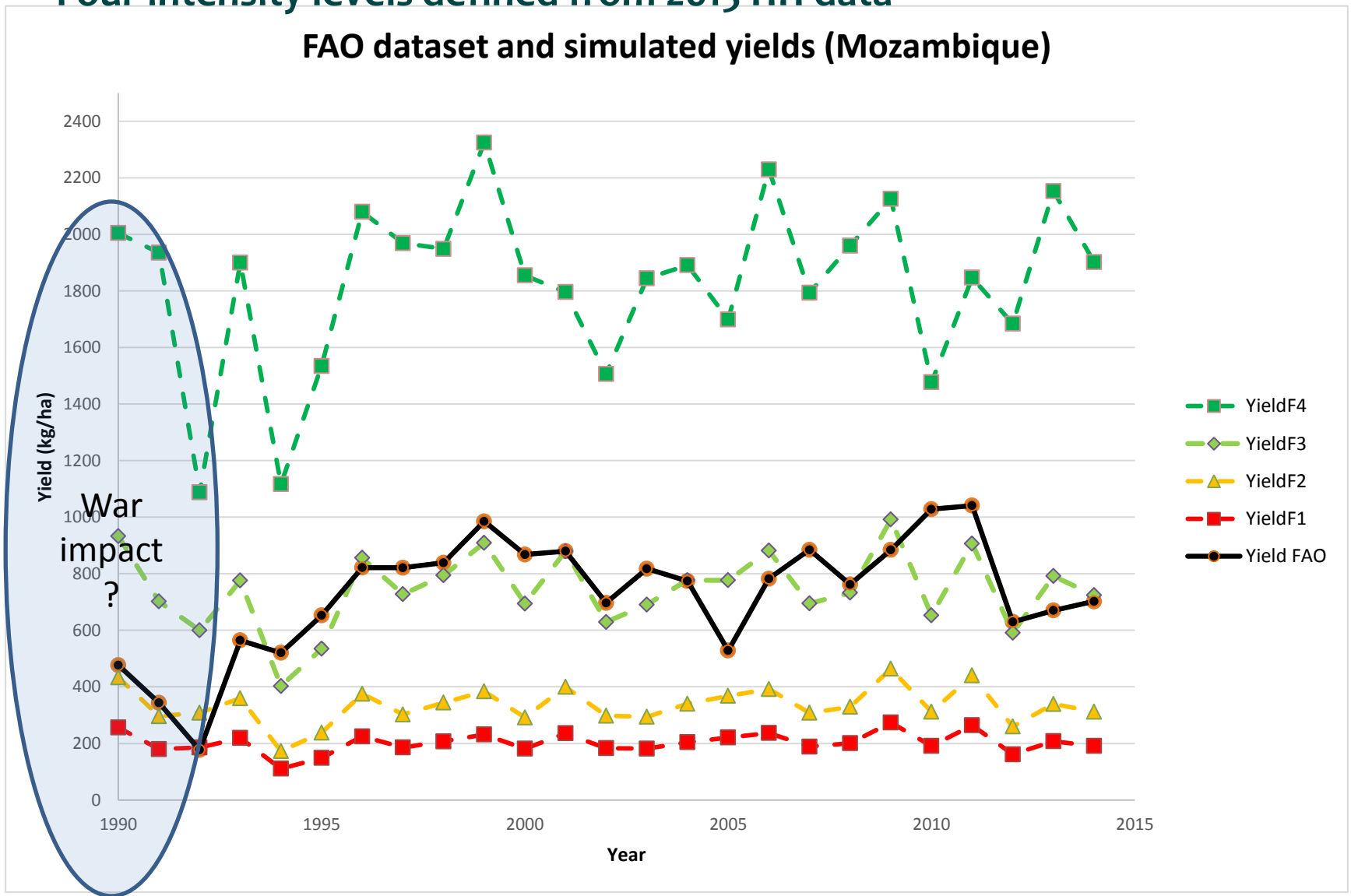
Model must be able to reproduce such yield variability (2015 HH data)



Crop model - Step (vi)

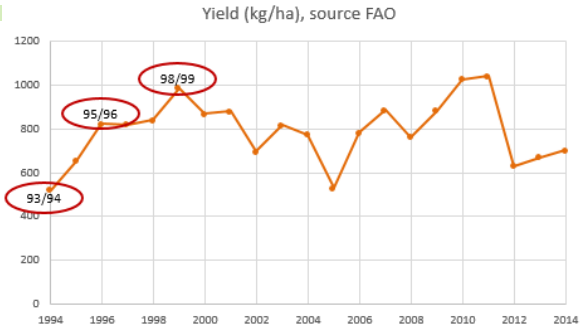
Link HH model to SARRA-O crop model

Four intensity levels defined from 2015 HH data

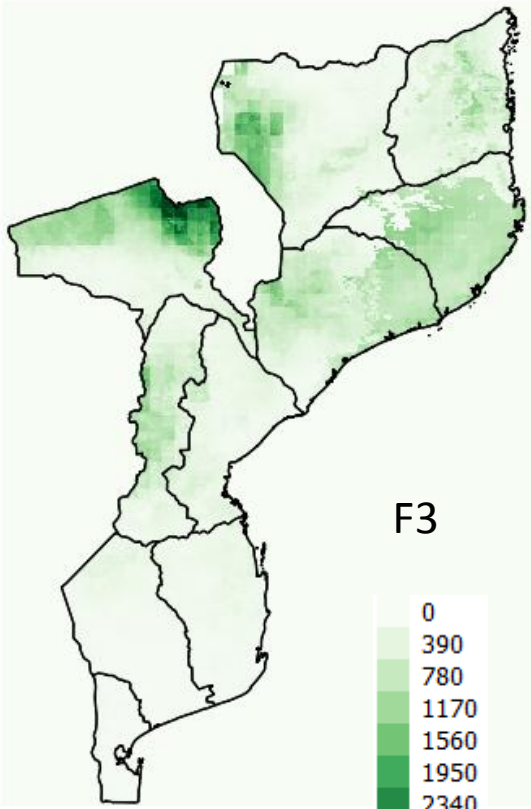


Crop model - Step (vi)

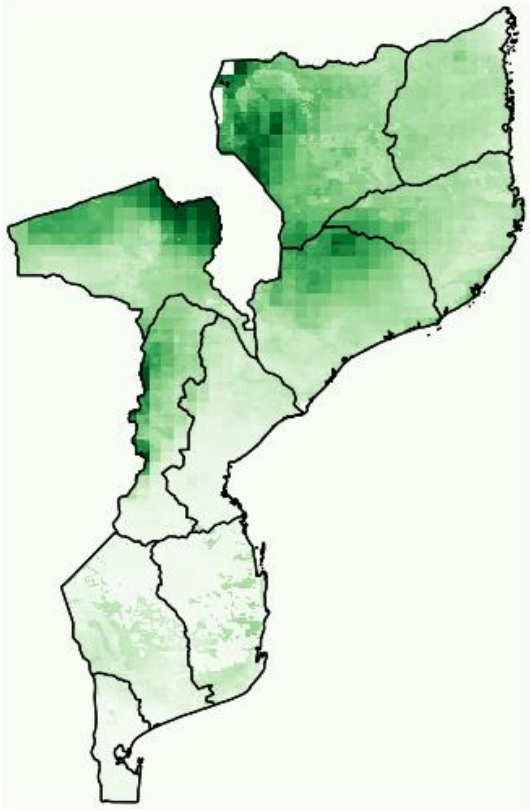
Link HH model to SARRA-O crop model



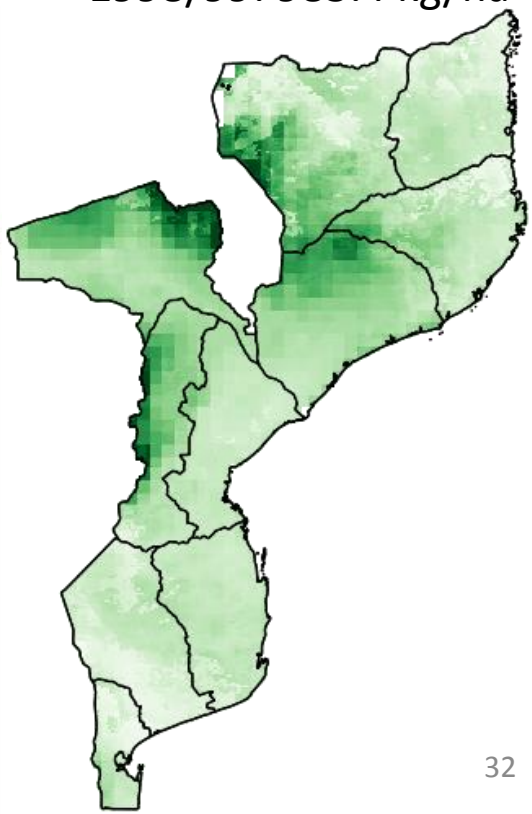
1993/94: 520.3 kg/ha



1995/96: 821.3 kg/ha

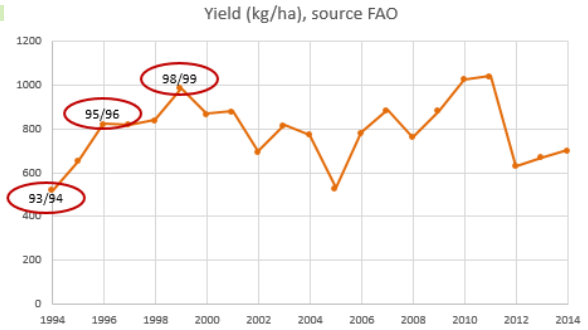


1998/99: 985.4 kg/ha

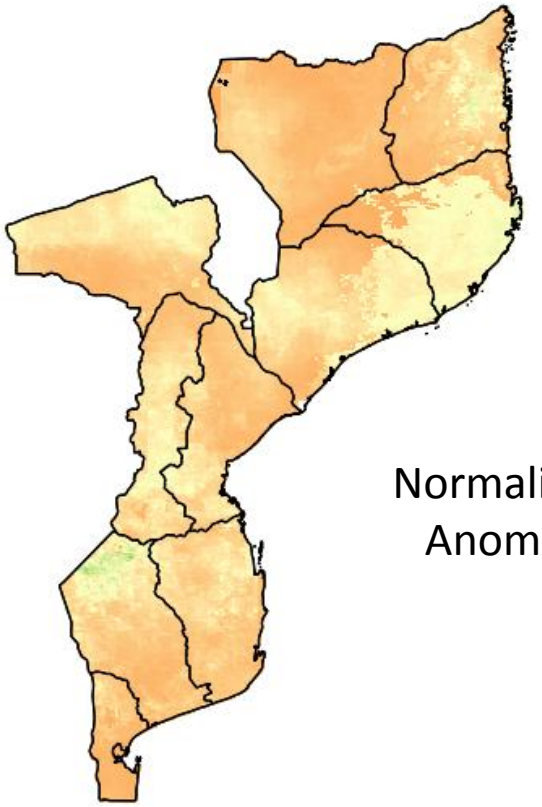


Crop model - Step (vi)

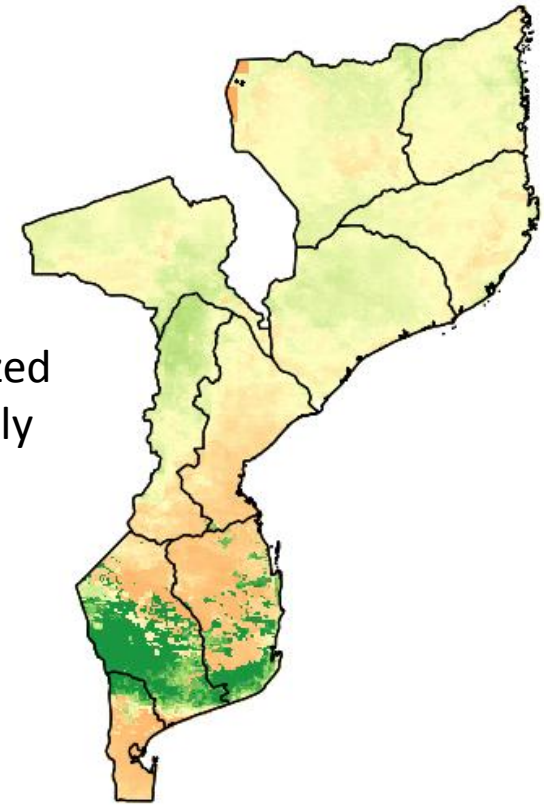
Link HH model to SARRA-O crop model



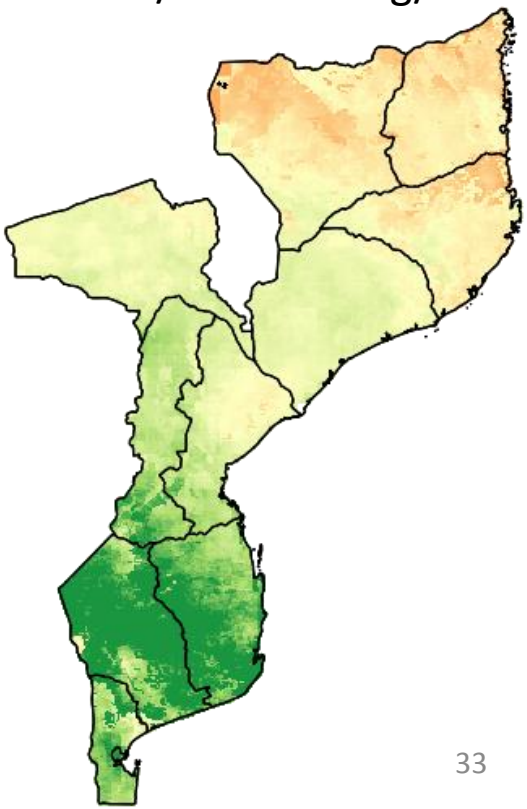
1993/94: 520.3 kg/ha



1995/96: 821.3 kg/ha

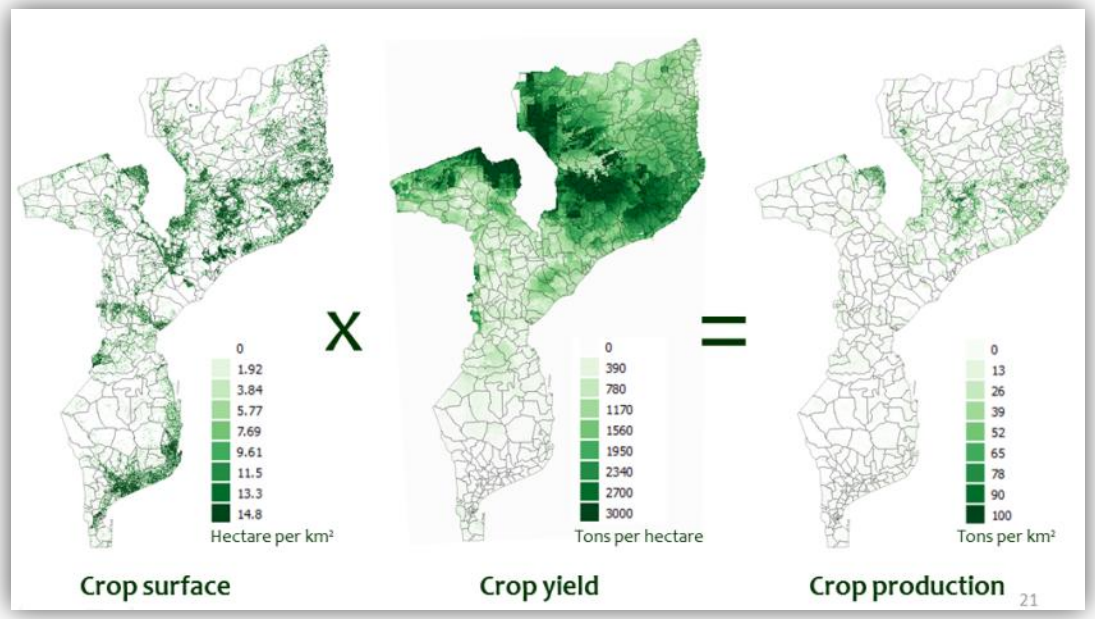


1998/99: 985.4 kg/ha



Normalized Anomaly

Next Steps



(vii) HH economic model, from crop production to Income

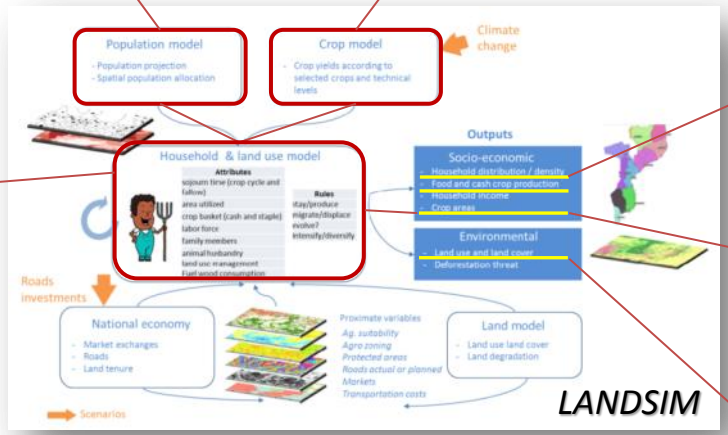
(viii) Influence of climate change on crop production

(ix) Implement and compare different scenarios

Population model

Crop model

Household model



Outputs:
HH density and distribution map

Outputs:
Crop production & Crop area maps

Outputs:
Land Cover Change Simulations 2007-2027

Thank you for your attention