TECHNISCHE UNIVERSITÄT DRESDEN

INCA Workshop 2012

Understanding the effects of climate change on the livelihood strategies of small farmers of the Andean Region: A modeling approach

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PhD candidate

Main supervisor: Prof. Uta Beger
Second supervisor: Prof. Thomas Berger

DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

Main research objective:

To analyze farmers' agronomic adaptation strategies to climate change and the effects of these strategies on the farmers' socioeconomic status.

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Research site:

Achamayo watershed

3 communities representing the upper, middle and lower part of the watershed

Area: ~248 sq. km

Population: ~ 17000

Altitudinal range : 3262 – 4500 masl

Precipitation: 800 – 1500 mm / year

Specific objectives

Obj.1: To anticipate the probable adaptation responds of farmers to proposed climate change scenarios.

Obj.2: To analyze the trade-off between the different adaptation strategies evaluated.

- Socio-economic outcomes

- Changes in land use patterns

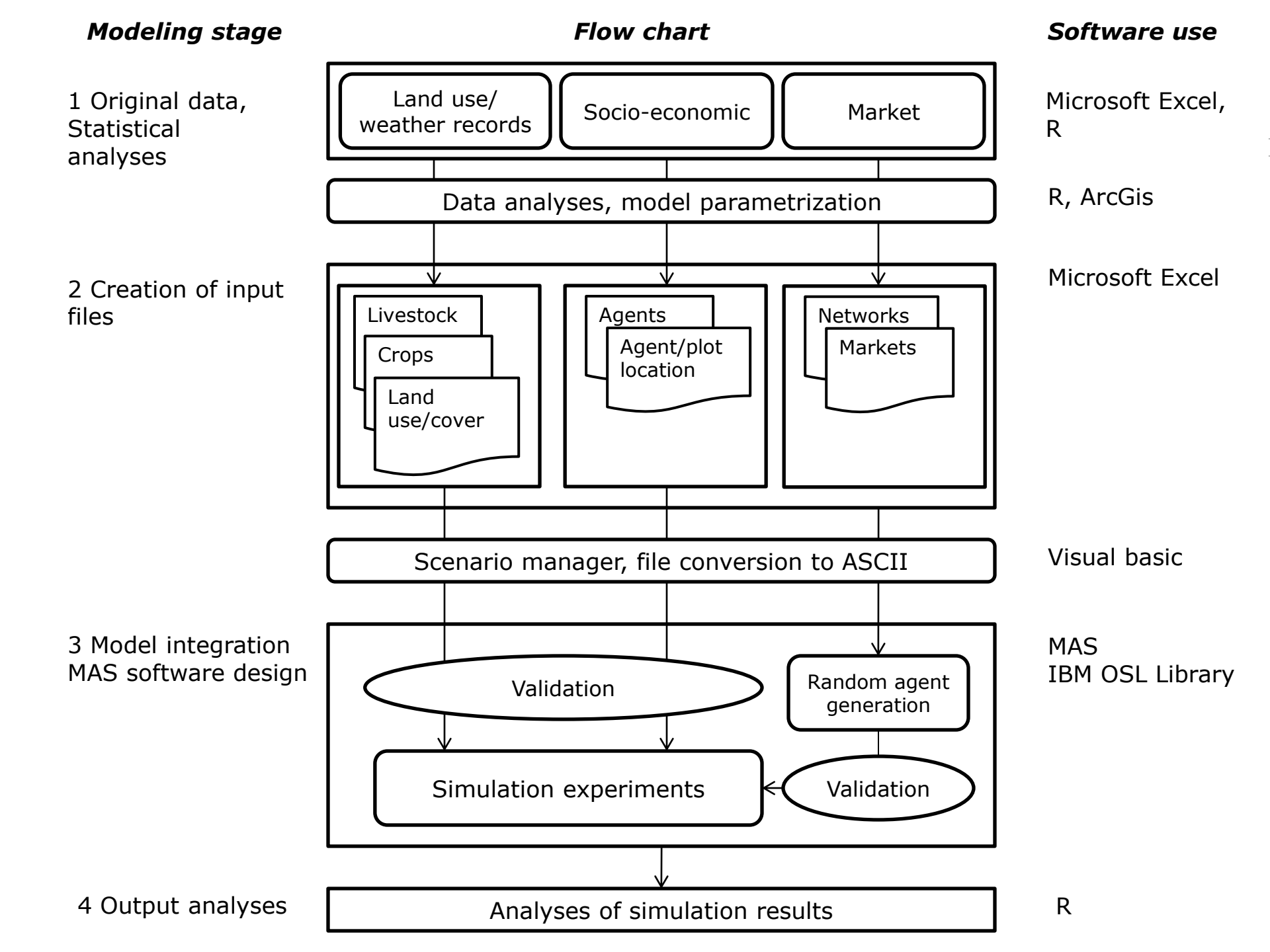
Methodology

- What is the model purpose?
  - ✓ To simulate the adaptation responds of farmers to CC
  - ✓ To estimate socioeconomic outcomes
  - ✓ To analyse possible improvements

- Which type of model will be used?
  - ✓ Mathematical programming model for descriptive (=positive) and prescriptive model application

- What software will be use?

  MP-MAS (Multi Agent – Mathematical Programming Systems)


Modeling stage
Flow chart
Software use
1 Original data, Statistical analyses
Land use/ weather records
Socio-economic
Market
Microsoft Excel, R
Data analyses, model parametrization
R, ArcGis
2 Creation of input files
Livestock
Crops
Land use/cover
Agents
Agent/plot location
Networks
Markets
Microsoft Excel
Scenario manager, file conversion to ASCII
Visual basic
3 Model integration MAS software design
Validation
Random agent generation
Simulation experiments
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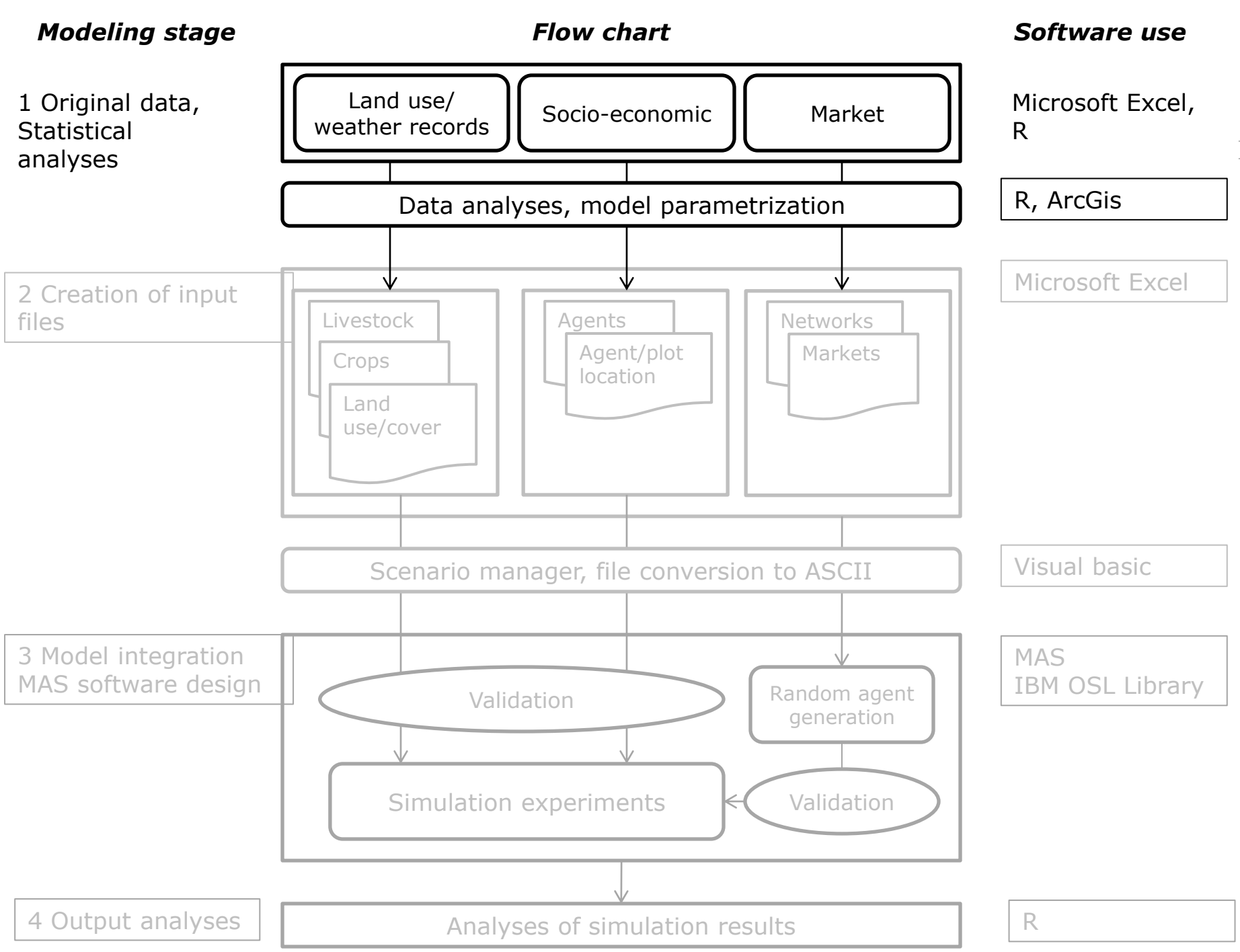
MAS
IBM OSL Library
4 Output analyses
Analyses of simulation results
R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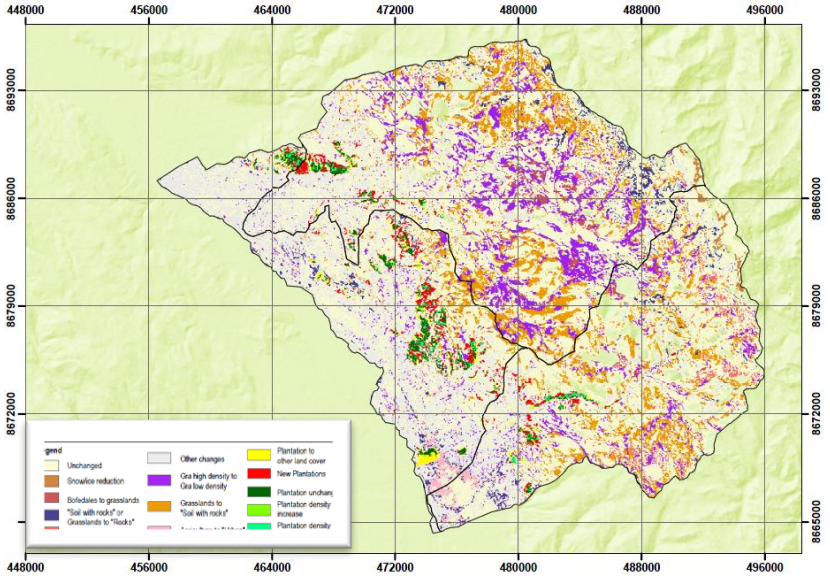
LAND USE

- Medina F. (2011) Monitoring and analyzing land use/land cover and their changes using Remote Sensing and GIS - Msc. Thesis **FINISHED**

- Drechsel J. Modeling and forecast of changes in land-use and land-cover, caused by climate Msc. Thesis – **ONGOING**

WEATHER

- Geophysical Institute of Peru - IGP



Medina (2011)

SOCIO-ECONOMIC DATA

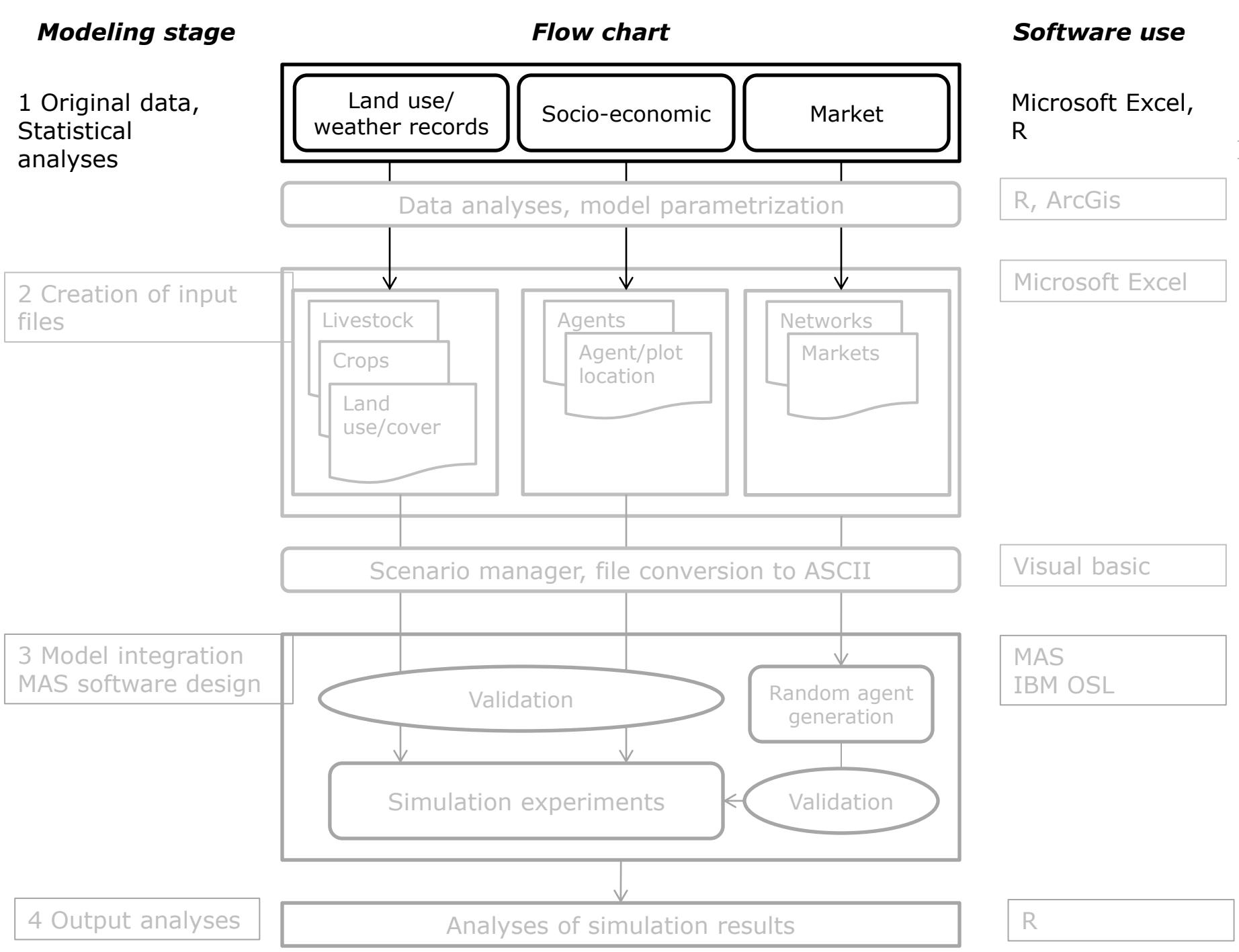
- Participatory workshops
- Semi-structured interviews
- Interviews with key informants
- Secondary data

OFF- AND OUT FARM LABOR

Wittman N. Msc. Thesis – **ONGOING**

MARKET

- Market survey
- Interviews with key informants
- Official reports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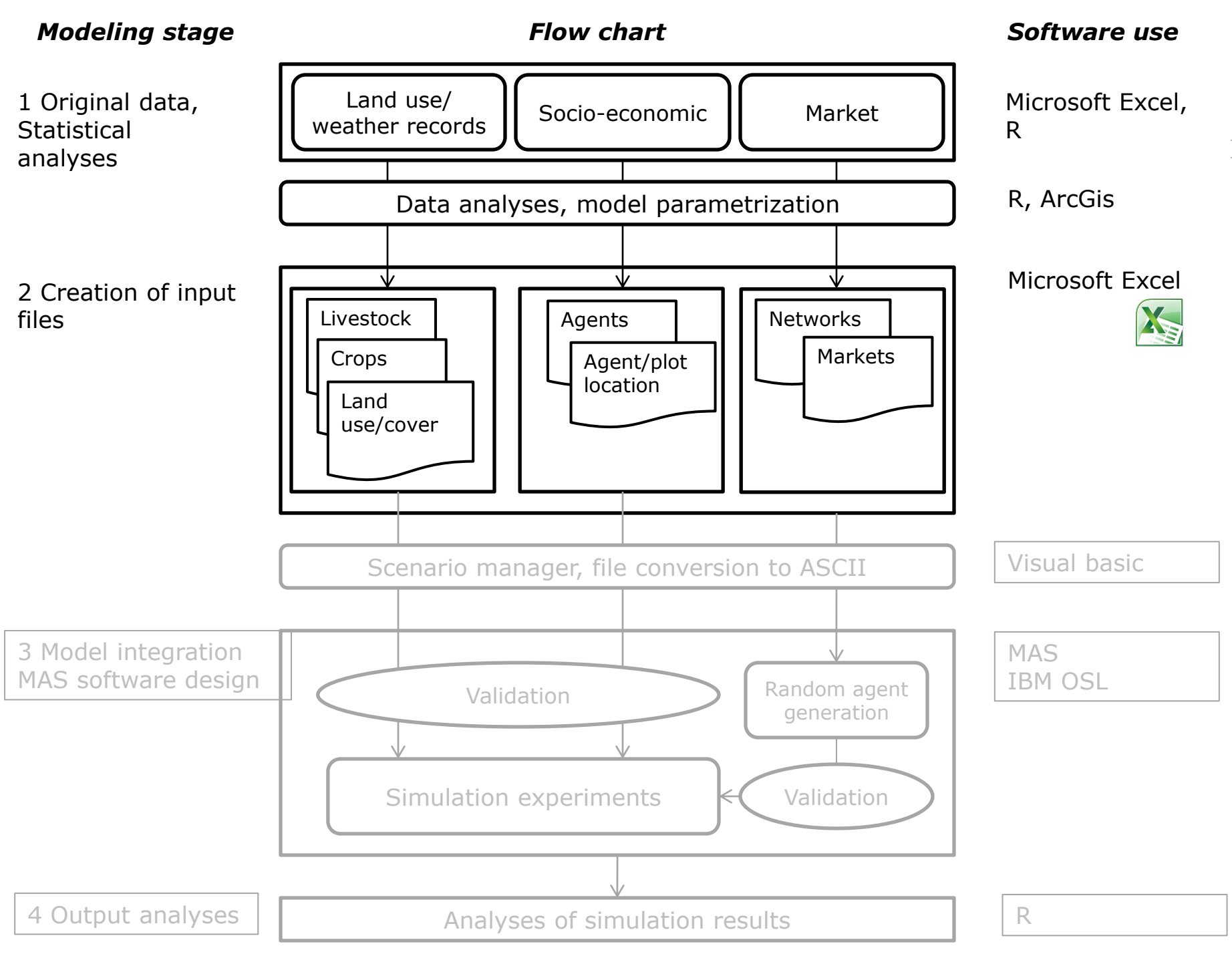
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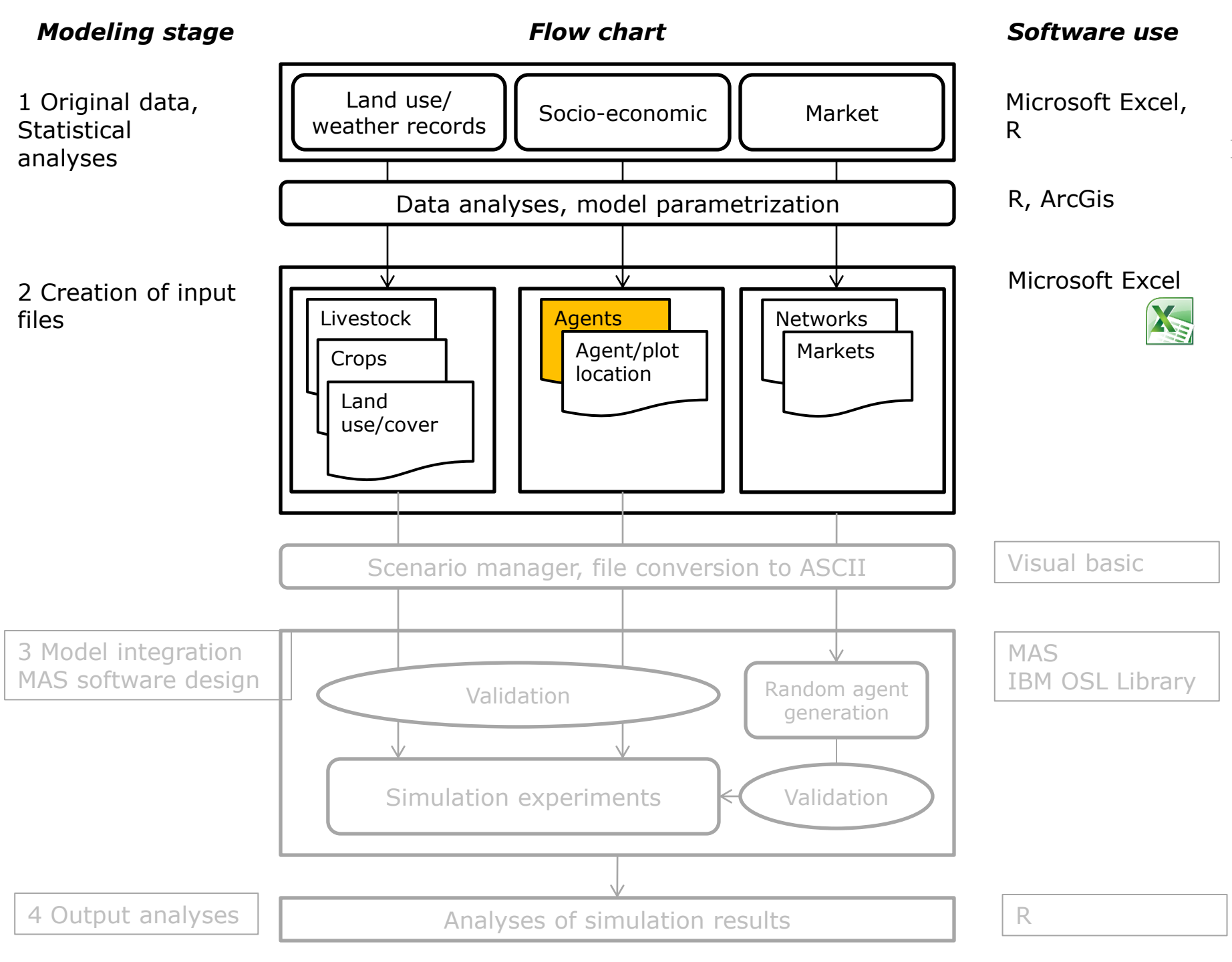
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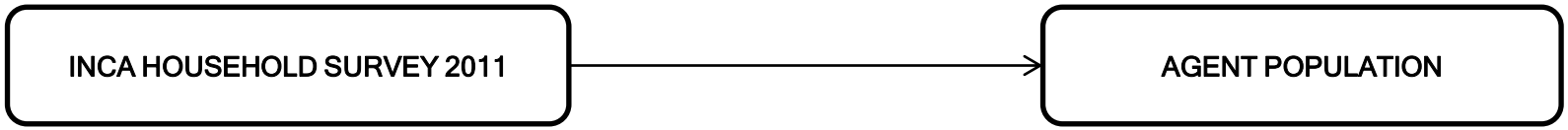
Generation of agents

- Agents represent farm households
- One-to-one correspondence between agents and real farm households
- State variables of the agents include
  - ✓ Household composition (hh members, age, sex, and labor supply),
  - ✓ Available resources (cash, livestock, trees, farm equipment),
  - ✓ Farm plots,
  - ✓ …

Generation of agents



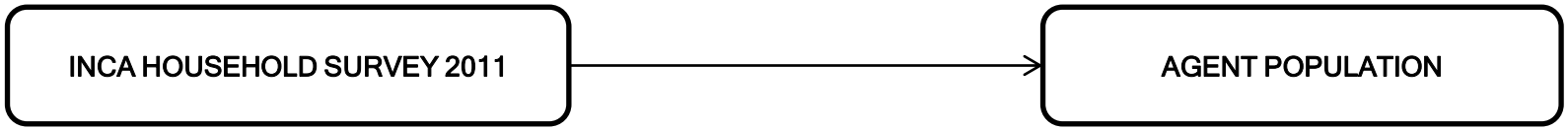
STEPS:

Classify sample into clusters

(hh size)

Cluster 0	1-2 household members
Cluster 1	3-4 hh members
Cluster 3	5-6 hh members
Cluster 4	>6 hh members

Generation of agents



STEPS:

Classify sample into 4 clusters

(hh size)

↓

Divide agents into sex-age categories

Marcatuna Cluster 1

Sex-age categories	Individuals per Cluster	Households per Cluster
female 0-8 years	2	2
female 9 - 17 years	3	3
female 18-64 years	8	7
female 65-100 years	1	1
male 0-8 years	1	1
male 9 - 17 years	3	3
male 18-64 years	7	6
male 65-100 years	3	3

Generation of agents

INCA HOUSEHOLD SURVEY 2011 → AGENT POPULATION

STEPS:

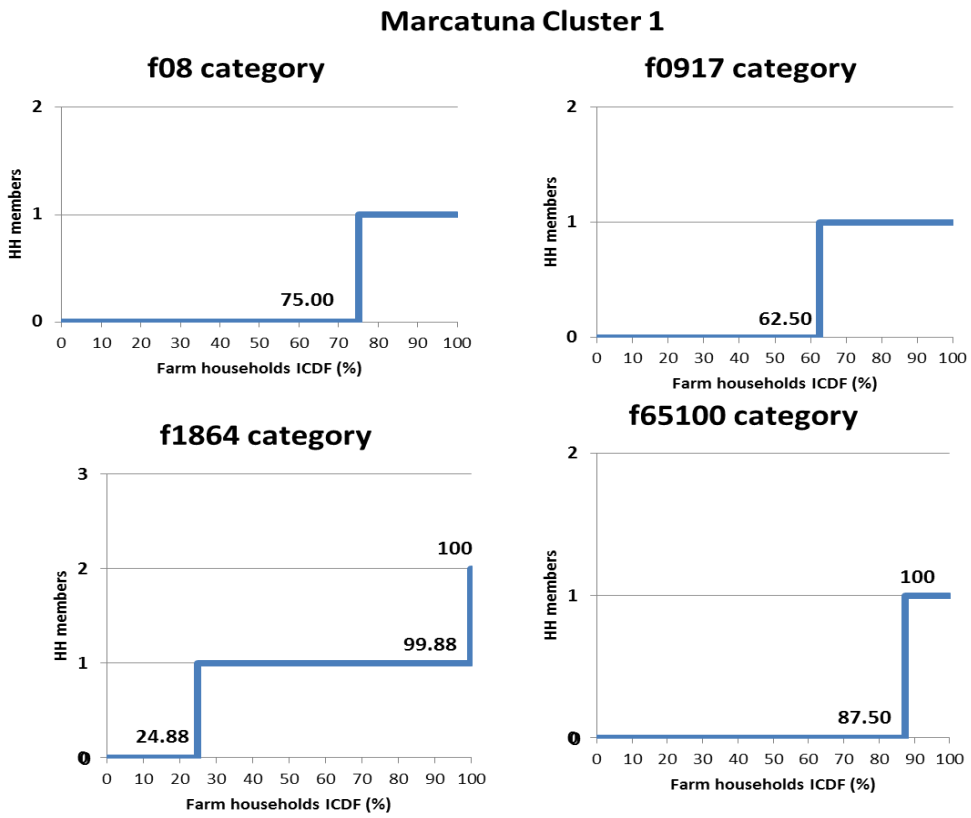
Classify sample into 4 clusters (hh size)

↓

Divide agents into sex-age categories

↓

Calculate the Inverse Cumulative Distribution Function (ICDF) for each category



Example for one single agent

Example for one single agent (1)

AGENT

- A Farm Household

AGENT CHARACTERISTICS

- 4 Household members (2 working adults in average age of 50 years and 2 minors).
- Only adults supply labor

INITIAL CONDITIONS

- Cash available: 1400 nuevos soles
- Land available: 1,6 has.
- Labor available: 389 day labor

MODEL PURPOSE

To understand how households allocate their assets to different agricultural land uses, when facing a diversity of agricultural options and set of constraints.

It is assumed that the farm household wants to maximize its expected total grow margin

Example for one single agent (2)

ACTIVITIES

The household (agent) can choose from 5 different types of crops to grow:

1.	potato1 (yungay variety)	*Solanum tuberosum*
2.	potato2 (canchan variety)	*Solanum tuberosum*
3.	olluco	*Ullucus tuberosus*
4.	barley	*Hordeum vulgare*
5.	haba bean	*Vicia faba*

CONSTRAINTS

- Crop rotation period: 4 years and 4 years of fallow
- Potato once every 8 years
- Olluco once every 8 years
- Cebada and habas any time

- Excel.

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		Solution vector:	0.000	2002.000	1600.000	0.000	227.427	0.000	0.200	0.200	0.000	0.154	1.046	107.365	1.600	1400.000
		Price vector:	0.500	0.500	0.520	0.860	1.220	-4028.400	-4256.400	-1513.900	-1538.500	-1593.400	0.000	0.000	0.000	0.000
		ACTIVITIES	Sell yungay_sm	Sell canchan	Sell olluco	Sell cebada_grain	Sell habas_dry	Grow yungay_sm	Grow canchan	Grow olluco	Grow cebada_grain	Grow habas_dry	Fallow	Labor transfer	Land transfer	Transfer liquidity
CONSTRAINTS	LHS	sign	RHS	kg	kg	kg	kg	kg	ha	ha	ha	ha	ha	ha	jornales	hectareas	soles
Cash (soles)	1400.000	<=	1400.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**
Cash constraint	0.000	<=	0.000	0.000	0.000	0.000	0.000	0.000	**4028.400**	**4256.400**	**1513.900**	**1538.500**	**1593.400**	0.000	0.000	0.000	**-1.000**
Land (hectares)	1.600	<=	1.600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**	0.000
Land constraint	0.000	=	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	0.000	**-1.000**	0.000
Rotation_yungay	-0.200	<=	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**	0.000	0.000	0.000	0.000	0.000	0.000	**-0.125**	0.000
Rotation_canchan	0.000	<=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**	0.000	0.000	0.000	0.000	0.000	**-0.125**	0.000
Rotation_olluco	0.000	<=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**	0.000	0.000	0.000	0.000	**-0.125**	0.000
Rotation_cabada_grain	-0.800	<=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**	0.000	0.000	0.000	**-0.500**	0.000
Rotation_habas_dry	-0.646	<=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**	0.000	0.000	**-0.500**	0.000
Fallow	0.246	>=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**	0.000	**-0.500**	0.000
Labor (jornales)	107.365	<=	389.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**	0.000	0.000
Lab_jan	-3.937	<=	0.000	0.000	0.000	0.000	0.000	0.000	**11.000**	**4.000**	0.000	**13.000**	0.000	**-0.083**	0.000	0.000	0.000
Lab_feb	-6.343	<=	0.000	0.000	0.000	0.000	0.000	**26.000**	**11.000**	**2.000**	**11.000**	0.000	0.000	**-0.083**	0.000	0.000	0.000
Lab_march	-8.943	<=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**-0.083**	0.000	0.000	0.000
Lab_apr	-5.543	<=	0.000	0.000	0.000	0.000	0.000	**26.000**	**2.000**	**15.000**	0.000	0.000	0.000	**-0.083**	0.000	0.000	0.000
Lab_mai	-3.943	<=	0.000	0.000	0.000	0.000	0.000	**11.000**	**2.000**	**23.000**	0.000	0.000	0.000	**-0.083**	0.000	0.000	0.000
Lab_jun	0.000	<=	0.000	0.000	0.000	0.000	0.000	**22.000**	**15.000**	**22.000**	0.000	**10.000**	0.000	**-0.083**	0.000	0.000	0.000
Lab_jul	-8.480	<=	0.000	0.000	0.000	0.000	0.000	**11.000**	0.000	0.000	**10.000**	**3.000**	0.000	**-0.083**	0.000	0.000	0.000
Lab_aug	-4.480	<=	0.000	0.000	0.000	0.000	0.000	0.000	**20.000**	0.000	**8.000**	**3.000**	0.000	**-0.083**	0.000	0.000	0.000
Lab_Sep	-7.880	<=	0.000	0.000	0.000	0.000	0.000	0.000	**3.000**	0.000	**3.000**	**3.000**	0.000	**-0.083**	0.000	0.000	0.000
Lab_oct	-6.263	<=	0.000	0.000	0.000	0.000	0.000	**20.000**	**8.000**	0.000	0.000	**7.000**	0.000	**-0.083**	0.000	0.000	0.000
Lab_nov	-7.743	<=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**6.000**	0.000	0.000	0.000	**-0.083**	0.000	0.000	0.000
Lab_dec	-8.943	<=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**3.000**	0.000	0.000	**-0.083**	0.000	0.000	0.000
Cons_potatoes	0.000	<=	0.000	0.000	0.000	0.000	0.000	**1.000**	**1.000**	0.000	0.000	0.000	0.000	0.000	**-0.125**	0.000	0.000
Yungay (kg)	0.000	<=	0.000	**1.000**	0.000	0.000	0.000	0.000	**-9100.000**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canchan (kg)	0.000	<=	0.000	0.000	**1.000**	0.000	0.000	0.000	0.000	**-10010.000**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Olluco (kg)	0.000	<=	0.000	0.000	0.000	**1.000**	0.000	0.000	0.000	0.000	**-8000.000**	0.000	0.000	0.000	0.000	0.000	0.000
Cebada_grain (kg)	0.000	<=	0.000	0.000	0.000	0.000	**1.000**	0.000	0.000	0.000	0.000	**-1885.420**	0.000	0.000	0.000	0.000	0.000
Habas_dry (kg)	0.000	<=	0.000	0.000	0.000	0.000	0.000	**1.000**	0.000	0.000	0.000	0.000	**-1473.460**	0.000	0.000	0.000	0.000

Results for the single agent model(1)

FIGURE 1.

Crop mix to maximize expected total gross margin

The selection is **price sensitive**

In real life → both varieties simultaneously

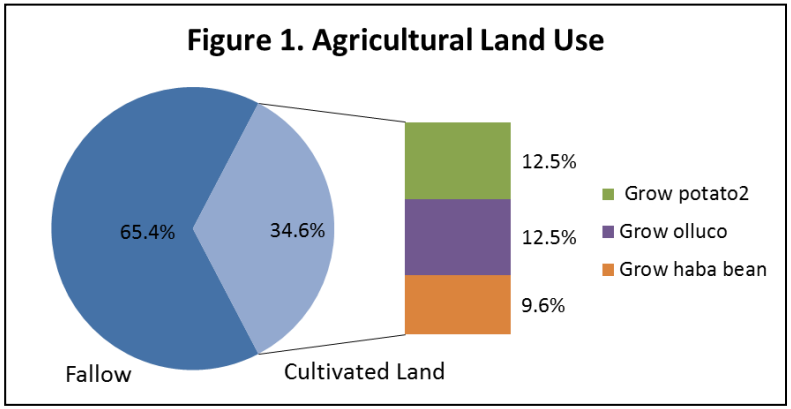
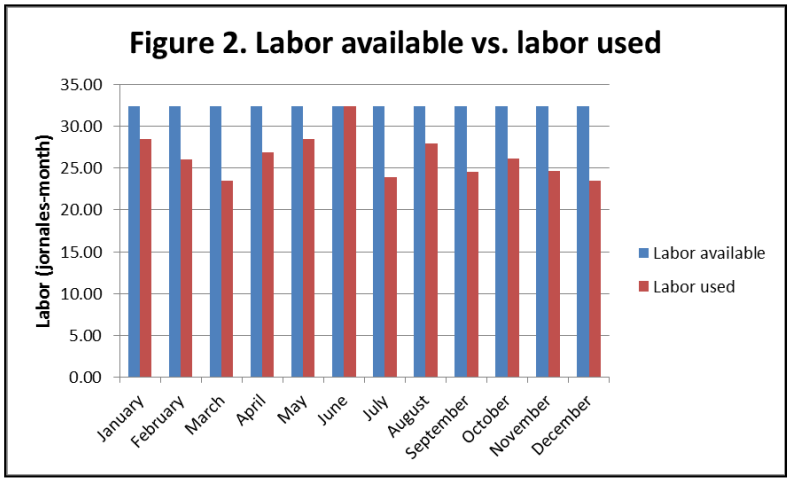


FIGURE 2.

At the present time, **labor** is a main constraint when analyzed on a **monthly basis**



Other scenarios:

FIGURE 3.

Increase in labor availability → shift its production to a more **labor demanding** (but also **more profitable) crop** mix.

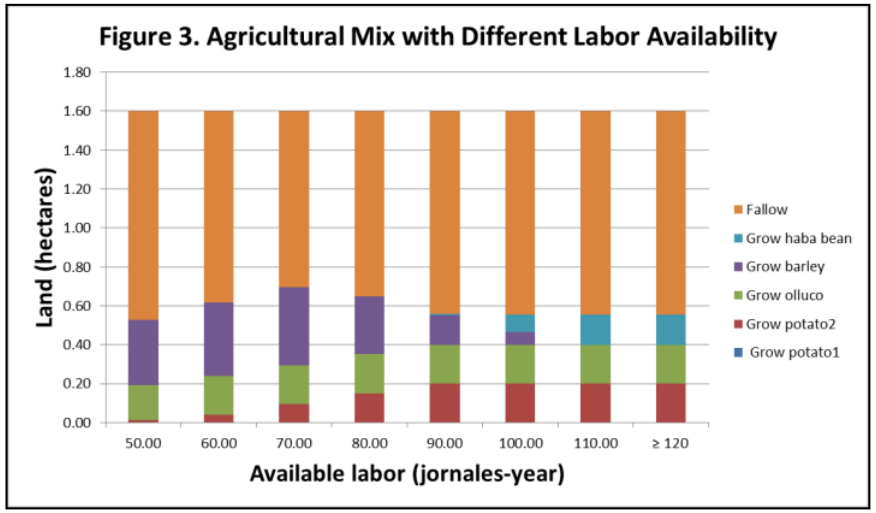
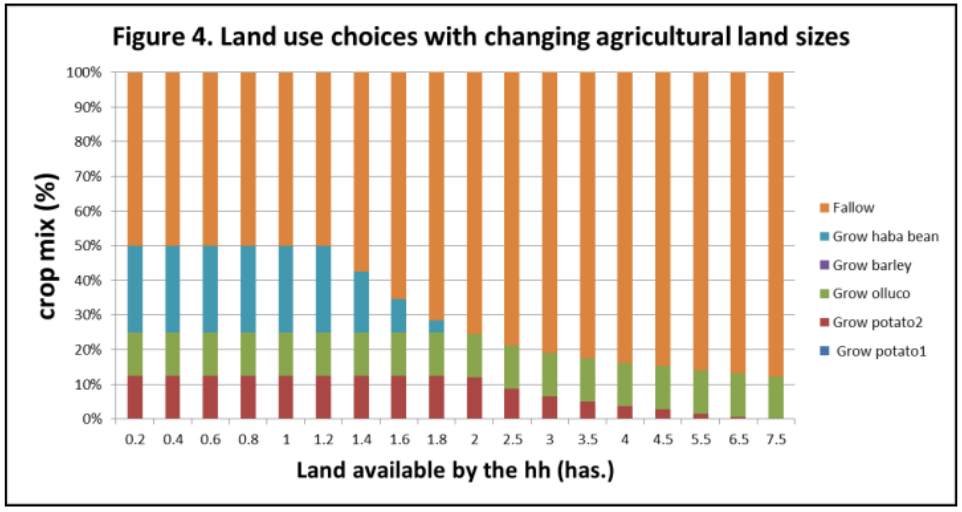
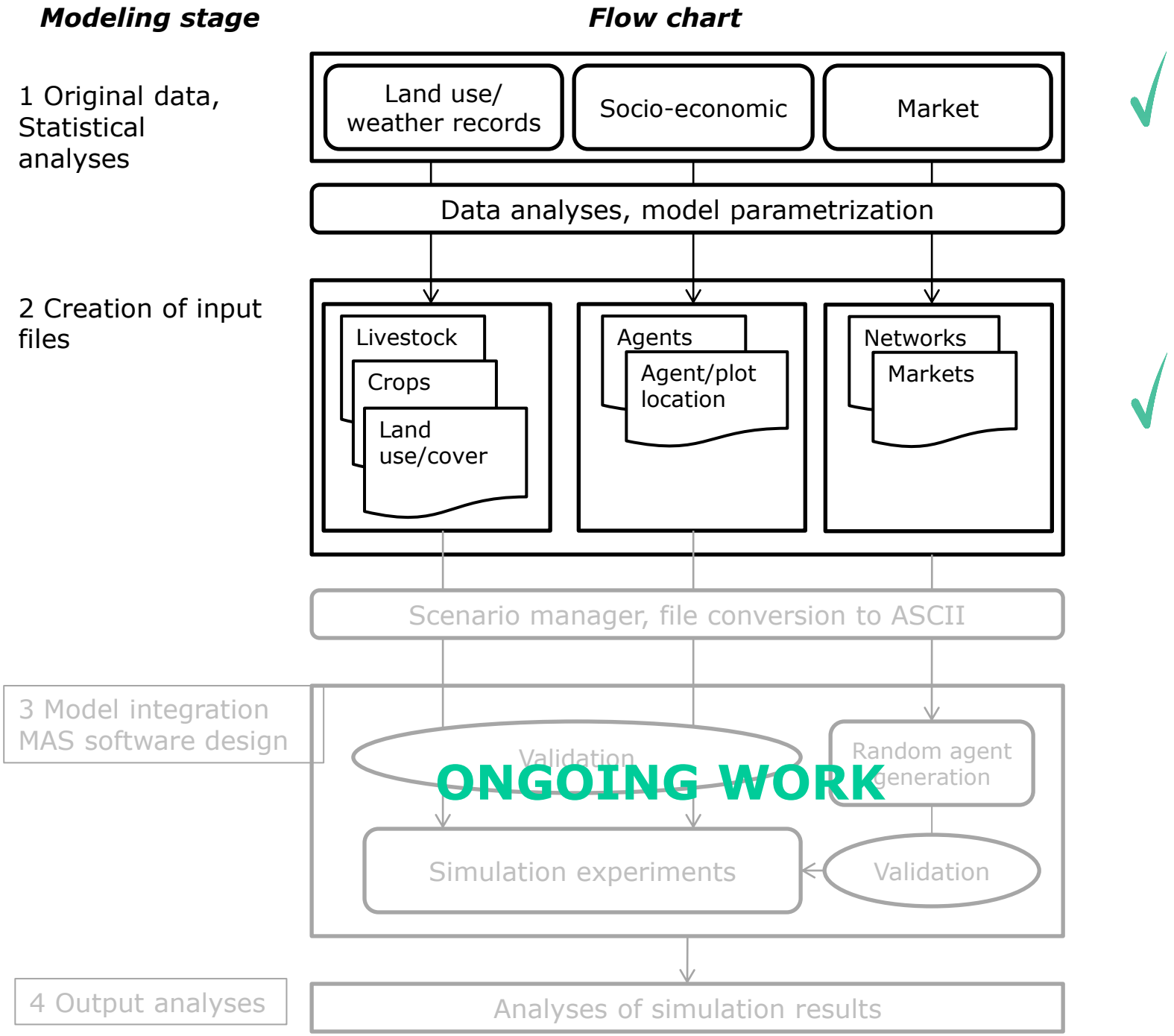


FIGURE 4.

Increasing land availability → labor and cash become constraints.

Specialization of the household, producing only the most profitable crop (Olluco) would be the optimal strategy for maximizing profit → DOESN'T TAKE INTO ACCOUNT HOUSE CONSUMPTION

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Conclusions and Outlook

- Further productive activities and constraints need to be taken into account in order to better approach the decision making at household level for the study area.
- Further model development will broaden the scope from a single household to the community level.
- Other land use types will be included such as agriculture, grasslands, forest plantations and urban areas.
- Water availability as abiotic driver of land use change, market forces, as well as potential policy interventions (e.g. credit, subsidies) for local livelihood improvement will be considered.

MUCHAS GRACIAS POR SU ATENCION

Acknowledgements:

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- INCA project team