Modelling height distribution on young cork oak plantations in Portugal

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Centro de Estudos Florestais

Education and Culture — Erasmus Mundus — MEDfOR

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2. Material

3. Methods

4. Results
&
discussion

5. Conclusion

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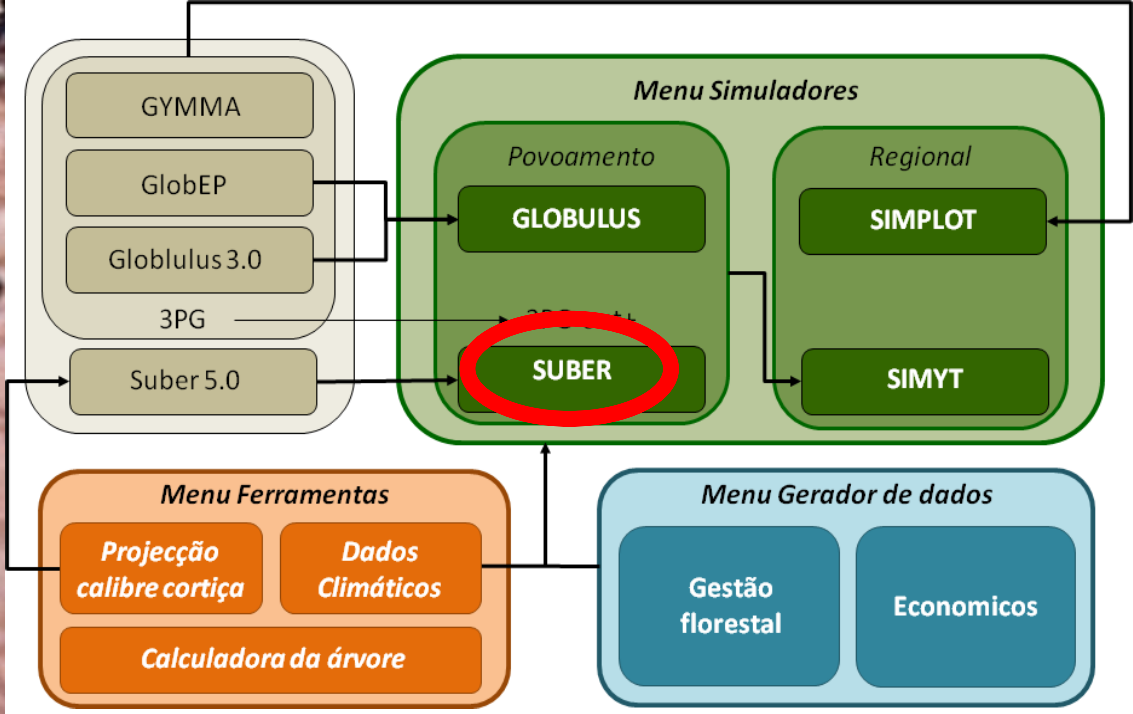

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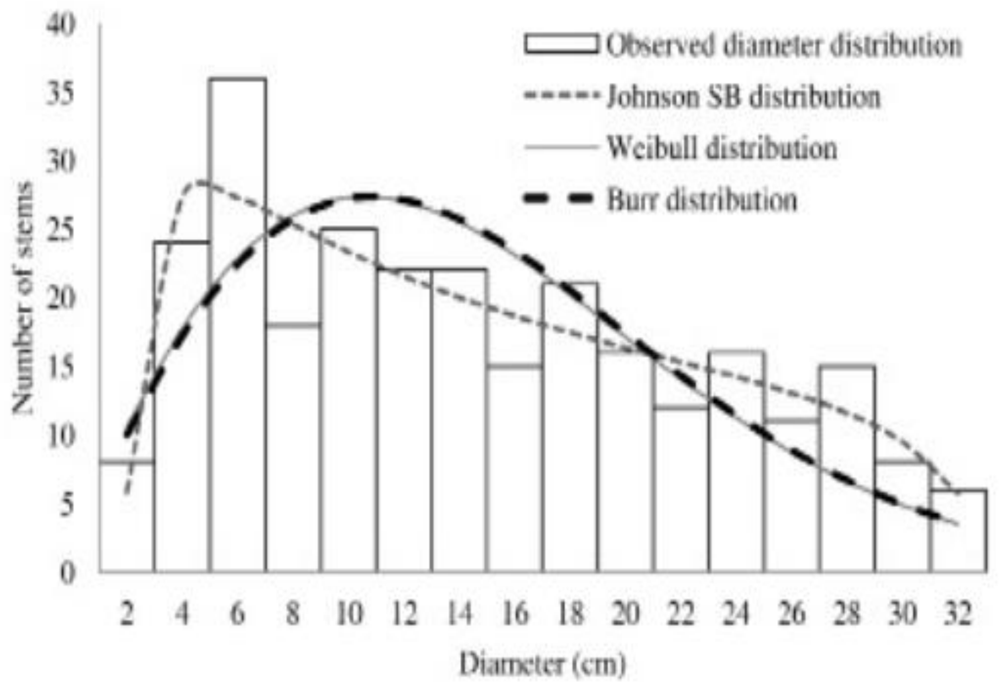
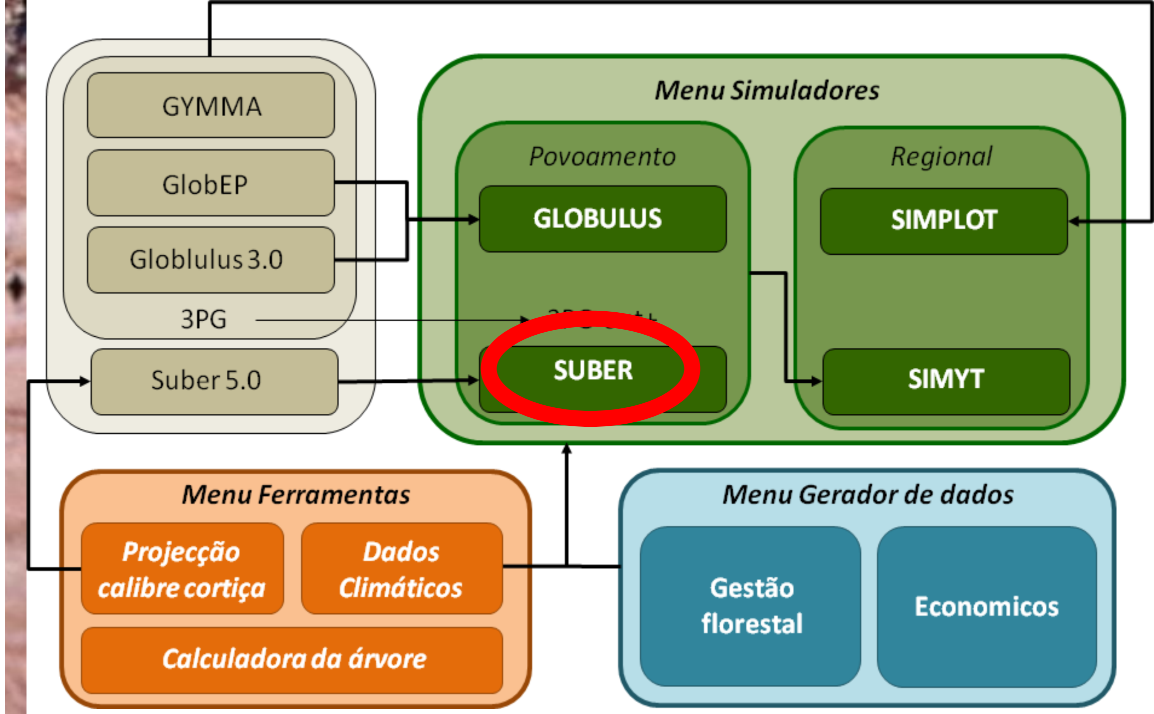


Khongor et al. (2011)



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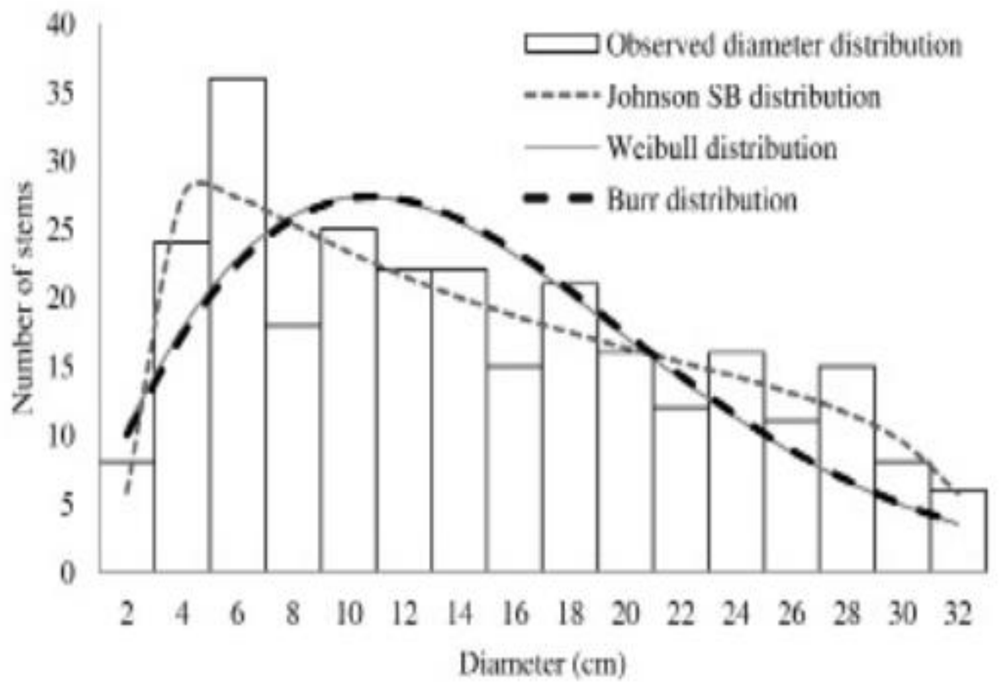

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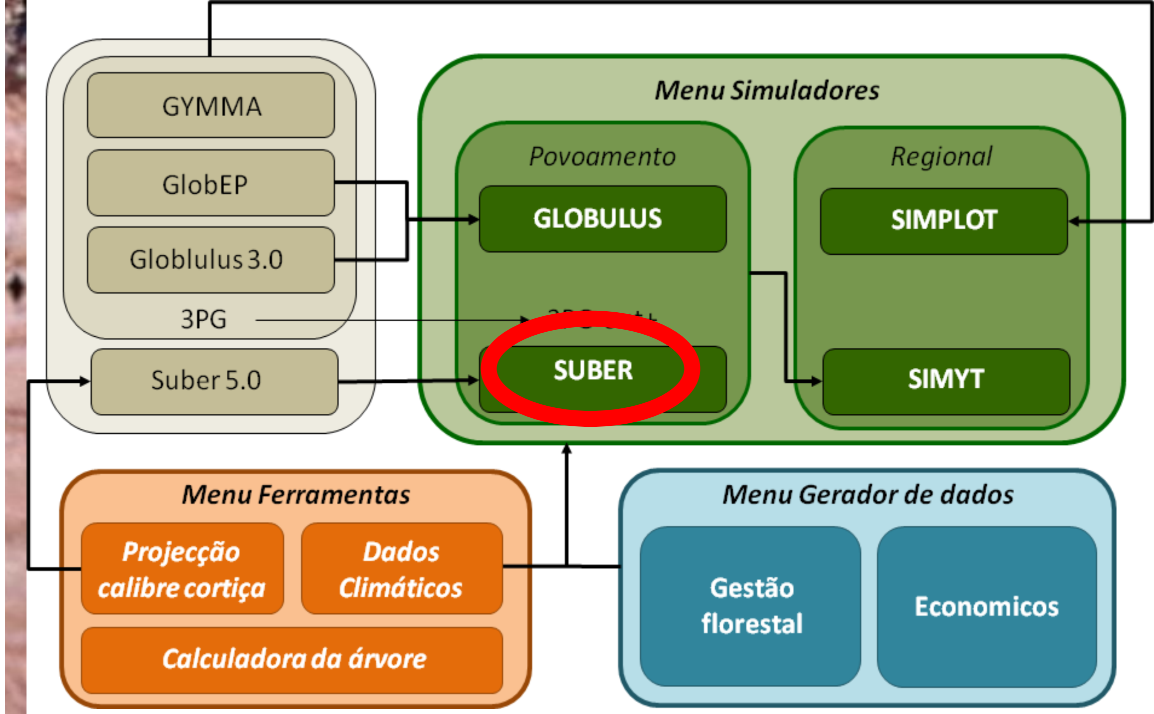

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- **Diameter distribution** → determines variables of state
  → Initialize individual tree models
- **Height distribution** → unique variable in young stands

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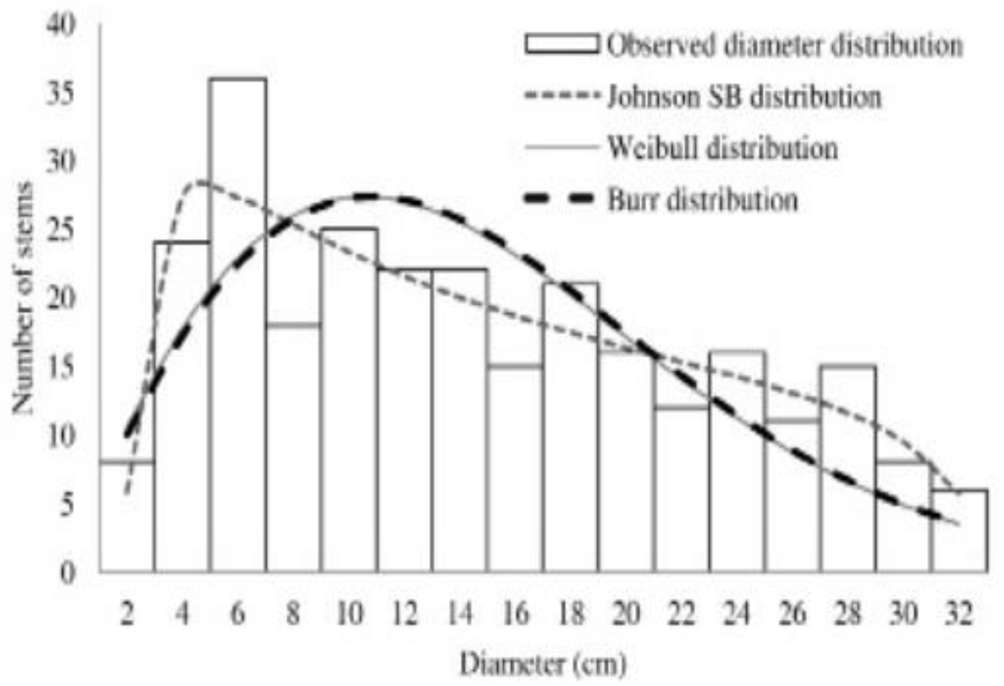

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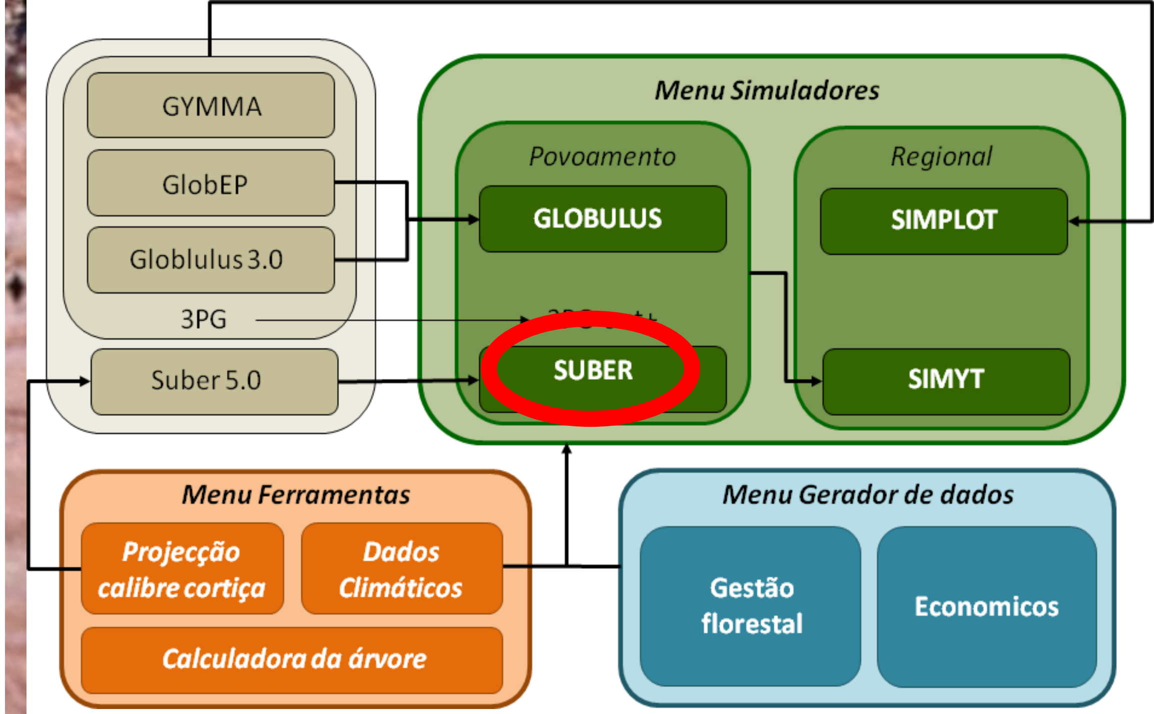

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Approaches for predicting the parametric diameter/height distribution:

- Parameter prediction
- Parameter recovery

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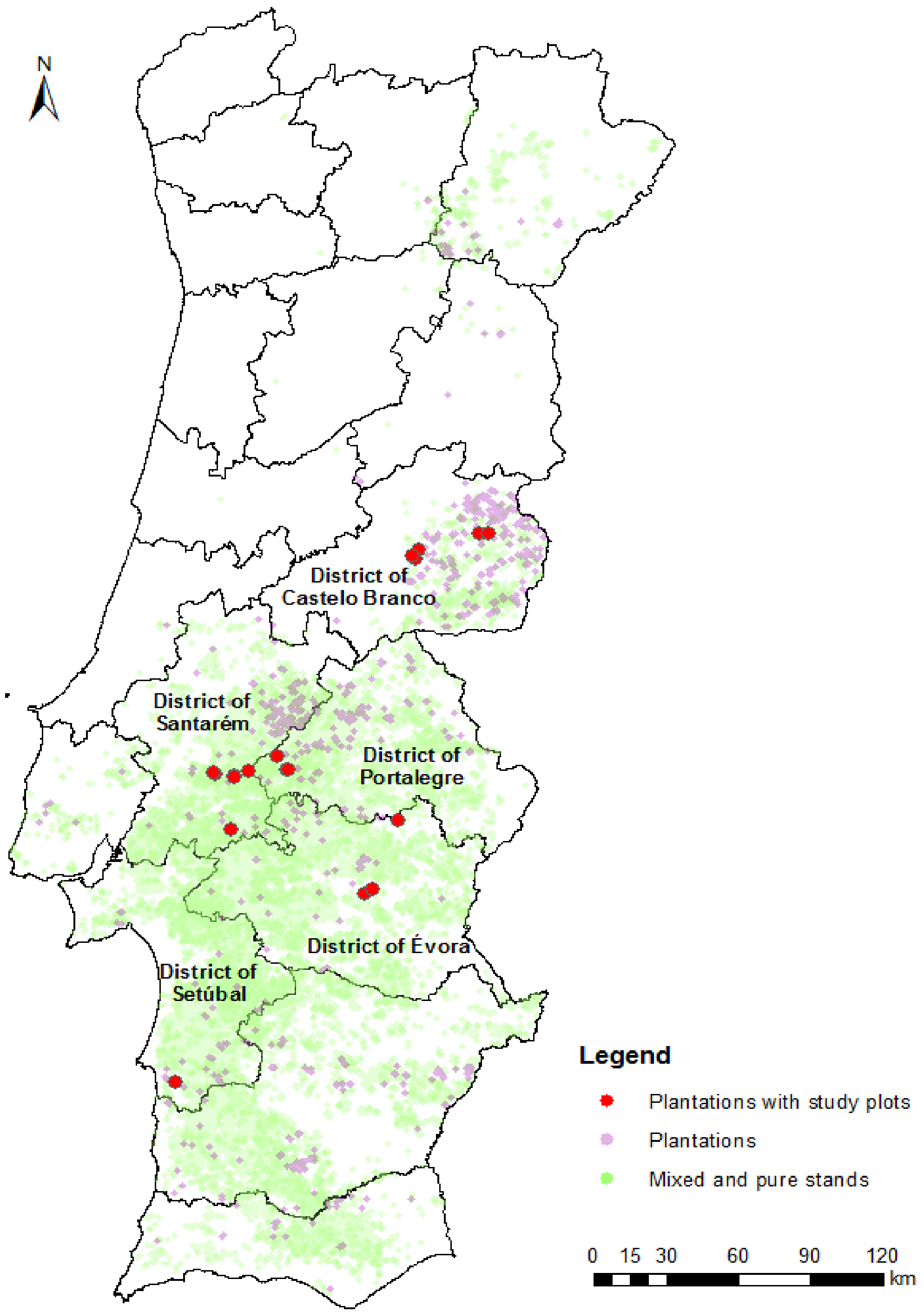

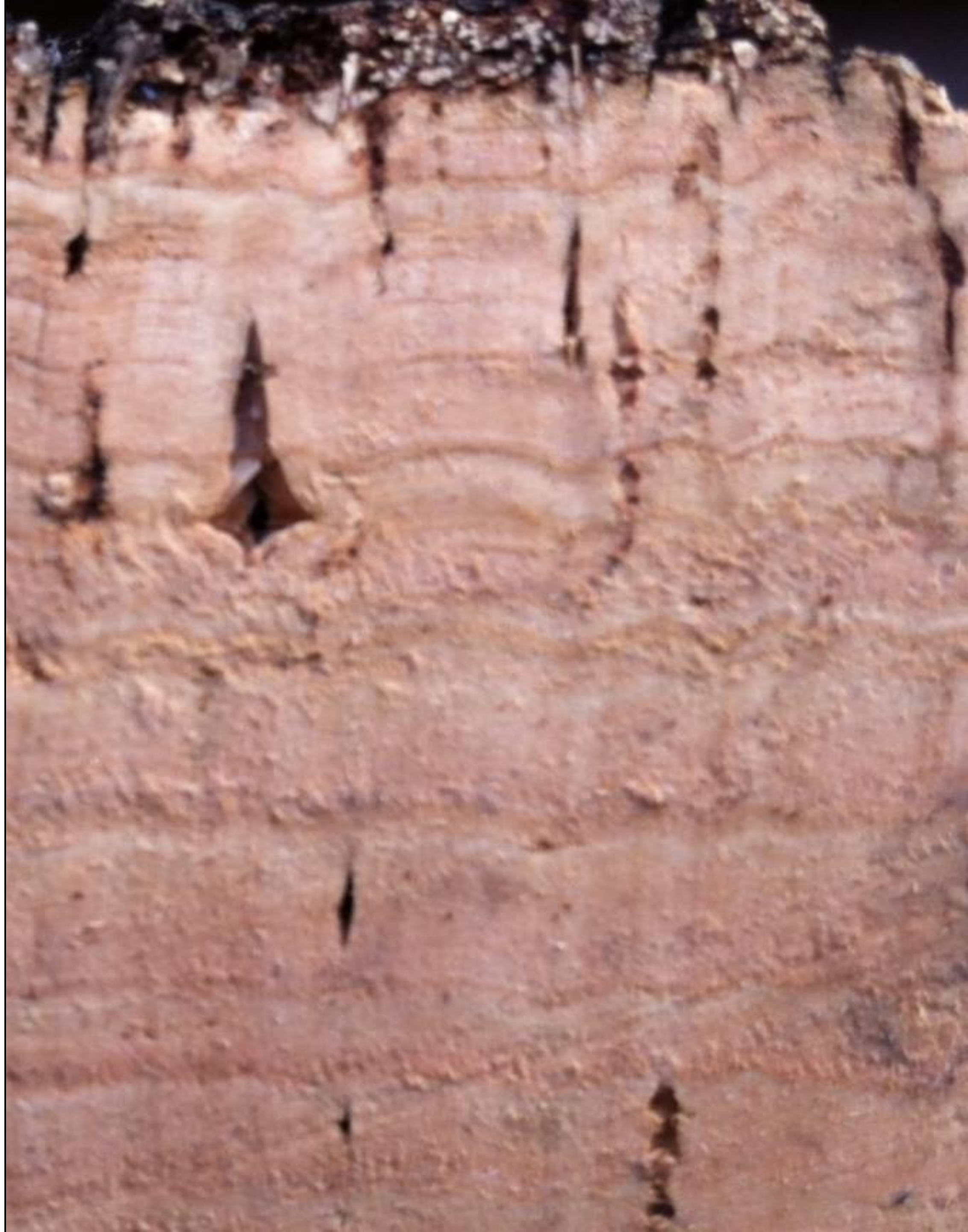

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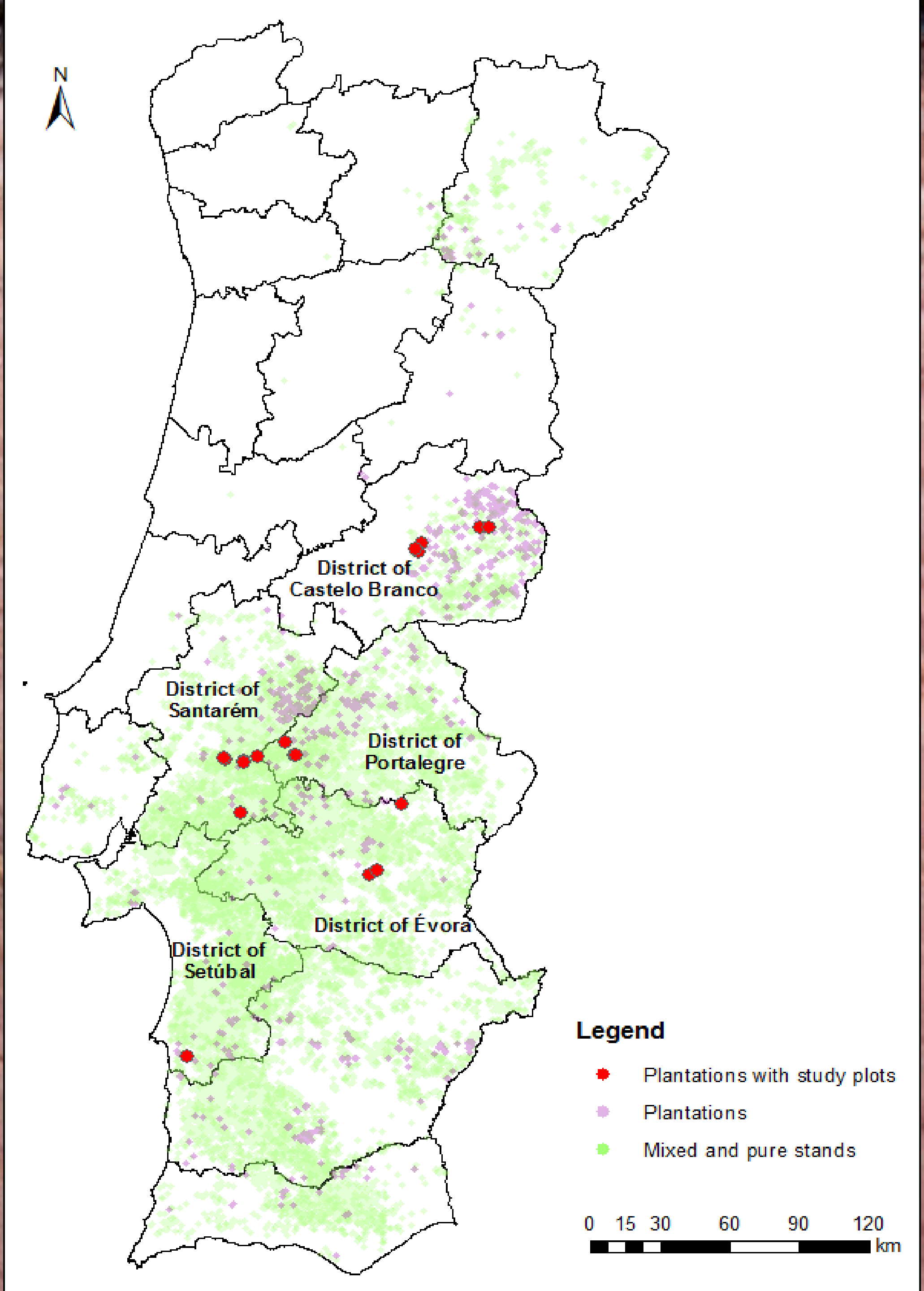

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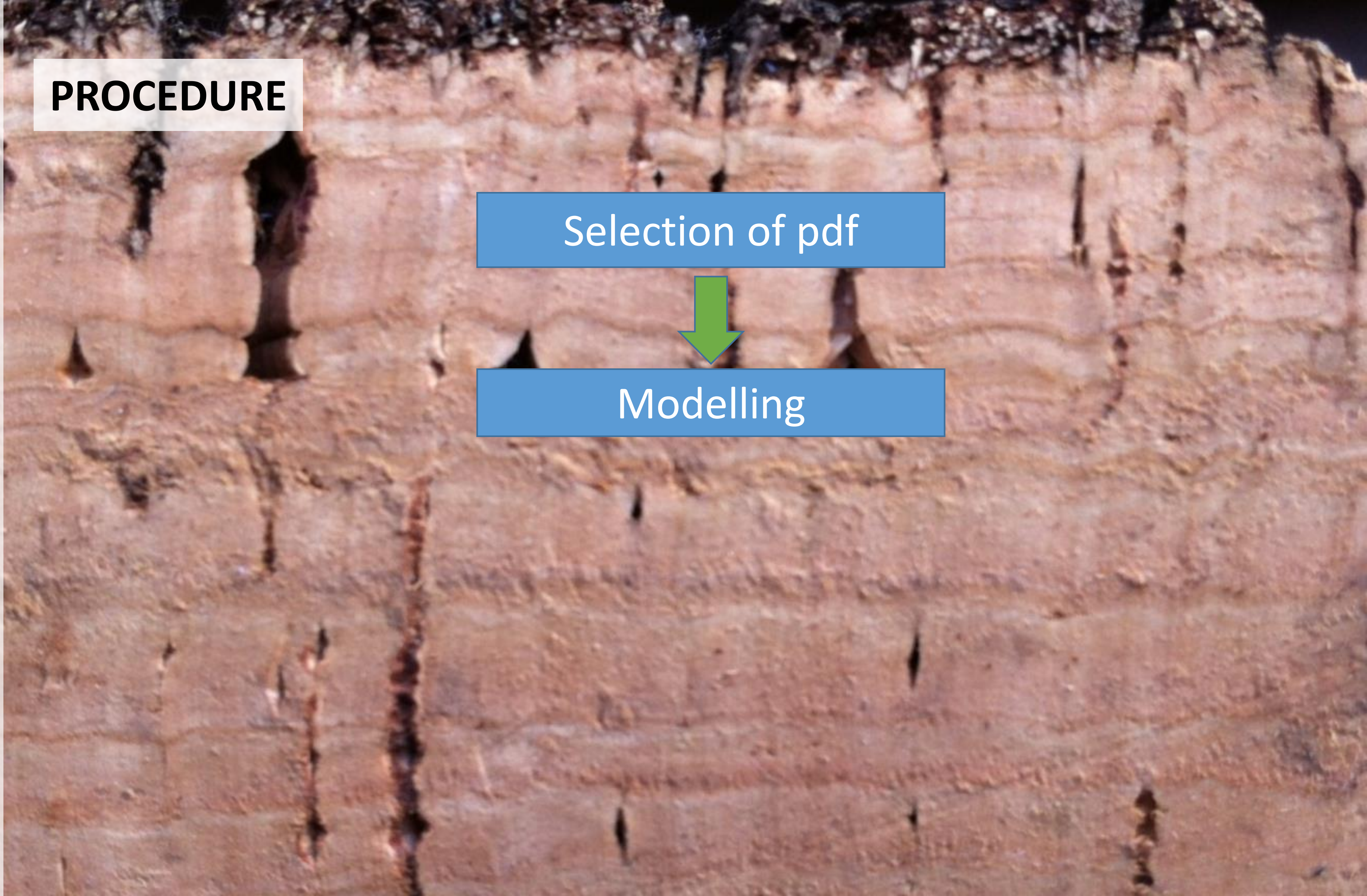

PROCEDURE

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Modelling

PROCEDURE

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Modelling

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PROCEDURE

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Validation

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Modelling

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Validation

1. SELECTION OF THE PDF

$$\boxed{\sqrt{\beta_1} = \frac{\mu_3}{(\mu_2)^{\frac{3}{2}}}}$$

$$\mu_k = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^k}{n}$$

$$\boxed{\beta_2 = \frac{\mu_4}{(\mu_2)^2}}$$

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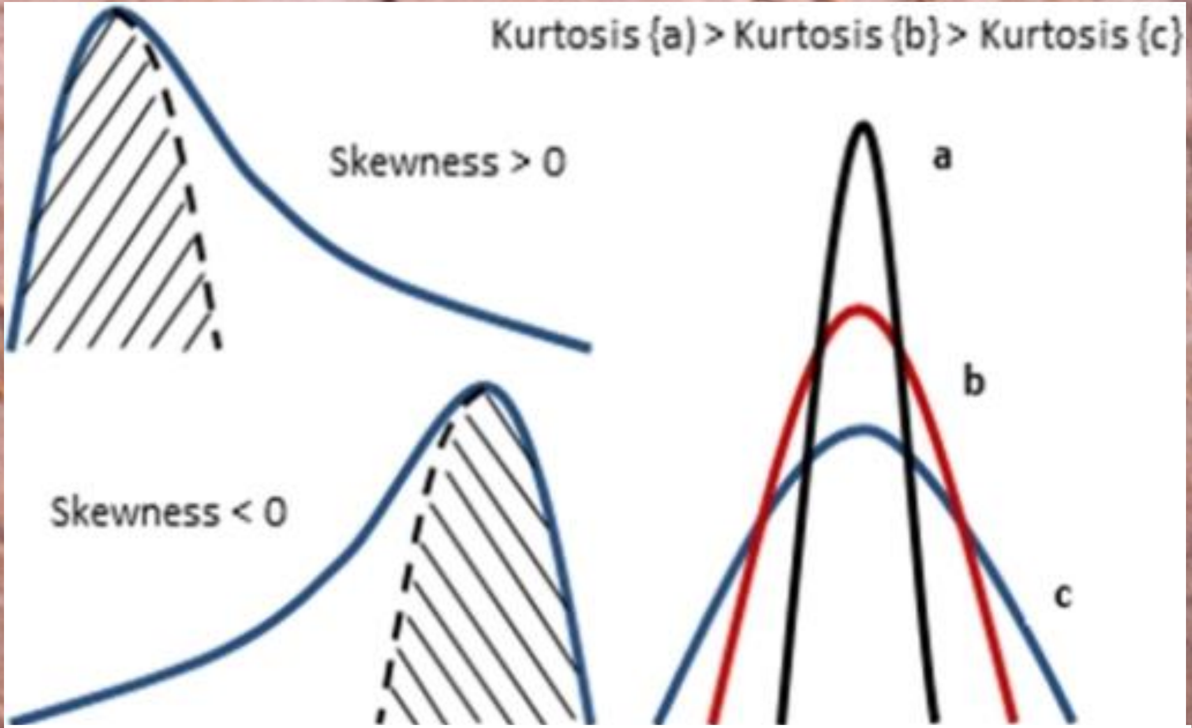

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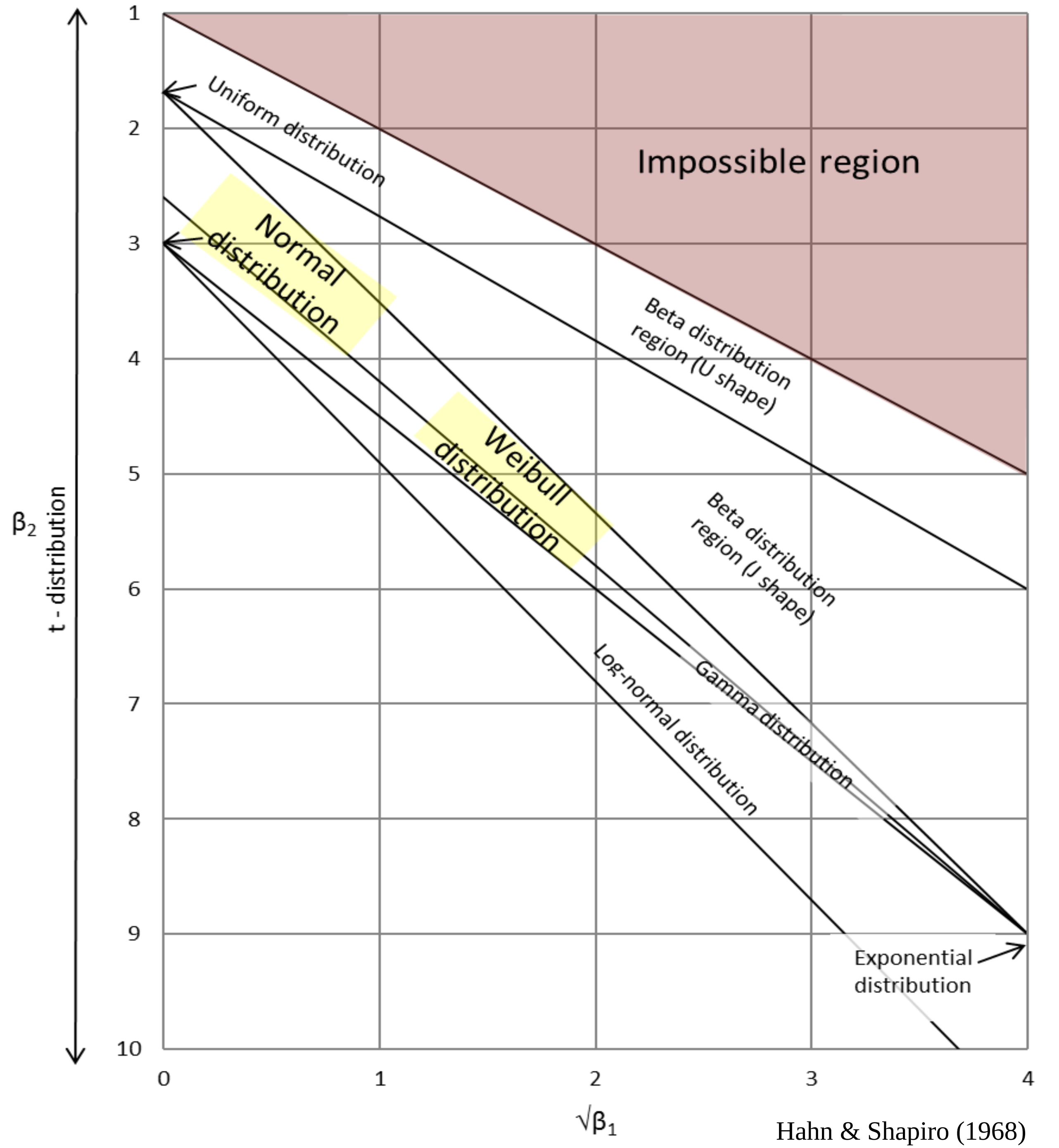

Hahn & Shapiro (1968)

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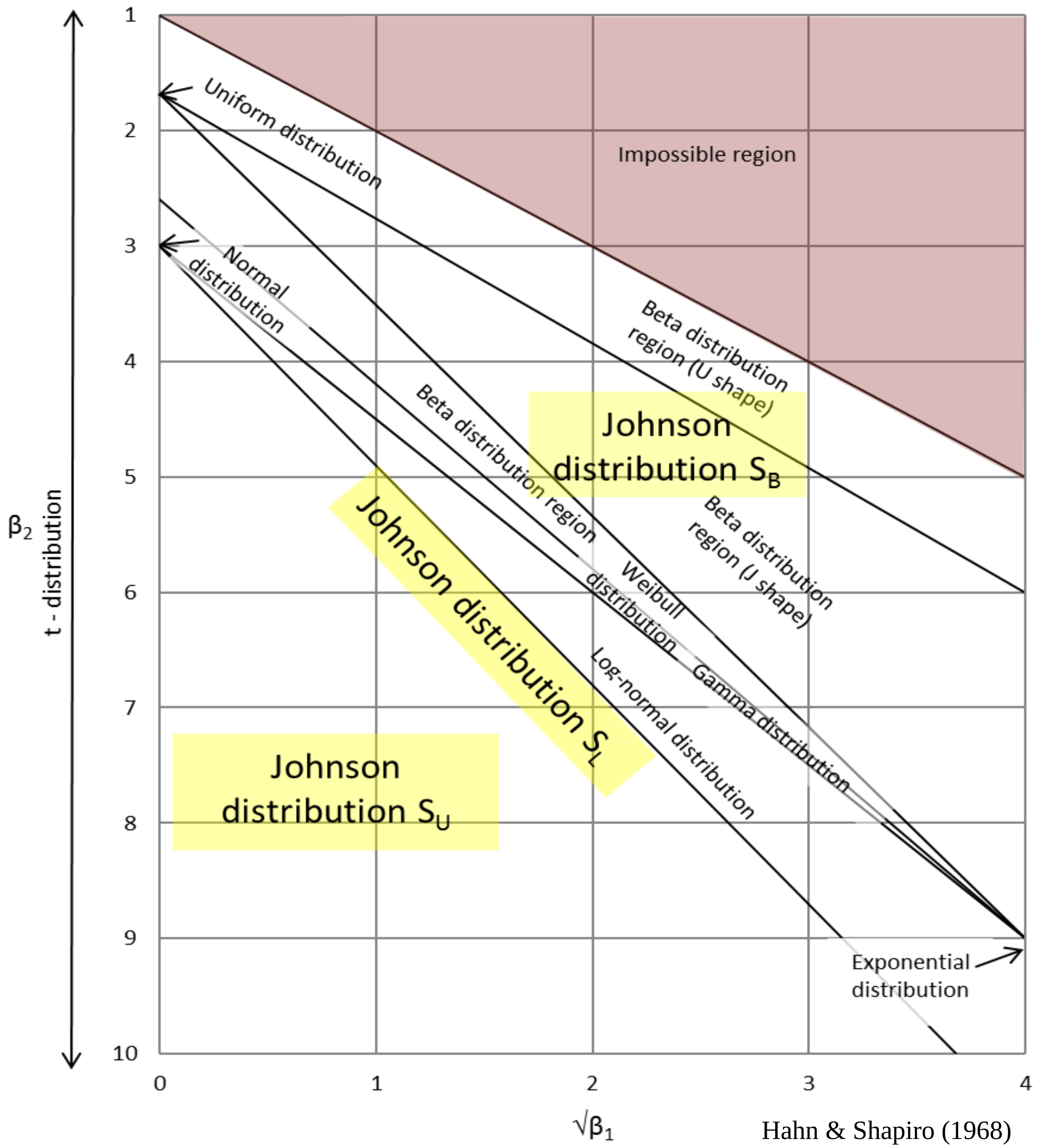

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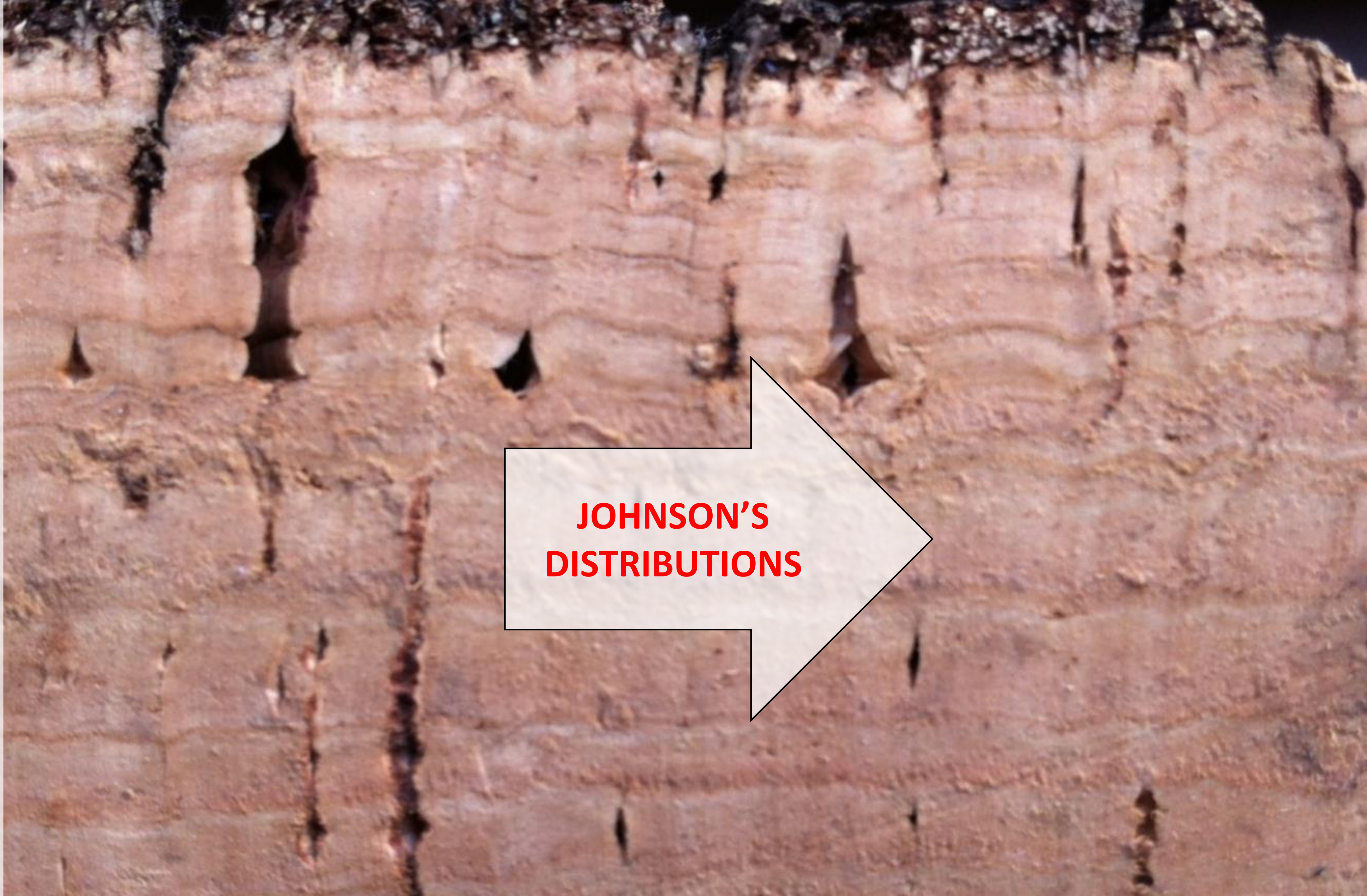

JOHNSON'S DISTRIBUTIONS

INPUTS

- Mean height
- Standard deviation
- Skewness
- Kurtosis

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JOHNSON'S DISTRIBUTIONS

OUTPUT

?

2. MODELLING THE JOHNSON'S PARAMETER RECOVERY

SCATTERPLOT MATRIX

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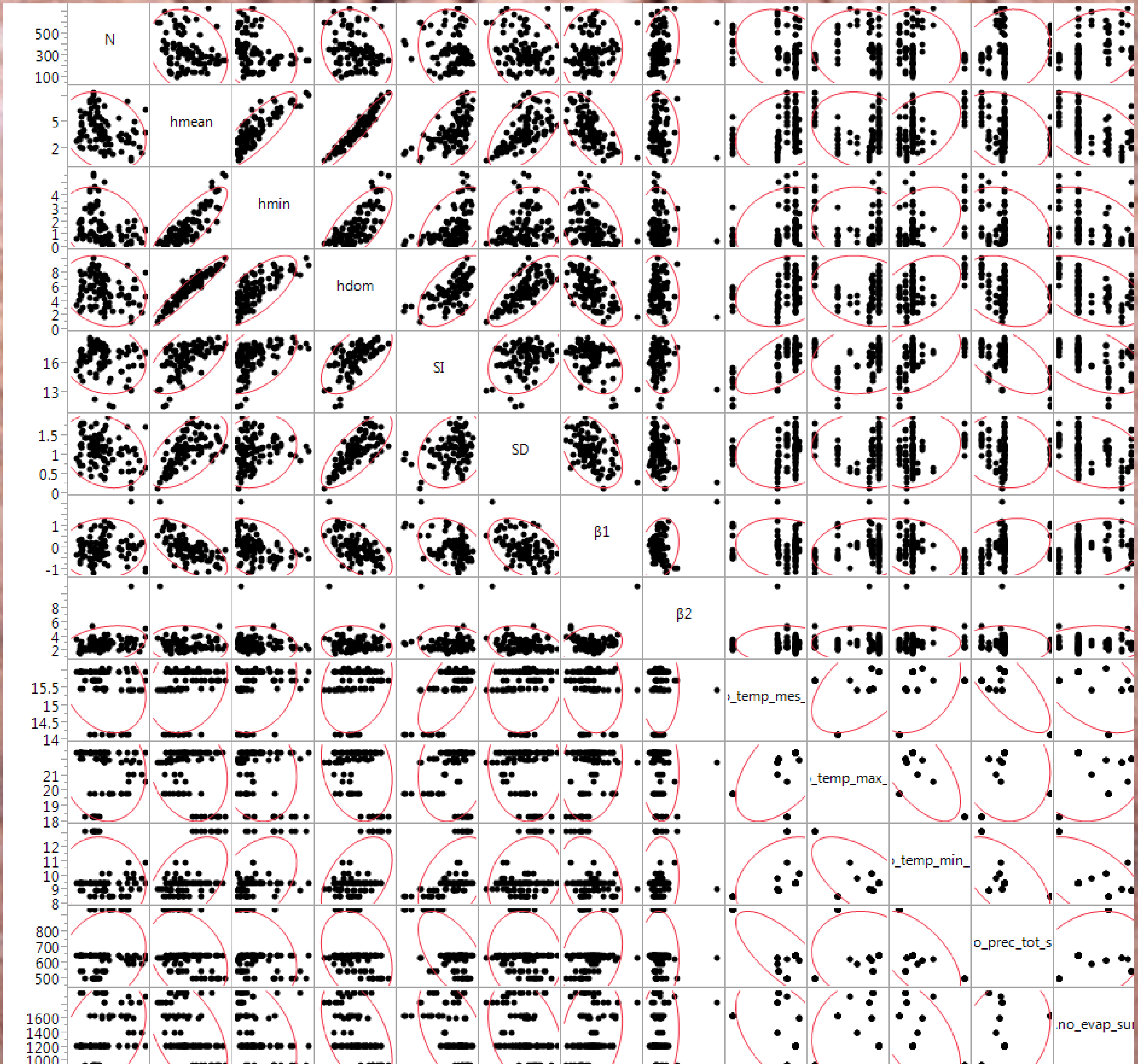


2. MODELLING THE JOHNSON'S PARAMETER RECOVERY

MODELS

- Linear models
  - Standard deviation
  - Skewness
  - → All possible regressions
- Nonlinear models
  - Mean height
  - Kurtosis
  - → Other method

3. FITTING JOHNSON'S DISTRIBUTION

INPUTS

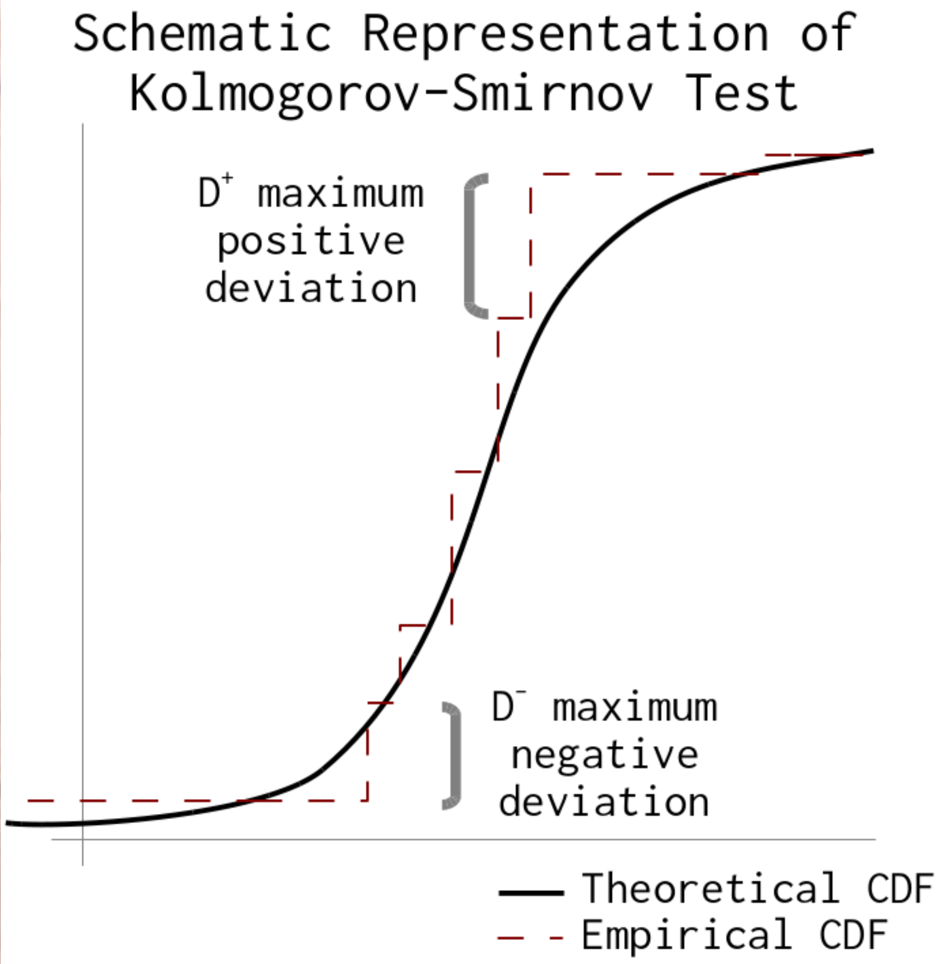
- Mean height
- Standard deviation
- Skewness
- Kurtosis

JOHNSON'S PACKAGE

OUTPUT

- Shape, Range, location — parameters
- Type (S_B, S_U, S_L)
- Error

4. GOODNESS OF FIT OF THE SIMULATED DISTRIBUTIONS



https://research.neustar.biz/2012/04/18/statistical-toolbox-the-kolmogorov-smirnov-test/

$$D_n = \max_{1 \le i \le n}\left(F(x_i) - \frac{i-1}{n}, \frac{i}{n} - F(x_i) \right)$$

– Comparison → Johnson vs. Real

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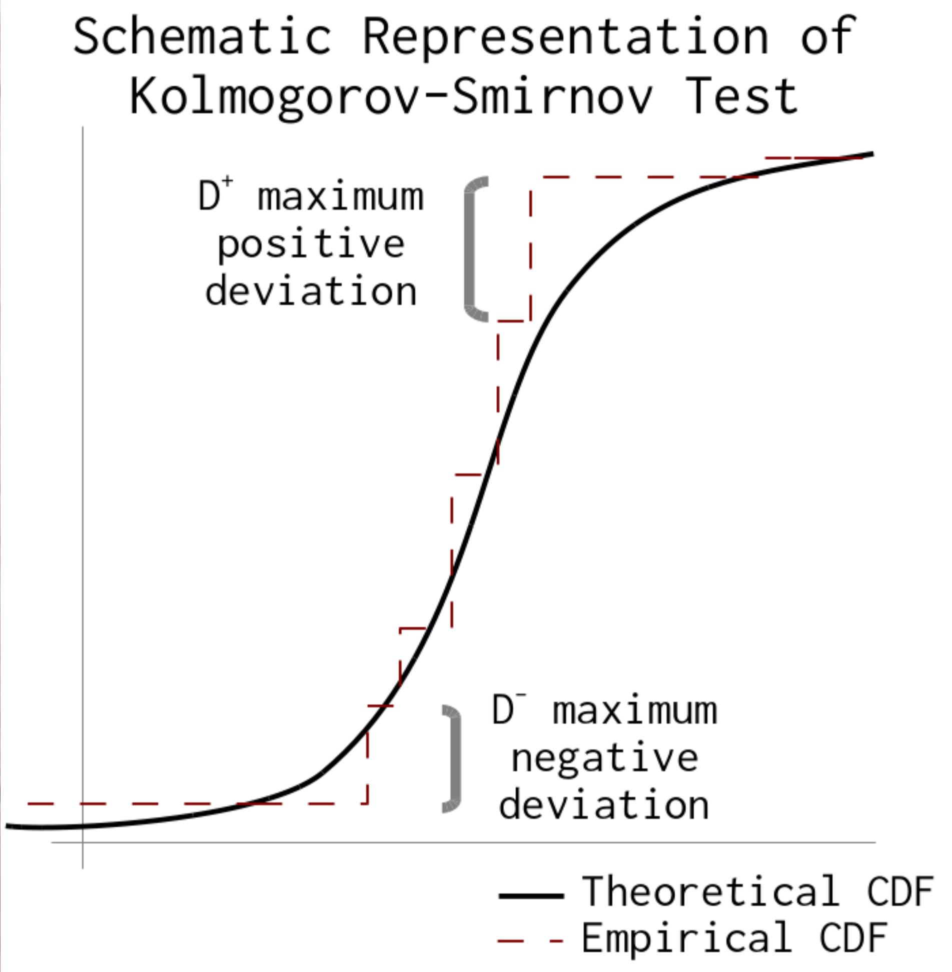

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- Ho: $F(x) = F^*(x)$ → p-value > 0.01
- H_1: $F(x) \neq F^*(x)$ → p-value < 0.01

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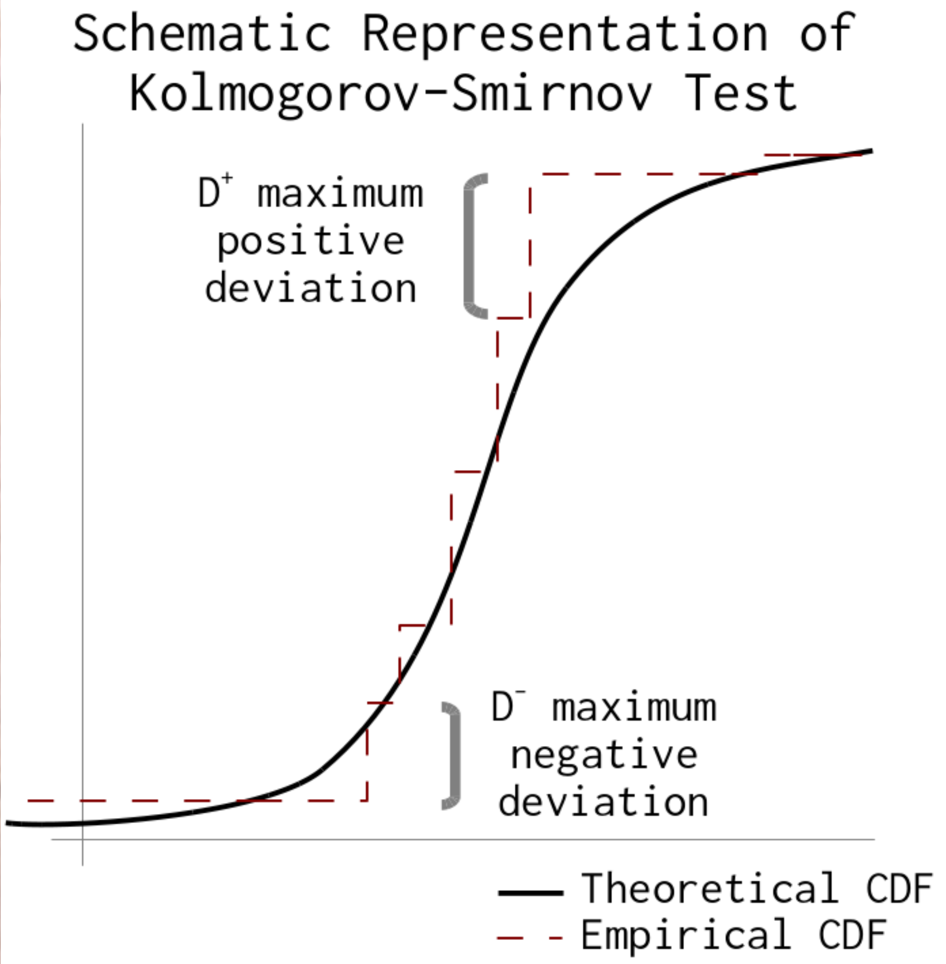

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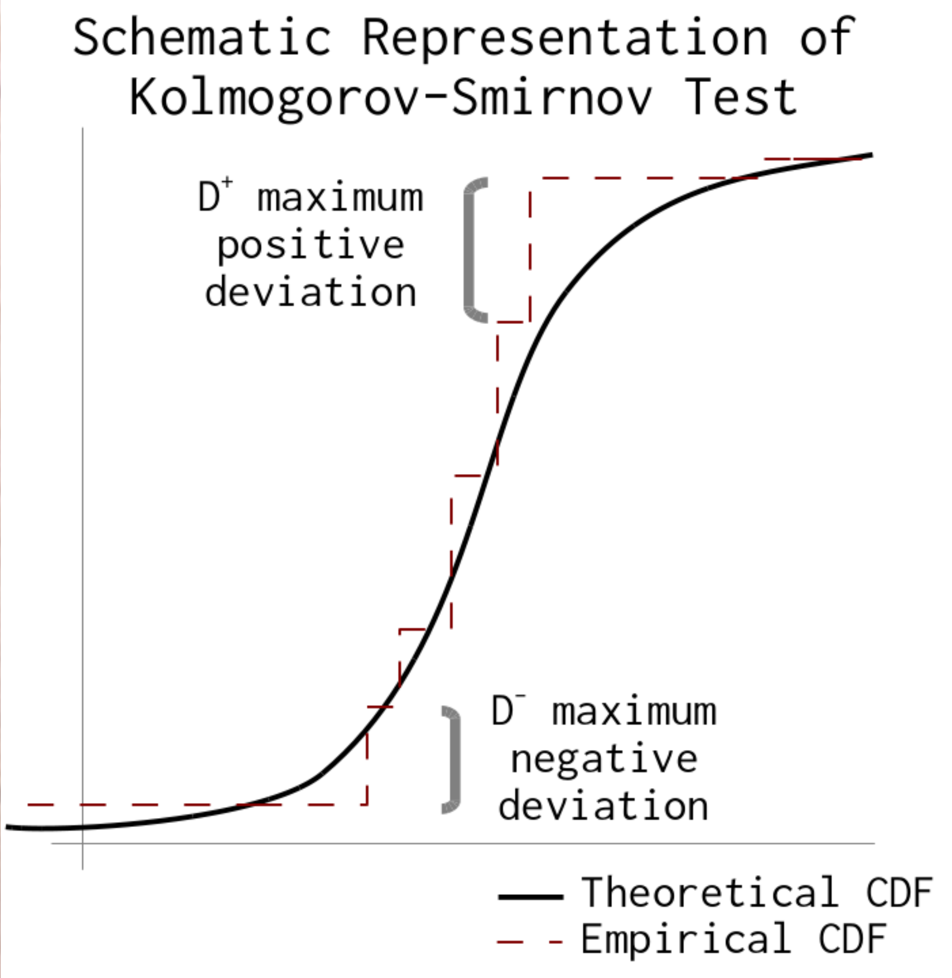

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- 100 repetitions x plot measurement

- 80% or more with p-value > 0.01

GOOD SIMULATION

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PROCEDURE

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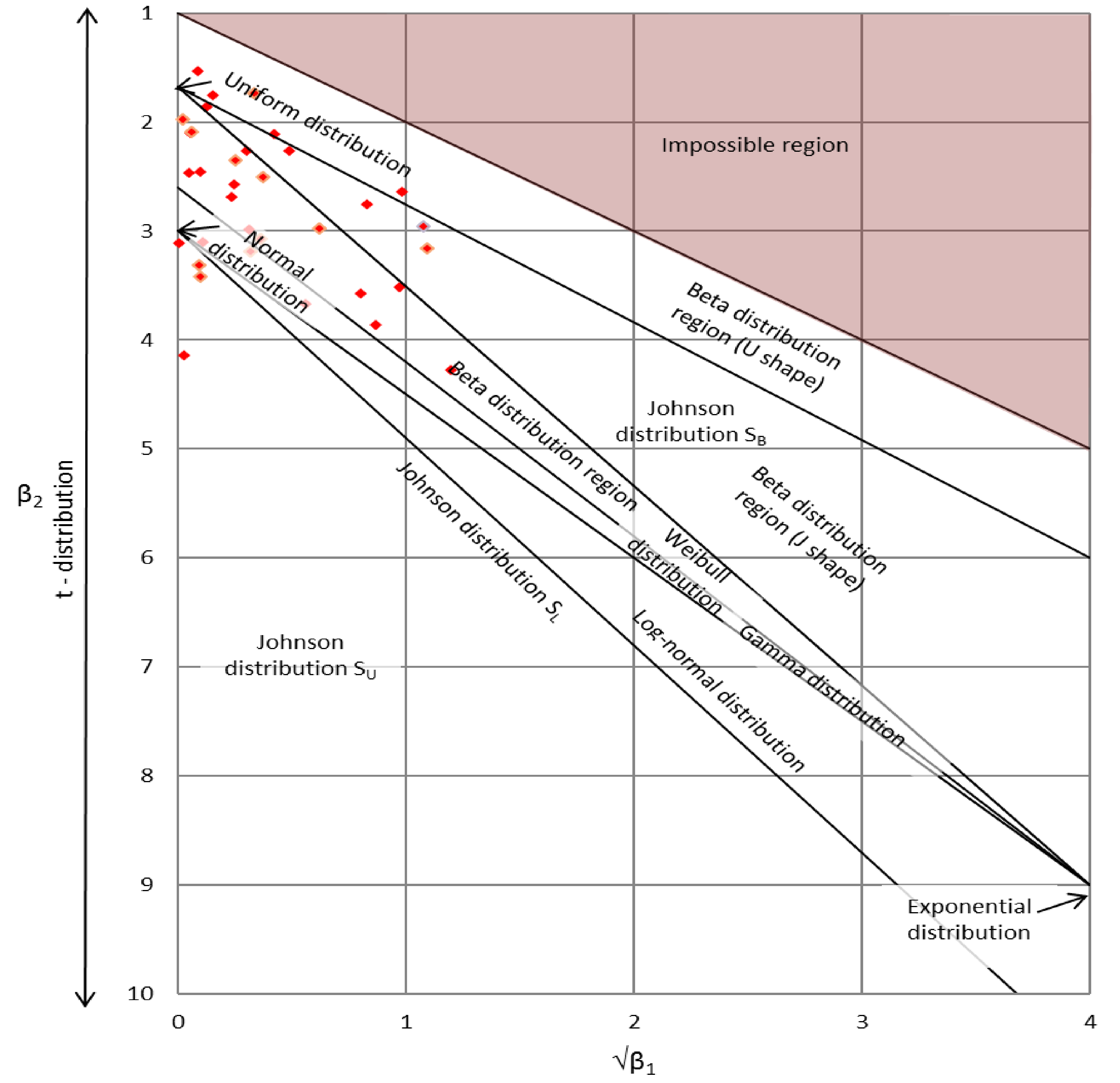

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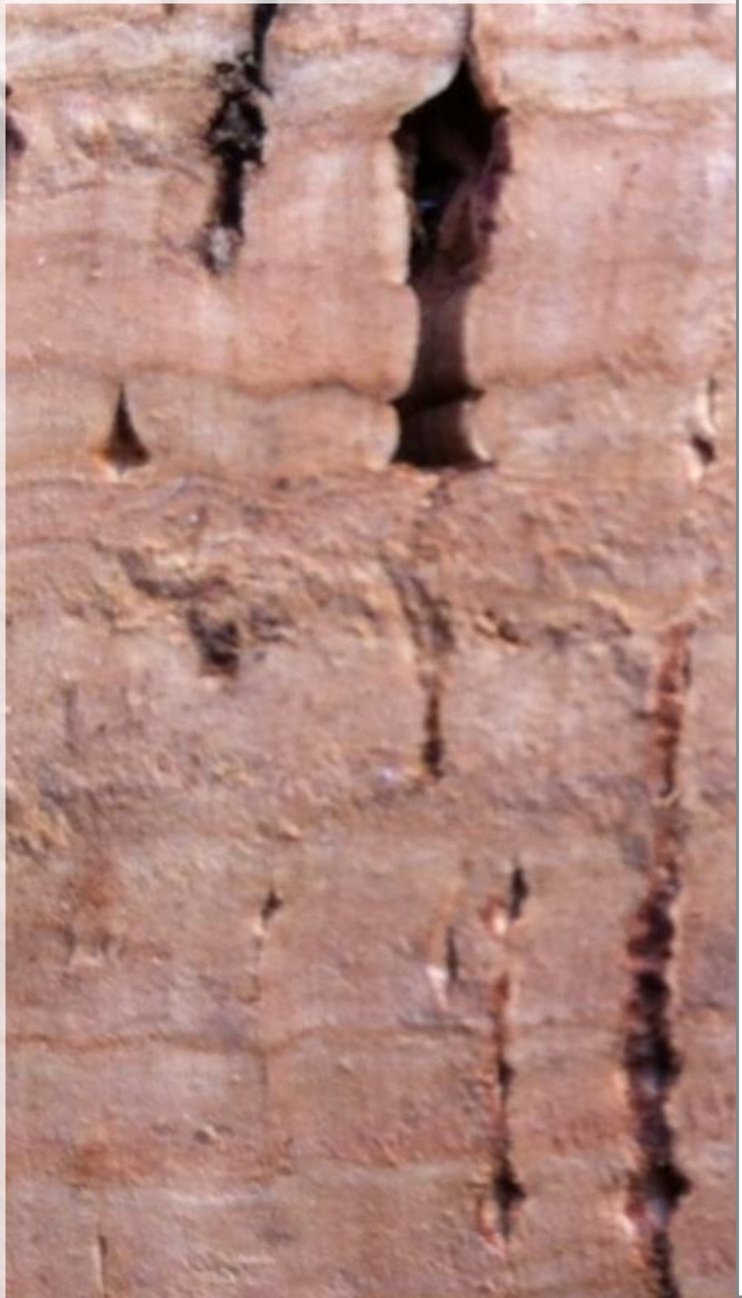

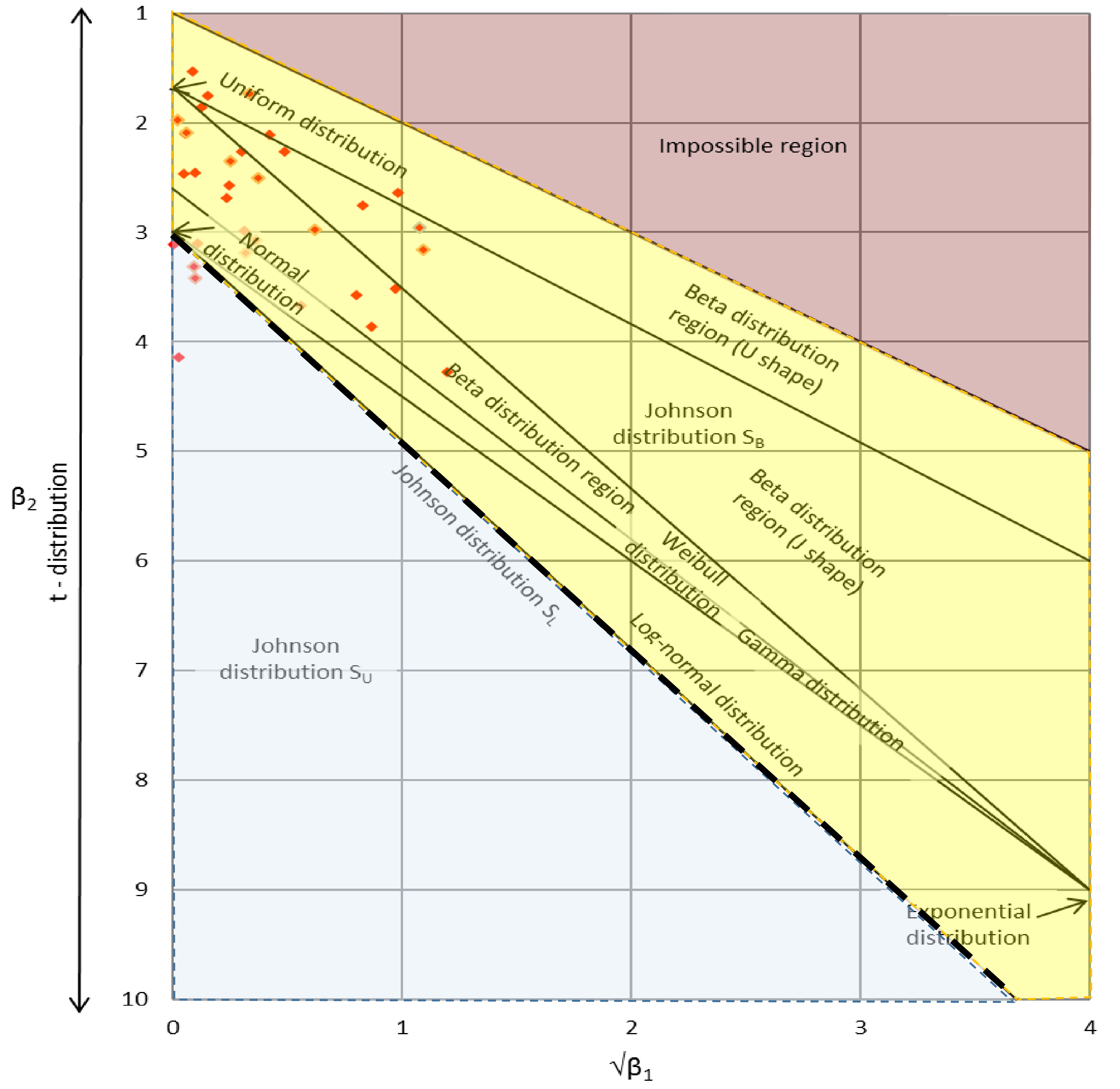

1. SELECTION OF A PDF

- **Blue dots** →
  6 – 10 years
- **Green dots** →
  11 – 13 years
- **Orange dots** →
  14 – 16 years
- **Red dots** →
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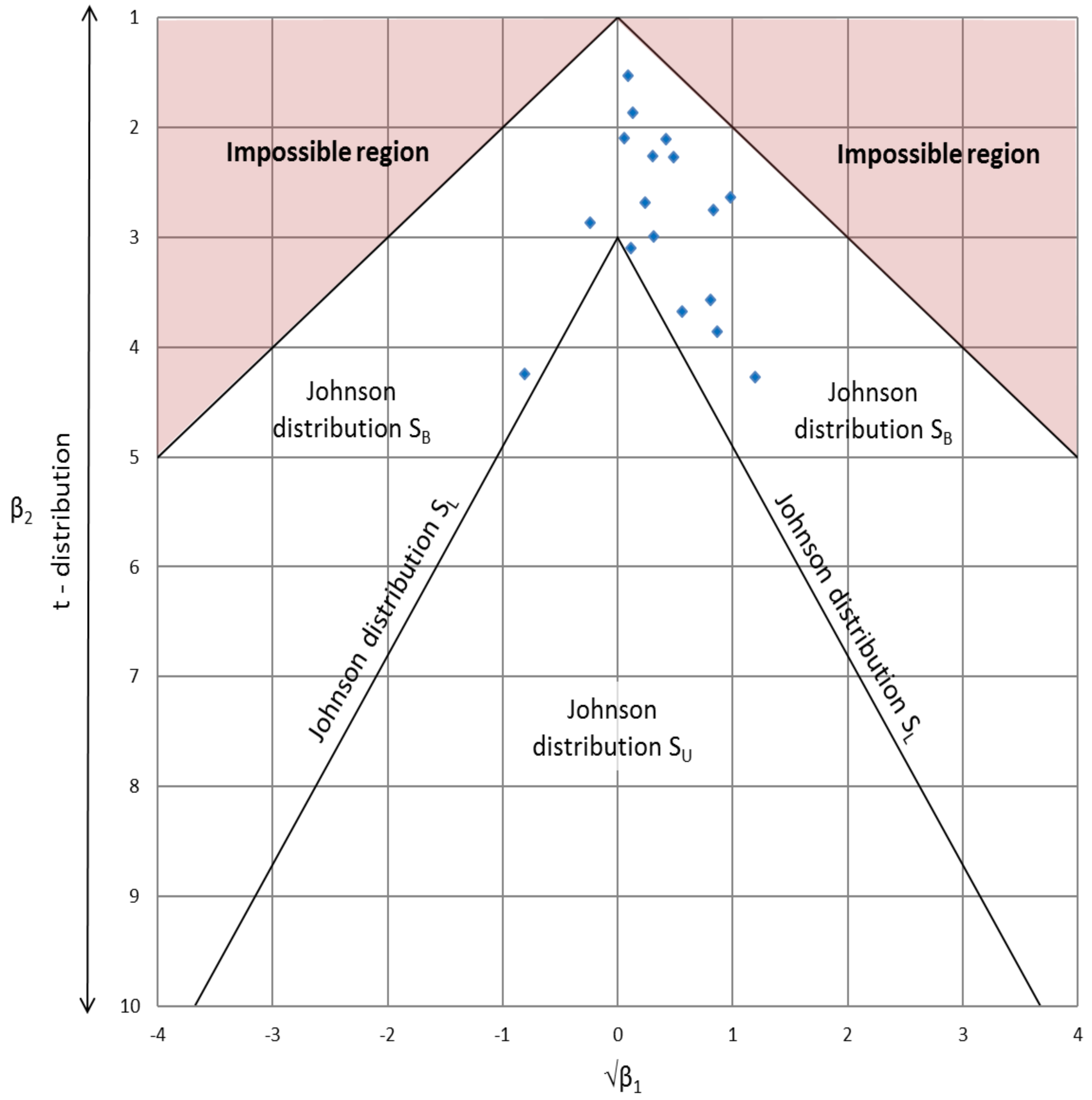

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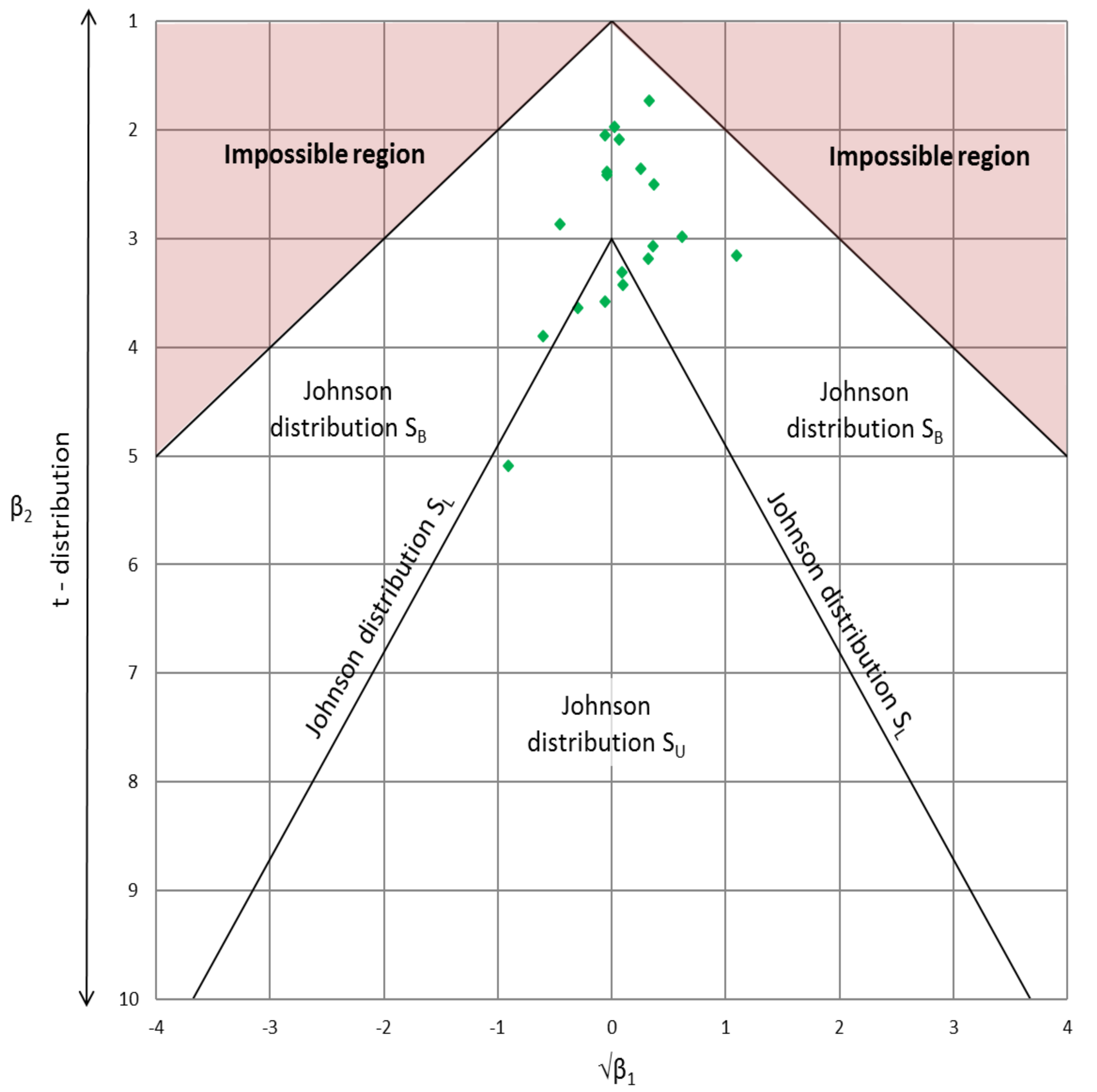

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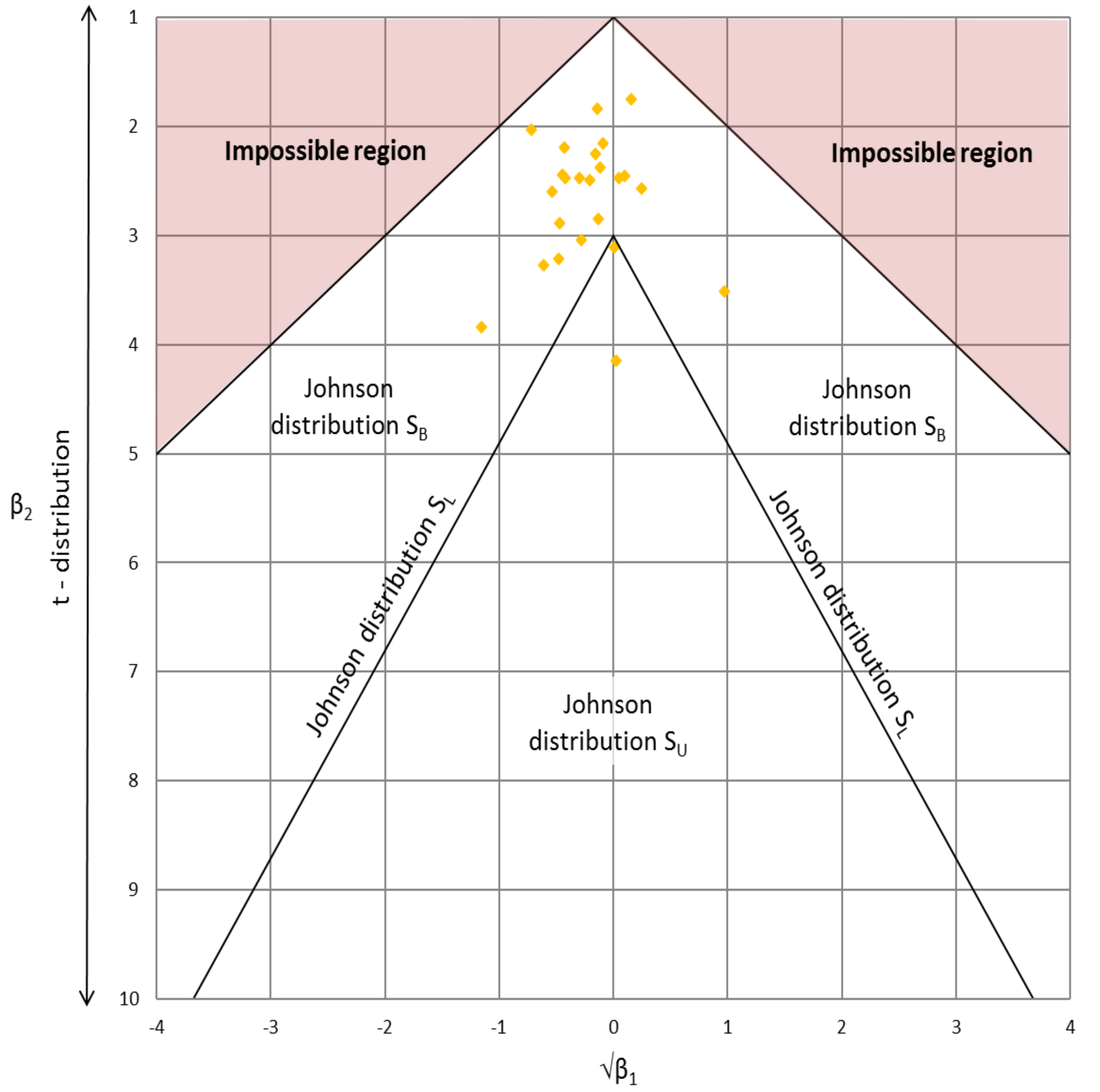

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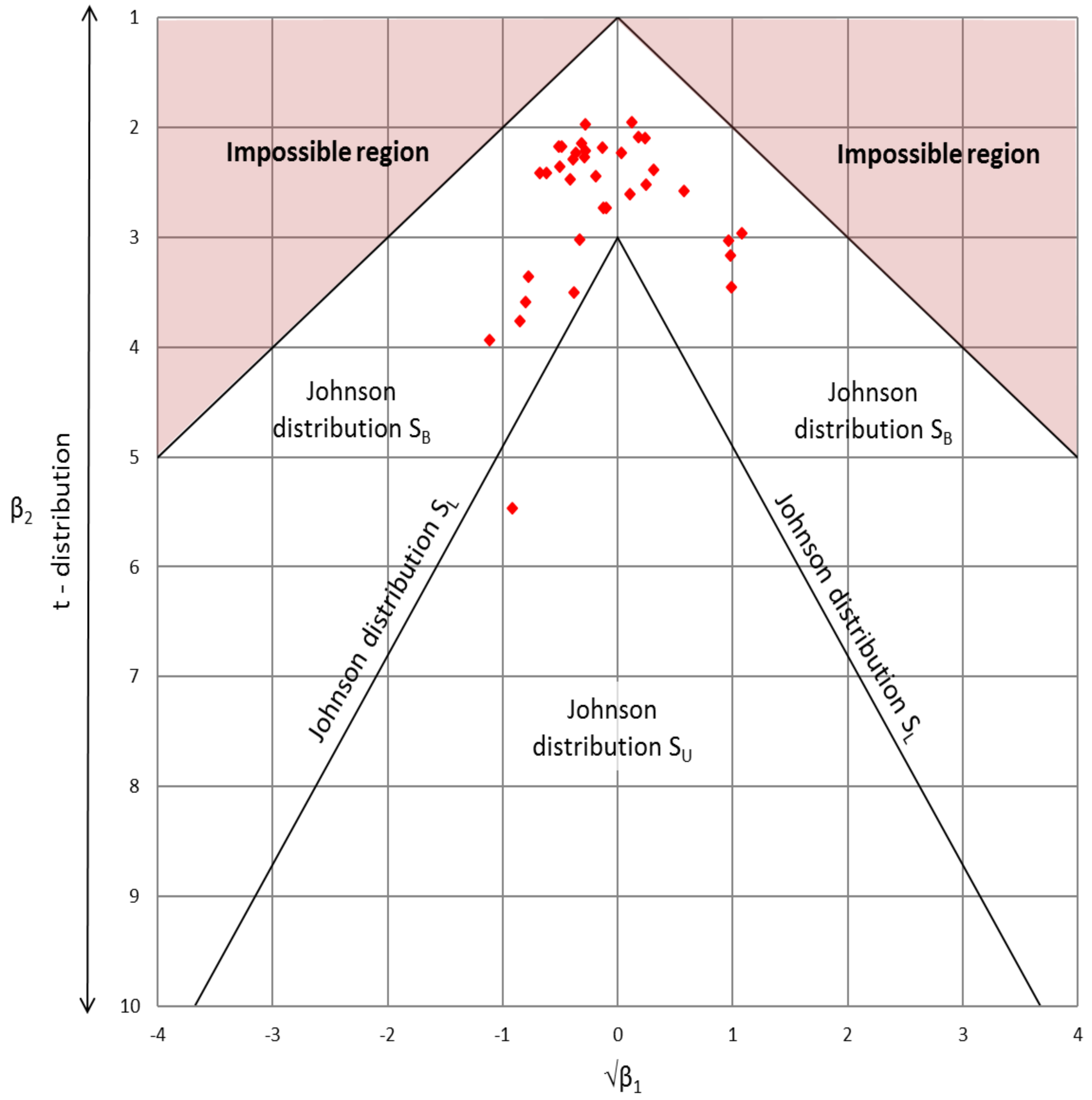

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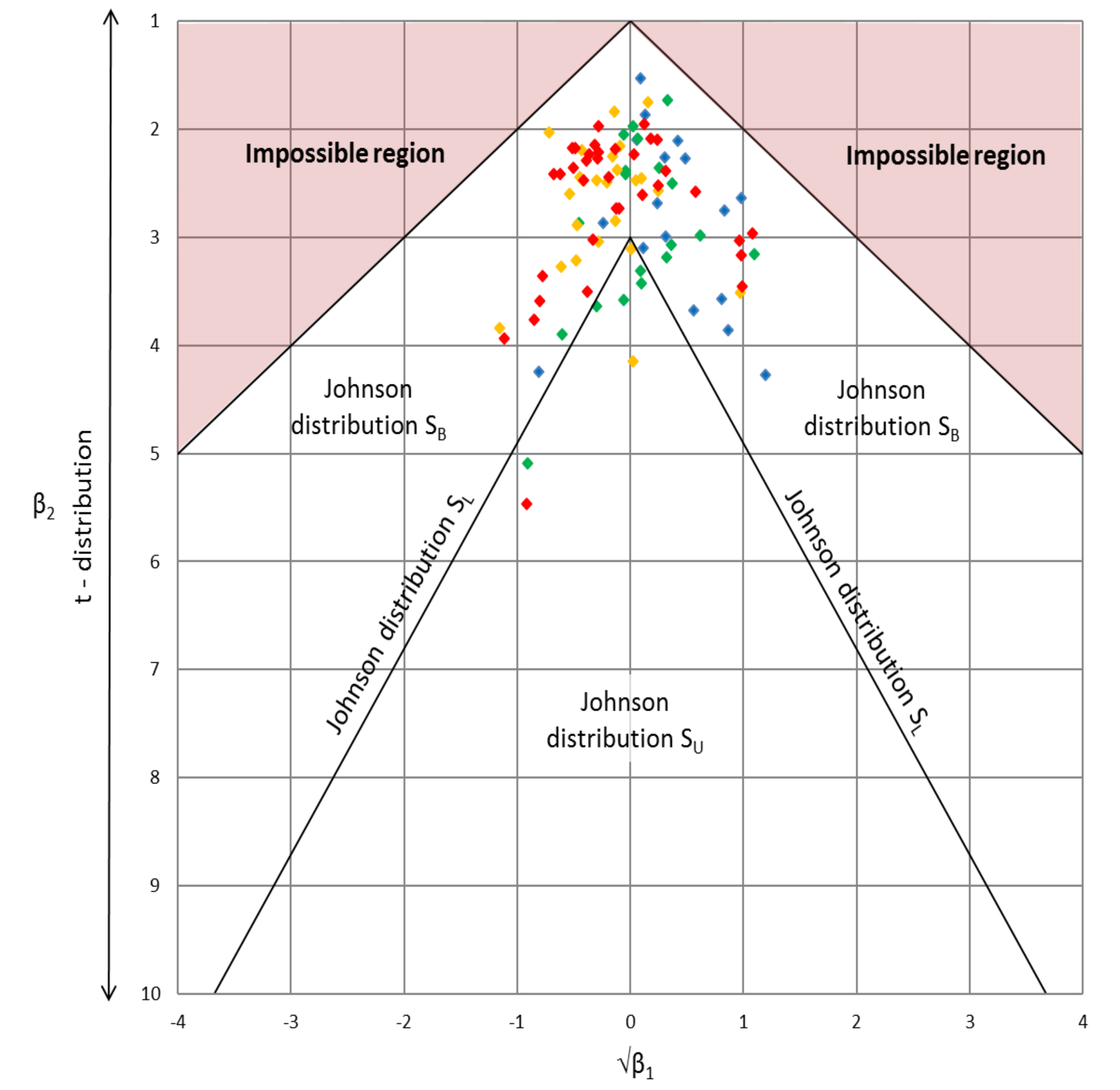

2. MODELLING

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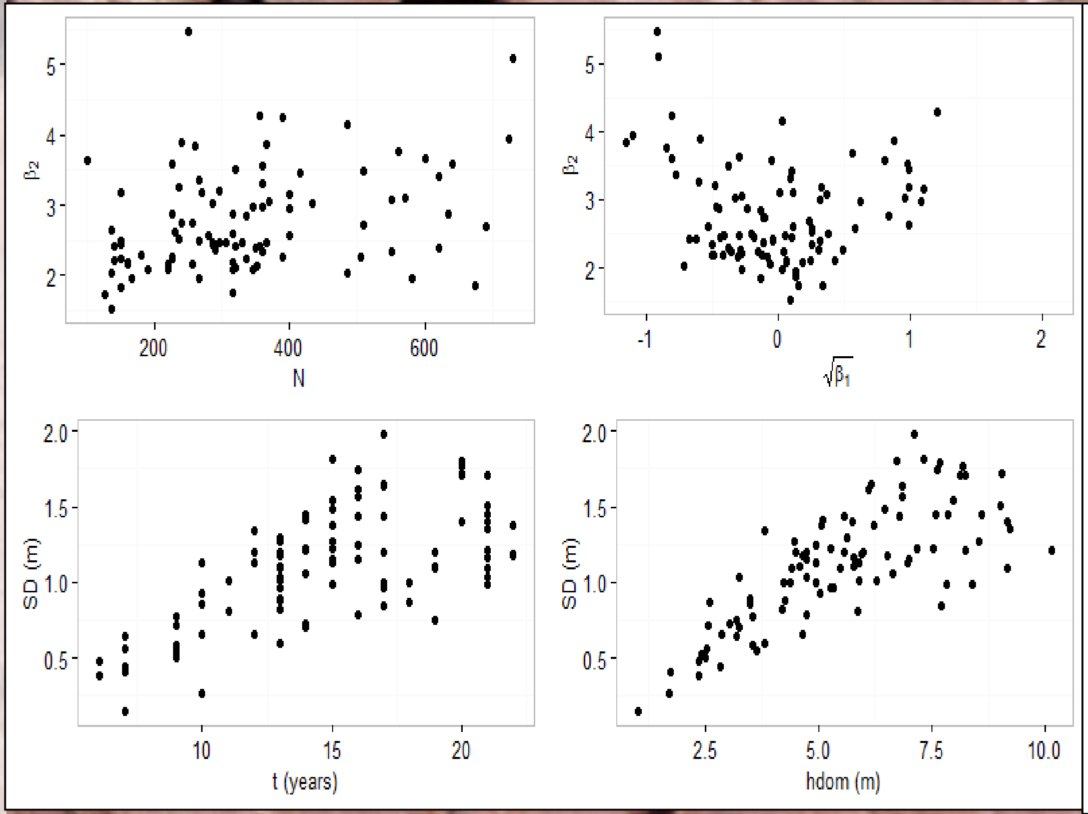

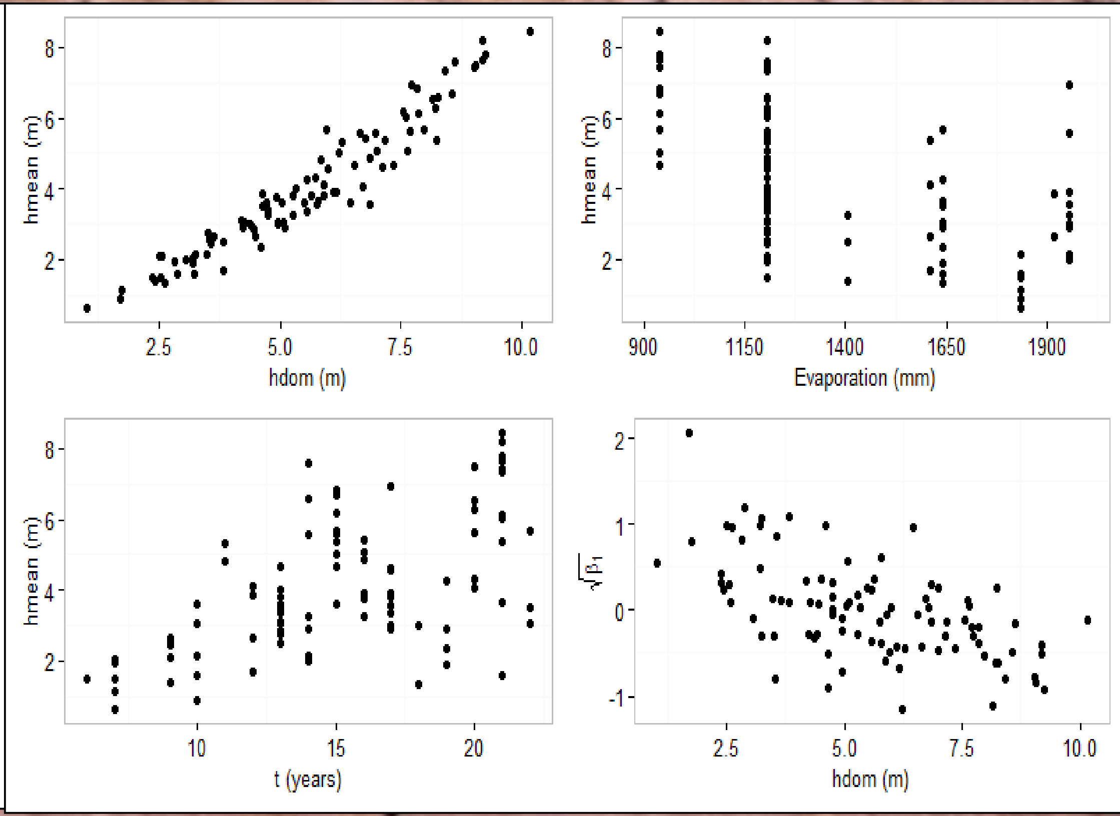

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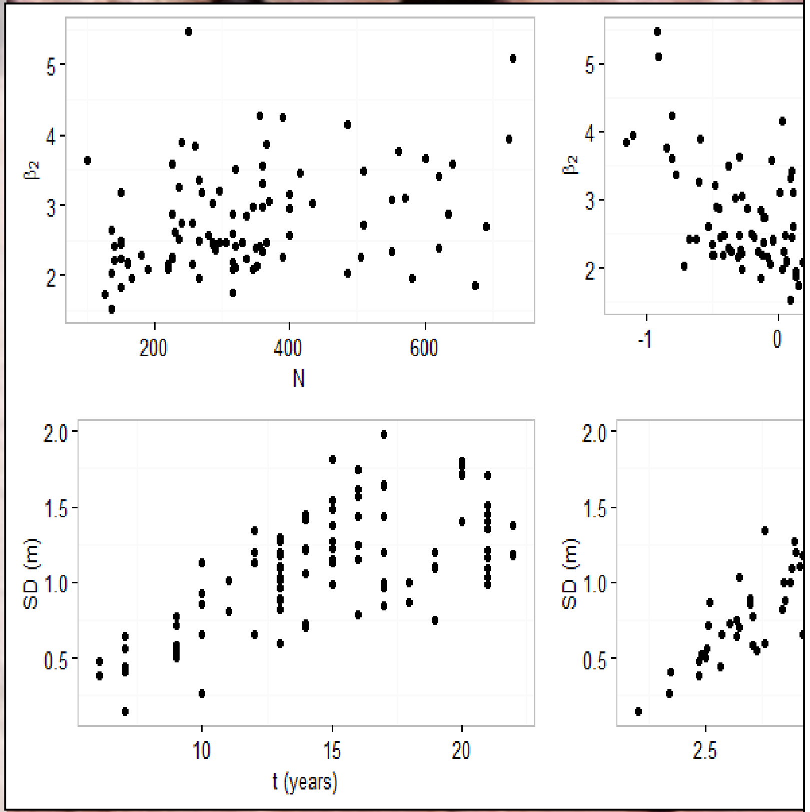

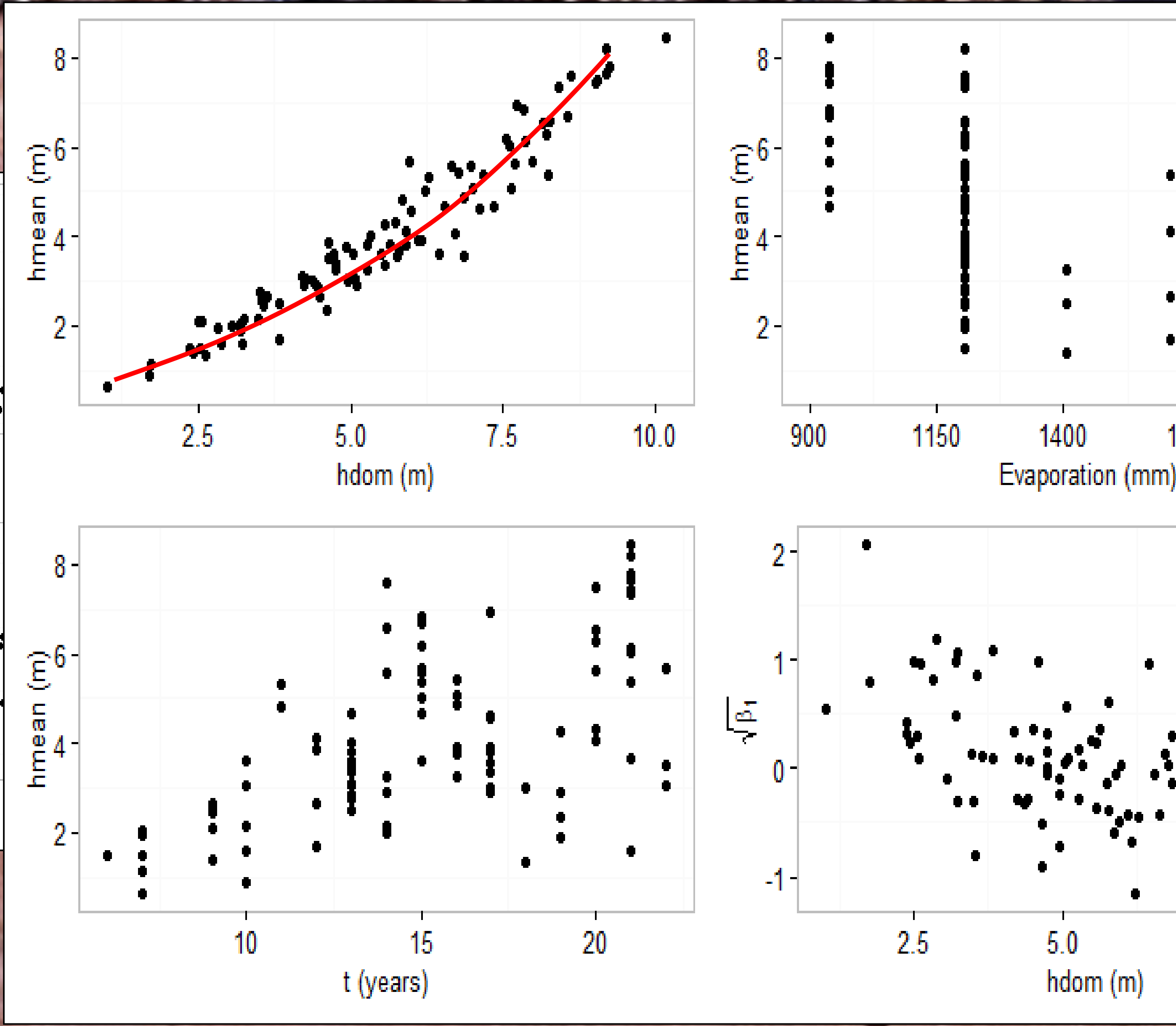

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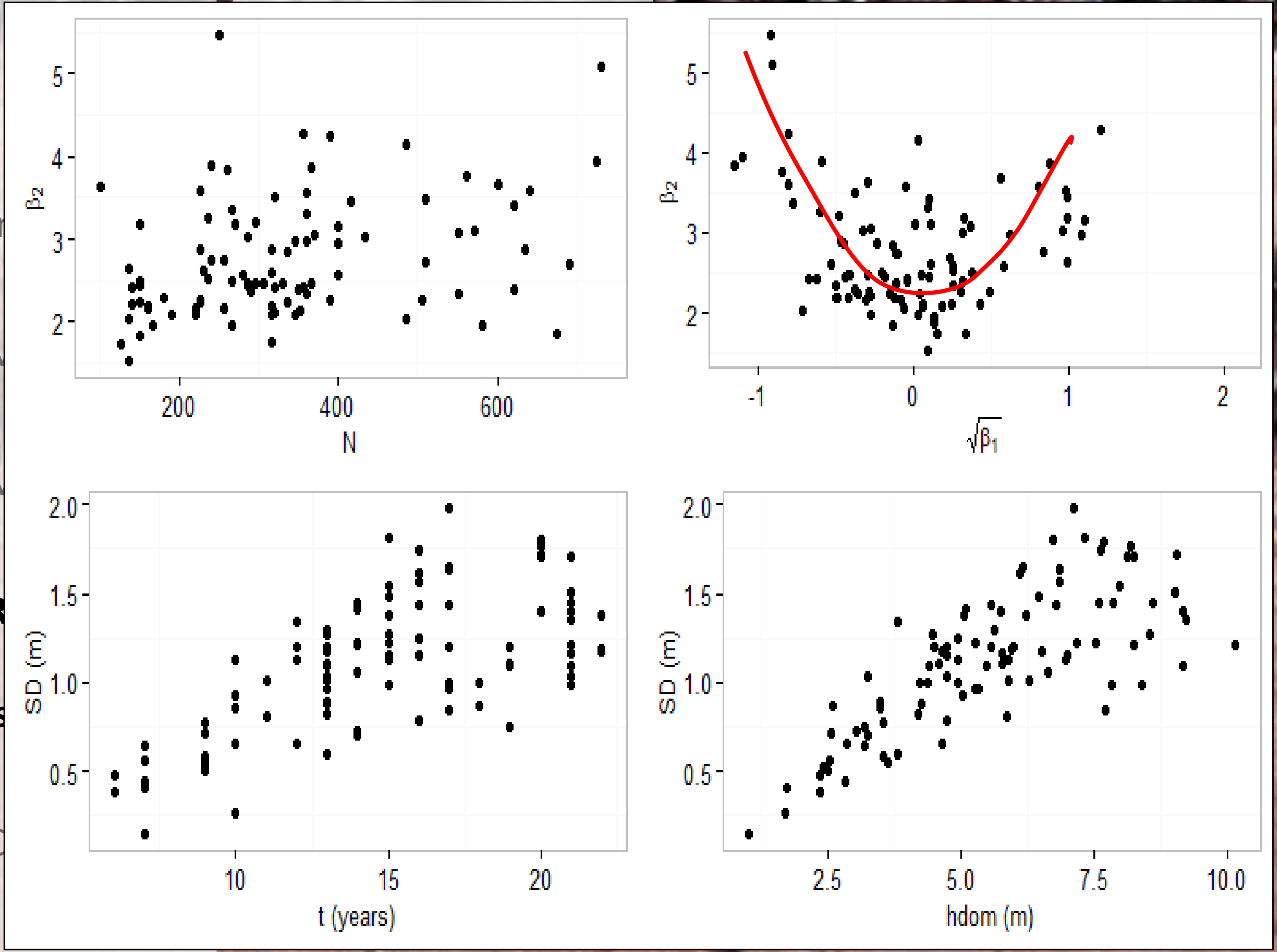
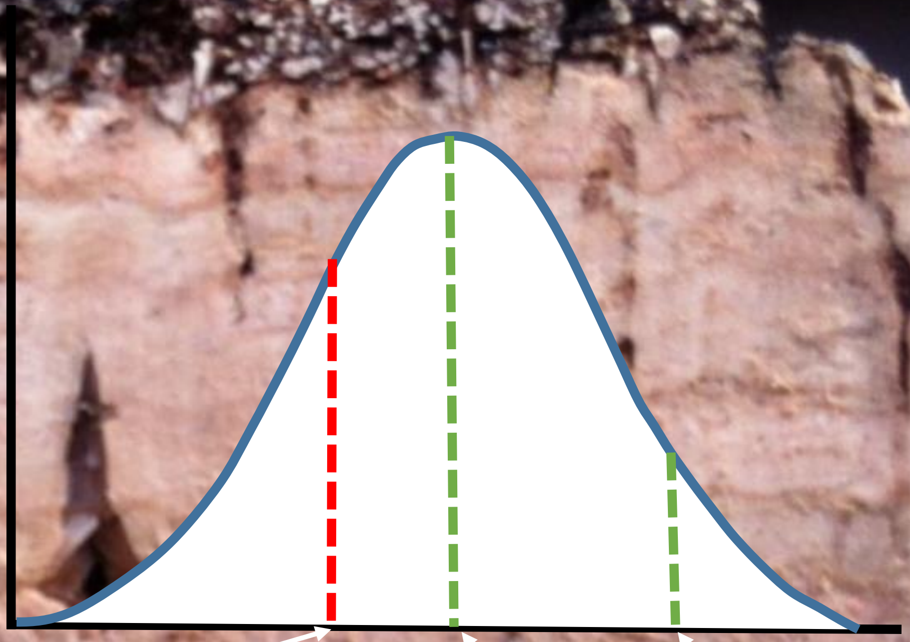


5. C

2. MODELLING

Model	Statistic	
	ef	MSE
$hmean = hdom - \left(a_{11} \cdot exp\left(-a_{12} \cdot Evap - a_{13} \cdot t\right)\right) \cdot hdom$	0.914	0.300
$SD = a_{21} \cdot t + a_{22} \cdot hdom$	0.619	0.057
$\sqrt{\beta_1} = a_{30} + a_{31} \cdot hdom$	0.345	0.212
$\beta_2 = a_{40} + a_{41} \cdot N + a_{42} \cdot \sqrt{\beta_1}^2 = a_{40} + a_{41} \cdot N + a_{42} \cdot \left(a_{30} + a_{31} \cdot hdom\right)^2$	0.206	1.039

2. MODELLING



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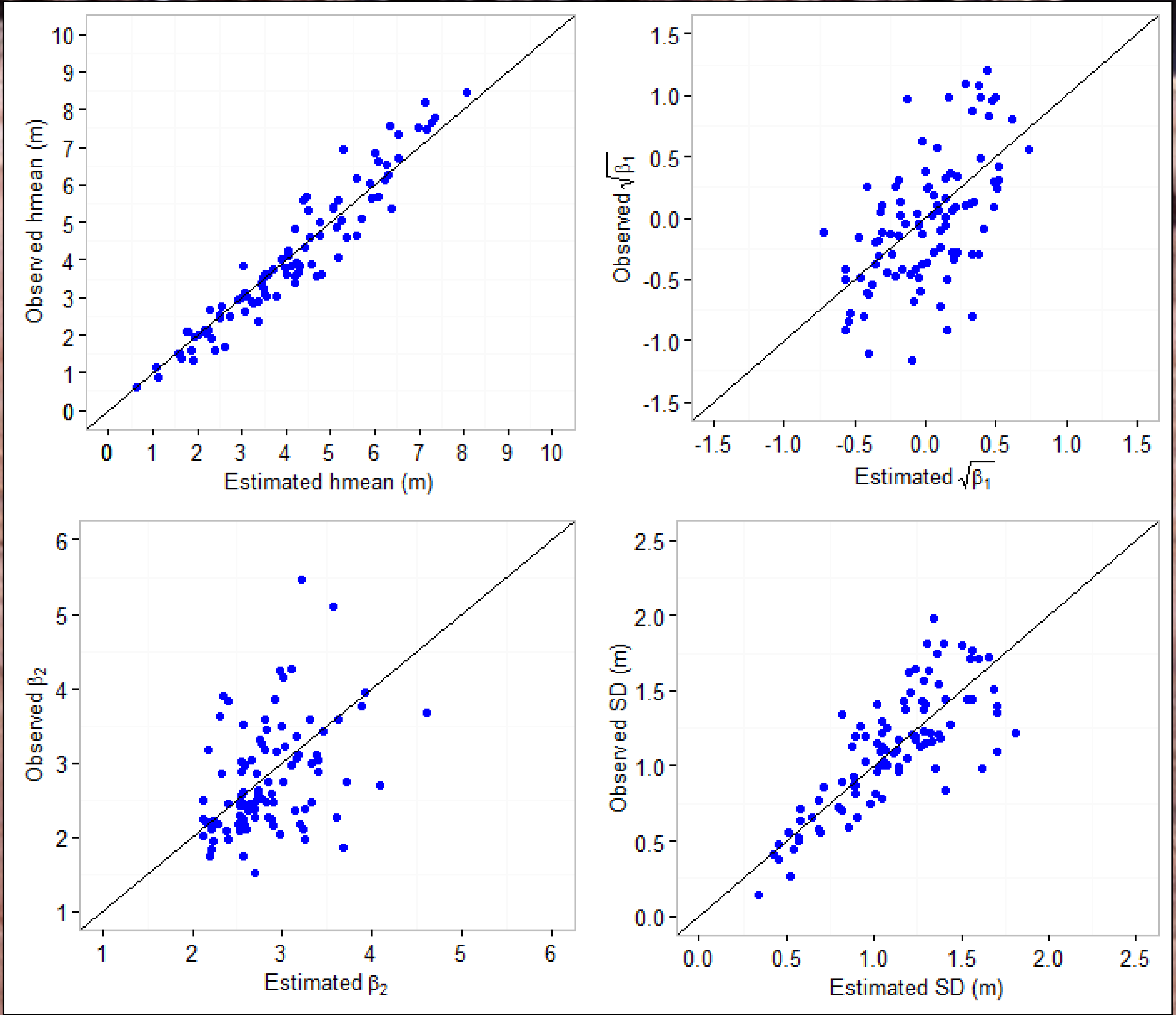
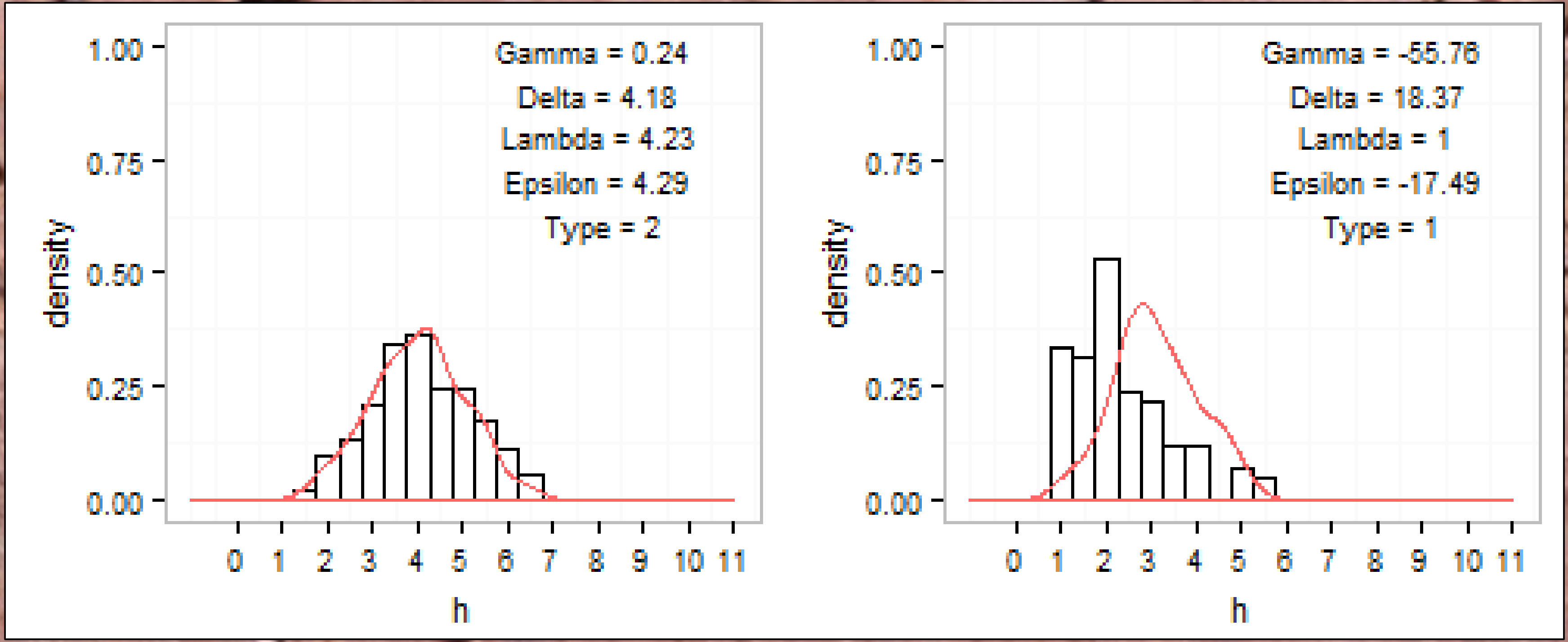


Observed hmean (m)
Estimated hmean (m)
Observed $\sqrt{\beta_1}$
Estimated $\sqrt{\beta_1}$
Observed β_2
Estimated β_2
Observed SD (m)
Estimated SD (m)

3. SIMULATION



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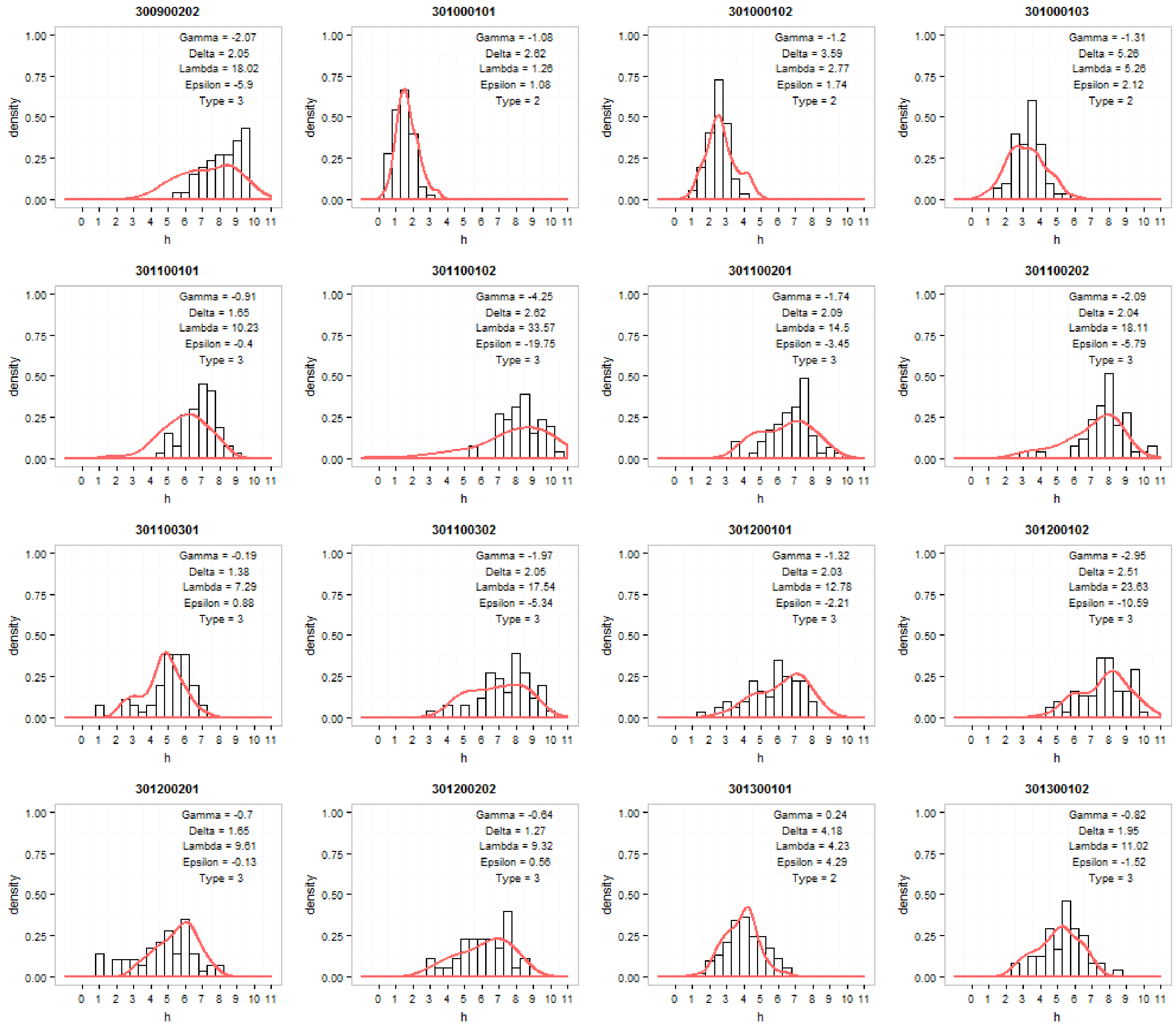

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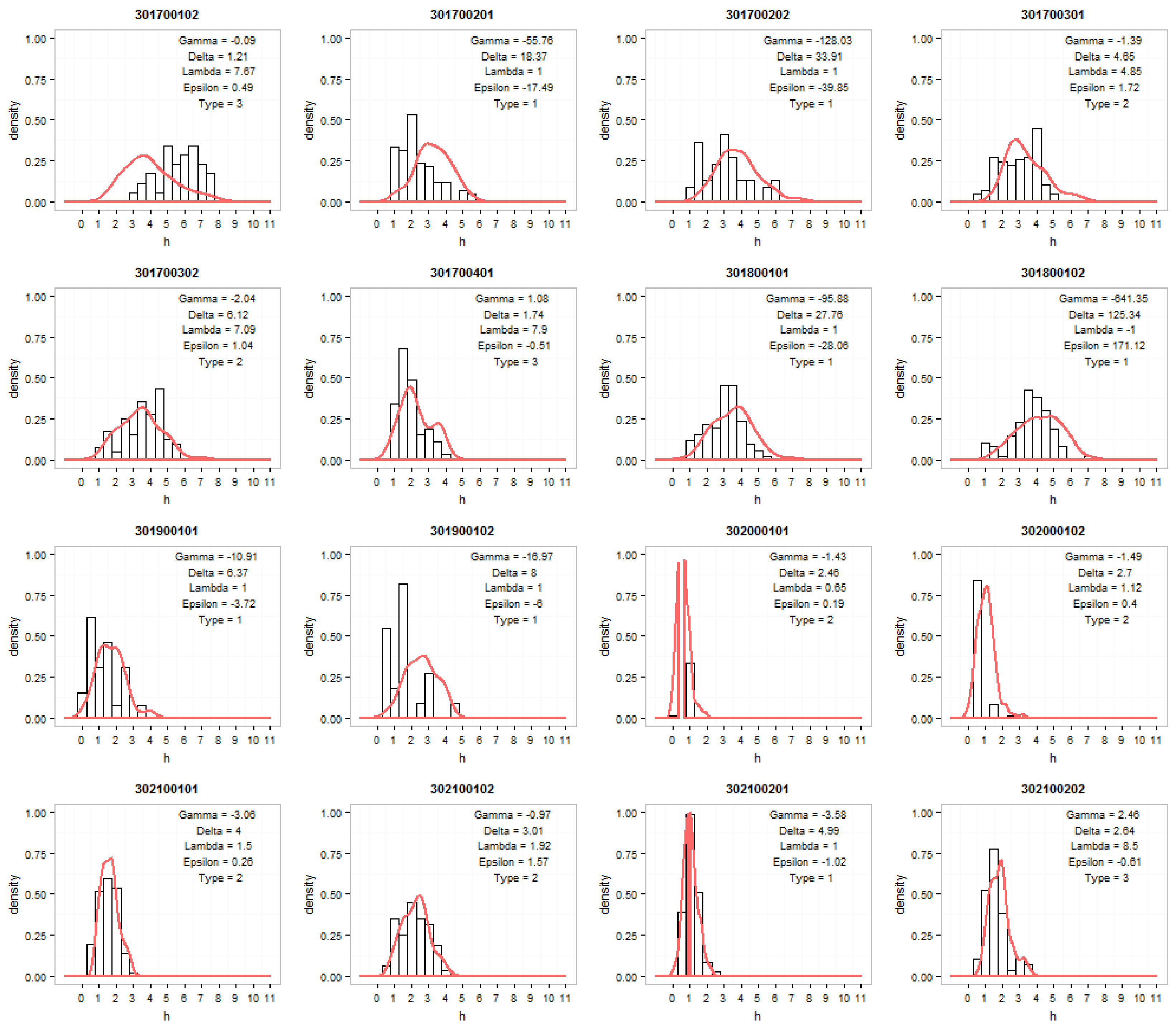

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1. The Johnson’s distribution is the best p.d.f.

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2. Linear regression → standard deviation & skewness models

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6. No pattern explains the behavior of the other 34%

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5. 66% plots measurements (K-S test)→ simulated ∼ observed

6. No pattern explains the behavior of the other 34%

7. Acceptable simulation of the height distributions


OBRIGADO!!!
ÁGUA

Characterization and Conservation of Wetlands with Global Change Dynamics: A Case Study on Ratargul Swamp Forest, Bangladesh

Author: Akbar Hossain Kanan

Supervisor: Prof. Dr. Maria Teresa Ferreira

Dr. Maria do Rosário Fernandes

Contents

1. Introduction

- ✓The RAMSER convention: wetlands are the permanent or temporary water body. In case of marine water depth, the low tide does not exceed 6 m (Sultana, et al., 2009).
- ✓Wetland is considered as the "Biological Supermarket" (Nabahungu and Visser, 2011).
- ✓Wetland acts as kidney and buffer (Kangalawe and Liwenga, 2005).
- ✓Wet land plays a vital role in the development of human culture and society with the provision of tangible and intangible benefits (Islam, 2010).

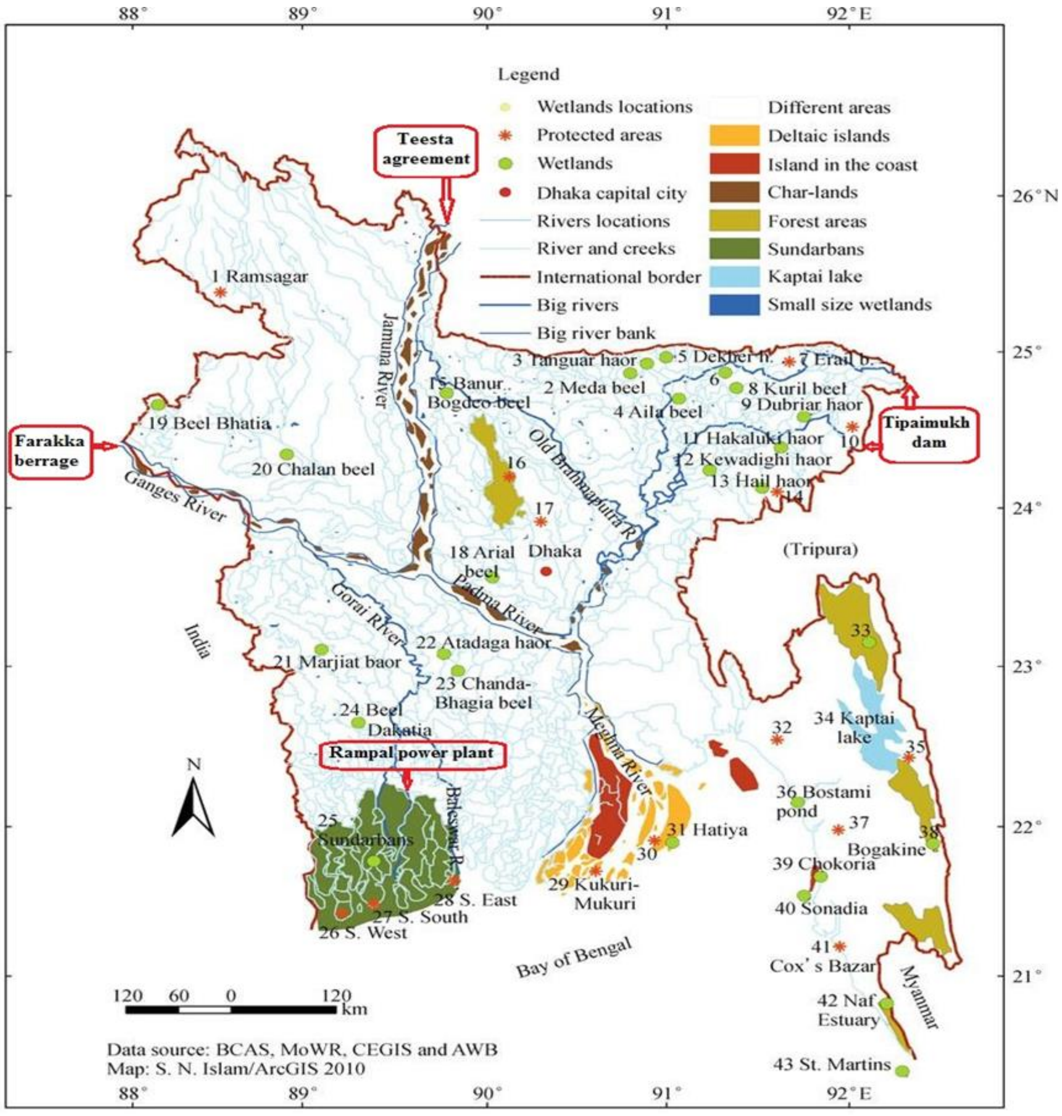
1. Introduction

- ✓Most importantly wetland resources play imperative role for livelihood security of poor and developing countries (Opio, 2011).
- ✓However, high rate of population growth and excess resources extraction from the wet lands are the major problems for sustainability.
- ✓Geographically most of the areas of Bangladesh lie in the largest delta in the world.
- ✓About, 700 rivers has flowed across the country where 50% of total lands are wetland.

1. Introduction

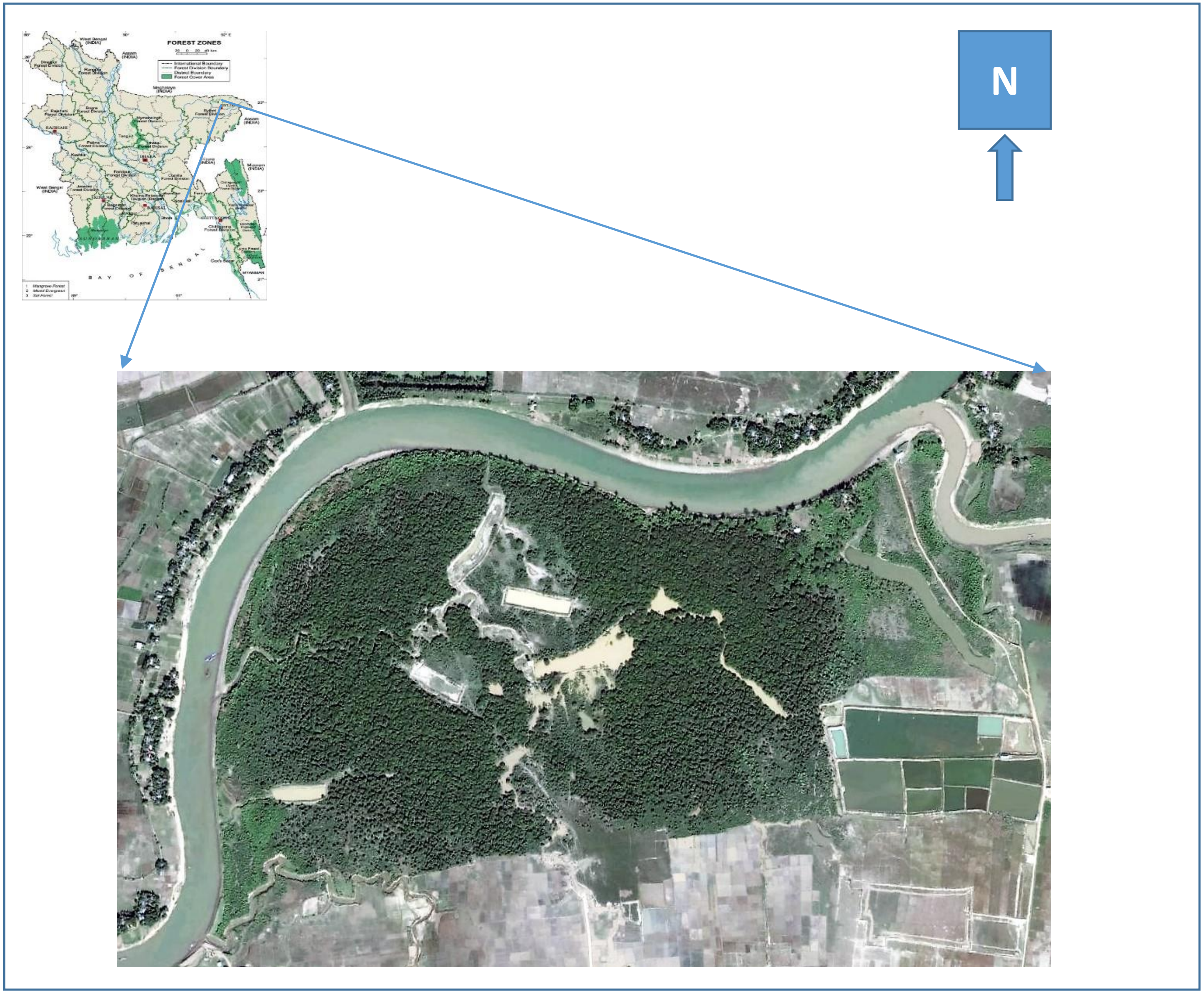
- ✓5,000 spp of flowering plants; 1,500 spp of vertebrates including 750 spp of birds; 500 spp of coastal, estuarine, fresh water fishes inhabit in the wetlands area; 260 species of fresh water fishes exist in the wetlands (Bhuiyan, 2013).
- ✓About, 50% people are directly depended on wetland resources for livelihood (Islam, 2010) where, 6-8% revenue comes from only haor areas (Bhuiyan, 2013).
- ✓70% of animal protein of the country comes from fresh water fishes (Bhuiyan, 2013).

1. Introduction



Major wetlands and ecologically sensitive areas

2. Study area (Ratargul Swamp Forest)



2. Study area (Ratargul Swamp Forest)

- This is only one fresh water swamp forest of Bangladesh with special features, locally called “Amazon of Bangladesh” (Dey, 2013)

- About 73 spp of plants, 26 spp of mammals, 175 spp of birds (including 46 migratory birds), 9 amphibians, 4 spp of snakes, 20 spp of reptiles exist in this wetland (IUCN, 2004).

- About 94 spp of fish inhabit in the forest. Among them 28 spp are threatened, of which 14 are vulnerable, 10 are endangered and 4 are critically endangered (Islam et al., 2016).

2. Study area (Ratargul Swamp Forest)

- It ensure better socio-economic life of rural people by providing job opportunities, food and nutrition, fuel, fodder, transportation, irrigation, tourism.......

- This swamp forest are now considerable threat due to man-made disturbances.

For instance, over fishing (complete fishing by dewatering, gearing and fencing), navigation, irrigation, agricultural land expansion, infrastructure, human habitat, deforestation, tourism activities, illegal hunting of birds and animal, use of pesticides and other activities.

3. Objectives

i. To find out characteristics, functions, values and services

ii. To explore the role of wetland on livelihood security of local people

iii. To find out disturbances and the best management options

4. Methodology

- ❑ Used qualitative and quantitative approaches

1. **Primary data collection:** PRA technique was used in 5 villages to collect socio-economic information. From each village-

   a) Households survey (30)

   b) Key informant interview (5)

   c) Focus group discussion (2)

4. Methodology

2. Secondary data collection: To locate peer reviewed journal two web based engines were used.

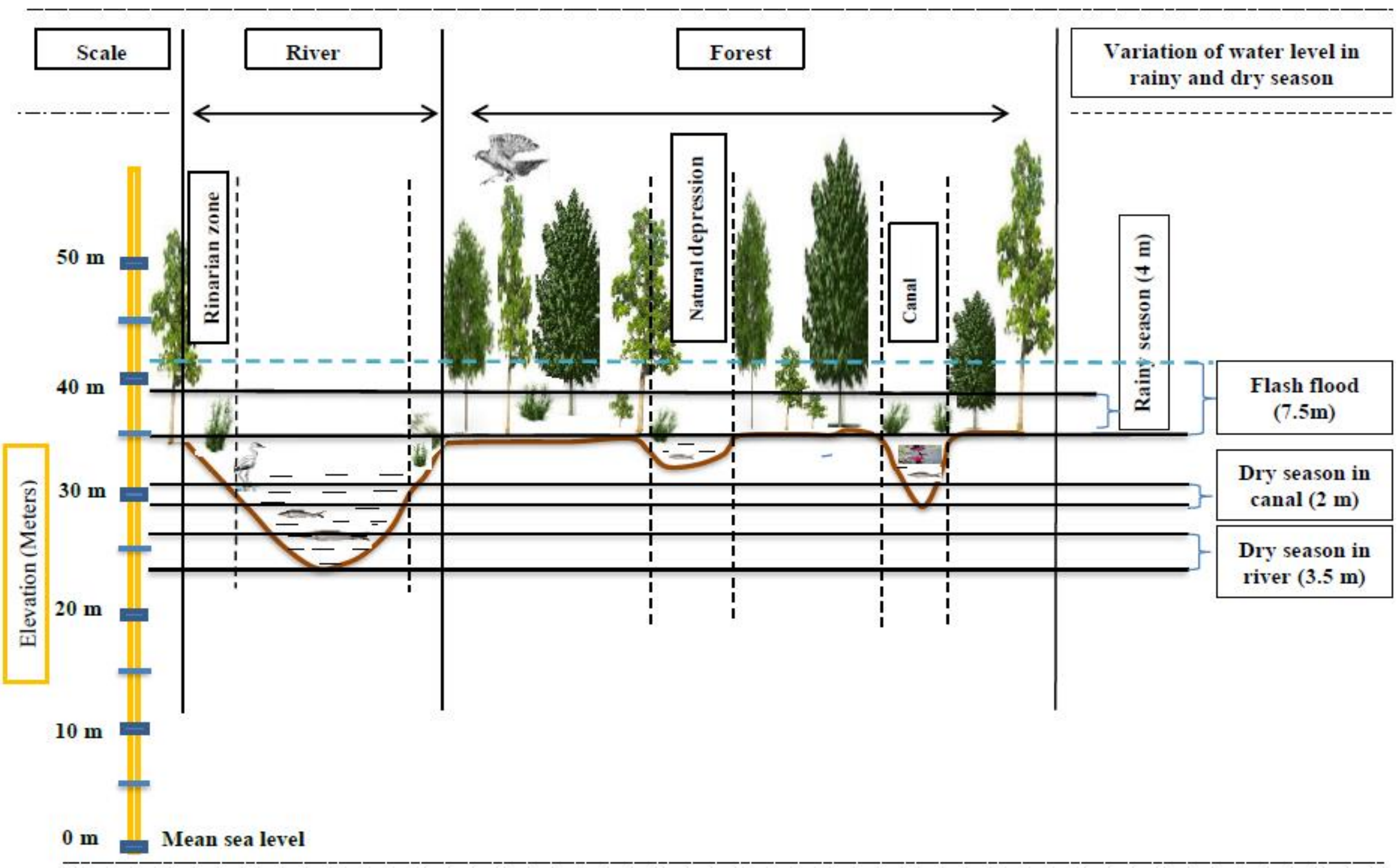
a) Science direct

b) Proquest

3. **GIS approach:** Arc-GIS was used to find out land used change from 2005 t0 2015.

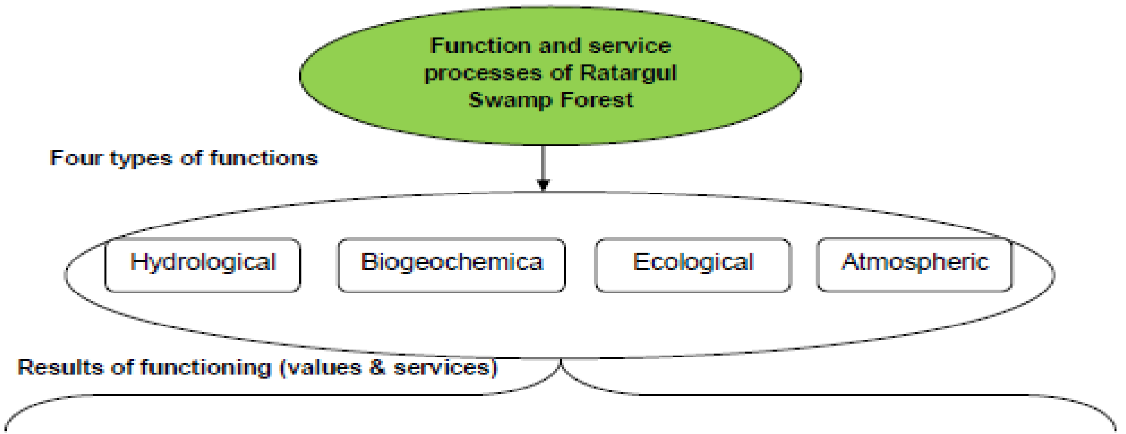
5. Results and discussions

5.1 Landscape setting and variation of water level in different seasons



5. Results and discussions

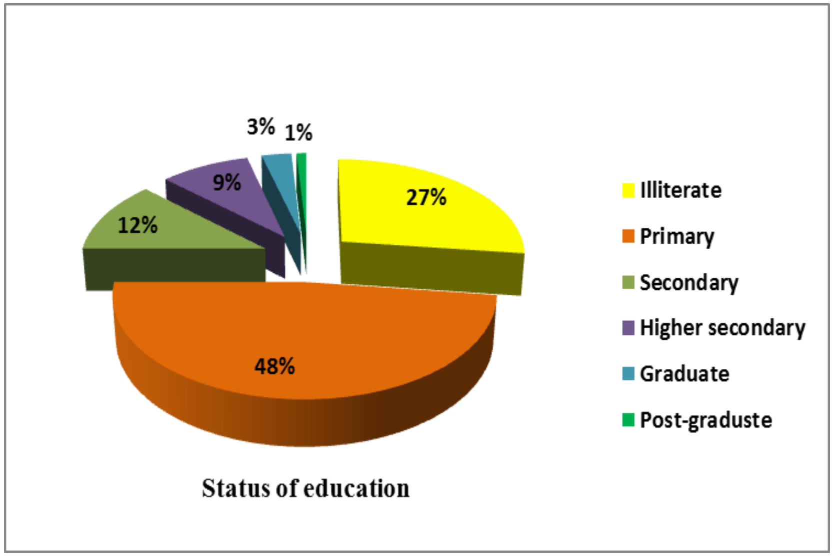
5.2 Function and ecosystem services

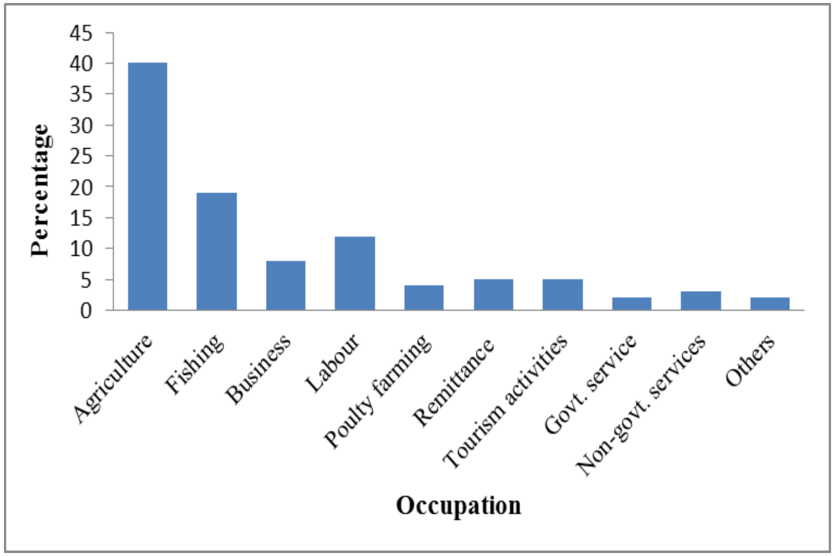


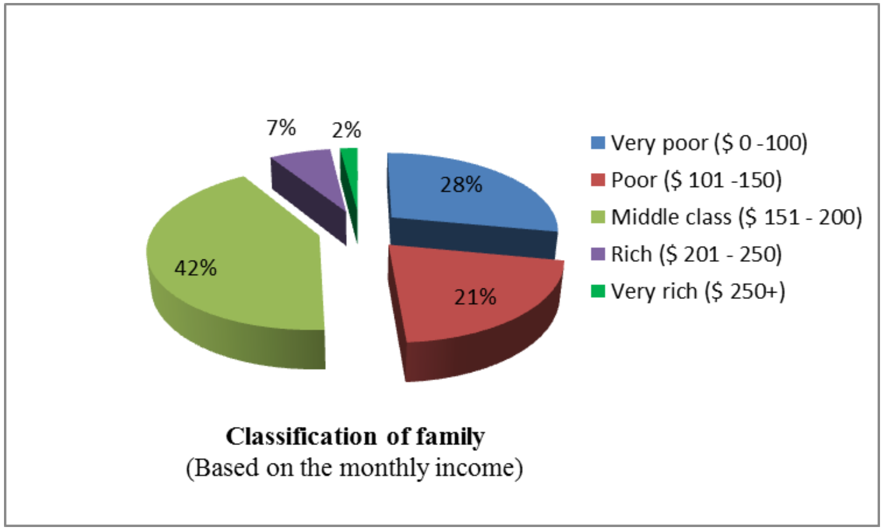
Values of swamp forest	Types of ecosystem services
Environmental	Maintenance of hydrological cycle, water storage and discharge, flood control and regulation, transport of sediments, purification of water, pollution control, reduce of erosion, soil formation, food chain and habitat maintaining, biodiversity protection, maintenance of landscapes and balance of ecology etc.
Economic	
Direct value	Agriculture, forestry, fishing, hunting, wild food, grazing, livestock, fuel, fodder, honey, fruits and wood, supply of raw materials and other direct values.
Indirect value	Benefits from improvement of water quality, storm and flood prevention, pollution control, drought control, provision for medicinal plants etc.
Option value	Benefits from ensuring the option for a future use.
Existence value	Benefits from conserving or willingness to sacrifice a part of one's income in order to conserve resource especially natural amenities.
Bequest value	Benefits from ensuring that certain goods will be preserved for future generations.
Social	Provision of settlement, migration, field of education and research, employment opportunity and livelihood security and others social activities.
Cultural	Ecotourism and recreation, cultural heritage, natural heritage, cultural landscapes and beauty, cultural values, aesthetic values, spiritual values, ethical values etc.

5. Results and discussions

5.3 Socio-economic status and dependency of local people of swamp forest area

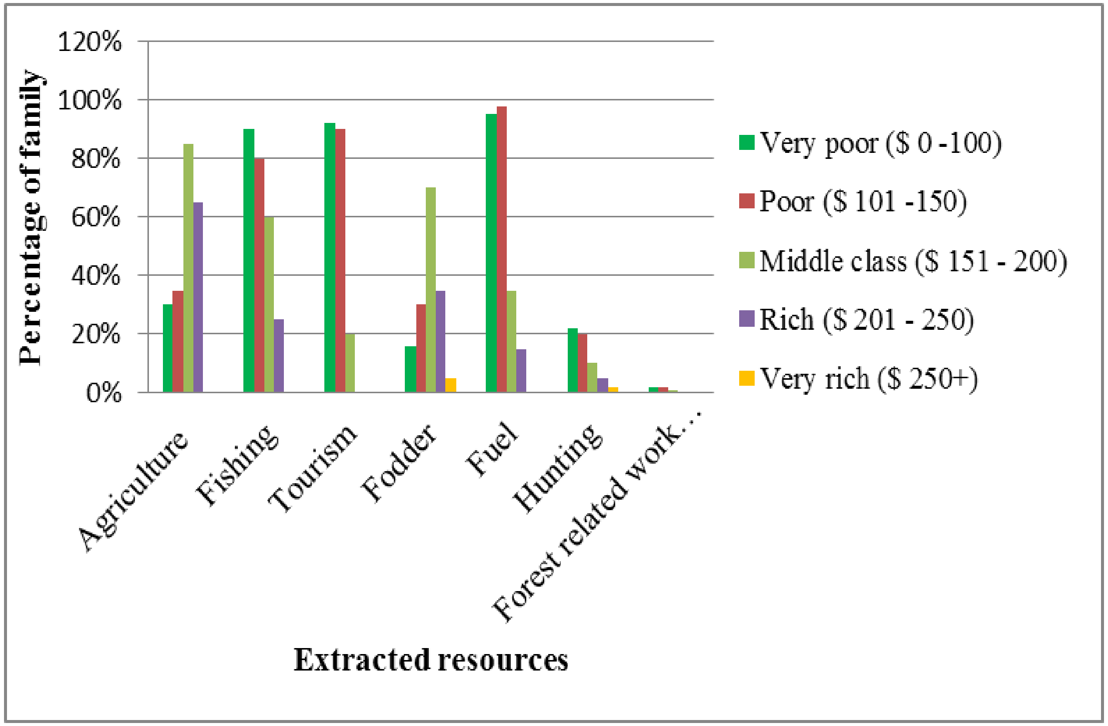






5. Results and discussions

5.4 Alternative occupation and income sources related to swamp forest



5. Results and discussions

5.5 Existing problems in Ratargul Swamp Forest

1. **Man made disturbances include:** Excess collection of fuel wood, medicinal plants, illegal felling, over fishing, irrigation, grazing and agricultural land expansion, infrastructure, human habitat, tourism activities, illegal hunting……

Fuel wood collection

Illegal felling

Extreme fishing

Grazing and agricultural expansion

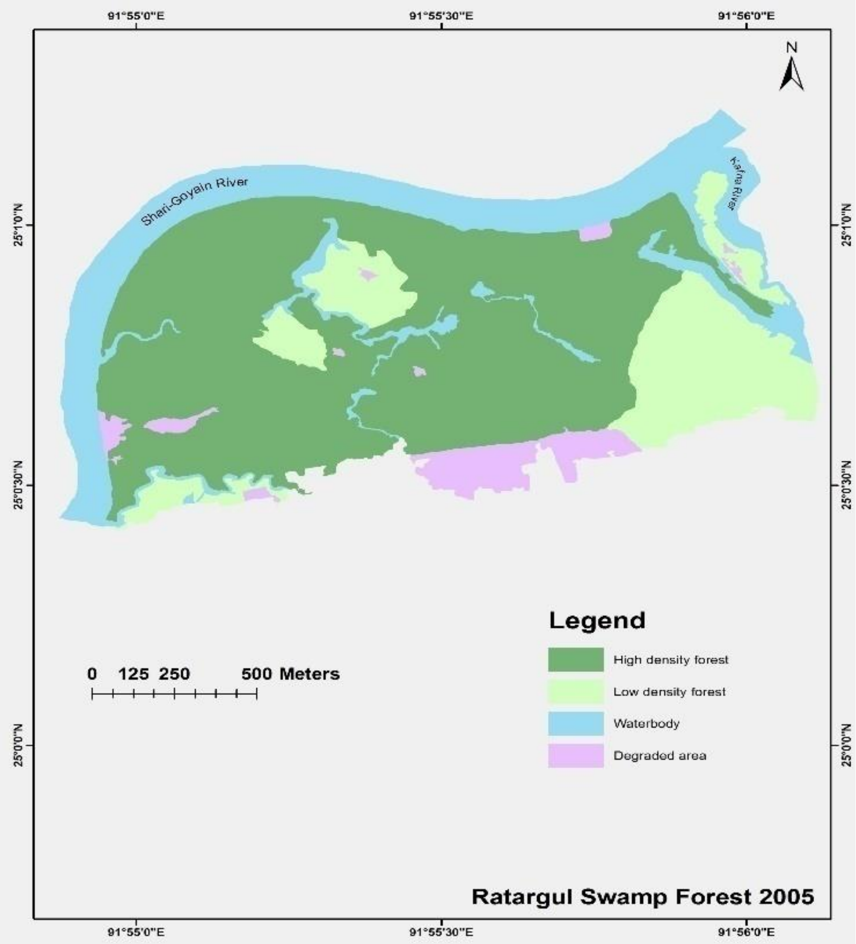
5. Results and discussions

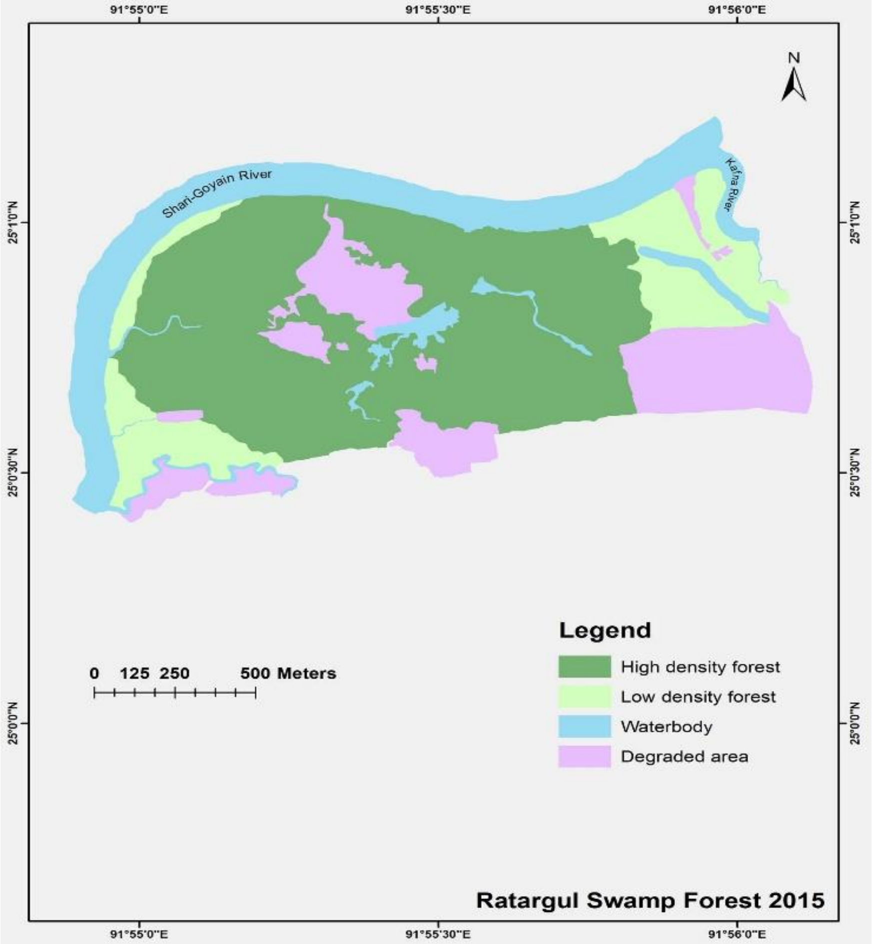
2. **Climate change impact:**

- Irregular and heavy rainfall
- Flash flood
- Storm
- Certain variation temperature
- Siltation etc.

5. Results and discussions

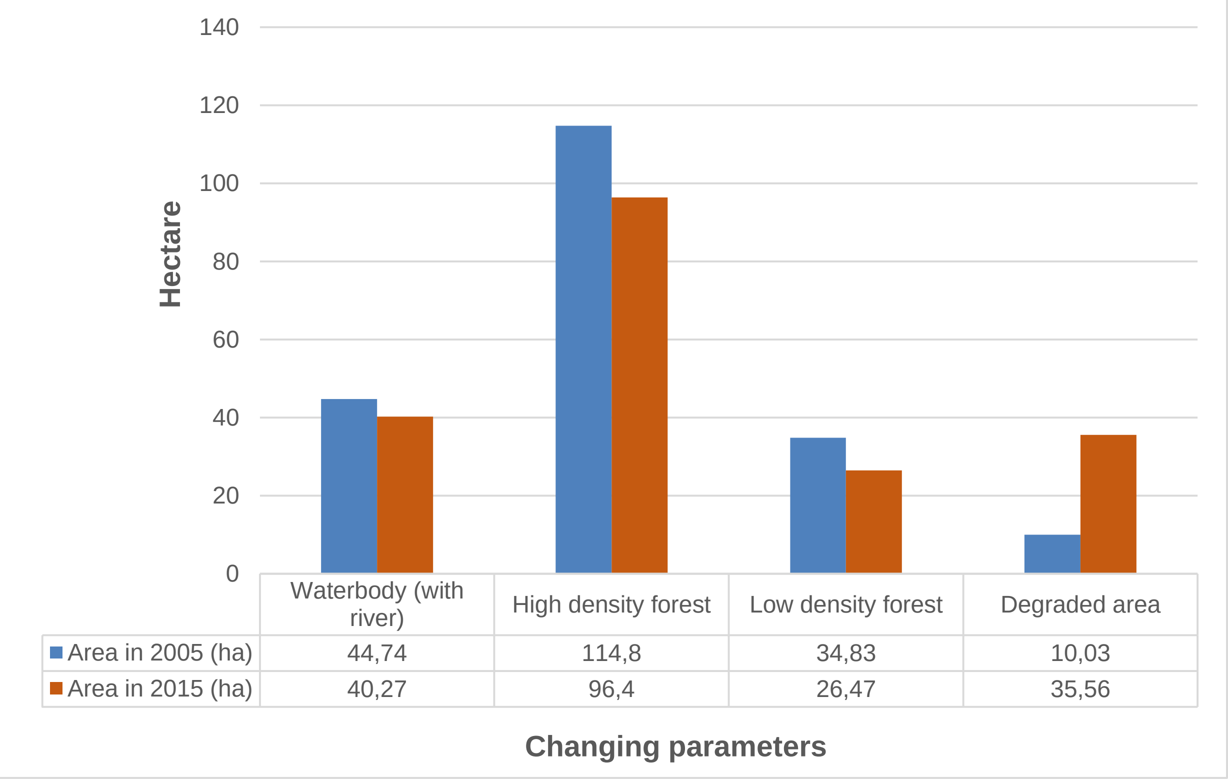
5.6 Consequence of problems based on periodic map analysis (2005 and 2015)





5. Results and discussions

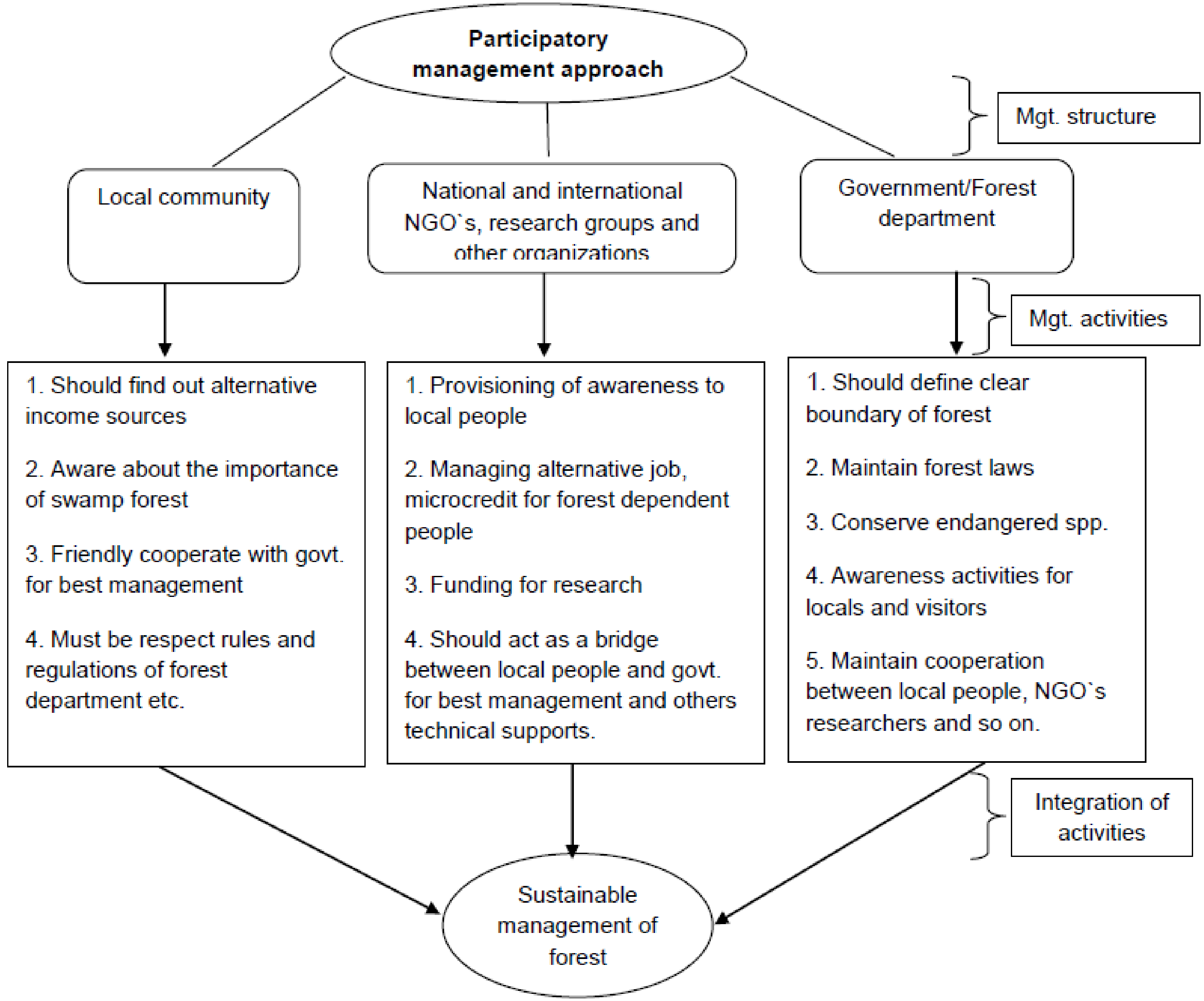
5.7 Criteria of land use change between the year of 2005 and 2015



	Waterbody (with river)	High density forest	Low density forest	Degraded area
Area in 2005 (ha)	44,74	114,8	34,83	10,03
Area in 2015 (ha)	40,27	96,4	26,47	35,56

5. Results and discussions

5.8 Proposed management approach to overcome existing problems



6. Conclusion

- ❖ In Bangladesh, 50% of people directly dependent on wetland resources and 70% of animal protein comes from freshwater fish.
- ❖ Ratargul Swamp Forest is located 35 m above mean from sea level. The height of the forest floor water level is varied in different seasons.
- ❖ This forest provides various products and ecosystem services, which plays a key role in the livelihood of the local population.

6. Conclusion

❖ But, degradation and disturbance of the forest is significant.

For instance, the high-density forest was reduced in 18.40 hectares and the deraded area increased by 25.53 ha from 2005 to 2015.

❖ However, the **participatory forest management approach** could be an effective tool for sustainable management.

Education and Culture
Erasmus Mundus

MEDfOR

THANK YOU FOR YOUR KIND ATTENTION!

LISBOA Universidade de Lisboa
Università degli Studi di Padova
Universitat de Lleida
Universidad de Valladolid
Università degli Studi della Tuscia
Universidade Católica Portuguesa

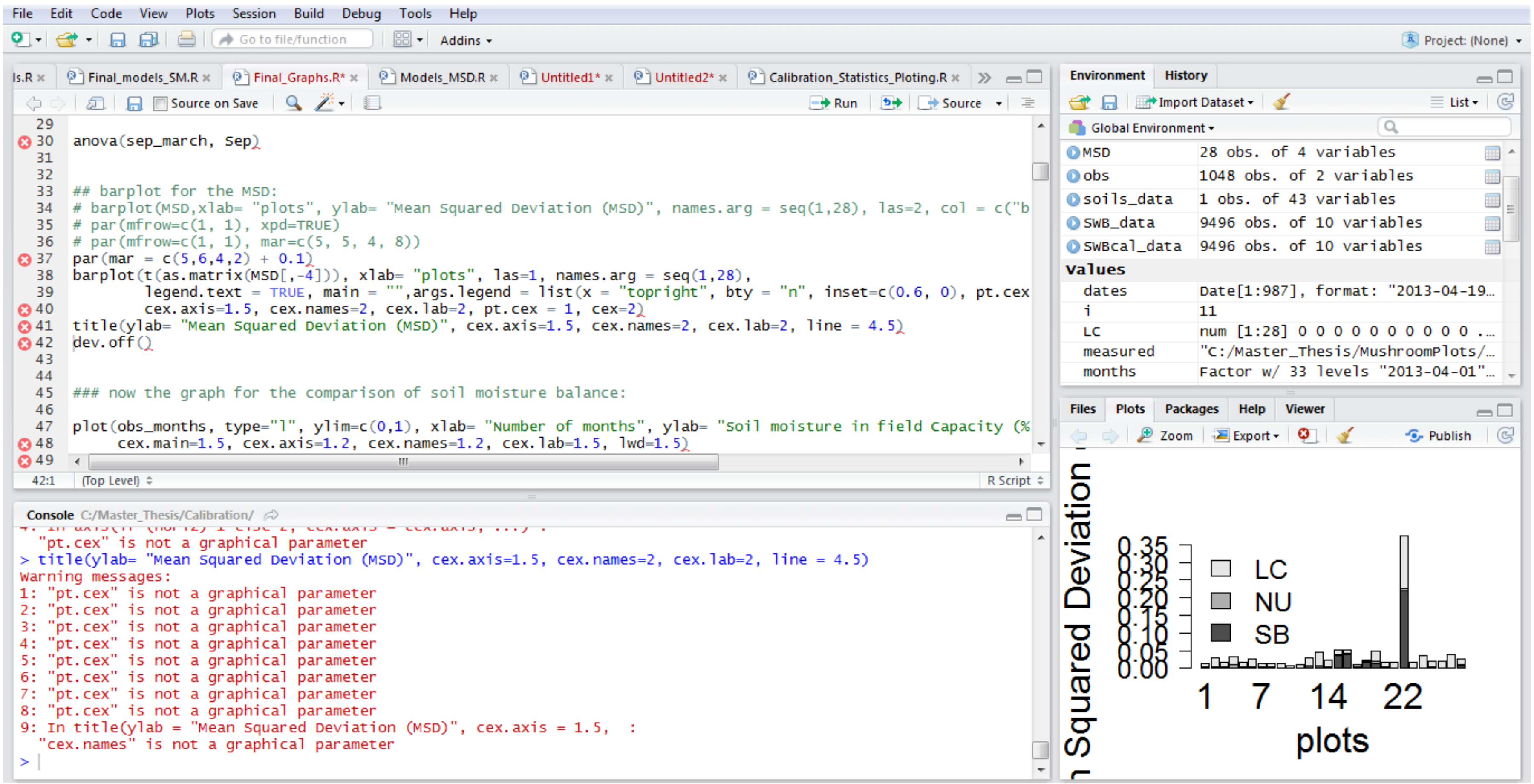
Effect of climatic and micro-climatic conditions on the provisioning of fungal-based ecosystem services in Mediterranean pine stands

Asaf Karavani

Sergio de Miguel and Miquel De Cáceres

These are mushrooms

These are also mushrooms



Outline

- Introduction
- Objective
- Materials and methods
- Results & Discussion
- Conclusions

Introduction

- Fungal-based ecosystem services (ES):
  - Provisioning
  - Supporting
  - Regulating
  - Cultural
- The cultural ES has a significant importance in the Mediterranean.

Introduction

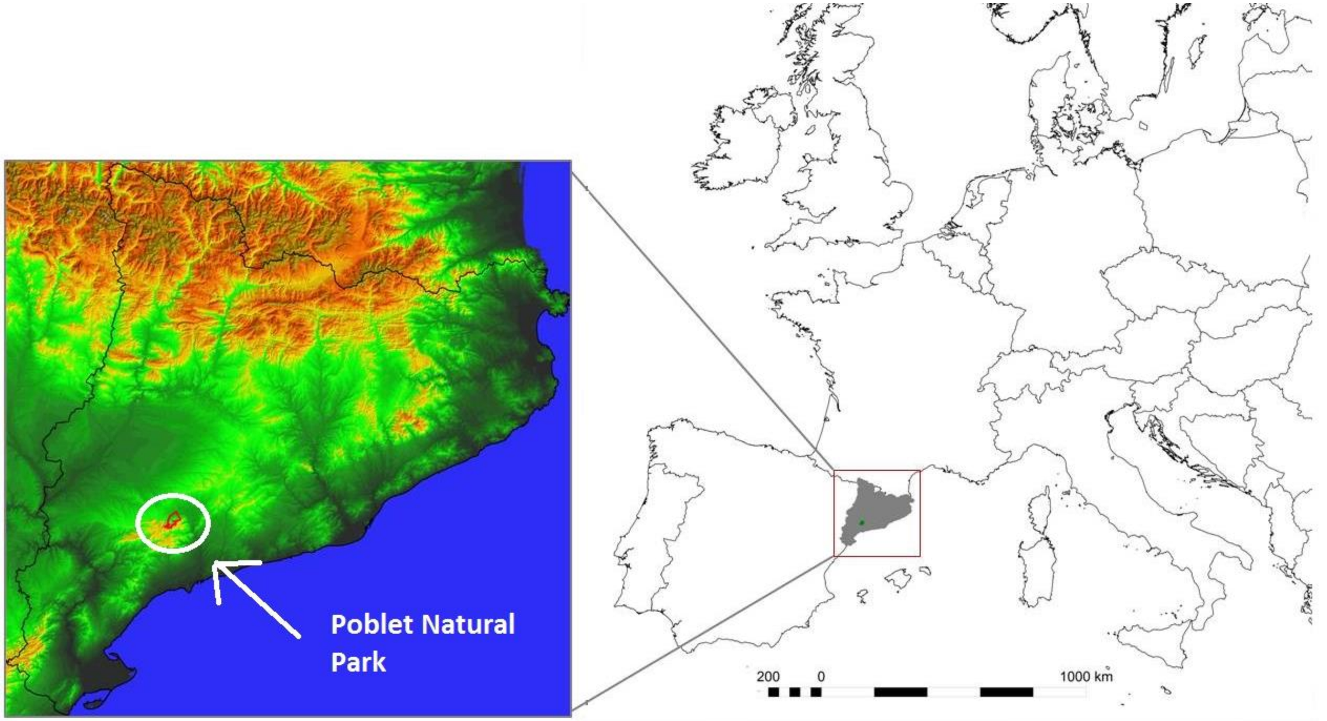
- Factors affecting mushroom productivity:
  - Climate
  - Site and soil characteristics
  - Forest structure
- Micro-climate; plot-specific climate.
  - What is micro-climate?
  - Soil moisture

Objectives

I. How climatic and micro-climatic conditions influence mushroom productivity and fungal-based ES.
II. What is the relationship between climate and micro-climate.
III. Distinguish between conditions required for mushroom emergence and conditions favoring increase in yield.

Materials and methods

- **Location.**
- Mushroom data.
- Climate data.



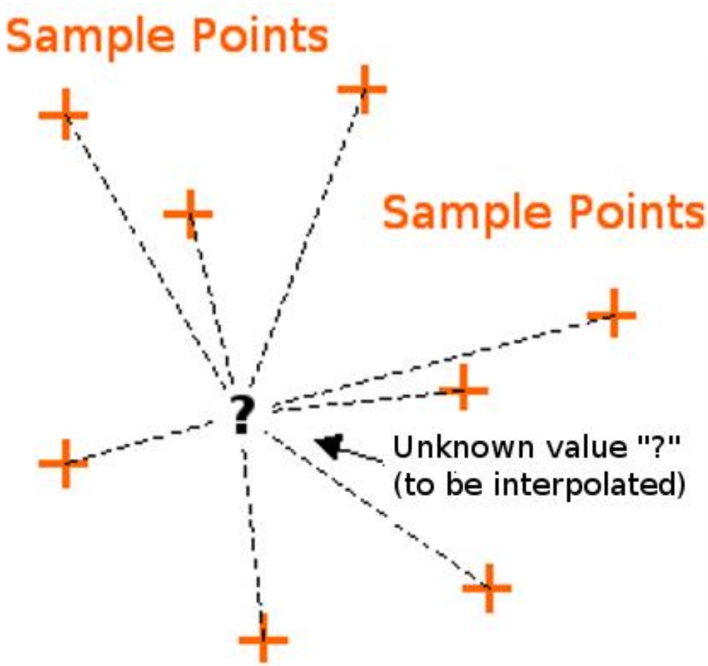
Materials and methods

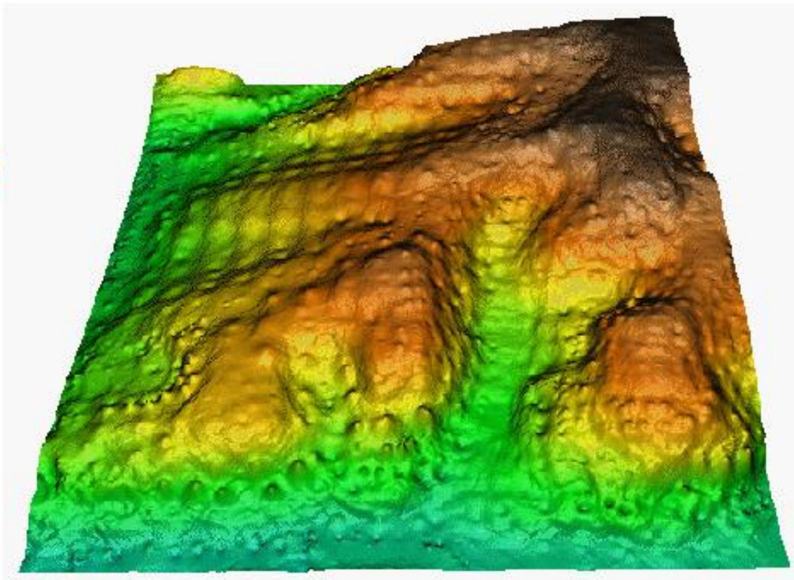
- Location.
- **Mushroom data.**
- Climate data.

	Total	Edible	Marketed
Total number of species	364	119	7
Annual yield (kg ha^{-1} yr^{-1})	2278	1976	978
Dominant species (%)	*Lactarius spp*. 34	*Lactarius spp.* 39	*Lactarius spp*. 79 *Macrolepiota procera* 13

Materials and methods

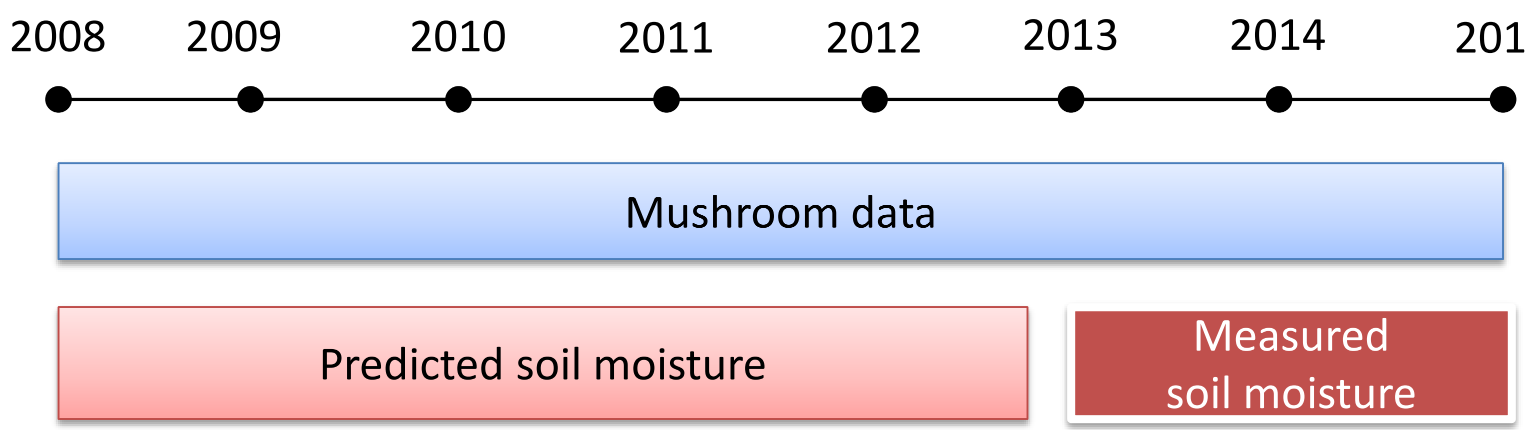
- Location.
- Mushroom data.
- **Climate data.**





Materials and methods

- **Soil moisture data.**
  - Soil water balance model (De Cáceres et al., 2015).
  - Reconstruction of past soil moisture values.



Mushroom production models

mixed-effect models with plot random effects

Climate-based and micro-climate-based

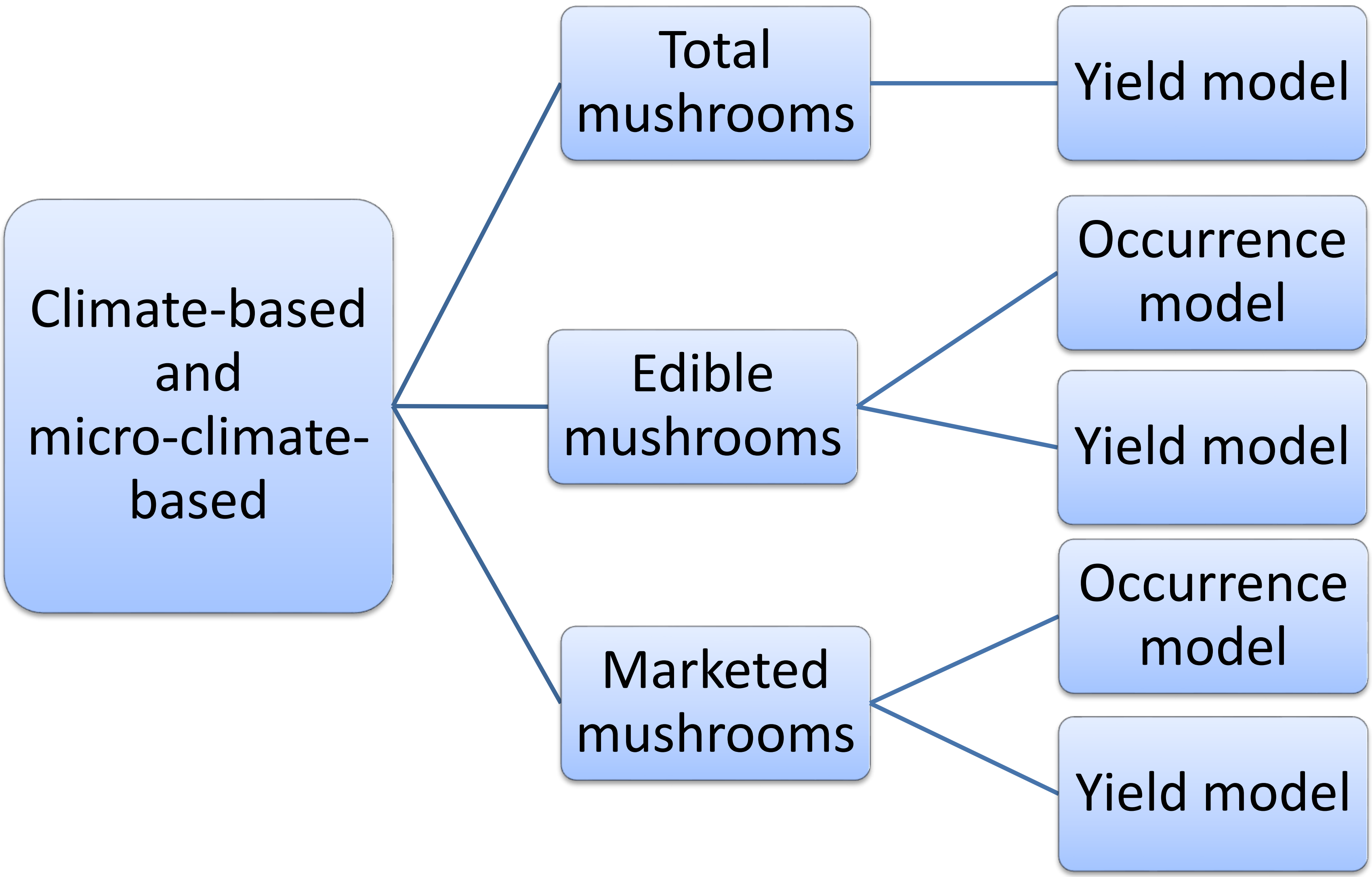
- Total mushrooms
- Edible mushrooms
- Marketed mushrooms

Predictors, monthly values of:

- Precipitation (mm)
- Number of rainy days
- Temperature (C); min, max, average
- Relative humidity (%); min, max, average

Mushroom production models

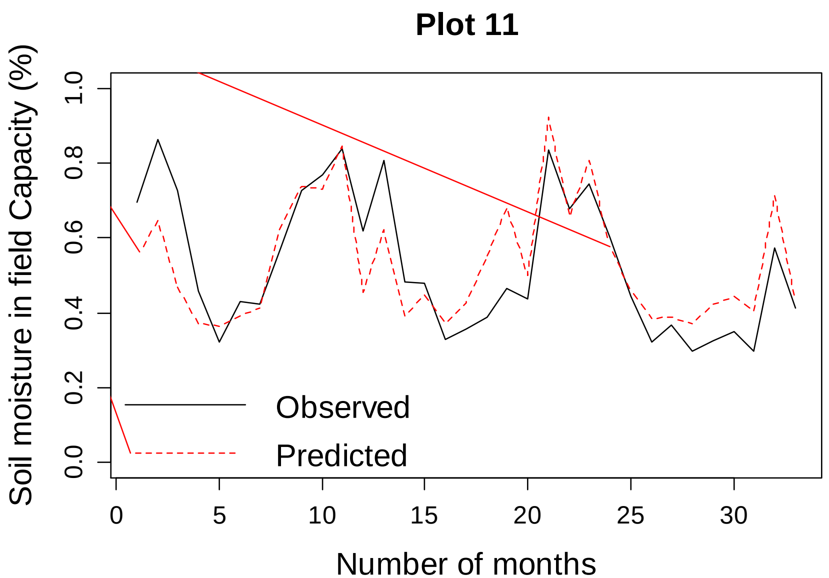
two-stage modelling approach

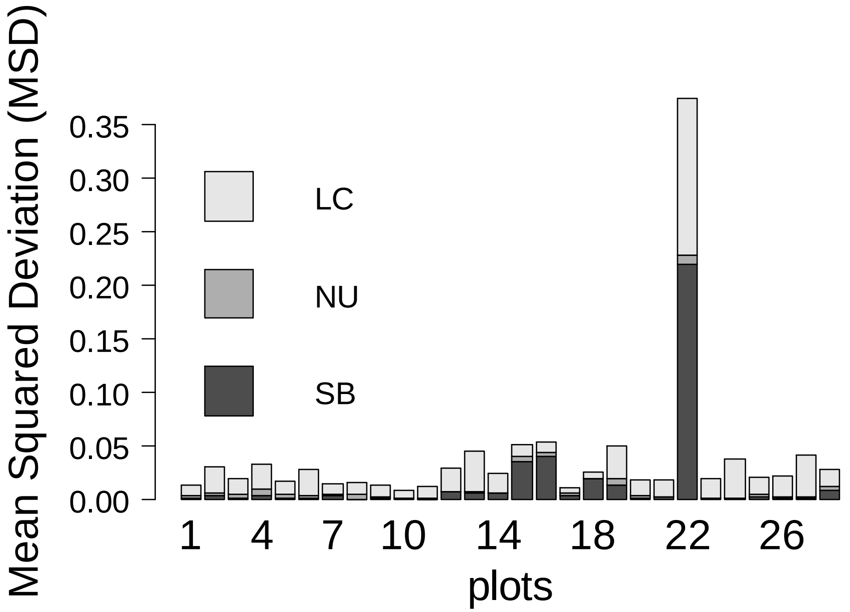


Results & Discussion

Soil water balance model

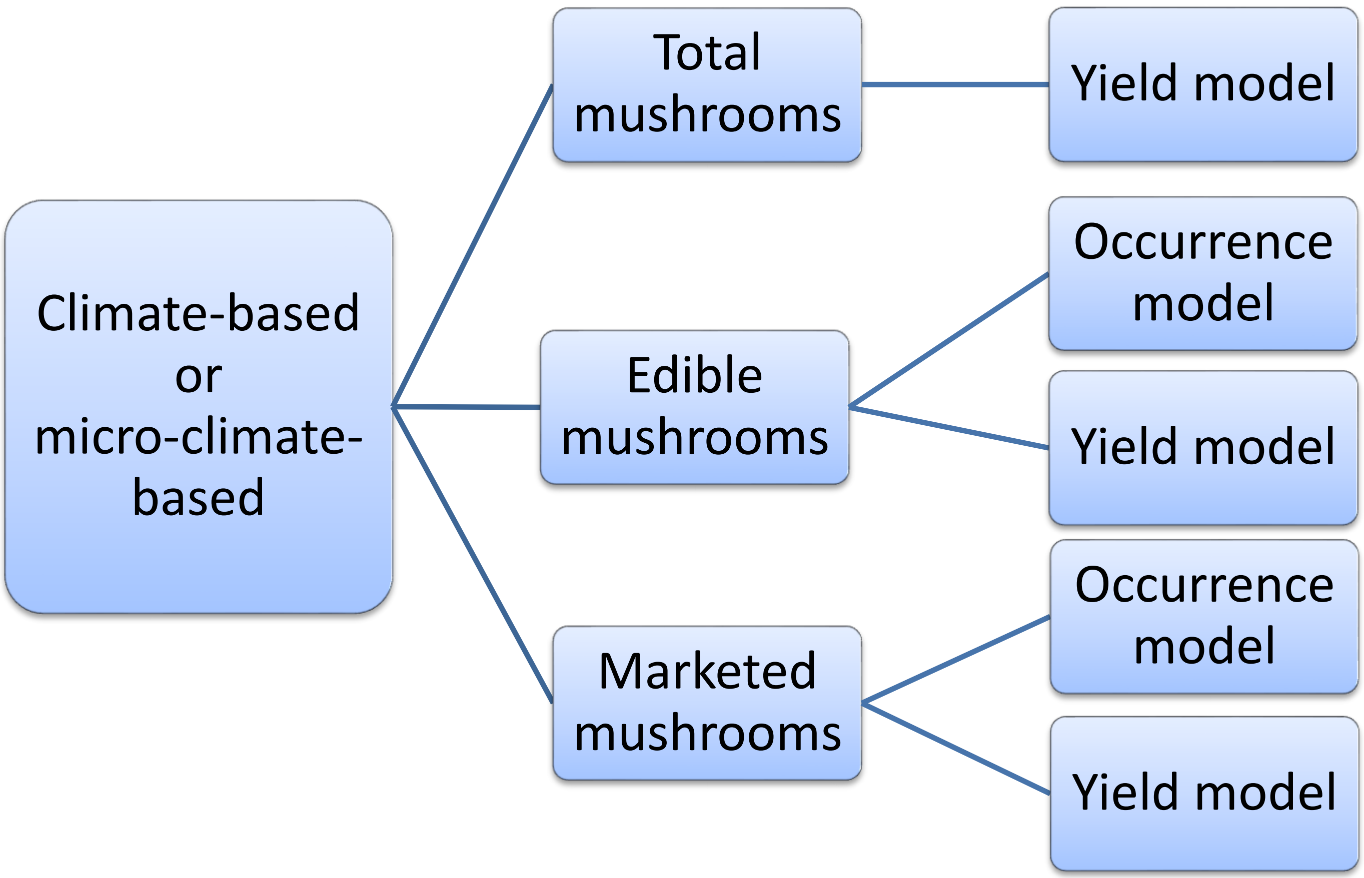
- Observed vs predicted soil moisture.
- Validation and calibration.



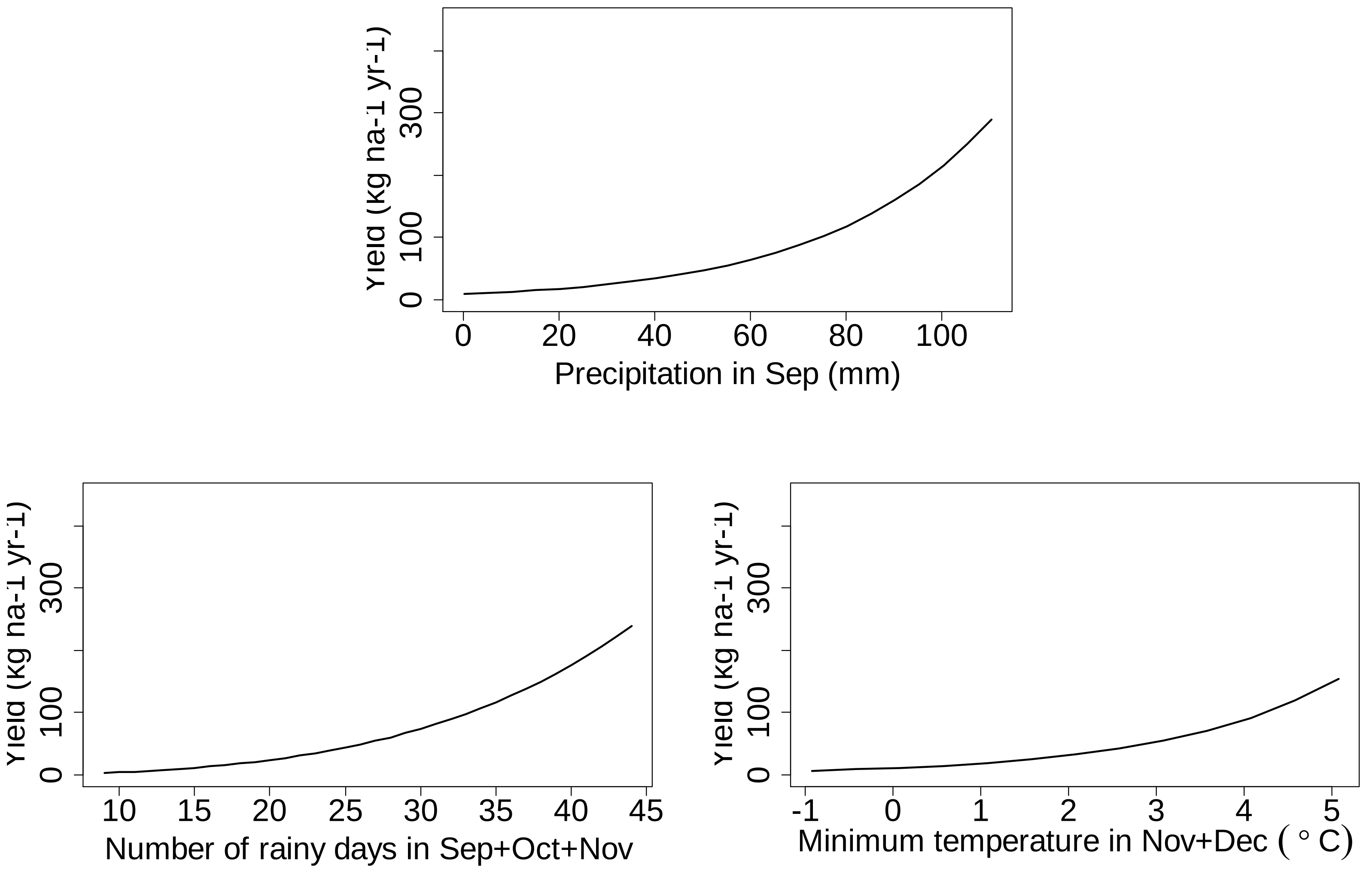


Mushroom production models

selected predictors of each model

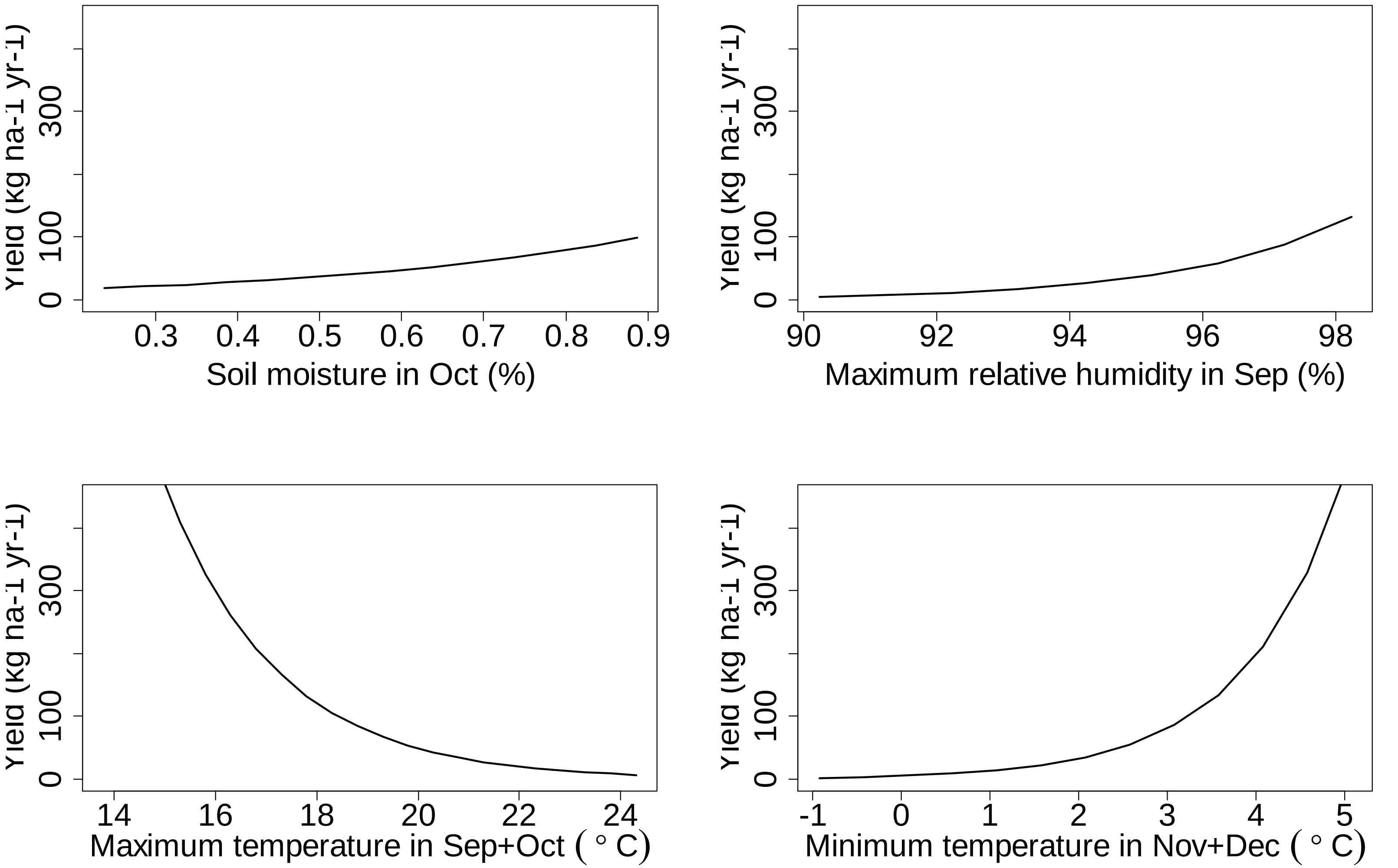


Total mushroom yield
Climate-based model



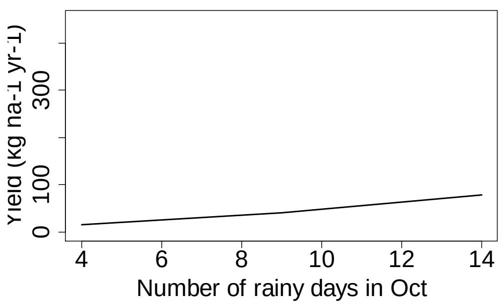
Total mushroom yield

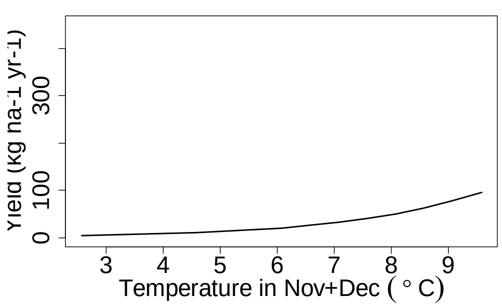
Micro-climate-based model



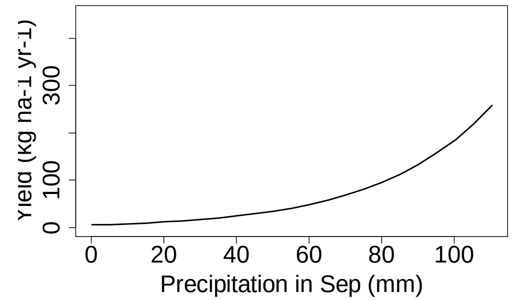
Edible mushrooms:
Climate-based model

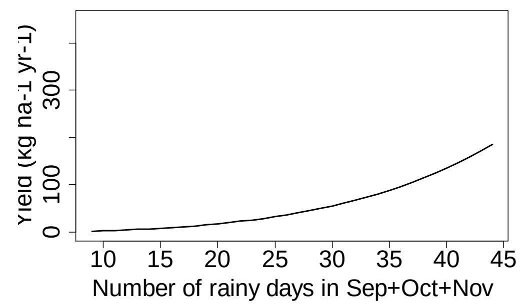
Predictors affecting occurrence model

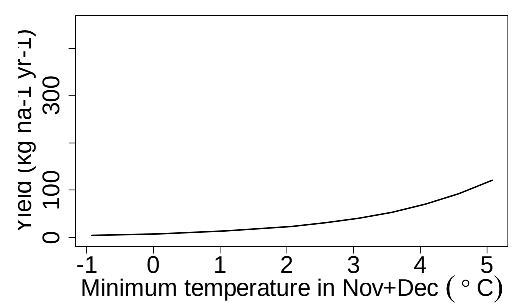




Predictors affecting yield model



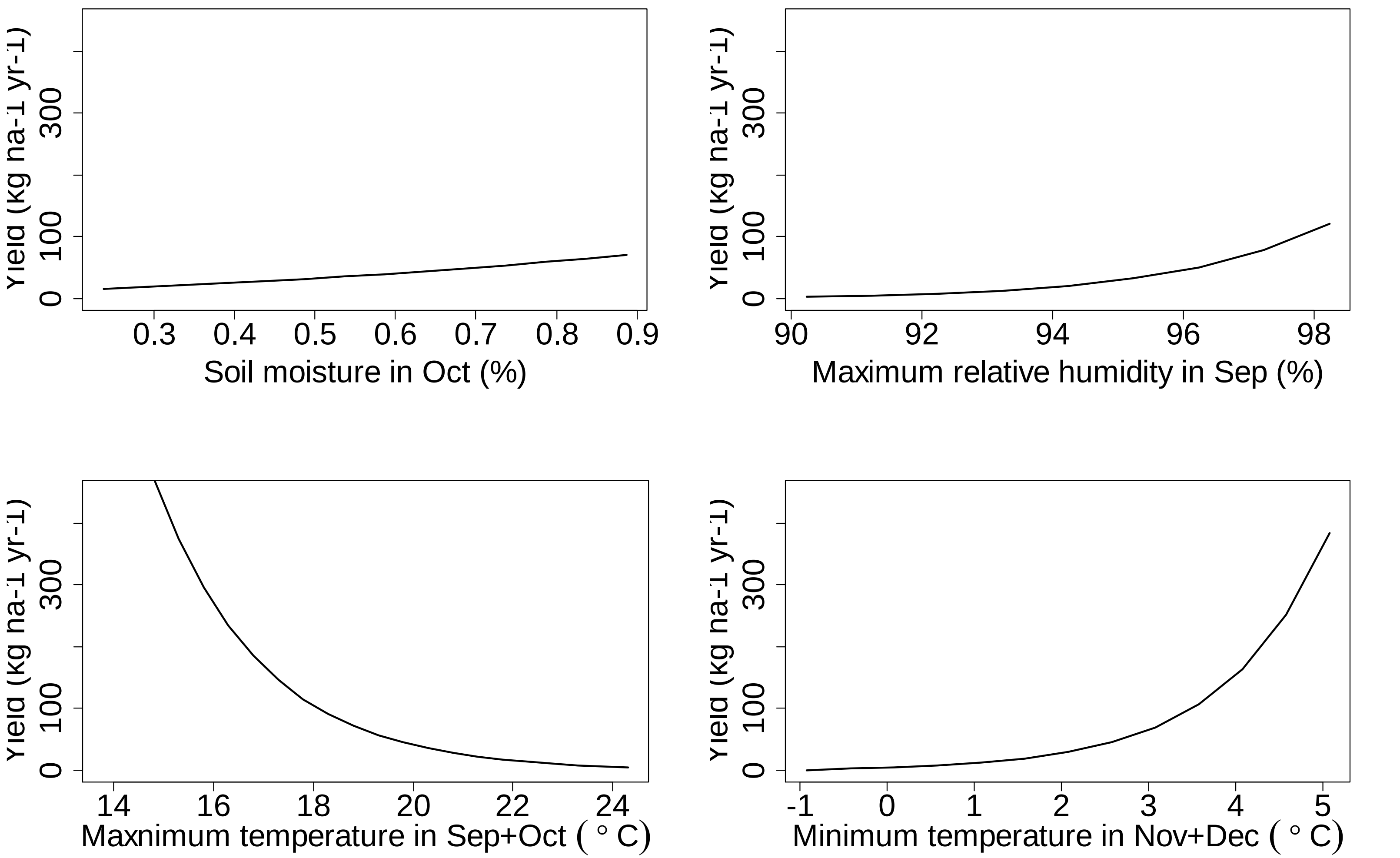




Edible mushrooms

Micro-climate-based model

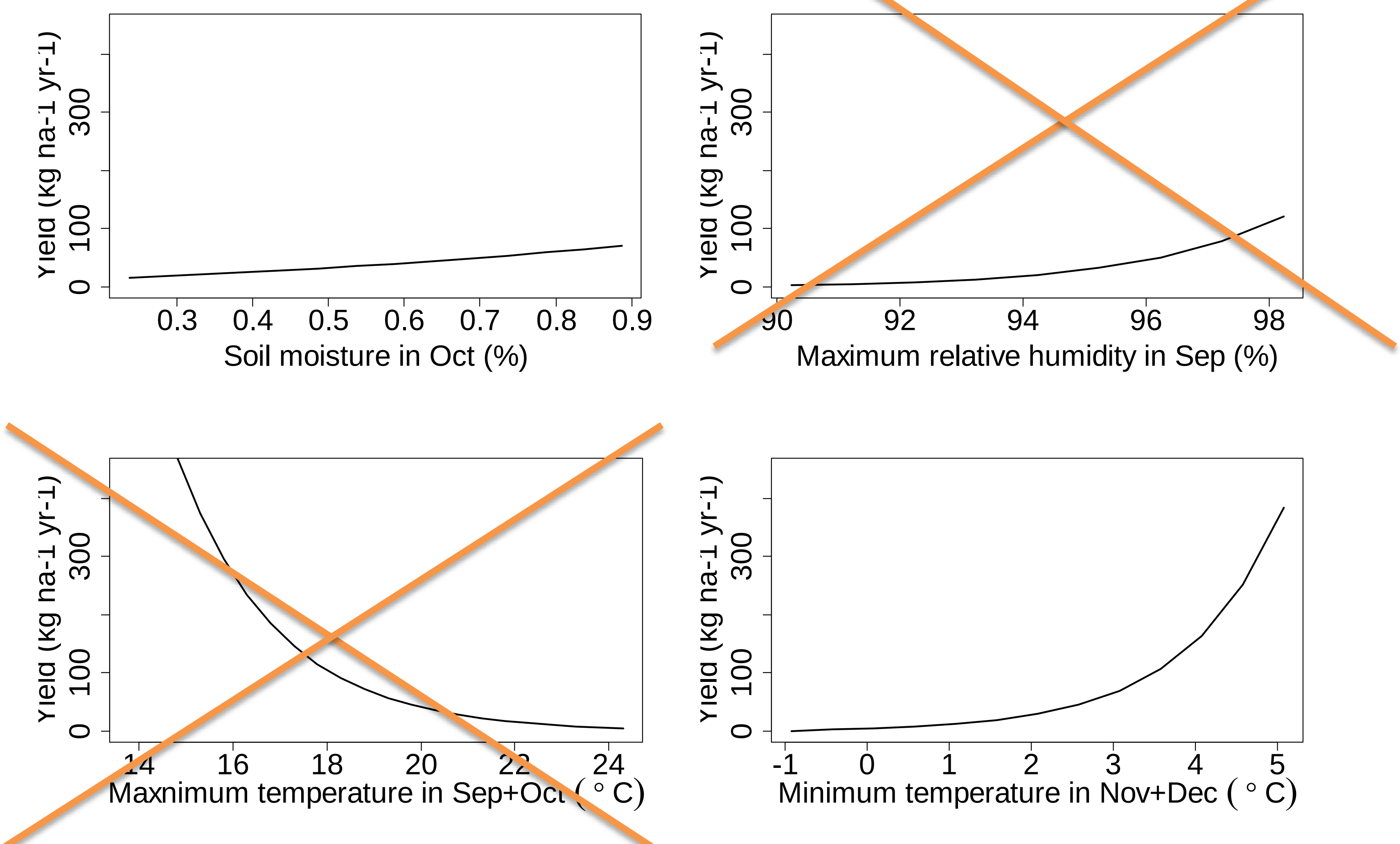
Predictors affecting yield model



Edible mushrooms

Micro-climate-based model

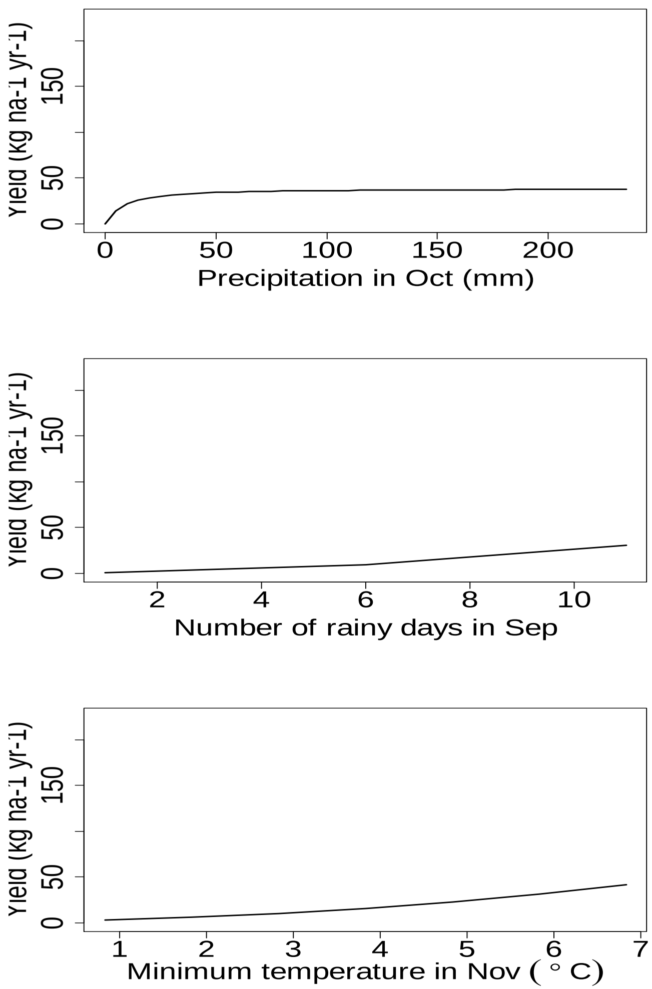
Predictors affecting occurrence model



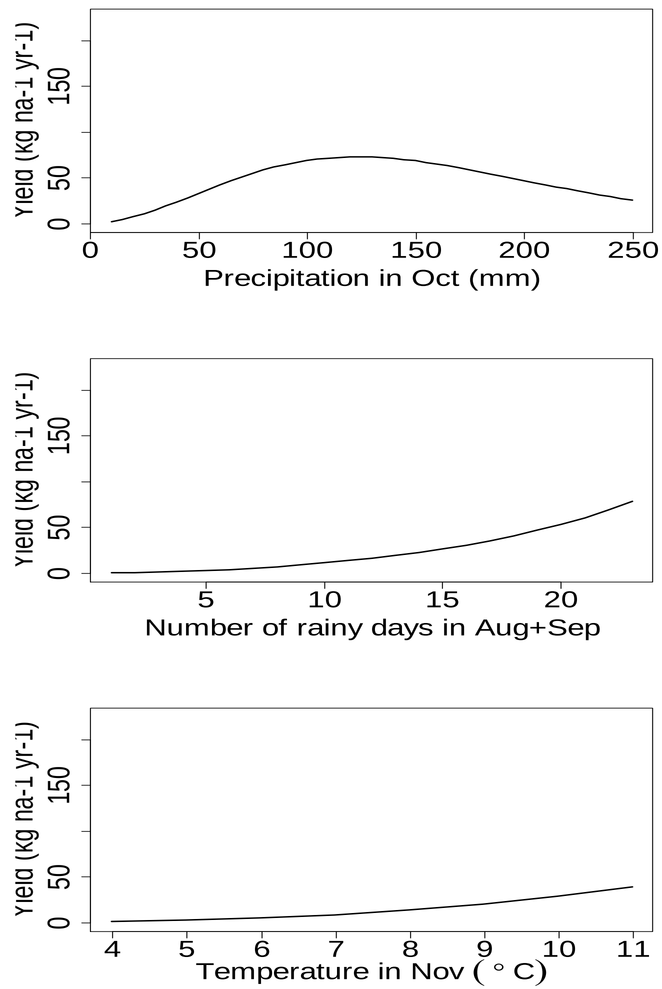
Marketed mushrooms

Climate-based models

Predictors affecting occurrence model



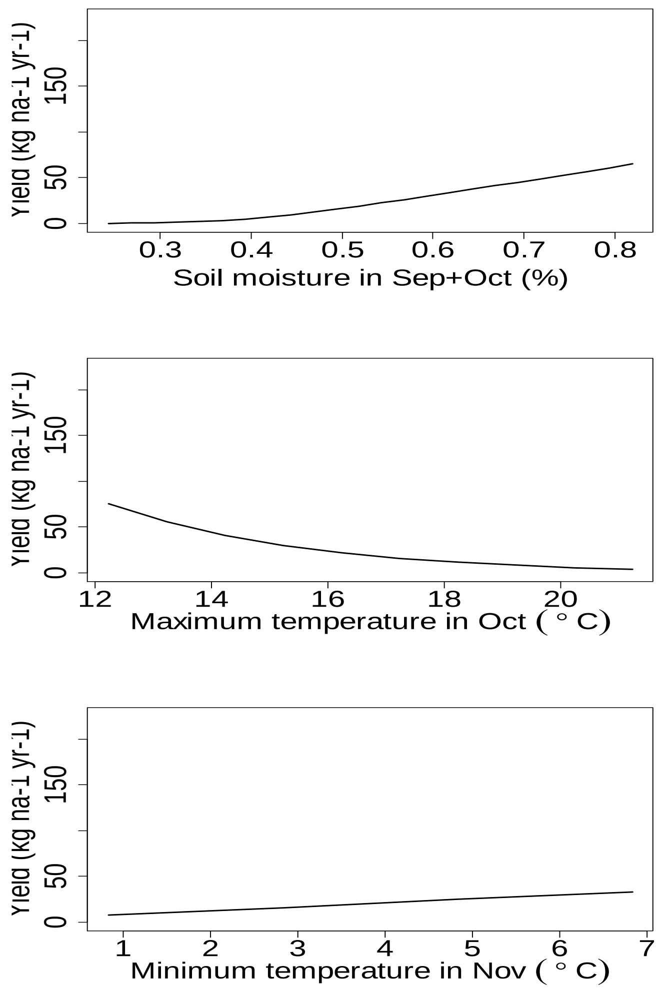
Predictors affecting yield model



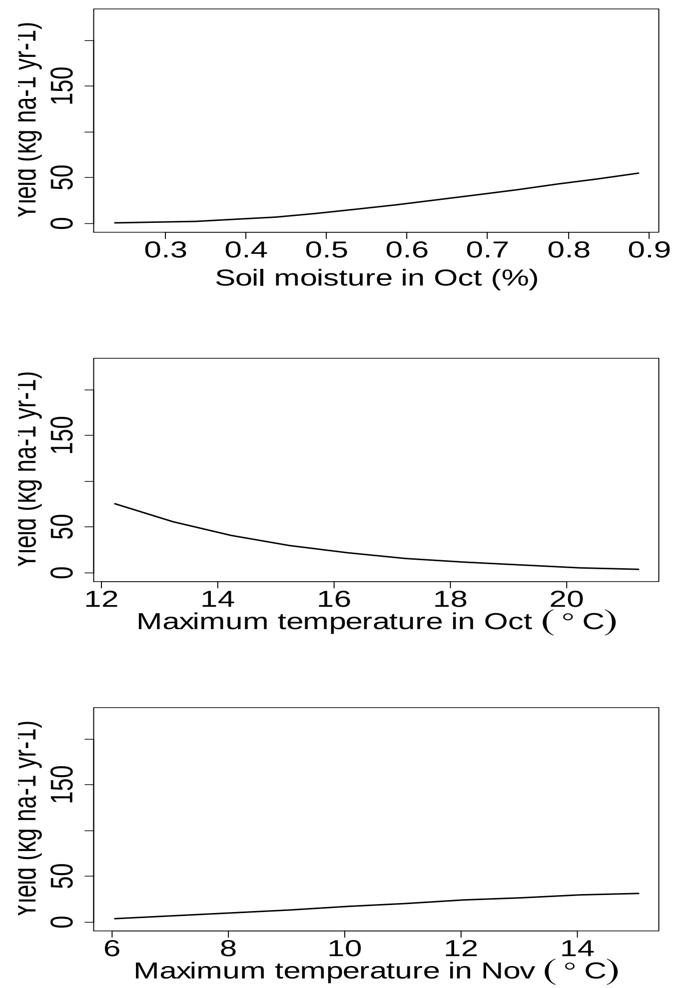
Marked mushrooms

Micro-climate-based models

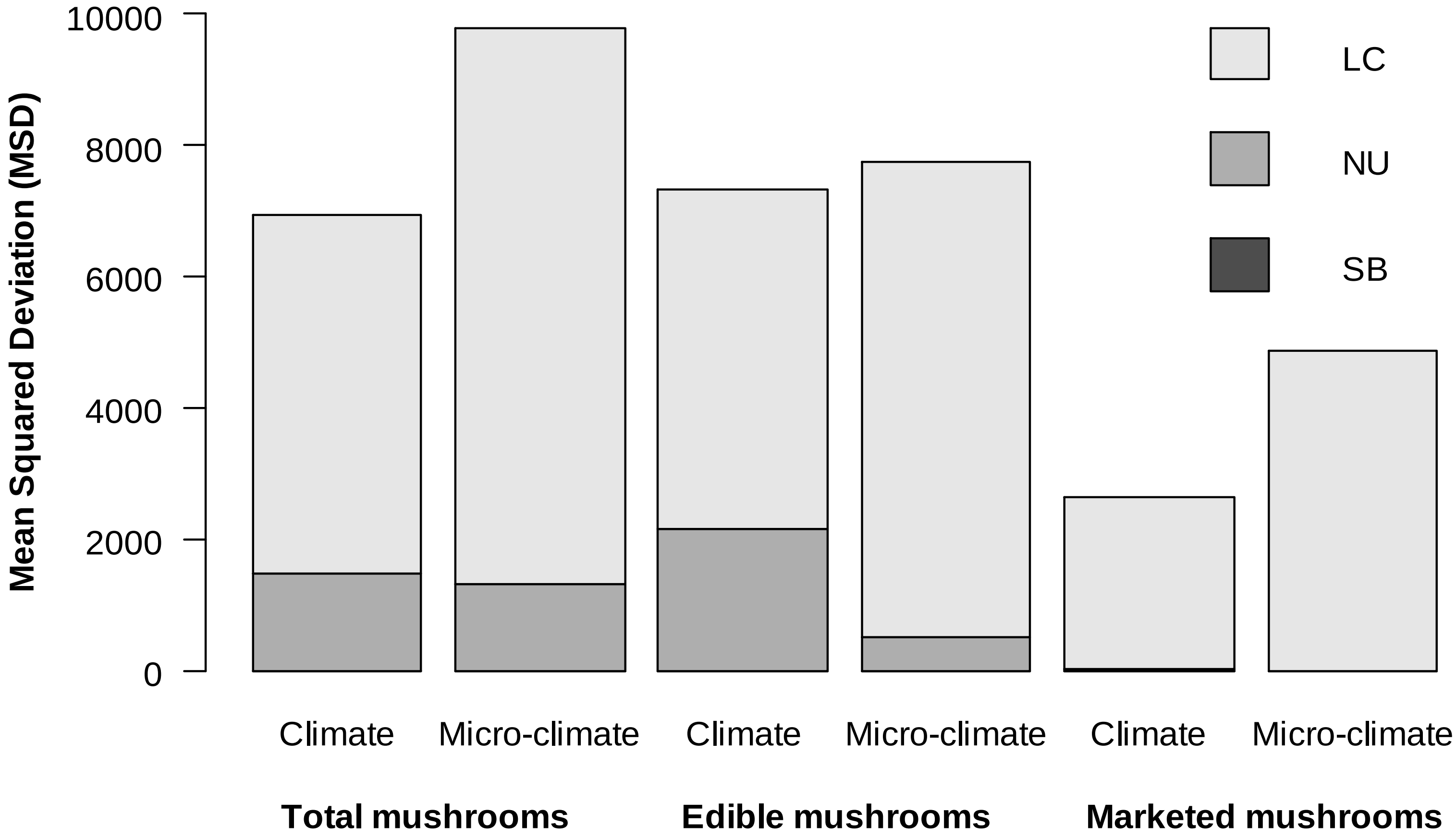
Predictors affecting occurrence model



Predictors affecting yield model



Performance of models



Conclusions

I. Occurrence and yield models

- Yield models consisted of larger number of predictors.
- Predictors of yield models covered the whole extent of the fruiting season.
- Precipitation is essential for mushroom occurrence, though excessive wet conditions may have negative effect on yield.

II. Effect of climatic and micro-climatic conditions

- Weather affects mushroom productivity during the fruiting season.
- Precipitation and temperature are the most important predictors.
- Soil moisture effect is limited to warm months.
- Maximum and minimum temperatures proved more significant than mean values.
- Temperature had both positive and negative effects.
- Concerns for the cultural ES of mushroom picking and trade in the context of climate change.

III. Interaction between climatic and micro-climatic variables

- Precipitation is positively correlated with soil moisture of the same and following month.
- Soil moisture matches the initiation of fruiting period, while precipitation appears significant once month earlier.
- Drivers vs. predictors.

Key message & Future research

- Micro-climate-based models can provide more profound insight into the process of mushroom fruiting.
- If the main objective is yield prediction, climate-based models may be sufficient.
- Higher temporal resolution is needed to further clarify the interaction between climate and micro-climate and their effect on mushroom production.

תודה רבה!!!
Thank you!!!

Extra slides just in case…

- Total mushroom models

Model	Predictor	Coeff.	Estimate	St. error	T value
Climate-based	Intercept	β_0	-5.498	0.615	-8.945
	P 9	$\beta 1$	0.022	0.002	9.337
	log(raindays 9 +10 +11)	$\beta 2$	2.096	0.205	10.195
	(Tmin 11 +12)	$\beta 3$	0.259	0.029	8.791
Micro-climate-based	Intercept	β_0	-29.849	4.835	-6.173
	SM 10	$\beta 1$	2.536	0.600	4.224
	(Tmax 9 +10)	$\beta 2$	-0.225	0.029	-7.710
	(Tmin 11 + 12)	$\beta 3$	0.445	0.046	9.634
	RHmax 9	$\beta 4$	0.403	0.058	6.939

Results

- Edible Mushroom model.
  - Climate-based model.

Model	Predictor	Coeff	Estimate	St. error	T value	P value
Probability of occurrence	Intercept	α_0	-13.135	4.188		0.002**
	Sqrt(raindays 10)	$\alpha 1$	3.388	1.301		0.009**
	sqrt(T 11 +12)	$\alpha 2$	2.291	0.718		0.001**
Yield	Intercept	β_0	-5.828	0.842	-6.921	
	P 9	$\beta 1$	0.025	0.002	9.237	
	log(raindays 9 +10 +11)	$\beta 2$	2.031	0.260	7.794	
	(Tmin 11 +12)	$\beta 3$	0.269	0.037	7.251	

Results

- Edible Mushroom model.
  - Micro-climate-based model.

Model	Predictor	Coef f	Estimate	St. error	T value	P value
Probability of occurrence	Intercept	α_0	-17.008	12.630		0.178
	Sqrt(SM 10)	$\alpha 1$	44.221	21.509		0.040*
	(Tmin 11 +12)	$\alpha 2$	9.722	2.628		0.000***
Yield	Intercept	β_0	-184.915	28.923	-6.393	
	Sqrt(SM 10)	$\beta 1$	3.243	1.023	3.168	
	(Tmax 9 +10)	$\beta 2$	-0.235	0.034	-6.869	
	(Tmin 11 +12)	$\beta 3$	0.425	0.057	7.352	
	Log(RHmax 9)	$\beta 4$	42.313	6.593	6.417	

Results

- Marketed mushroom models
  - Climate-based models

Model	Predictor	Coeff	Estimate	St. error	T value	P value
Probability of occurrence	Intercept	α_0	-7.589	1.591		0.000***
	Raindays 9	$\alpha 1$	0.466	0.079		0.000***
	Log(P 10)	$\alpha 2$	1.144	0.286		0.000***
	Tmin 11	$\alpha 3$	0.369	0.148		0.013*
Yield	Intercept	β_0	-9.236	1.634	-5.652	
	(raindays 8 +9)	$\beta 1$	0.127	0.021	5.949	
	P 10	$\beta 2$	-0.045	0.007	-6.086	
	Sqrt(P 10)	$\beta 3$	1.006	0.137	7.311	
	Log(T 11)	$\beta 4$	2.823	0.626	4.508	

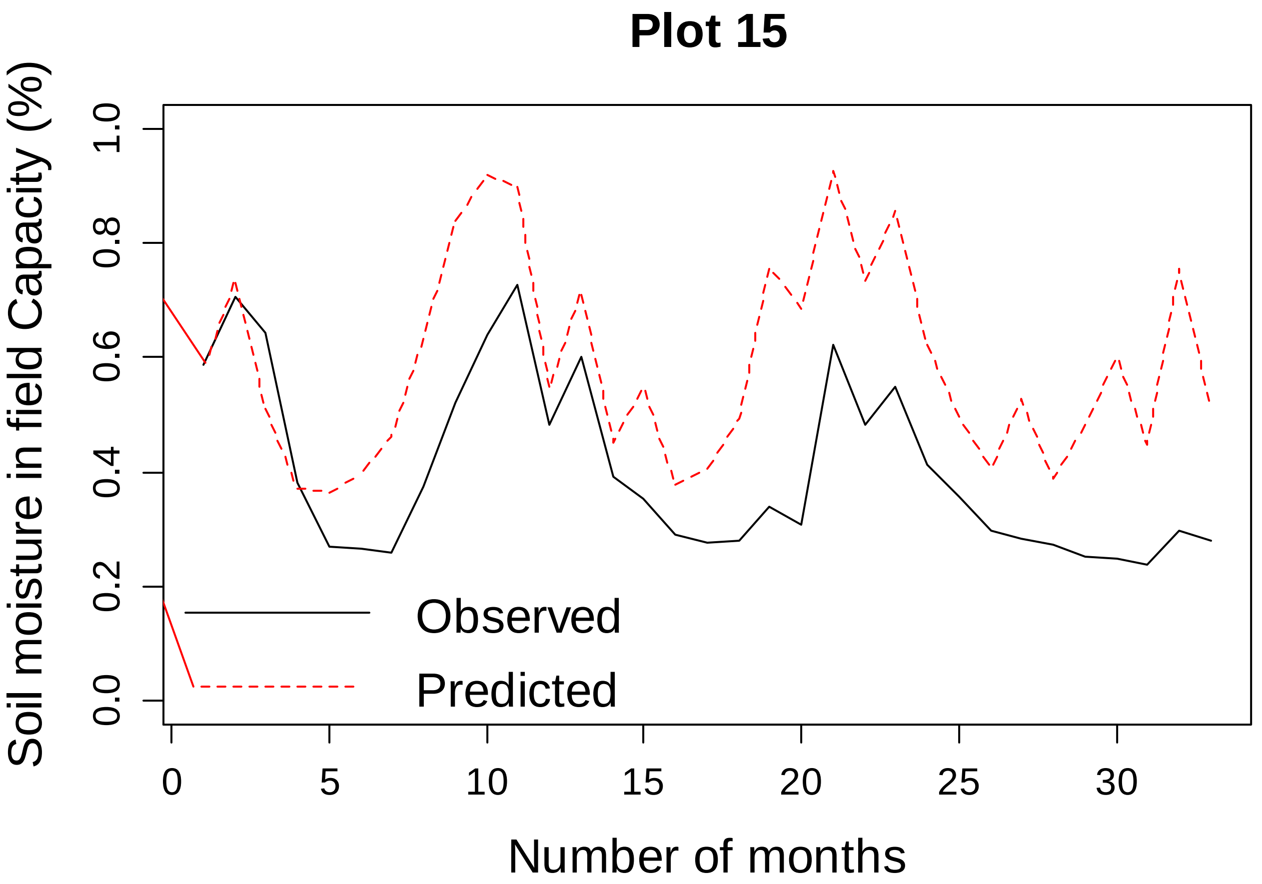
Results

- Marketed mushroom models
  - Micro-climate-based models

Model	Predictor	Coeff	Estimate	St. error	T value	P value
Probability of occurrence	Intercept	α_0	1.909	2.258		0.398
	(SM 9 +10)	$\alpha 1$	6.847	1.217		0.000***
	Tmax 10	$\alpha 2$	-0.624	0.151		0.000***
	Tmin 11	$\alpha 3$	0.784	0.204		0.000***
Yield	Intercept	β_0	-3.099	2.491	-1.244	
	Log(SM 10)	$\beta 1$	1.859	0.446	4.169	
	Tmax 10	$\beta 2$	-0.285	0.127	-2.245	
	Tmax 11	$\beta 3$	4.839	1.661	2.913	

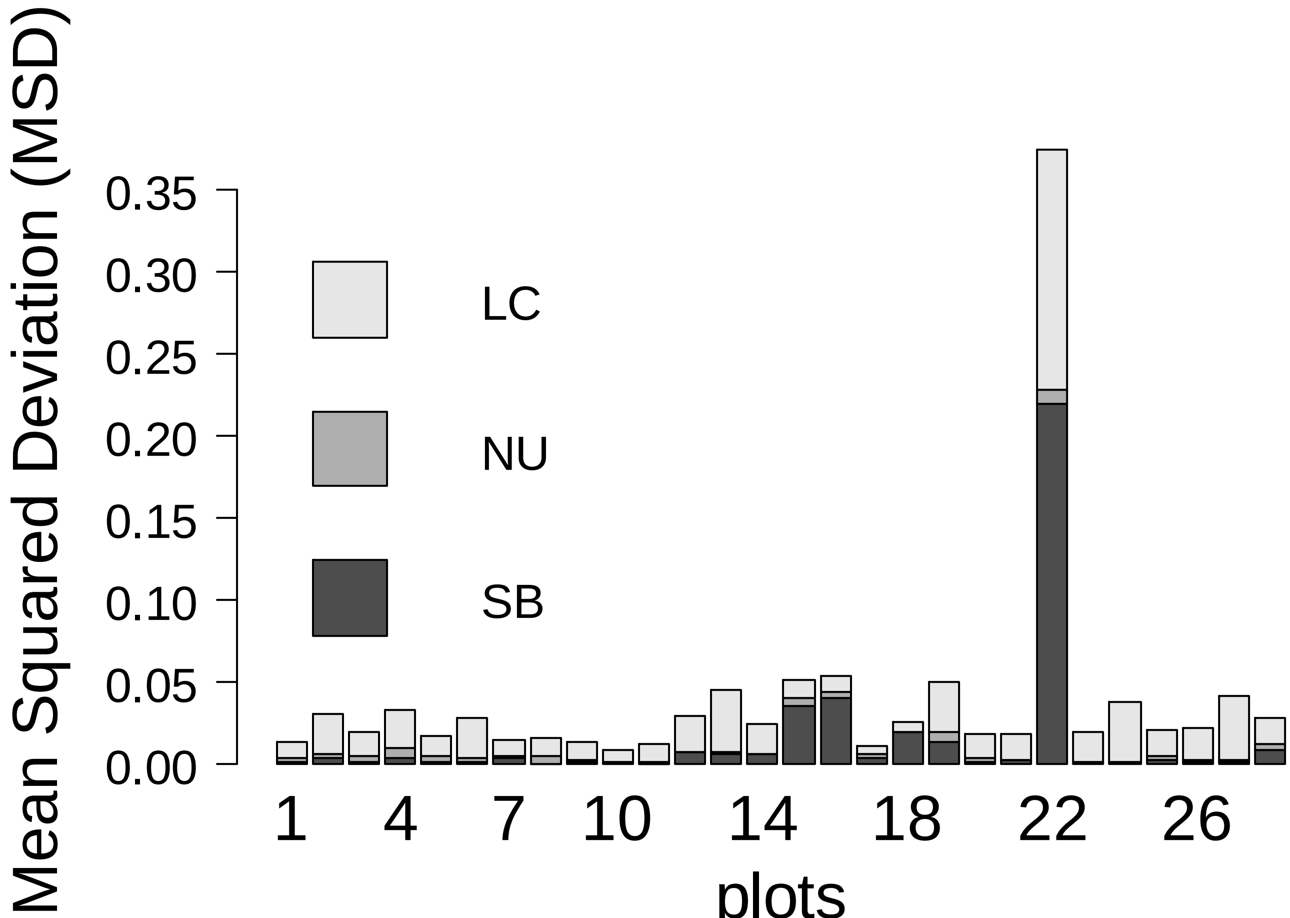
Soil water balance model

- False prediction of rain event

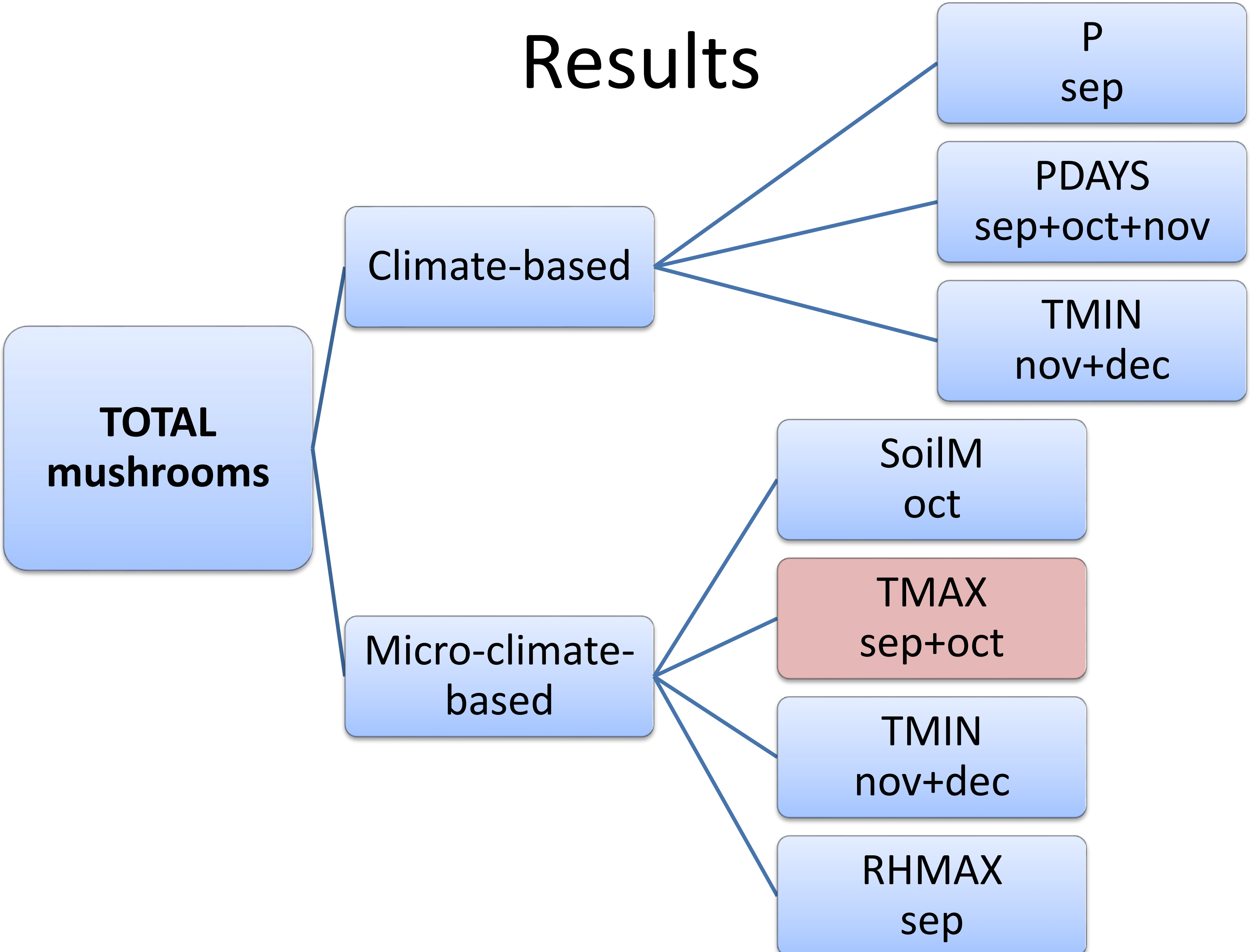


Soil water balance model

- Validation and calibration.

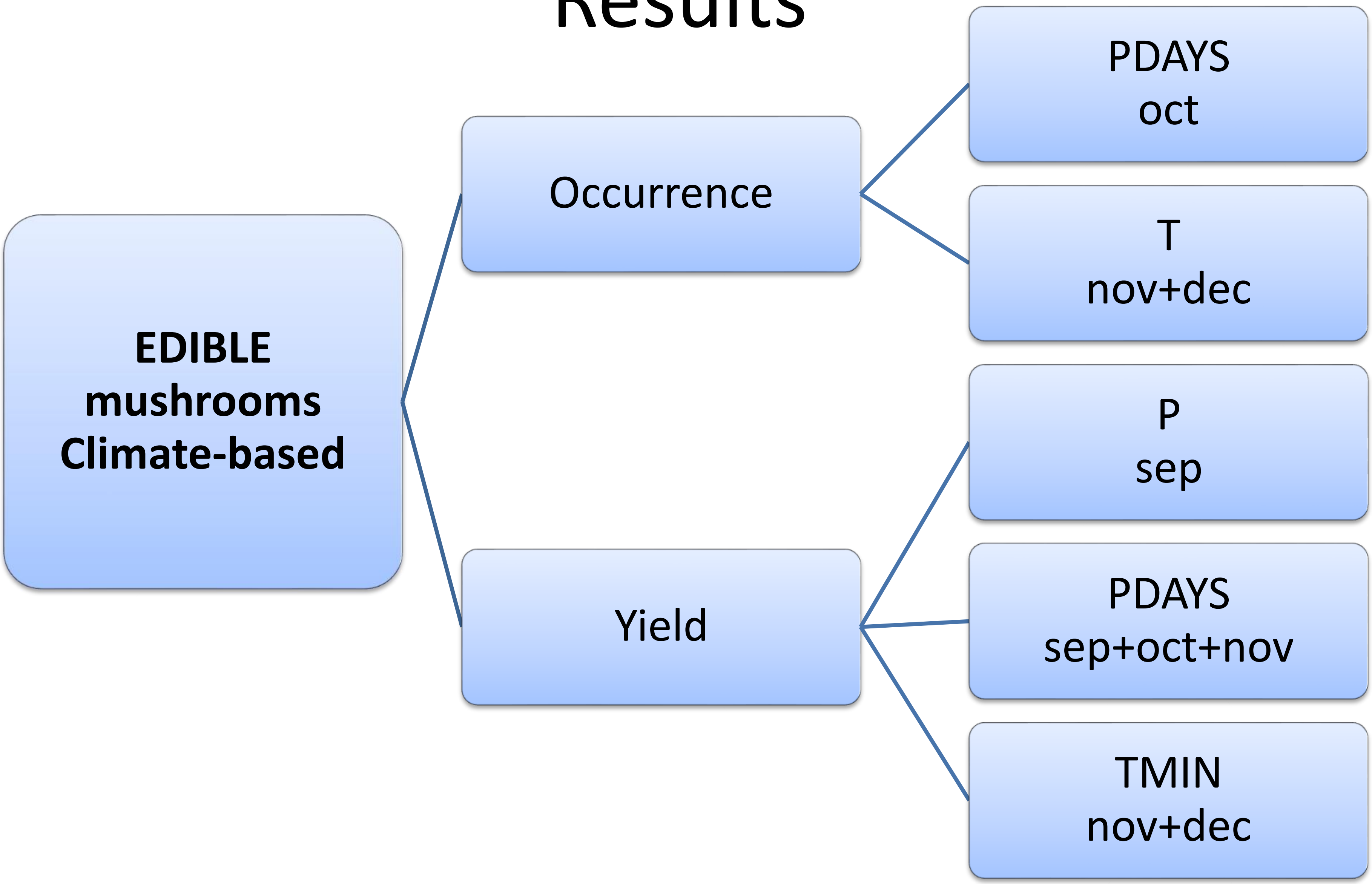


Results

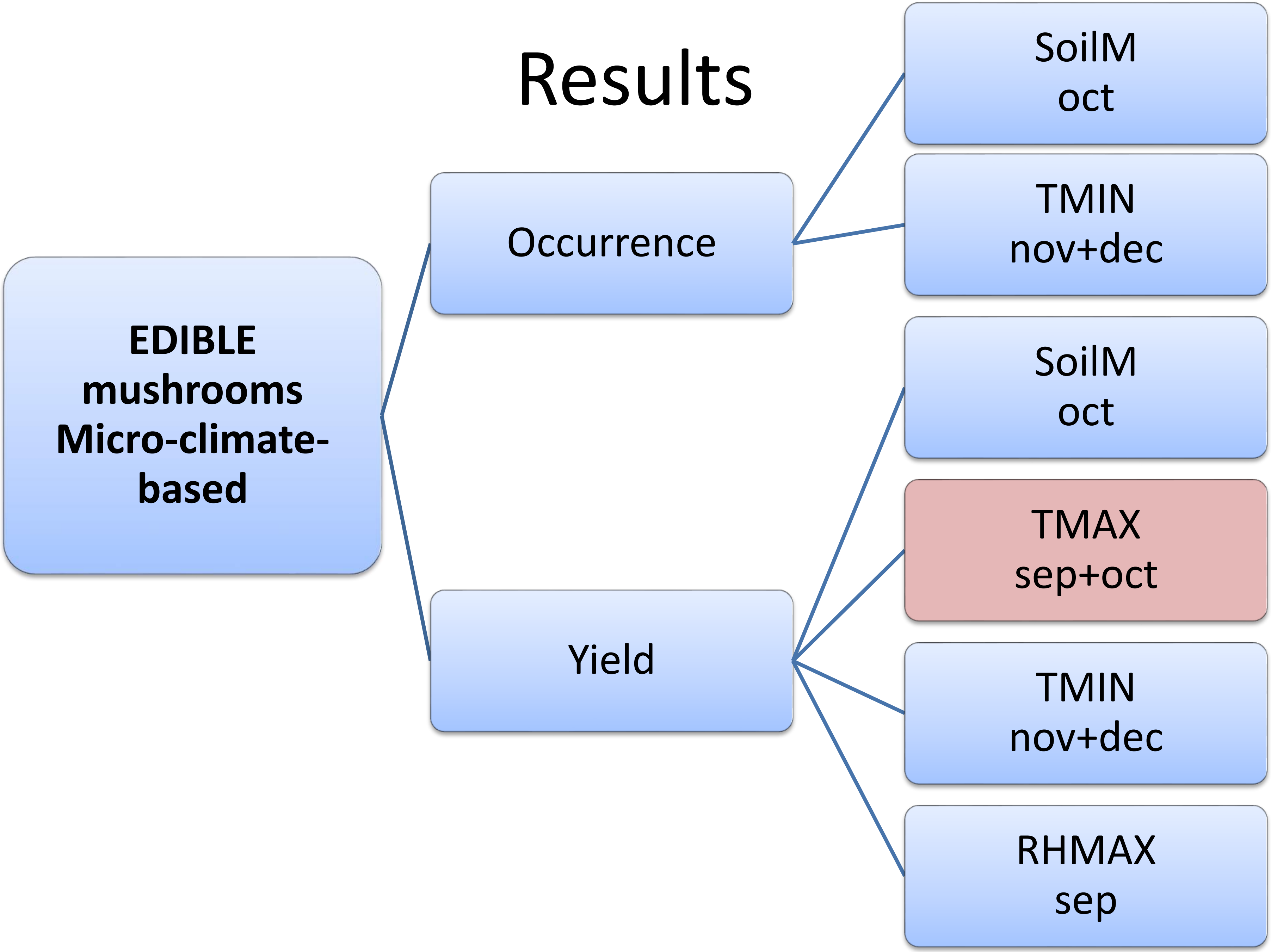


TOTAL mushrooms
Climate-based
Micro-climate-based
P sep
PDAYS sep+oct+nov
TMIN nov+dec
SoilM oct
TMAX sep+oct
TMIN nov+dec
RHMAX sep

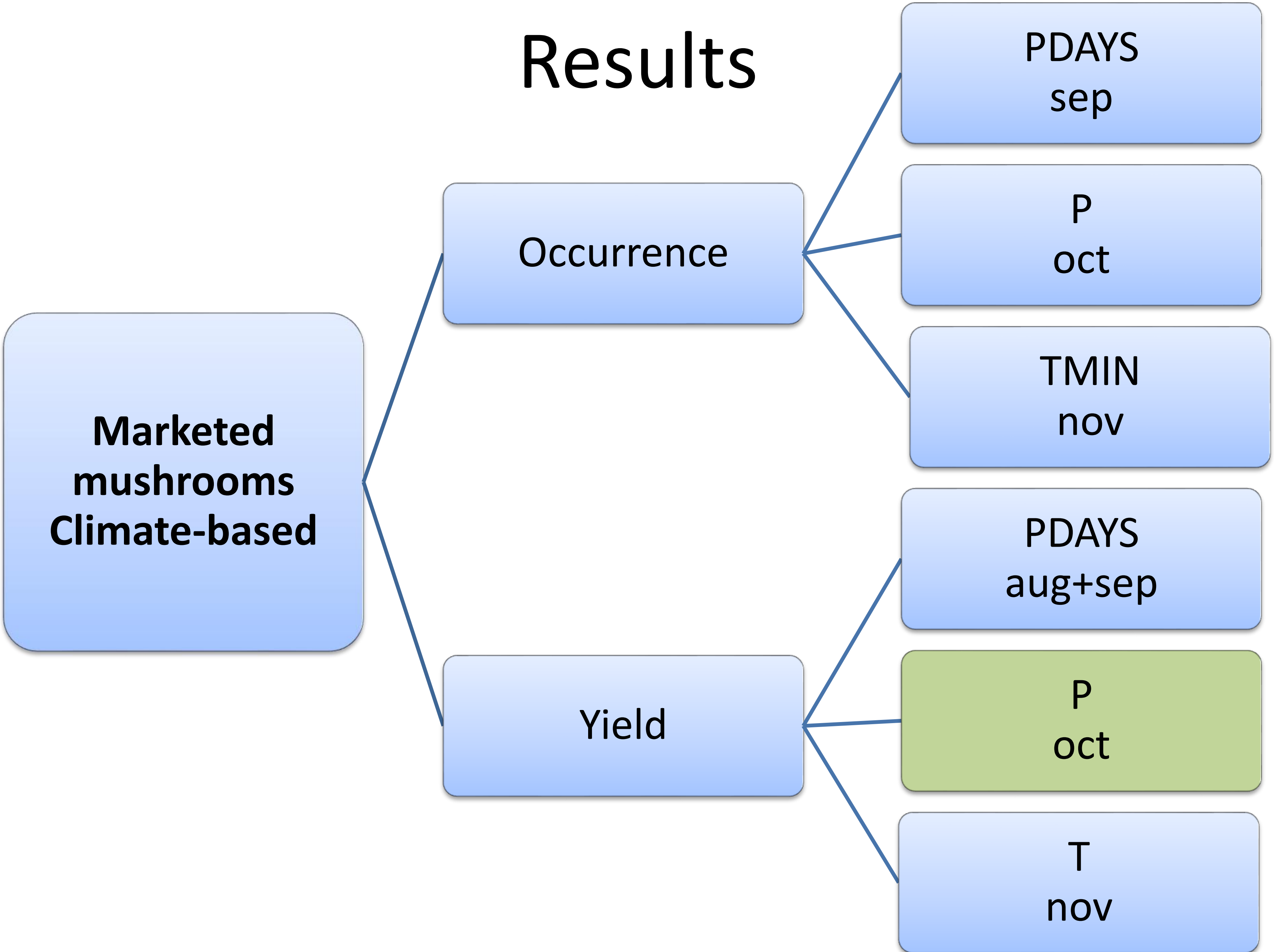
Results


EDIBLE mushrooms Climate-based
Occurrence
Yield
PDAYS oct
T nov+dec
P sep
PDAYS sep+oct+nov
TMIN nov+dec

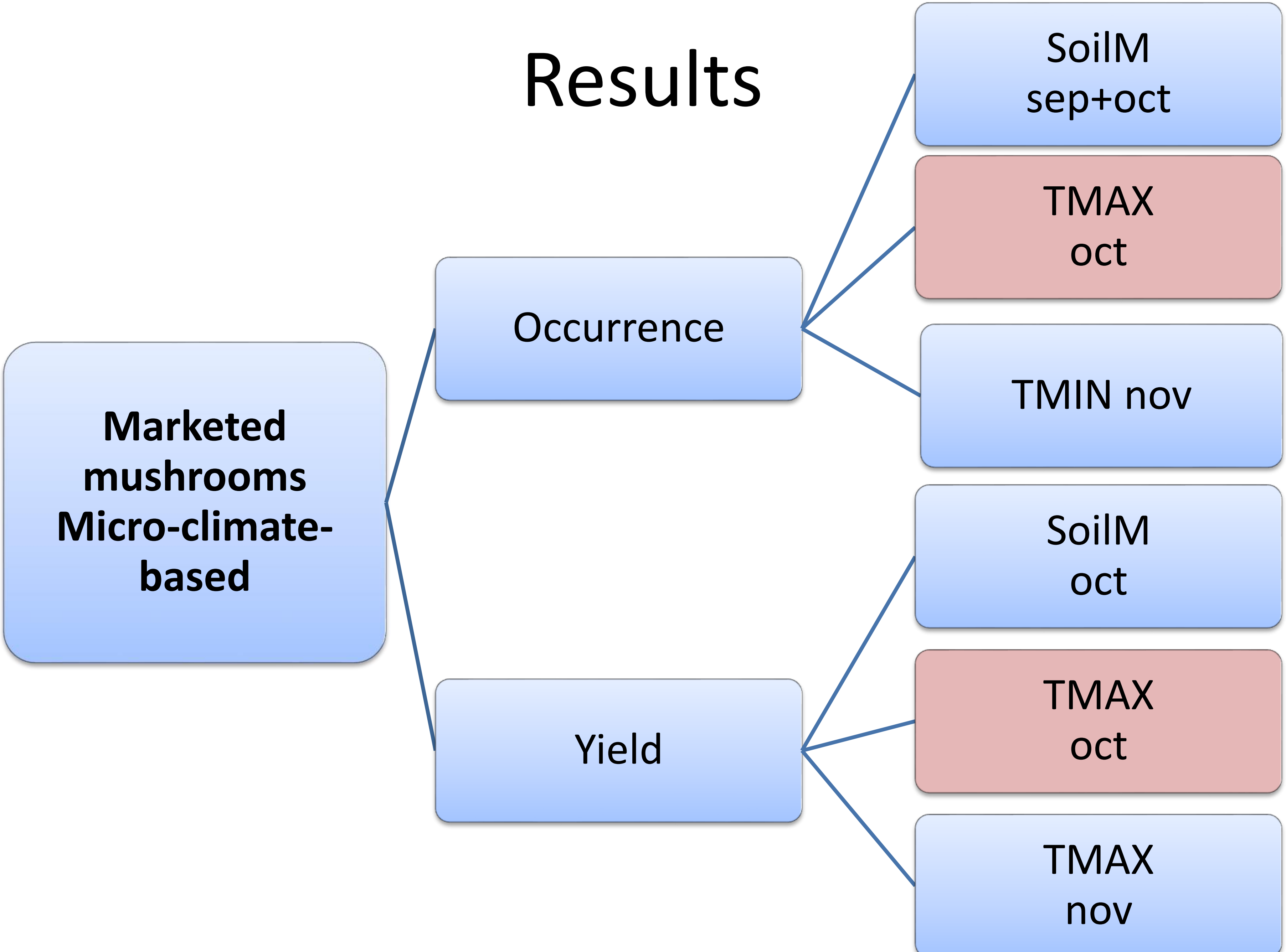
Results


EDIBLE mushrooms Micro-climate-based
Occurrence
Yield
SoilM oct
TMIN nov+dec
SoilM oct
TMAX sep+oct
TMIN nov+dec
RHMAX sep

Results

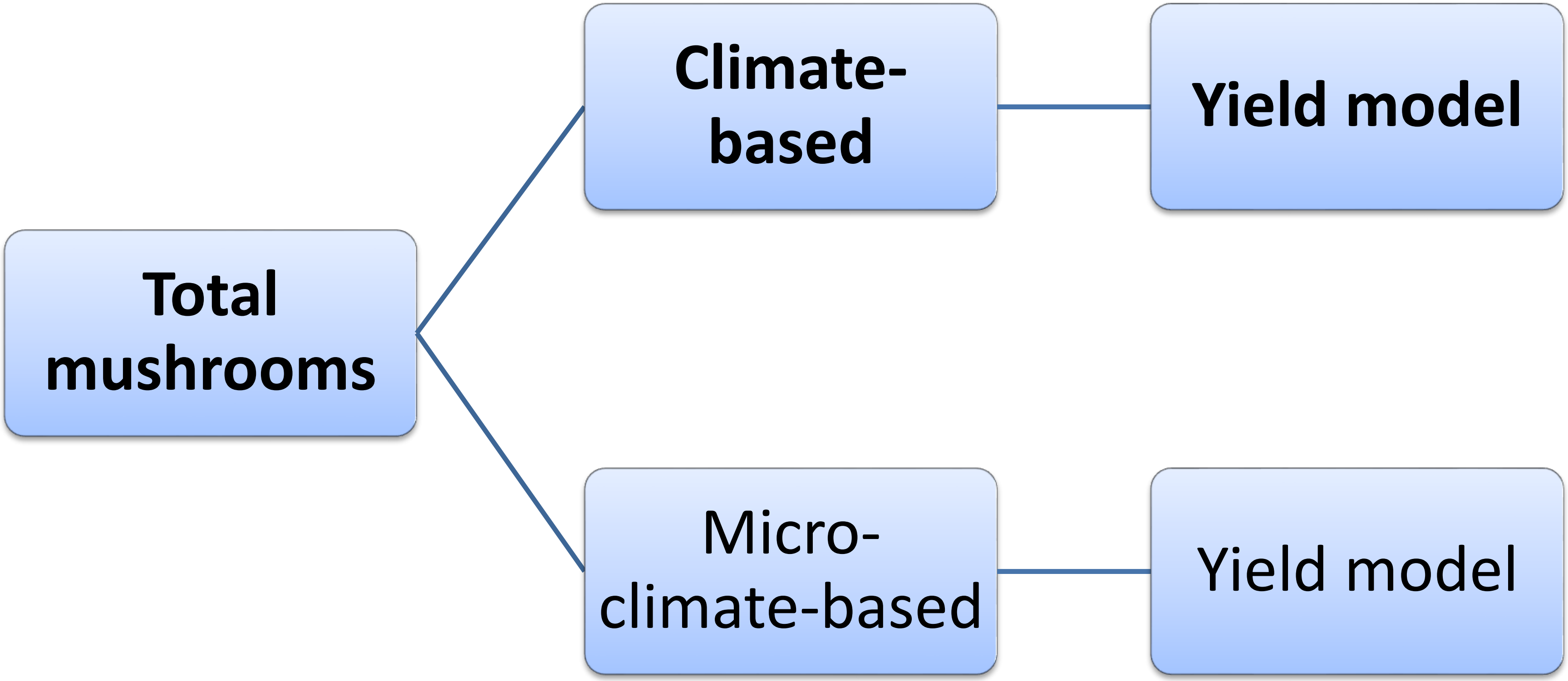

Marketed mushrooms Climate-based
Occurrence
Yield
PDAYS sep
P oct
TMIN nov
PDAYS aug+sep
P oct
T nov

Results

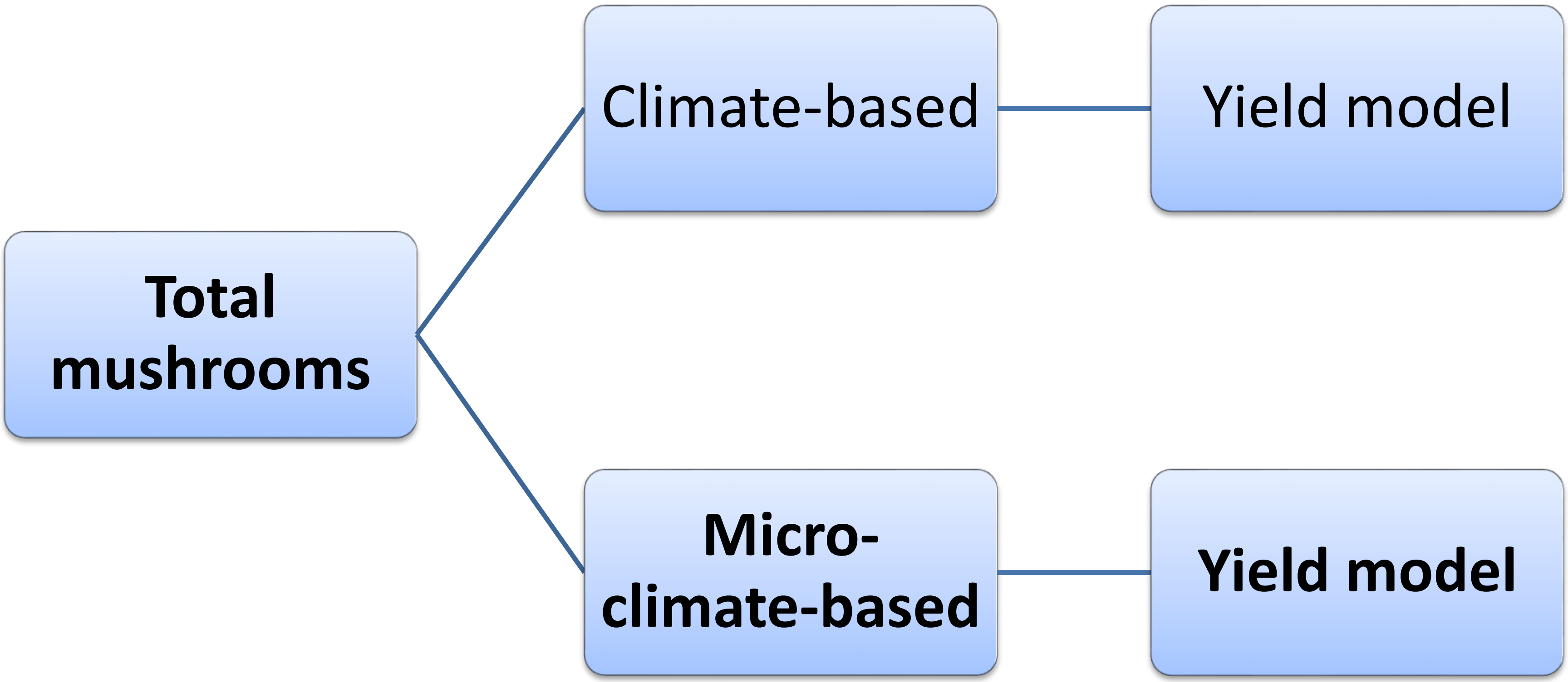


Marketed mushrooms Micro-climate-based
Occurrence
Yield
SoilM sep+oct
TMAX oct
TMIN nov
SoilM oct
TMAX oct
TMAX nov

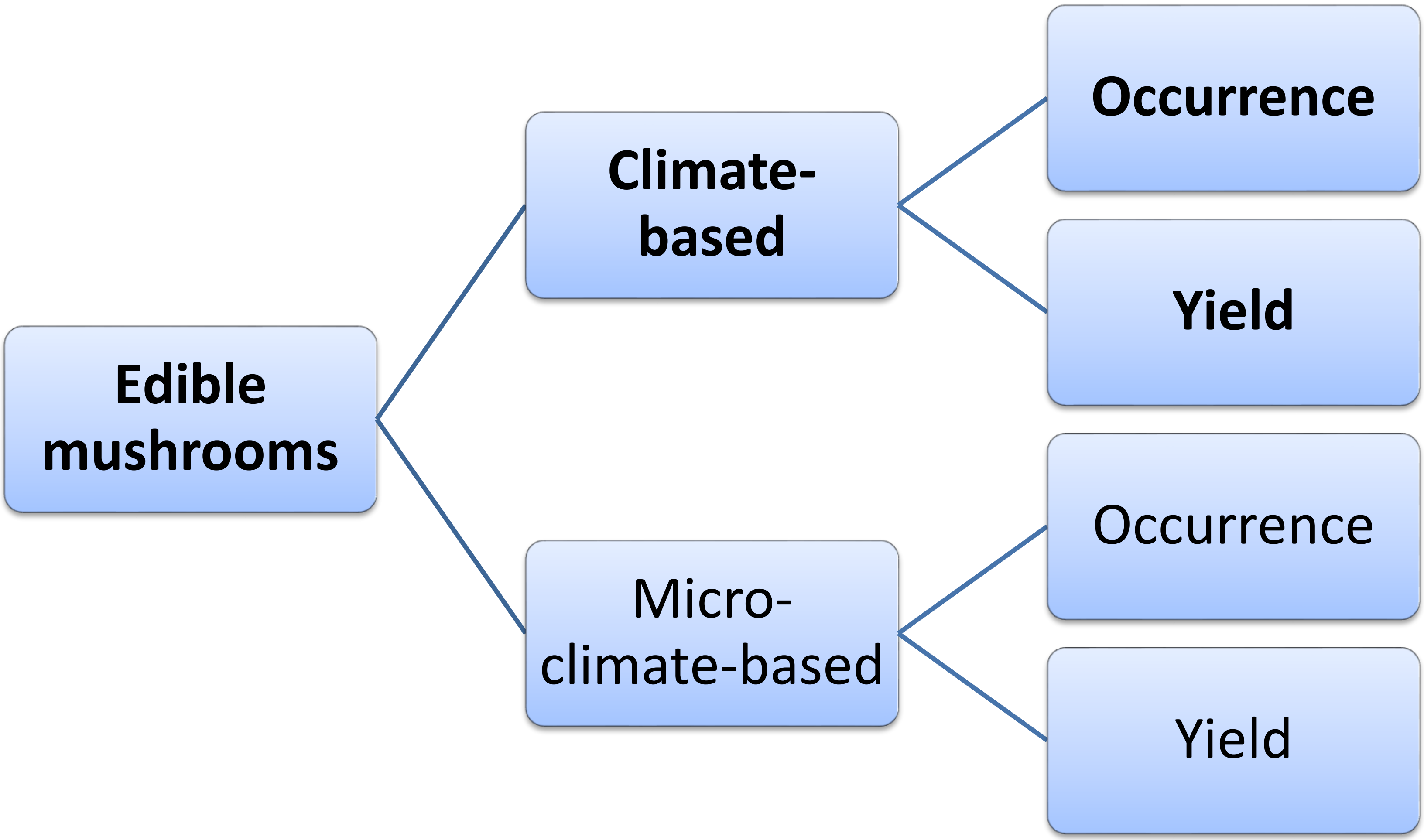
Results


Total mushrooms
Climate-based
Yield model
Micro-climate-based
Yield model

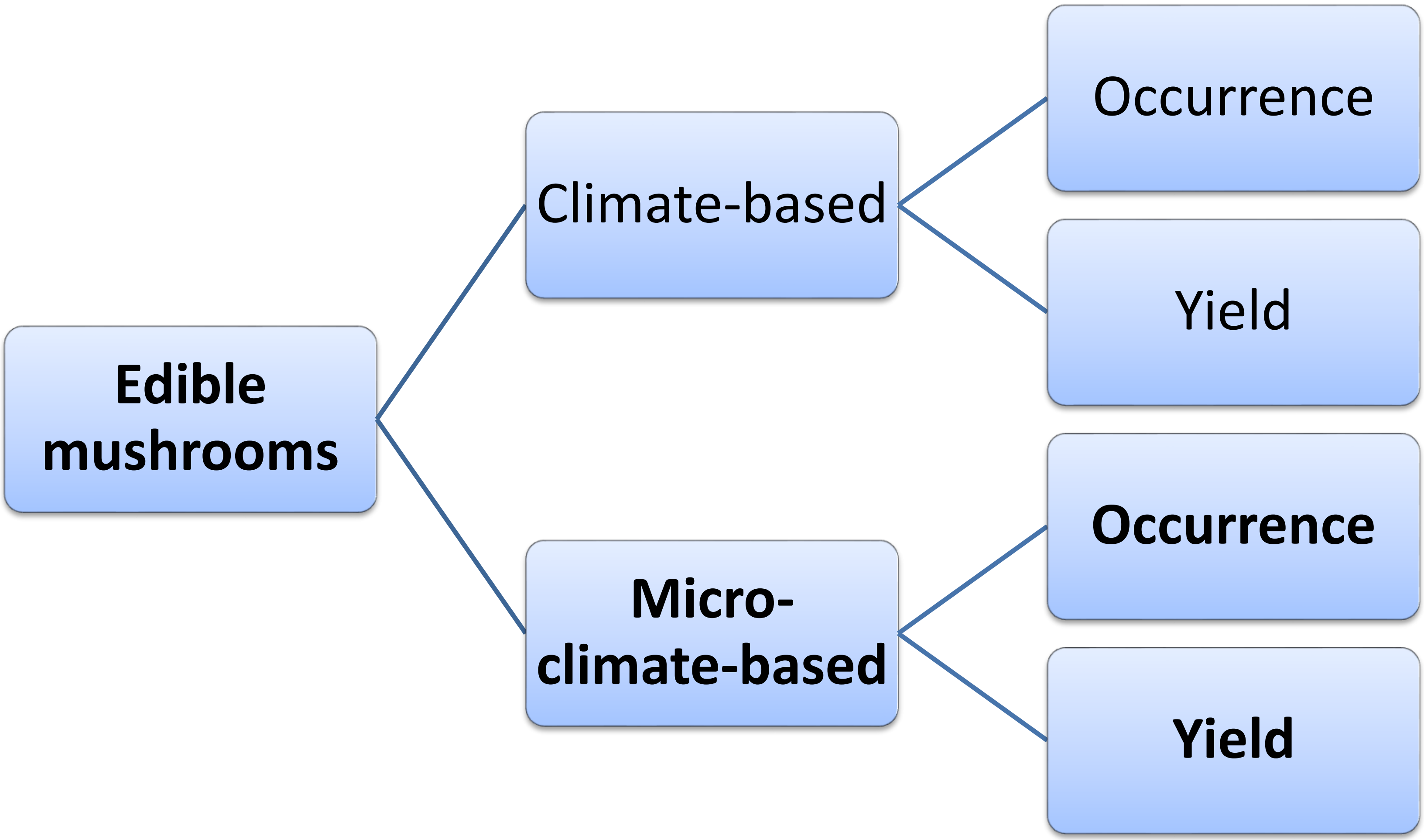
Results


Climate-based
Yield model
Total mushrooms
Micro-climate-based
Yield model

Results

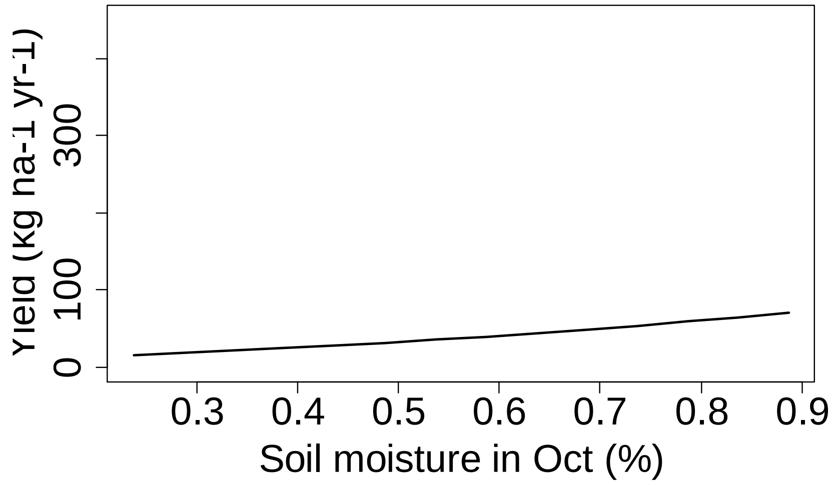

Edible mushrooms
Climate-based
Occurrence
Yield
Micro-climate-based
Occurrence
Yield

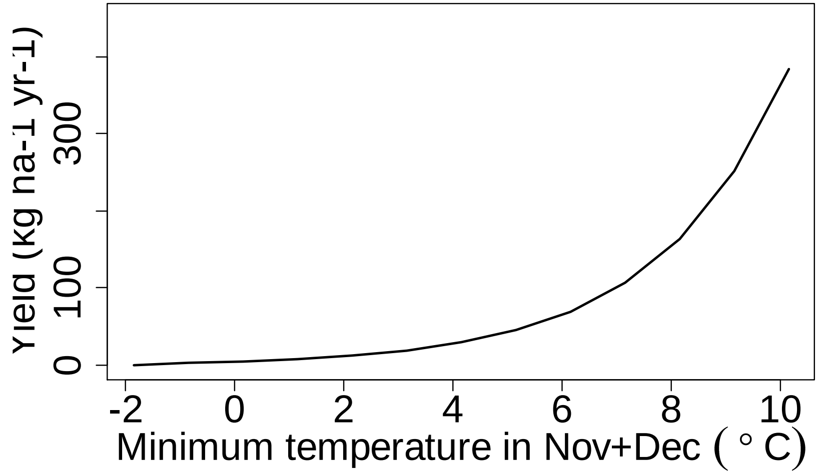
Results


Edible mushrooms
Climate-based
Micro-climate-based
Occurrence
Yield
Occurrence
Yield

Micro-climate-based model for edible mushrooms

Occurrence models





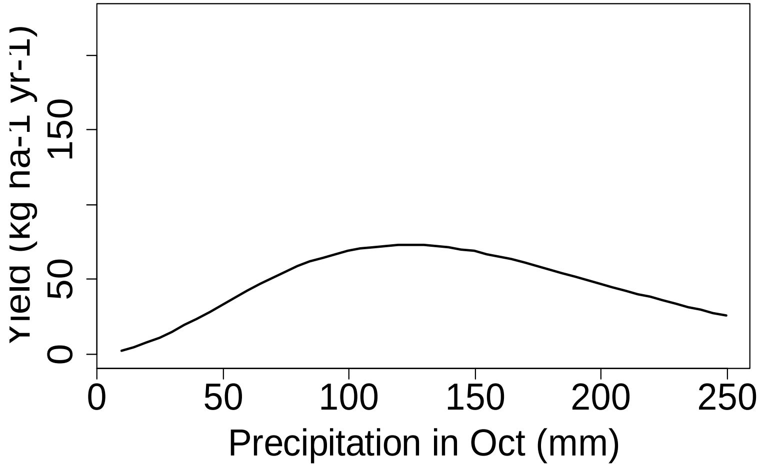
II. Occurrence and yield models

- Models differed in their predictors.
- **Yield models consisted of larger number of predictors.**
- **Yield models extended over the whole fruiting season.**
- Precipitation is essential for mushroom occurrence, though excessive wet conditions can have negative effect on yield.

Edible, climate-based	Predictor
Probability of occurrence	+ PDAY oct + T nov+dec
Yield	+ P sep + PDAYS sep+oct+nov + TMIN nov+dec

II. Occurrence and yield models

- Models differed in their predictors.
- Yield models consist of larger number of predictors.
- Yield models extend over the whole fruiting season.
- **Precipitation is essential for mushroom occurrence, though excessive wet conditions may affect yield negatively.**

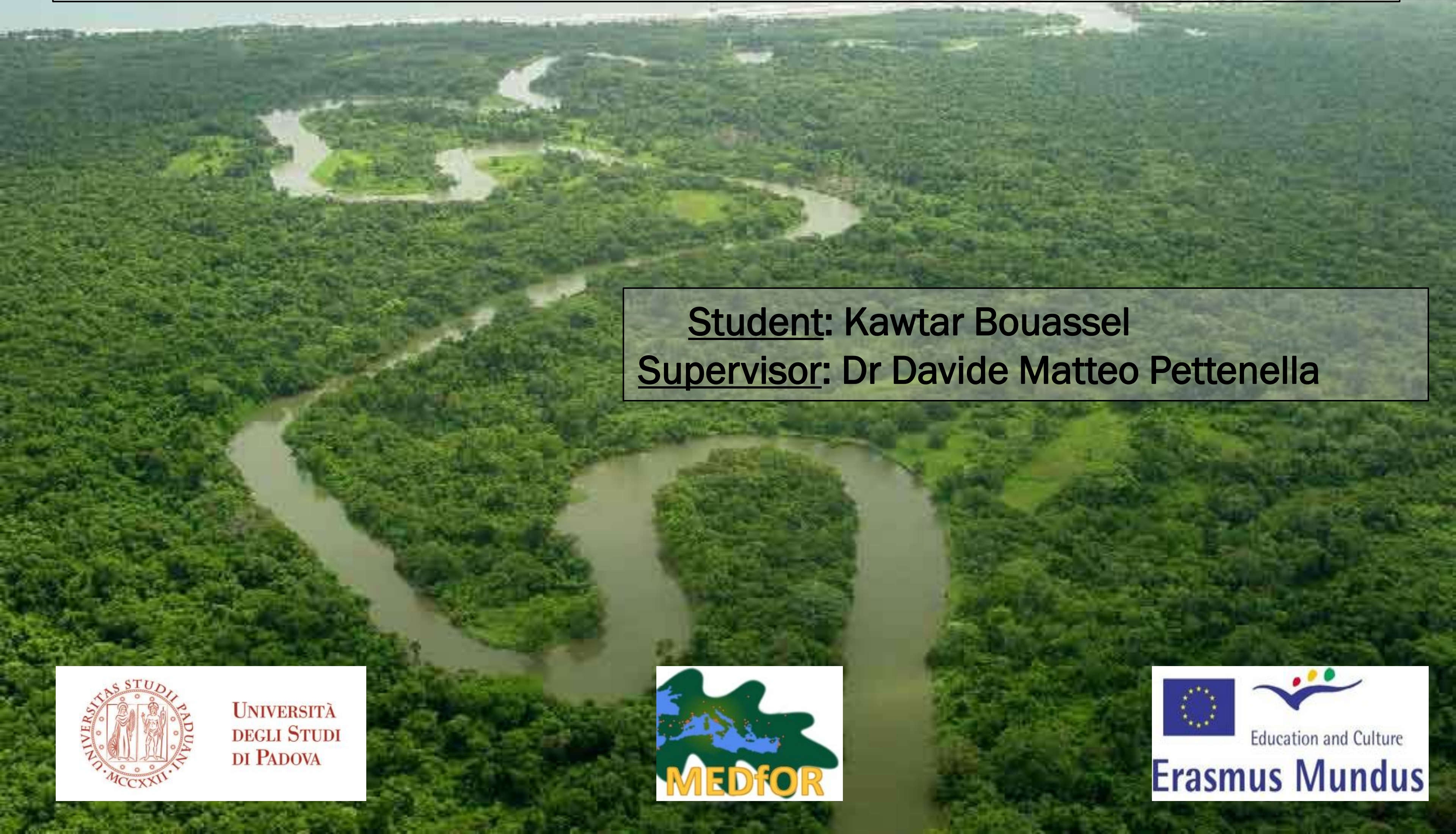


I. Impact on different fungal-based ecosystem services

- Models for total mushrooms yield and edible mushroom yield shared similar predictors.
- Predictors in marketed mushroom models shifted one month earlier.
- Concerns for the cultural ES of mushroom picking and trade, especially in the context of climate change.

TIMBER TRACEABILITY IMPACT ON FOREST GOVERNANCE IN TROPICAL COUNTRIES.

The study case of Honduras



Student: Kawtar Bouassel

Supervisor: Dr Davide Matteo Pettenella

UNIVERSITÀ DEGLI STUDI DI PADOVA

MEDfOR

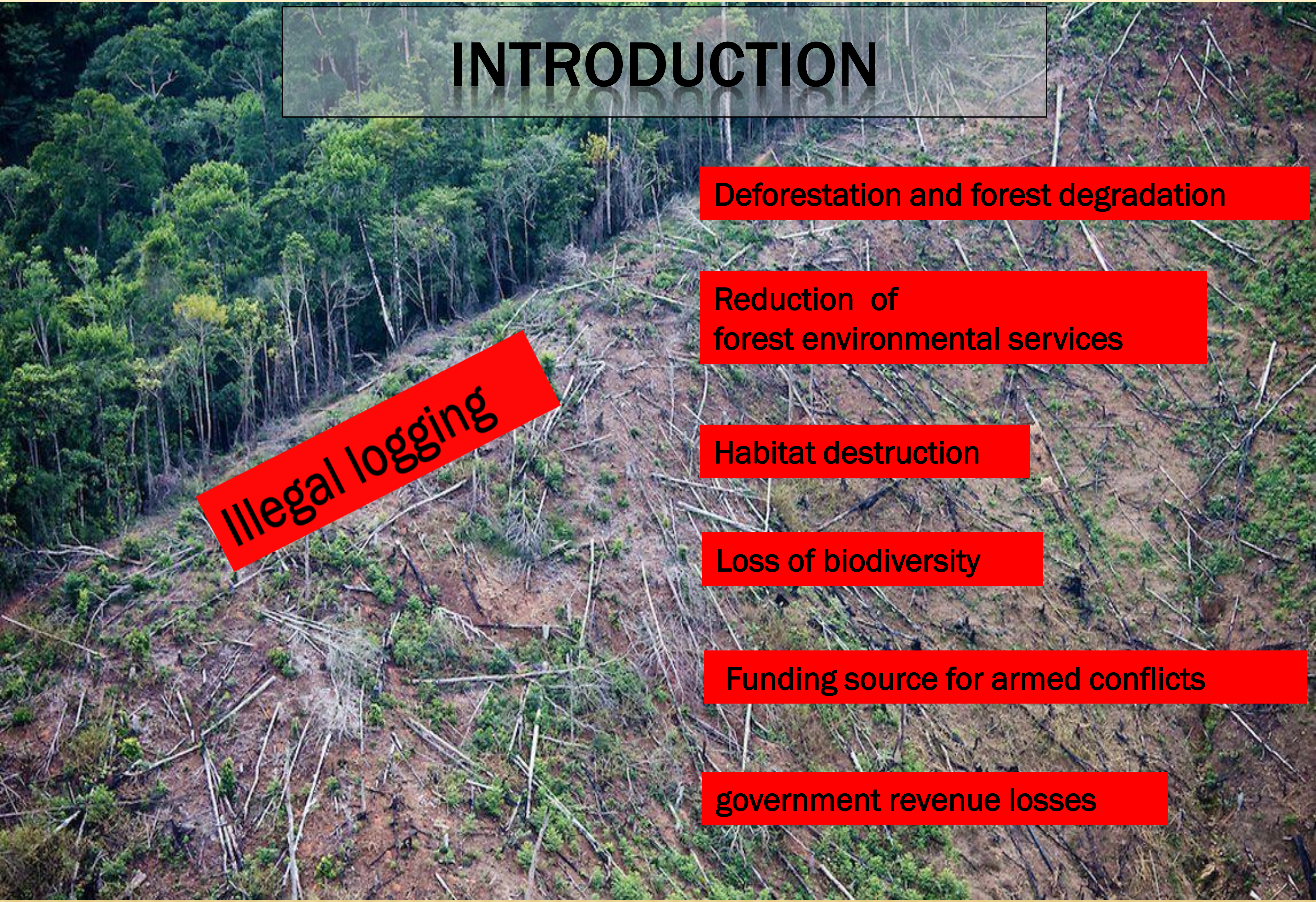
Education and Culture

Erasmus Mundus

CONTENT

- Introduction
- Problem statement
- Objectives
- Theoretical Framework
- Methodology and methods
- Hypothesis
- Limitation
- References

INTRODUCTION



Illegal logging

- Deforestation and forest degradation
- Reduction of forest environmental services
- Habitat destruction
- Loss of biodiversity
- Funding source for armed conflicts
- government revenue losses

CERTIFICATION

- Beginning of the80s

Boycotts of tropical timber

Responsible management certification:

Legality certification:

Certification require reliable traceability systems

- Verification
- SVLK : Sistem Verifikasi Legalitas Kayu (Indonesia)
- Timber Legality Verification of Rainforest Alliance.
- Etc.

TRACEABILITY SYSTEMS

- Late 2000s: northern countries regulations to limit illegal timber imports:
  - United States: Lacey Act
  - Europe: Règlement du Bois de l’Union Européenne (RBUE)
- Importers must thus establish mechanisms to certify the legality or "due diligence" of their supplies.
- In parallel: national traceability systems are being implemented by different timber exporting countries.
  - Some traceability systems are incorporated in the Legality Verification System (LVS) of the EU FLEGT Action Plan (published in 2003).

Examples of Traceability systems

Governmental enterprise	Benin
National traceability system	Liberia
Private forestry company	Cameroon
NGO (REM): monitoring system	D R C
Traceability system adapted to community forestry	Gabon

GOOD FOREST GOVERNANCE

- The Governance of Forests Initiative (GFI) Guidance Manual

Accountability

Transparency

Participation

Coordination

Capacity

OBJECTIVES

Timber traceability impact on forest governance

1. Conceptual framework for the tree terms: Traceability, Control and Verification.

2. Description of traceability system and the current legal situation in the forestry sector in Honduras

3. Identification of the impact on: Accountability, Capacity, coordination, Participation and Transparency

THEORETICAL FRAMEWORK

- Traceability concept:

le Bureau international des poids et des mesures (BIPM): "traceability is the property of a measurement results whereby the result can be related to a reference through a documented unbroken chain of calibrations, each cont

Charter Quality Institute CQI: "traceability through the accurate maintenance and retention of records provides the ability to identify and track a product or a component through its provenance to its point of origin. The point of origin may be a particular lot or batch, production line or time frame or supplier. This then enables operational and economic benefits whereby component failure or fault occurrences can be traced and c

ISO 9001 " *traceability* is the ability to identify and trace the history, distribution, location, and application of products, parts, materials, and services.
A traceability system records and follows the trail as products, parts, materials, and services come from suppliers and are processed and ultimately distributed as final products and services".

THEORETICAL FRAMEWORK

- Control concept:

The Legal Free Dictionary defined control as:
“The power to direct, manage, oversee and/or restrict the affairs, busines s or assets of a person or entity.” It could be action of restriction, supervision, regulation, or restraint.

FLEGT Facility
The purpose of supply chain control is to ensure that unverified products and products that are possibly illegal do not enter the supply chain. Supply chain control enables countries and companies to track timber and timber products from a forest or point of import to a point of export.

THEORETICAL FRAMEWORK

- Verification concept:

FLEGT Facility: Each partner country government chooses a governmental or non-governmental body to verify that timber or timber products are legal. This verification body ensures that timber is produced and/or processed in a way that meets the requirements of the definition of legal timber, and that its supply chain has been controlled and checked. The verification body must have adequate re

PROFOR: Verification refers to the process of checking that the forest management and supply chain controls meet a defined set of requirements; in this case, legality. It usually involves audits of forest management units and processing facilities, including field inspections, and reviews of documentation and management systems. Legality verification systems can be broadly c
v

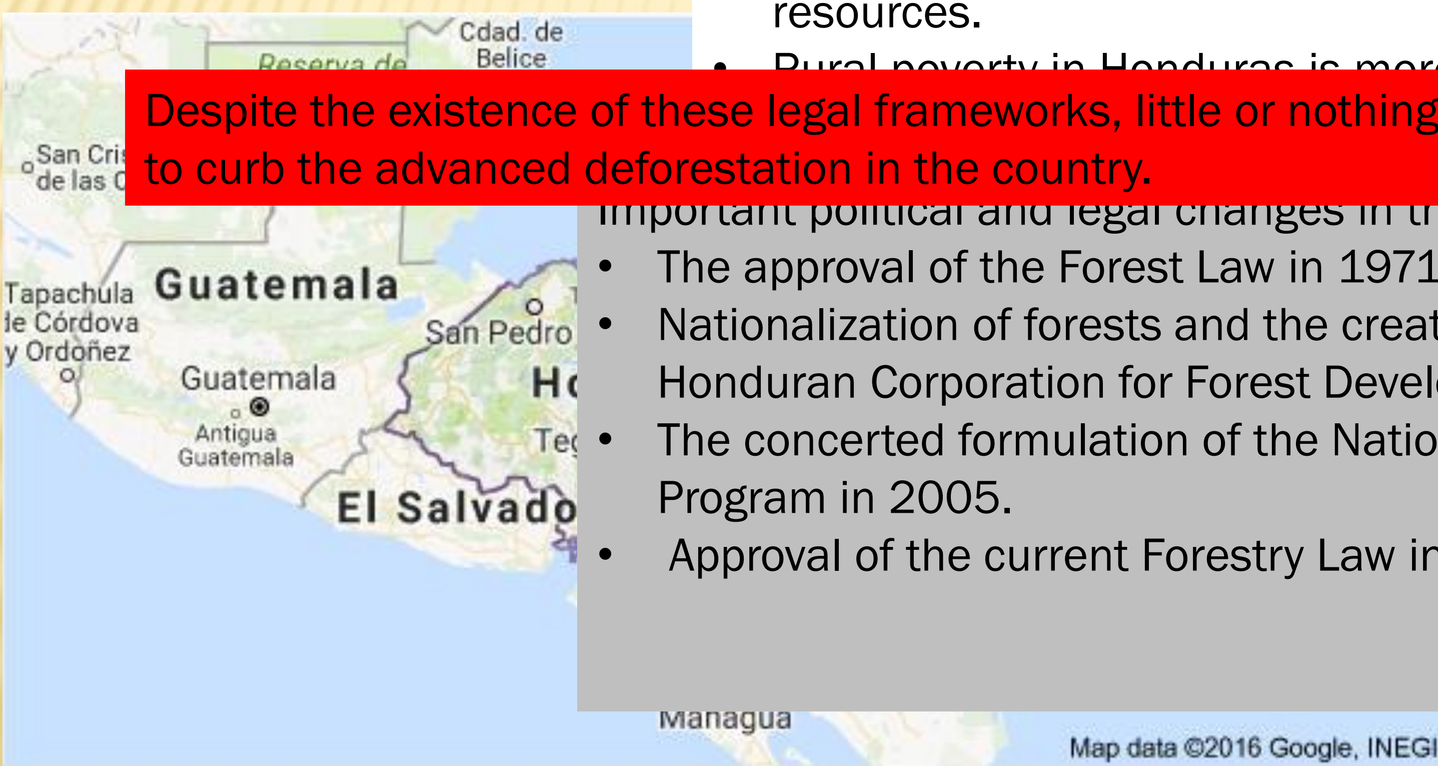
ISO 9001: verification is a process that uses objective evidence to confirm that specified requirements have been met. Whenever specified requirements have been met, a verified status is achieved. There are many ways to verify that requirements have been met. For example you could inspect something, you could do tests, you could carry out alternative calculations, or you could examine documents before you issue them.

METHODOLOGY

- Interview with the key informants: study case Honduras
- Study area:

Large tracts of pine and broadleaf forest.

- 50% of its surface is covered by forest.
- 1.5 million people are directly related to those resources.
- Rural poverty in Honduras is more than 60%



Despite the existence of these legal frameworks, little or nothing has been done to curb the advanced deforestation in the country.

Important political and legal changes in the last 40 years.

- The approval of the Forest Law in 1971.
- Nationalization of forests and the creation of the Honduran Corporation for Forest Development in 1974.
- The concerted formulation of the National Forest Program in 2005.
- Approval of the current Forestry Law in 2008.

Changes in Forest Cover in Honduras from 1991 to 2008

Forest type	Forest cover in 1991		Forest cover in 2008		Cover Reduction		Deforestation annual net rate	
	M of ha	%	M of ha	%	M of ha	%	ha	%
Pine	2.79	49	2.2	48.9	0.57	65.5	38000	1.712
Broadleaf	2.91	51	2.61	54.1	0.3	34.5	20000	0.766
Global average	5.7	100	4.83	100	0.87	100	58000	1.201

Source: Diagnosis of the legality verification system in Honduras forest sector. CATIE, p. 3, 2008

Problems	Components	Problems
Policy	• Forest Action Plan 1996-2015. • Forestry Law 2008. • Country Vision and Nation Plan 2009.	- Lack of priority to problems of administrative corruption and illegal logging. - Lack of financial resources by the institutions.
Institutional	Conservation Institute Forest (ICF) 2010	- Weak forestry institutions. - Lack of technical, administrative and financial autonomy. - Corruption and poor governance. - Weakness in local governments and community organizations.
technical	Forestry Law 2008	- Extension of the cattle frontier, agriculture, coffee production. - Lack of forest management.
Social	Social Forestry System 2010	- Migration and poverty. - Illegal Logging and degradation. - Lack of land and land tenure
Economic	Payment for environmental Services (PES) 2006	- High export trade of illegal timber - Unchecked forest concessions - No tax system to leverage resources from logging

METHODOLOGY

- **Identification of stakeholders:**
- Facilitator: Daphne Hewitt, FAO Forest Officer in EU FAO FLEGT Programme.
- Stakeholders:
  - **Governmental Institutions**
    - ICF: Instituto Nacional de Conservación.
    - Secretaría de Energía, Recursos Naturales, Ambiente y Minas
  - **NGOs**
    - Alianza Verde: Ecological sustainability and social justice
    - FDsF: Fundación Democracia sin Fronteras
    - FMV: Fundación Madera Verde
    - AFH: Agenda Forestal Hondureña

MERTHODOLOGY

- **Indigenous people associations**
  - CONPAH: Confederación de Pueblos Autóctonos de Honduras
  - ONILH: Organización Nacional Indígena Lenca de Honduras
  - OFRANEH: Organización Fraternal Negra Hondureña
- **Private sector:**
  - Industria Maderera Murillo y de Moor: Import/Export
  - IMAVE S. de R.L: Softwood sawmills
  - FAMASA S.A. DE C.V.: Wholesaler

INTERVIEW QUESTIONS

- What is your area of expertise and what is your role in supporting the development of timber traceability, control and verification systems?
- How can you define: traceability, control and verification
- Have you seen timber traceability, control and verification systems contribute to forest governance reforms? As far as possible please break your answer down into the following categories:
  - Accountability:
  - Capacity:
  - Coordination:
  - Participation:
  - Transparency:
- What other benefits/negatives effects have you seen?

HYPOTHESIS

We suppose that the impact of timber traceability will be highly perceived on:

- transparency
- participation
- cooperation

LIMITATIONS

- the scarcity of papers and research studies in this topic.
- No quantitative data, just qualitative one.
- The interviews cost.
- Time constraint.

THANK YOU FOR YOUR ATTENTION

Social Innovation in forestry: a preliminary analytical framework

Nathalia Formenton Cardoso
Supervisor: Dr. Laura Secco

University of Padua Department of Land, Environment, Agriculture And Forestry
Erasmus Mundus MS.c. MEDfOR
Academic Year 2014/16
02.07.2016

Outline

1. Theoretical background

2. Objectives

3. Methodology

4. Results and Conclusion

(to be developed)

Theorectical background (1/8)

Social Innovation

"Innovation"

The capacity to create and implement novel ideas which are proven to deliver value

"Social"

Delivering a value less concerned with profit and more with issues such as quality of life, solidarity and well-being

"Social Innovation (SI)"

=

The development and implementation of new ideas and new social relationships, offering solutions to a range of today's societal problems, which neither classic tools of government policy nor market solutions are able to solve *(EC, 2013).*

Theorectical background (2/8)

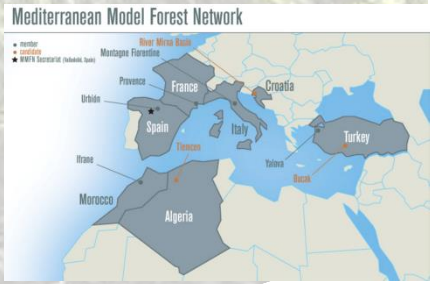
Social Innovation

OUTCOMES:

Product, production process, or technology (much like innovation in general);

Principle, an idea, a piece of legislation, a social movement, an intervention.

Improvement of human well-being



Theorectical background (3/8)

Social Innovation

It is NOT the tangible improvement itself, but new ***intended*** forms of collaborative action that enables the improvement in the first place.

Crucial for building shared visions, colations and networks, allowing a new costellations of actors to collaborate

Theorectical background (4/8)

Social Innovation

- Although social innovation is a common dynamic of human story

Mainstreaming in policy discourse has paradoxically emptied it of its innovative dimension

Poorly explored by discourse and research

Most of the definitions have emerged from people actively involved in solving practical problems

- **Need to coalesce around a single, common definition**
- **Define universally shared priorities (global challenges)**

Theorectical background (5/8)

Why Social Innovation in Forestry?

Global challenges

SI as the key to sustainable development

Pioneering role of forests in sustainable development.

Wood resources, enviromental value, **social** dimensions of forests

Social Innovation in Forestry

<u>Social and cultural approach:</u>

- Decent and health labor;
- Cultural and spiritual values;
- Traditional forest knowledge;
- Community management of natural resources; and
- **Rural development**

Theorectical background (6/8)

Rural development

- Cross-sector relationship between forestry, agriculture and their actors;
- Compared to cities, rural areas face problems related to disperse human capital, comparatively less developed infrastructure, unemployment, social exclusion (Grinberga-Zalite et al, 2015).
- Rural development public policies in forest-dominant areas focusing on supporting and developing multi actors networks of small and medium enterprises (SMEs) and entrepreneurship

SI can increase efficiency of rural development strategies to rescue marginalized rural societies through collective engagement

Theorectical background (7/8)

Promissing role in Forestry

US$ 450 billion to national incomes;
1% of the global GDP;
0.4% of formal employment in the global labor force (FAO, 2012)

resilience of communities, by providing sources of food, energy, shelter, fodder, fiber and income.

Global forest lost is still observed –agriculture responsible for approximately 80% of deforestation worldwide (FAO, 2016).

Poor governance is highlighted as significant driver of deforestation, where intersectoral linkages are weak.

Theorectical background (8/8)

Promissing role in Forestry

- The future of the people, who make a living in rural areas from forestry, will considerably depend on how individuals and institutions react in view of the challenges mentioned above, focusing on innovative integrated approaches to land use;

- Forestry is a promising field within which to investigate the role of social innovation in the support of adding **collective social value**

Objectives

1st: To **update the knowledge** about the process of social innovation in forestry

2nd: To identify **drivers, limiting factors, pre-condition and mechanisms** that can support or hinder social innovation in forestry

3rd : Development and preliminary test of an **analytical framework** by exploratory case-study approach

Methodology (1/3)

- Qualitative-based research

Literature Review

1st SO: To update the knowledge

Survey on Scopus database and Google (grey literature)

Research gap

1st SO: Scientific interest about topic

4 groups of key-words:

"social innovation" AND "forests“;
"social innovation" AND "rural development”;
"social entrepreneurship" AND "forest”;
"social entrepreneurship" AND "rural development"

Methodology (1/3)

Nvivo software

"…identify a text segment or image segment, assigns a code label, searches through the database for all text segments that have the same code label, and develops a printout of these text segments for the code."

- Word query to define the nodes to be coded
  - 2st SO: To identify elements that support or hinder SI
- Development of concept map from the coded articles
  - 3rd SO: Development of analytical framework

Methodology (3/3)

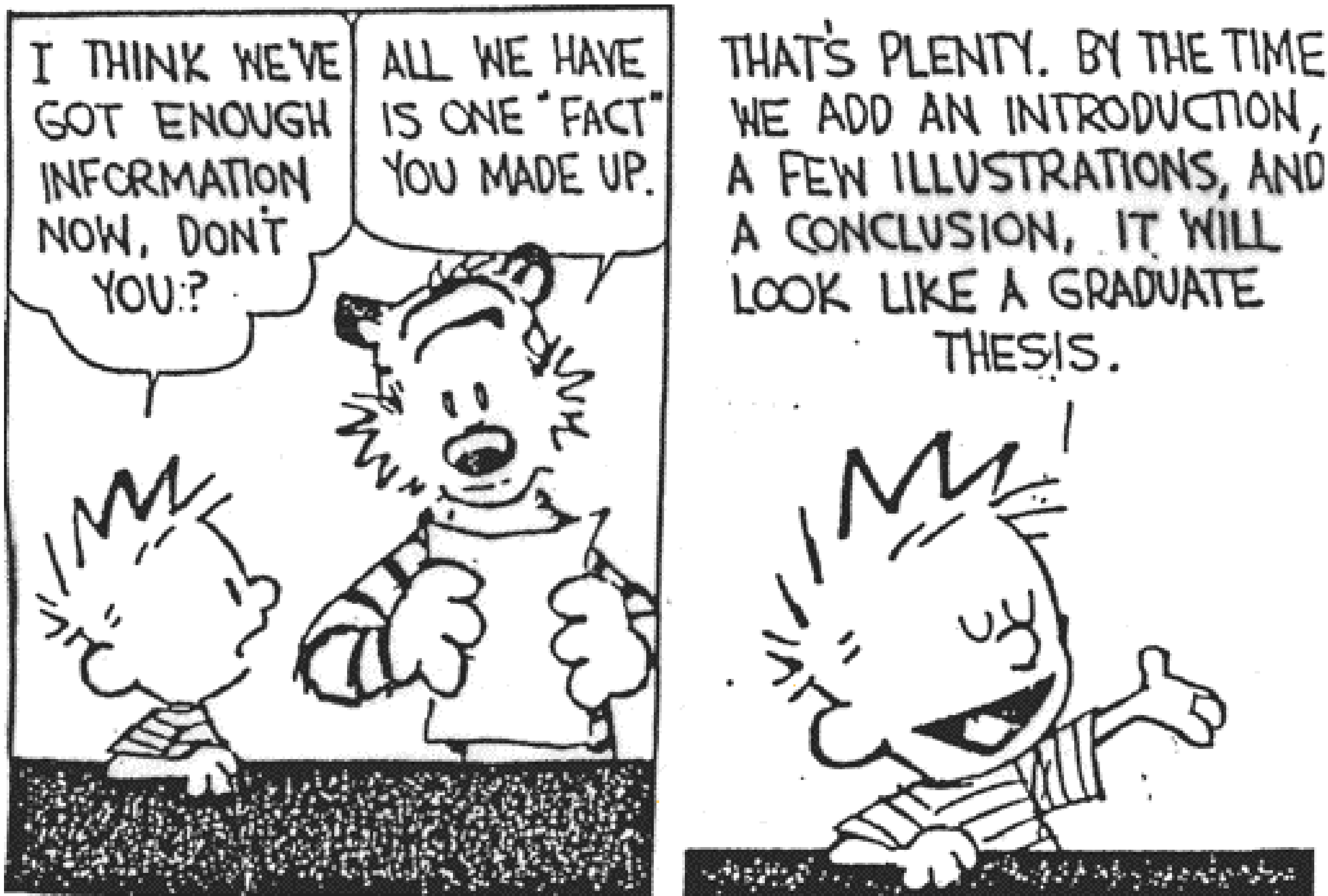
Exploratory case-study

- General Information
- Evaluation of elements from the analytical framework
- Identification of other relevant elements

3rd SO: Preliminay test of the analytical framework

- Experts engaged in projects that might support social innovation in forestry
- Short questionnaire anticipated by e-mail with a table to be filled in (the analytical framework);
- Semi-structured face-to-face interview to eventually integrate missing information.

Thank you!


I THINK WE'VE GOT ENOUGH INFORMATION NOW, DON'T YOU?
ALL WE HAVE IS ONE "FACT" YOU MADE UP.
THAT'S PLENTY. BY THE TIME WE ADD AN INTRODUCTION, A FEW ILLUSTRATIONS, AND A CONCLUSION, IT WILL LOOK LIKE A GRADUATE THESIS.

Developing a business model for small or low-intensity managed forest (SLIMF) owners under FSC Certification Scheme

Supervised By:
Professor Davide Pettenella
Università Degli Studi Di Padova, Italy

Co-supervisor:
Lucio Brotto
ETIFOR Srl - Forests Ideas Responsibility

Bishwajit Roy
Masters Student
Mediterranean Forestry and Natural Resource Management (MEDfOR)
Università Degli Studi Di Padova, Italy

OUTLINE

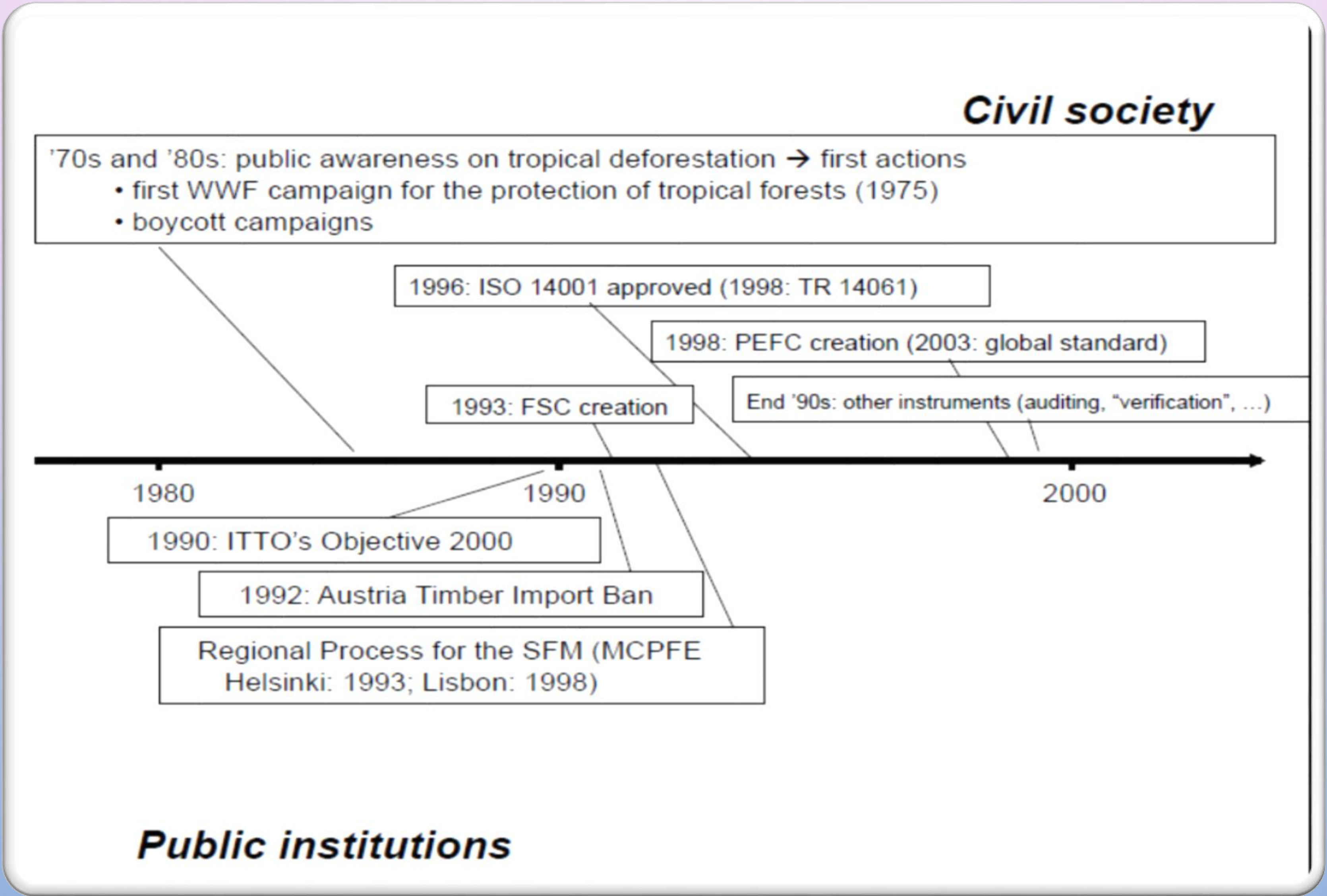
- Introduction
- Awareness with time
- Forest certification
- Forest Stewardship Council
- Small or low-intensity managed forest (SLIMF) holders
- Objectives
- Methodology
- Results
- Expected findings

Introduction

- Tropical forests 13% earth's land surface
- Source of natural resources for human kind and so on.
- Rate of deforestation 8.5 percent higher than during the 1990s (FAO, 2010b)

Awareness with time…

Awareness with time…



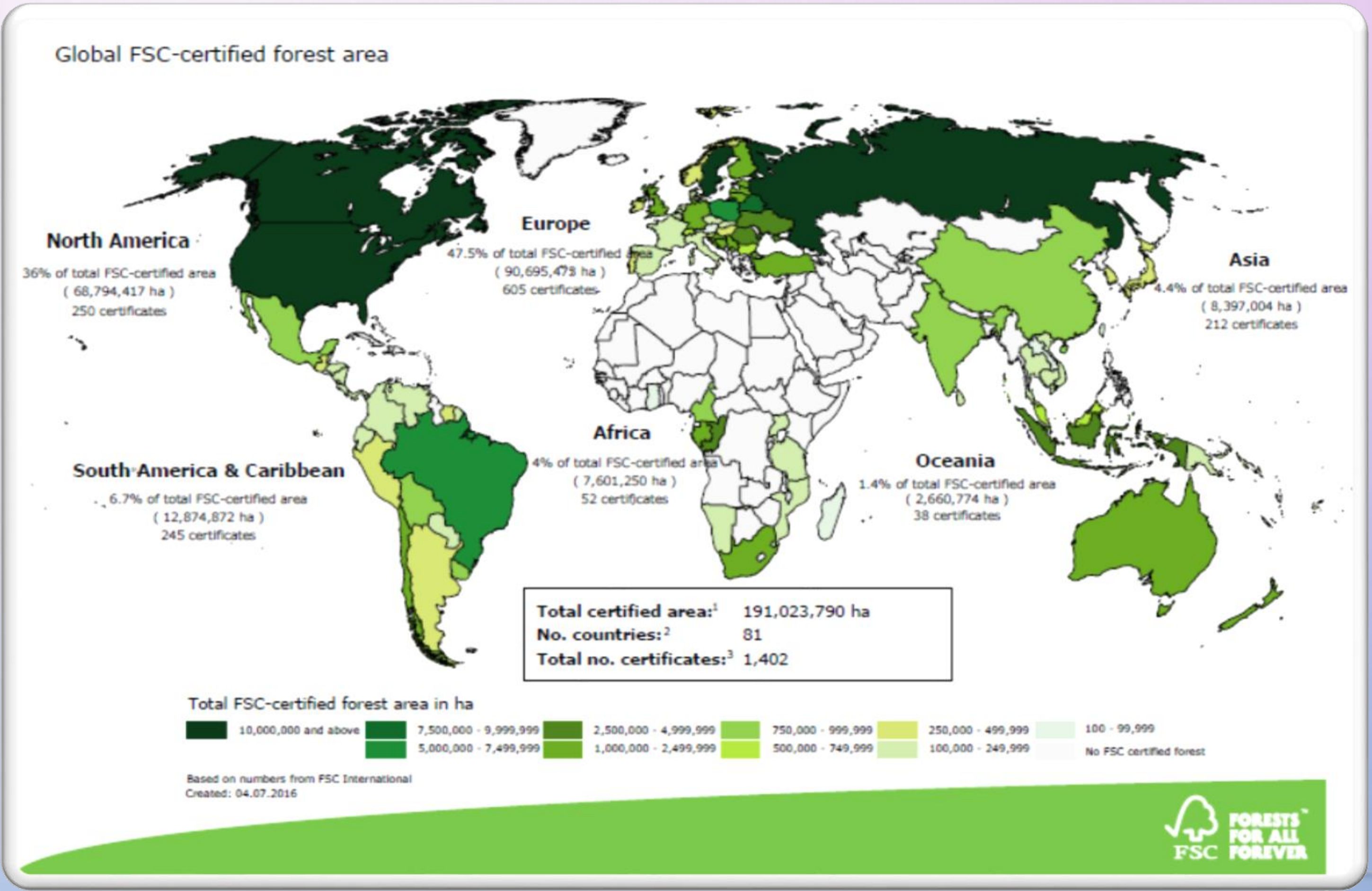
Source: Petenella, 2015 (Class material)

Journey of Forest Certification

- A market-based voluntary process
- Creating real incentives for SFM
- Certified by a third-party or certification body
- Against defined standards and criteria of responsible forestry practices developed by certification scheme

Forest Stewardship Council

- Environmentally appropriate
- Socially beneficial
- Economically viable



FSC, 2016

Small or low-intensity managed forest (SLIMF) (1)

- 60% of the total forest area (Di Lallo *et al*. 2016)
- SLIMF requirements:
- Small forest management unit:
    - ❖ A forest management unit with an area up to 100 ha
- Low intensity forest management unit:
    - ❖ Rate of harvesting <20 % of MAI
    - ❖ Annual harvest <less than 5000 cubic meters or
    - ❖ average annual harvest <5000 cubic meters per year

Small or low-intensity managed forest (SLIMF) (2)

Challenges faced:

- ❖ Lack of product development on quality / business development
- ❖ Poor market access
- ❖ Lack of knowledge on how to achieve certification
- ❖ Language!
- ❖ Lack of resources

Objectives

- To identify the strength and weakness of different business models at international level for small forest owners in and out of forestry sector.
- To ascertain clearly defined marketing strategy, business tools to improve the financial sustainability of smallholders products.
- To identify the available opportunities for easy access to international markets for their products.
- To help small forest holders to gain more benefits from the certification scheme as well as encouraging them to be part of certification process.

Methodology

Target group:

- ❑ Smallholders association;
- ❑ Consultants;
- ❑ FSC experts;
- ❑ Forest managers working with smallholders.

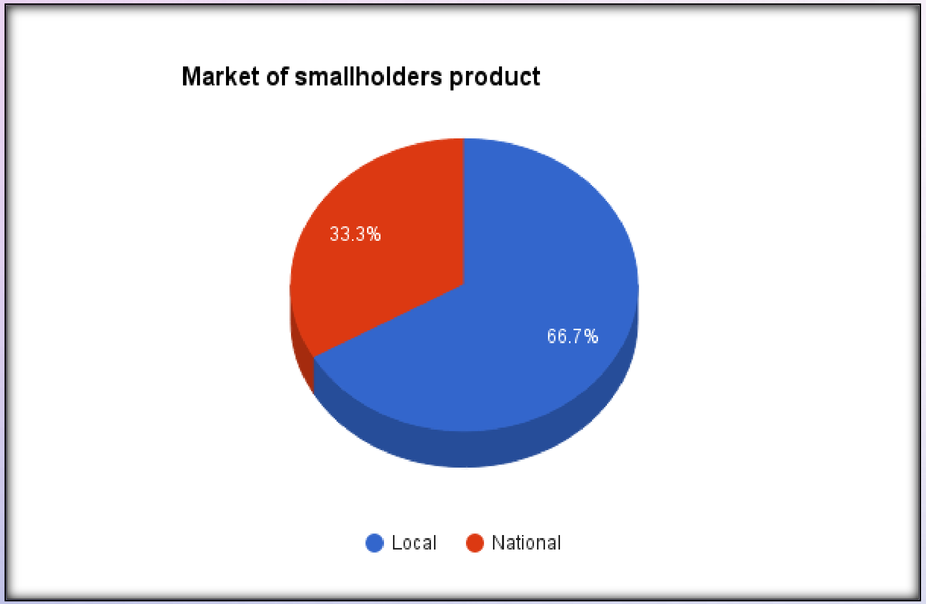
Methods

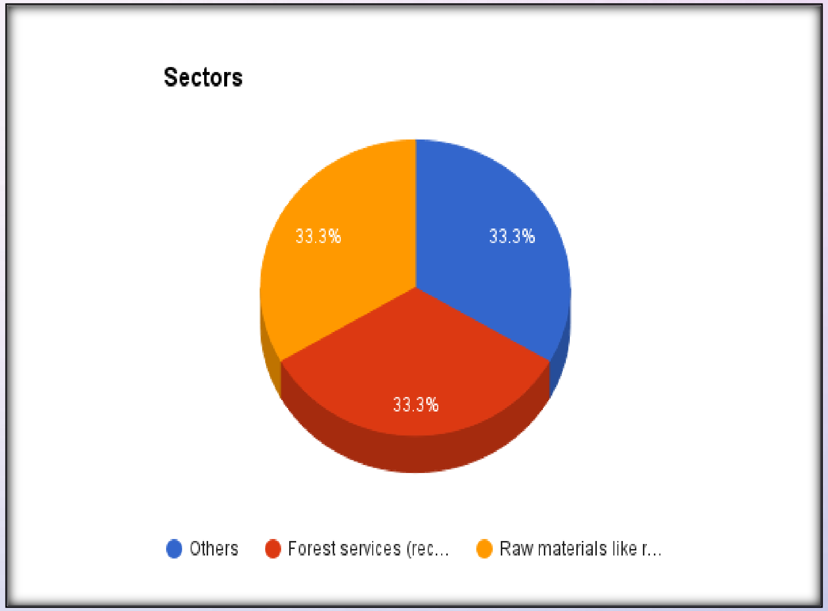
- Convenience sampling;

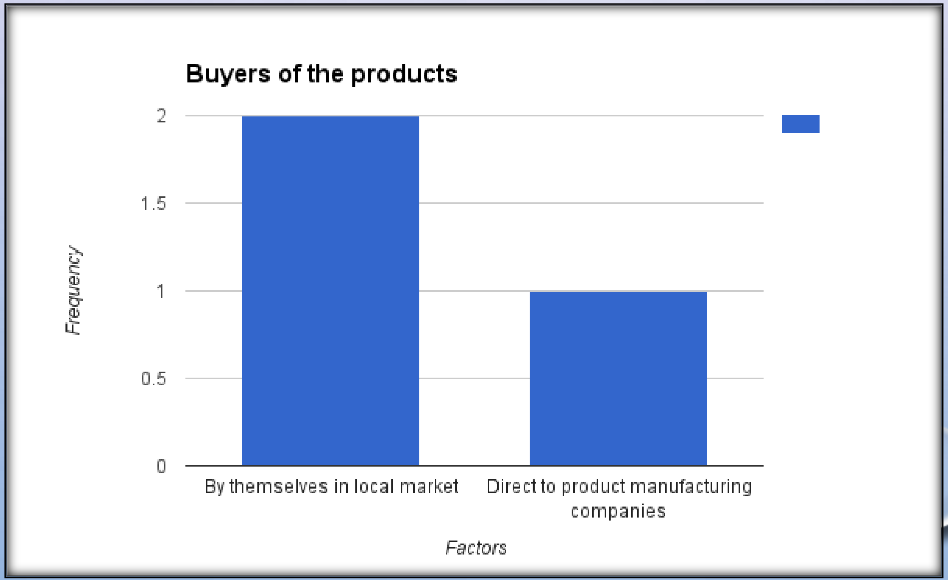
Data Collection:

- Skype interview
- Compilation of online questionnaire
  - ❑ Connection with the smallholders case study
  - ❑ Markets of small holders' products
  - ❑ Positive and negative aspects affecting the success of a small holders model

Results


Market of smallholders product
33.3%
66.7%
Local
National


Sectors
33.3%
33.3%
33.3%
Others
Forest services (rec...
Raw materials like r...


Buyers of the products
2
1.5
1
0.5
0
Frequency
By themselves in local market
Direct to product manufacturing companies
Factors

Expected findings

- Bringing out new ideas to facilitate the certification program for small forest owners.
- Step by step guide for small producers to identify the market opportunities and tools as well as their strength to have access to market and ensure financial sustainability.
- Finding out supporting organizations playing major role in making fsc certification possible, feasible and economically viable for small forest owners

Bringing back smile!

Thanks for your patience !!

ANALYSIS OF SUITABLE FOREST SPECIES FOR FORESTRY AND AGROFORESTRY USE IN CAPE VERDE

Sara Hassan

Prof. Giuseppe Scarascia Mugnozza

DIBAF

Cape Verde

Santiago

https://www.google.it/maps/place/Capo+Verde/@15.1200988,23.7452586,55650m/data=!3m1!1e3!4m5!3m4!1s0x9358f2159115131:0x6b1af236f918ea1f!8m2!3d15.120142!4d-23.6051722

Cape Verde

- 10 islands
- Population: 492,000
- land area of 4,033 km2

Soil

- Limited in size
- Formed from volcanic rocks
- Poor in organic matter
- Low potassium
- High phosphorus retention
- PH is neutral to alkaline

Occupation potentiality of soils in Cape Verde

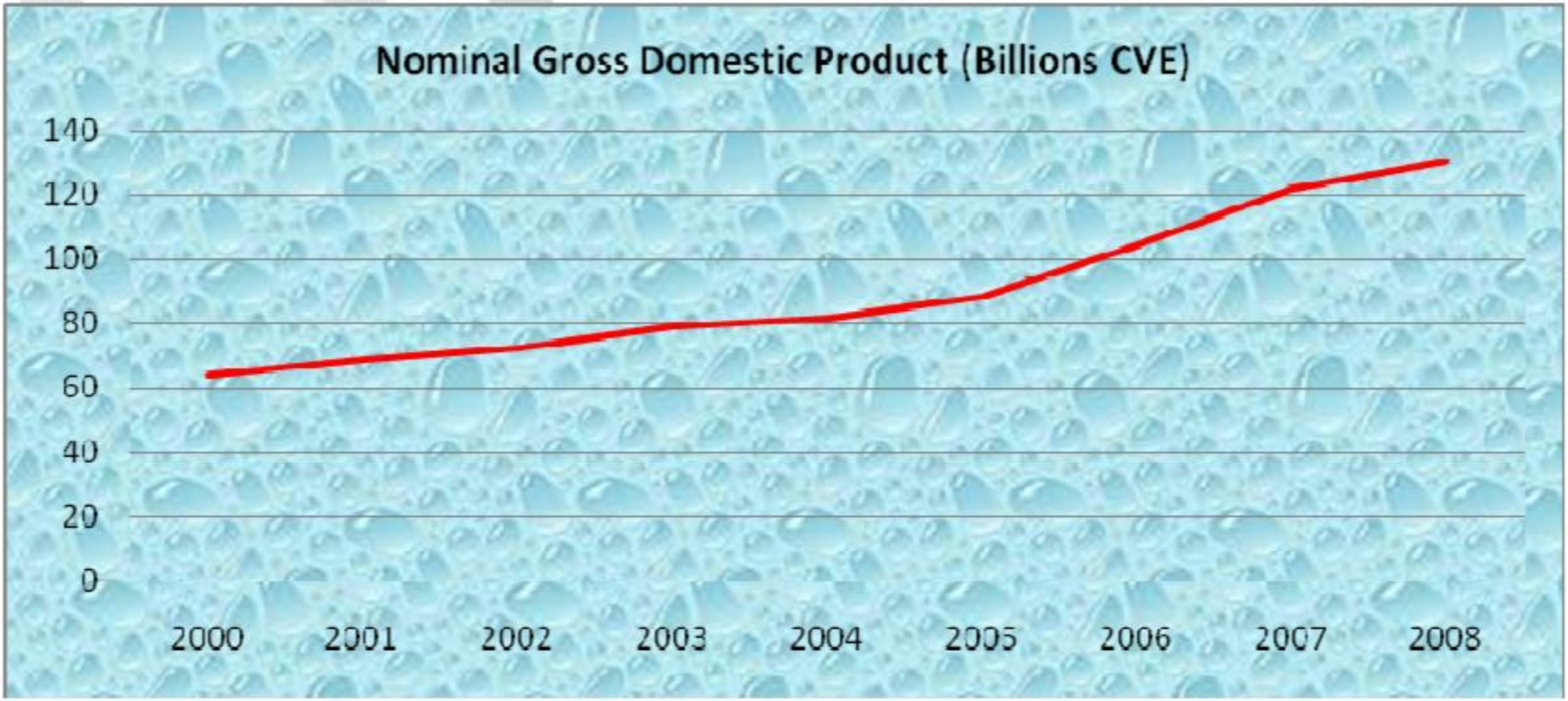
Potentiality	Surface (ha)	% of C. Verde surface
farmed land	38,969	9.7
irrigated	3,350	
pluvials	25,827	
agro-sylvi-pasturing	9,792	
sylvi-pasturing areas	55,457	13.7
forest of production	9,050	
forest of protection	46,407	
extensive pasturing domain	87,164	21.6
uncultivable lands	217,110	53.8
Total	**398,700**	**98.8**

From: CNUAD 92 – Report of Cape Verde

Sectoral composition in Cape Verde 2013

Source: Fifth National Report on the Status of Biodiveresity in Cape Verde

Economic growth of Cape Verde during 2000-2008

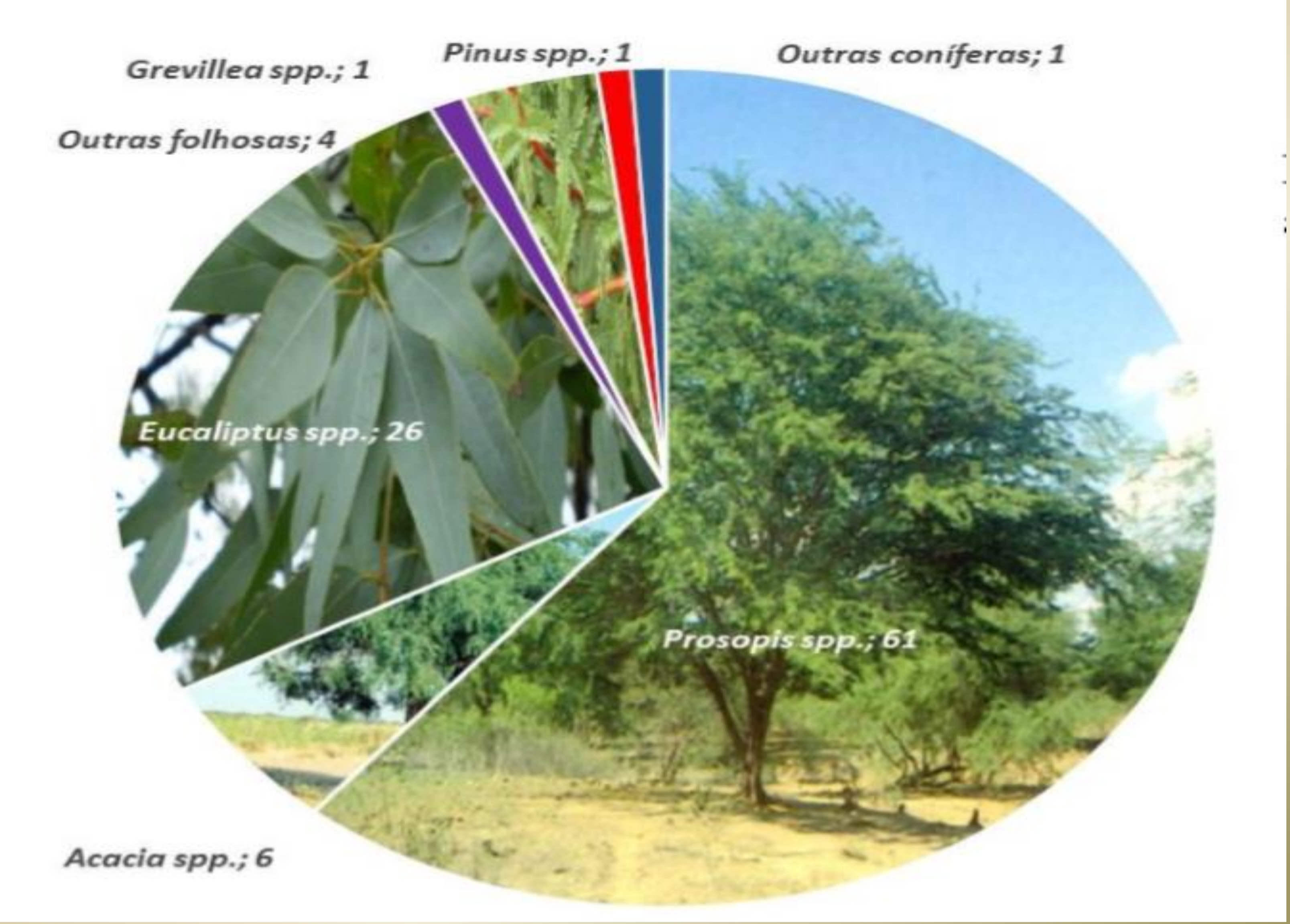


Source: Statistics from BCV

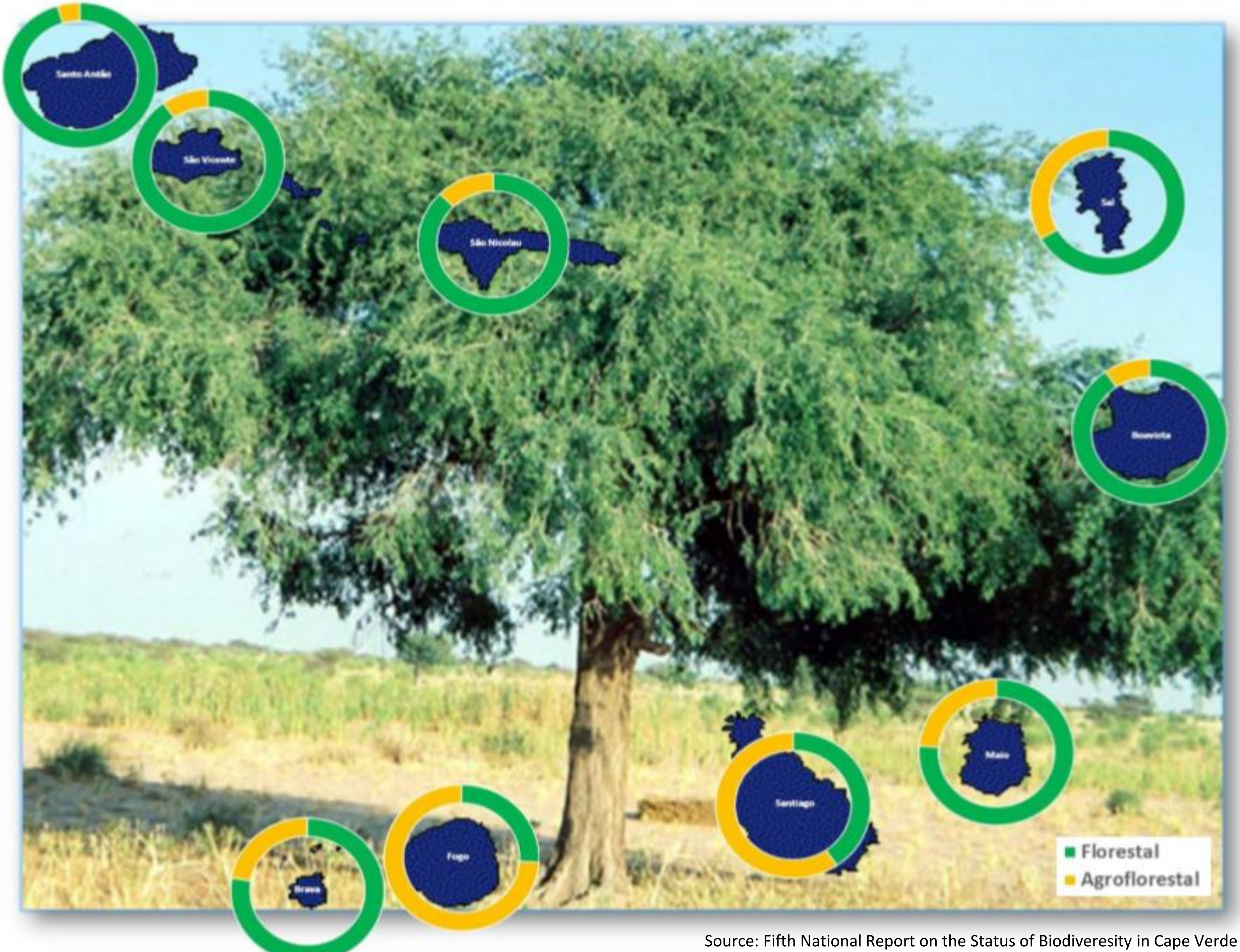
Challenges

- Water scarcity
- Climate change
- Poor soil quality
- Desertification
- Environmental pollution
- Capacity building

Species composition of Cape Verde forests 2013



Source: Fifth National Report on the Status of Biodiveresity in Cape Verde



Source: Fifth National Report on the Status of Biodiveresity in Cape Verde

First strategy: Wood production

Khaya senegalensis

Source:http://maderassostenibles.com/reforestationspecies.php

Eucalyptus citriodora

Source:http://arbornet.com.au/containertrees-corymbiacitriodoralemonscentedgum-p-964.html

Second strategy: Biofuel production

Jatropha sp

Third strategy: TWW plantation


Thank you

Using Yield-SAFE model to assess climate change impact on yield of coffee (*Coffea arabica*) under agroforestry and monoculture systems

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Dissertation to obtain the degree of Master in

Mediterranean Forestry and Natural Resources Management (MEDFOR)

Supervisors:

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1. Introduction

- Ethiopia is the origin of Coffee *(Coffea arabica, L.)*

- Is currently the leading coffee producer in Africa and ranked 5th in the world

- The country's economy is strongly dependent on coffee;

    - More than 35 % of total exports
    - More than 10 % of the GDP
    - There is a popular saying that "coffee is the backbone of our life"

Bossolasco, 2009

Introduction

- In Ethiopia, coffee production systems grouped:
  - Coffee plantations (5%) - monoculture system+ supplemented with inputs
  - Forest coffee (10%) - naturally growing under shade of trees
  - Semi-forest coffee (35%) - managed + cultural practices
  - Garden coffee (50%)
    - Grown in vicinity of farmers’ residences
    - managed + less supplemented inputs
    - Agroforestry based and monoculture systems
- For this study, we considered the garden coffee production systems

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Introduction

- The IPCC set CC emission scenarios depend on world future economy and population growth

  - RCP 4.5 scenario- assumes 500-720 ppm of CO_2 eq concentration in the Atm by 2100

  - RCP 8.5 scenario – assumes > 1000 ppm of CO_2 eq concentration in the Atm by 2100 (Wayne, 2013)

- In both scenarios, temperature will increase and precipitation more uncertain in Ethiopia

Introduction

- Change of these climate variables severely affect coffee growth

Effect of High temperature on coffee leaves and bean

Effect of drought on coffee leaves, Ethiopia

Girma et al., 2016

- Yield of coffee predicted in Ethiopia to decrease by
  - 65% in RCP 4.5 scenario
  - 100% in RCP 8.5, in 2080, if adaptations are not implemented (Davis et al., 2012)

Introduction

- Therefore, for sustainable coffee production adaptation strategies against CC is absolutely necessary

- Growing coffee under the shade of trees (agroforestry-based) is one of the strategies (Jaramillo et al., 2011)

- However, in Ethiopia, roles of shade trees on coffee production under long term CC have not been studied

Introduction

Objectives

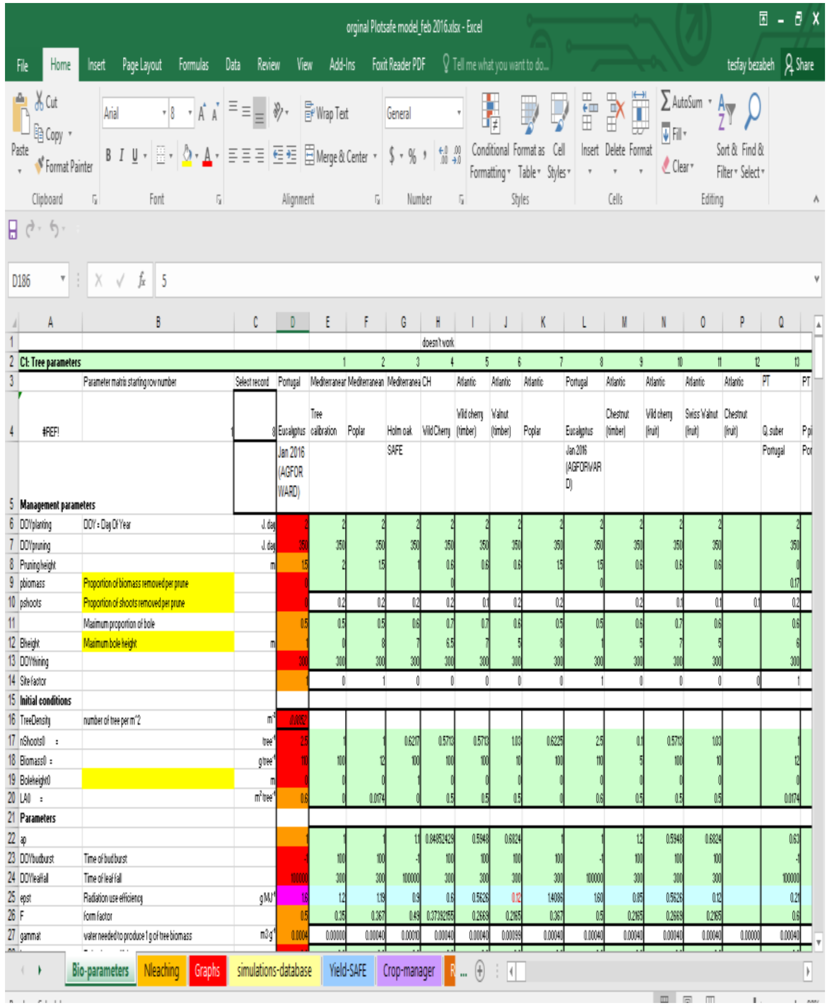
- Assessing coffee productivity in agroforestry and monoculture systems under different climate scenarios in the study districts

- Hoping to yield recommendations for coffee growers and policy makers

Introduction

- To achieved these objectives, we used Yield-SAFE model

- Yield-SAFE is:
  - a daily time step process-based
  - Predicting impact of climate, soil & management regimes on yields
  - Inputs: daily climate, soil, and growth parameters
  - Outputs: daily growth dynamics and yield of crops or trees



Bio-parameters module of Yield-SAFE model

2. Materials and Methods

2.1 Description of the study districts

- The Wonago district (South Ethiopia)
  - 11-27 °C
  - 1270-1390 mm
- The Limu kosa district (Southwest Ethiopia)
  - 12-30 °C
  - 1885 mm
- Manasibu district (West Ethiopia)
- Darolebu district (East Ethiopia)

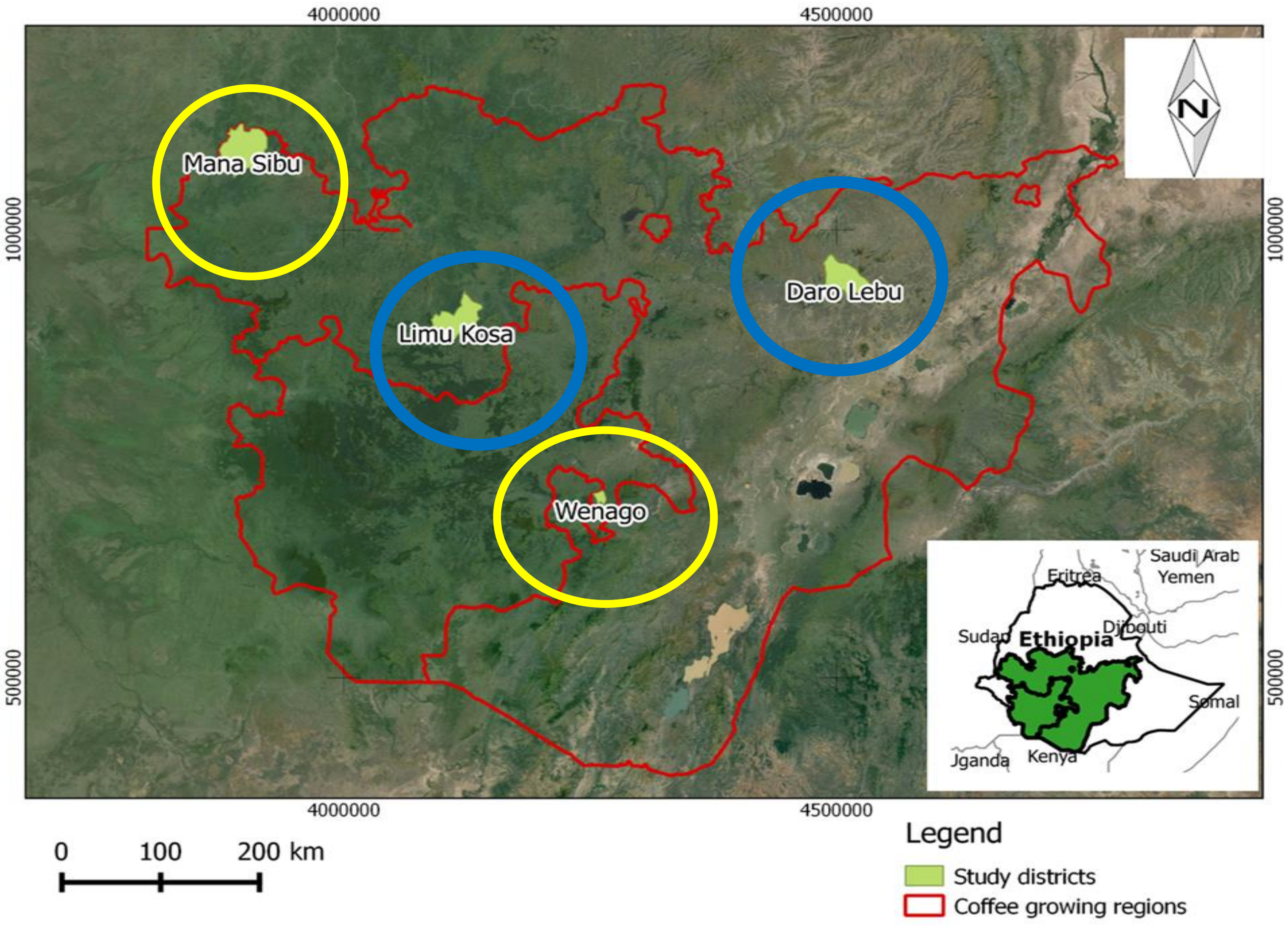


Fig 1. Geographical location of the study areas

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2.2 Tree species selection

- ***Albizia gummifera*** is a leguminous tree and the most appropriate shade tree (AF-based) for coffee in Ethiopia

- For Yield-SAFE model inputs, a general recommended densities of coffee and the tree were used

- In both districts, 60 trees ha^{-1} is the optimum number for the system

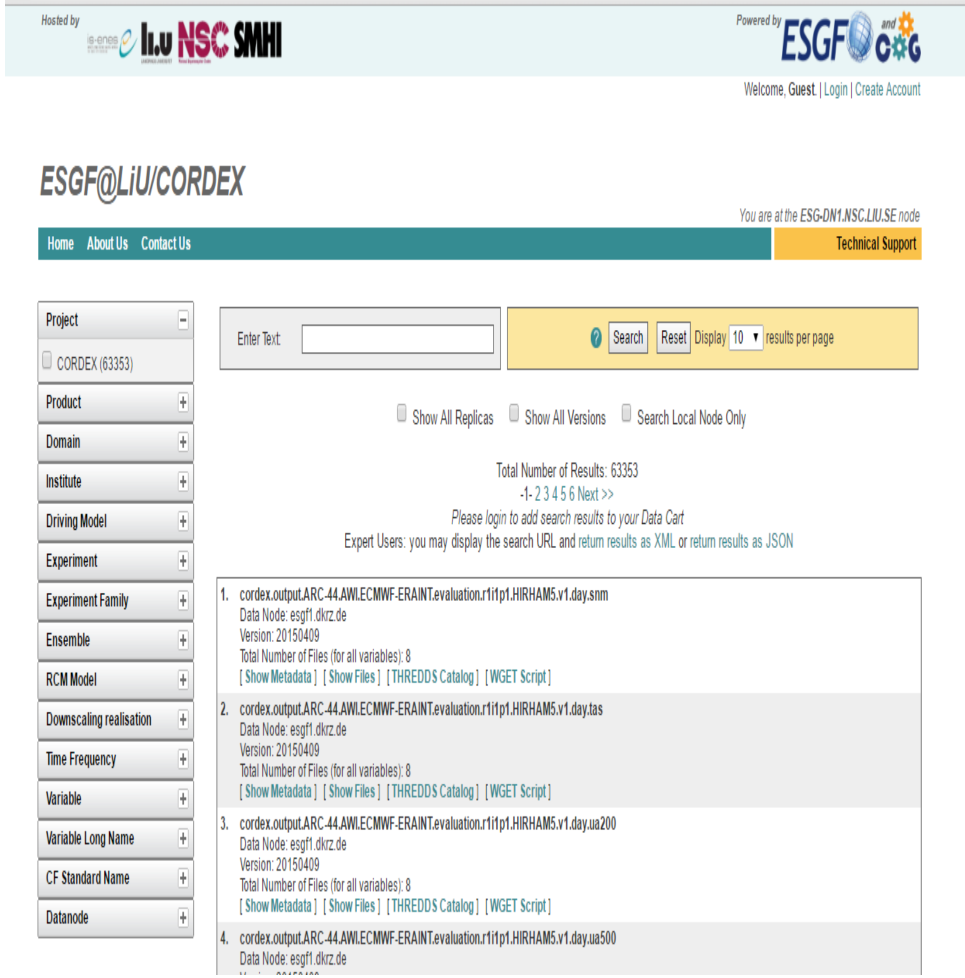
a multipurpose *Albizia gummifera tree*

Hiwot, 2011

2.3 Yield-SAFE model inputs for the study areas

Climate data inputs

- There is scarcity of long term historical daily climate data in the study areas
- So, simulated climate data (historical and future scenarios) was retrieved from the Earth System Grid (ESG)
- The datasets developed by HadCM2 climate model in ESG were used



ESG climate data portal

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Climate data inputs

- A daily
  - Min and Max temperature
  - Precipitation
  - Radiation,
  - RH and wind speed of historical and two scenarios were downloaded to use as Yield-SAFE inputs

- Two climate change scenarios were used (Wayne, 2013):
  - RCP 4.5
  - RCP 8.5

- A program in Python programming language was developed to retrieve the climate data

```
from netCDF4 import Dataset
import numpy as np
import datetime
import csv
import cgi
import sys
import os
import mat
def get_Rlat_Rlon(X,Y,arrLonLatRlonRlat):
Lons=[]
Lats=[]
RLons=[]
RLats=[]
c=0
for row in arrLonLatRlonRlat:
if c>0: #header
Lons.append(float(row[0]))
Lats.append(float(row[1]))
RLons.append(float(row[2]))
RLats.append(float(row[3]))
c +=1
```

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Yield-SAFE model inputs for the study areas

Coffee parameter inputs

Table 1. Parameter values for coffee obtained from literature

Parameter	Unit	Values	Reference
Radiation use efficiency (RUE)	g MJ^{-1}	0.06-2.76	Charbonnier, 2013
Water use efficiency (WUE)	m^3 g^{-1}	0.0037-0.0073	Beining, 2007
WUE	m^3 g^{-1}	0.0073-0.011	Hiwot, 2011
Specific Leaf Area (SLA)	m^2 kg^{-1}	14.21	Kufa & Burkhardt, 2015
SLA	m^2 kg^{-1}	9.8-11.6	Bote & Struik, 2011
Maximum leaf area	m^2 $tree^{-1}$	9-18	Montoya et al., 2013
Initial leaf area (4-month-old seedling)	m^2 $tree^{-1}$	0.189-0.22	Dias et al., 2007
Leaf area index		2.8-5	Kufa & Burkhardt, 2015
Leaf area index		0.8-2	Montoya et al., 2013
Harvest index	g g^{-1}	0.1-0.7	Rodrigues et al., 2015
Initial biomass (1 year old seedling)	g $tree^{-1}$	26-36	Kufa, 2012
Maintenance respiration coefficient	g g^{-1}	0.0031	Brand et al., 2002
Base temperature	°C	10.2	Pezzopane et al., 2012

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Yield-SAFE model inputs for the study areas

Tree parameter inputs

Table 2. Parameter values for *Albizia gummifera* tree obtained from literature

Parameter	Unit	Values	Reference
Light use efficiency (LUE)	g MJ^{-1}	0.76	Binkley et al., 1992
Water use efficiency (WUE)	m^3 g^{-1}	0.00004	Zahid et al., 2010
WUE	m^3 g^{-1}	0.00023	Andrew et al., 2013
Maximum leaf area	m^2 $tree^{-1}$	80-110	Andrew et al., 2013
Specific leaf area	m^2 kg^{-1}	2.96-3.65	Andrew et al., 2013
Leaf area index		1.3-4	Omer et al., 2016
Initial leaf area (6 months-old seedling)	cm^2 $tree^{-1}$	136-405	Missanjo & Maya, 2015
Initial biomass (6 months old seedling)	g $tree^{-1}$	11.3	Missanjo & Maya, 2015
Initial biomass (6-months old seedling)	g $tree^{-1}$	27.2	Andrew et al., 2013
Wood density	g m^{-3}	430, 000-800,000	Reyes et al., 1992

Yield-SAFE model inputs for the study areas

Soil inputs

- Soil texture and depth are also needed as inputs in Yield-SAFE model
- Based on FAO's classification, soil textural classes of the study areas:
    - Limu kosa district is Nitisol (very fine) with depth of 35 cm
    - Wonago district is Nitisol (very fine) with depth of 15-40 cm

2.4. Model calibration

- The yield of Albizia gummifera and coffee were simulated with Yield-SAFE model using:
  - Their monoculture growth parameters
  - 20 years of daily historical climate (1986-2005)
  - Soil inputs

- Albizia gummifera tree variables were calibrated using their reference values

- Yield of coffee was also calibrated in monoculture and under the tree (AF-based) using their reference values

- The well calibrated model was used to predict yield of coffee for 40 years of evaluation (current) climate (1966-2005) and the future scenarios (2006-2045)

3. Results

3.1 Model calibration outputs

Albizia gummifera tree

Limu kosa district

Wonago district

Tree biomass (kg $tree^{-1}$)

Diameter (cm)

Leaf area (m^2 $tree^{-1}$)

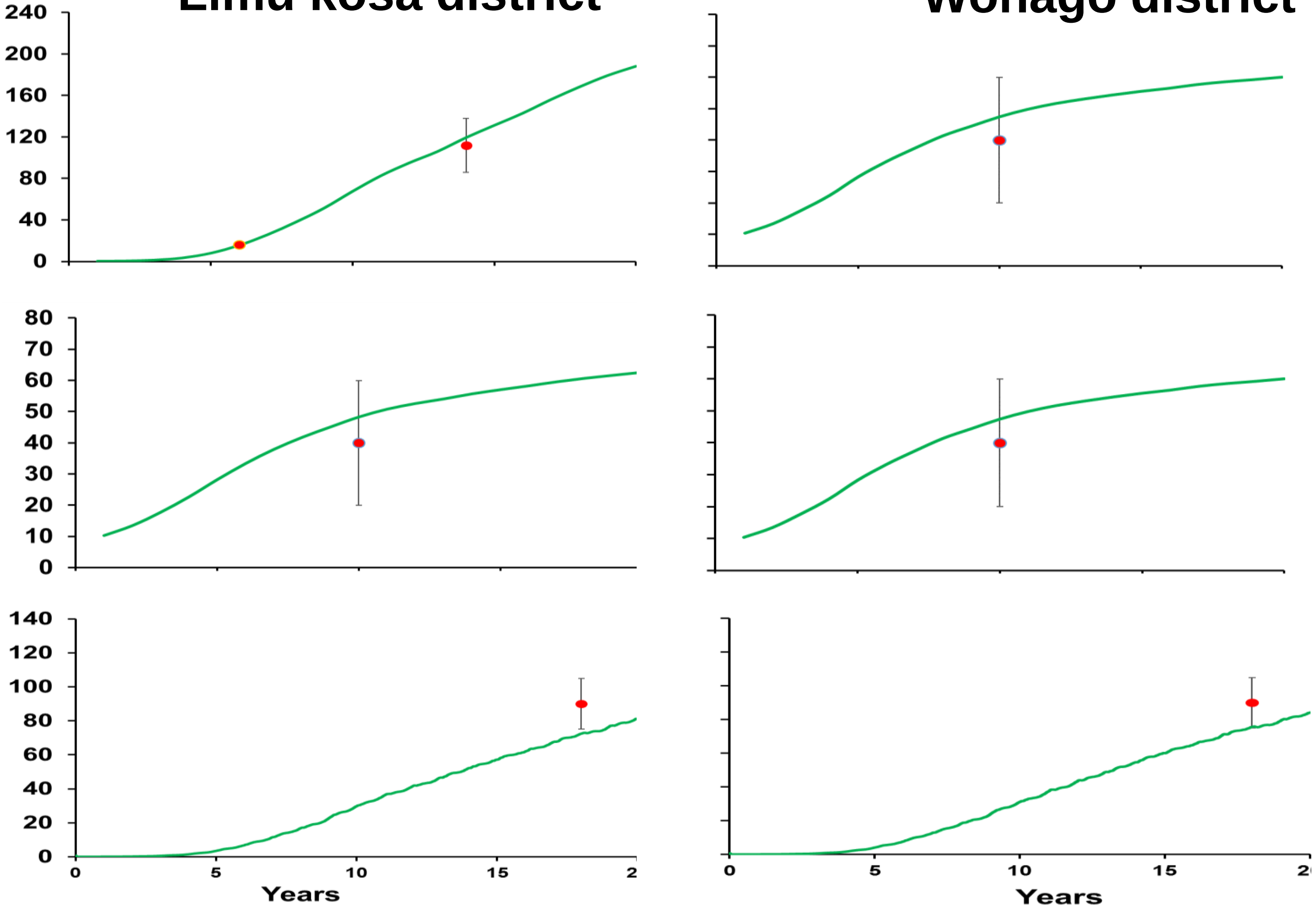
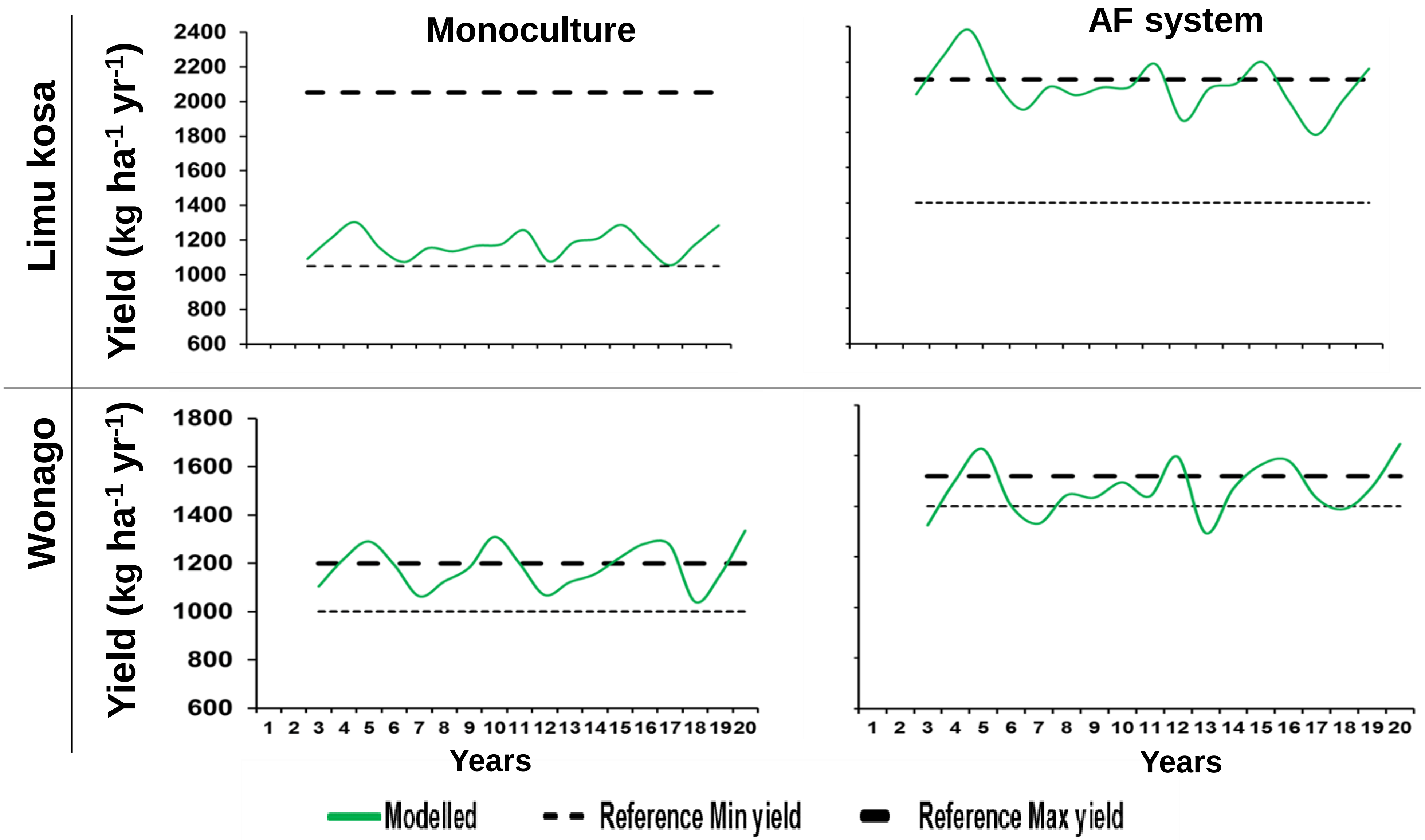


Fig 2 . Reference values (points) and Yield-SAFE model estimation (green line) (error bars show Max and Min values of tree variables)

Model calibration outputs

Coffee yield



3.2 Impact of climate change on coffee yield

Limu kosa district

Table 3. Average of 20 years' monthly temperature & total annual precipitation in current & future scenarios - HadCM2 climate model

Temperature (ºC)			Precipitation (mm)		
Current	RCP 4.5	RCP 8.5	Current	RCP 4.5	RCP 8.5
19.5	20 (+0.5)	20.4 (+0.9)	1265	1334 (+69)	1384 (+120)

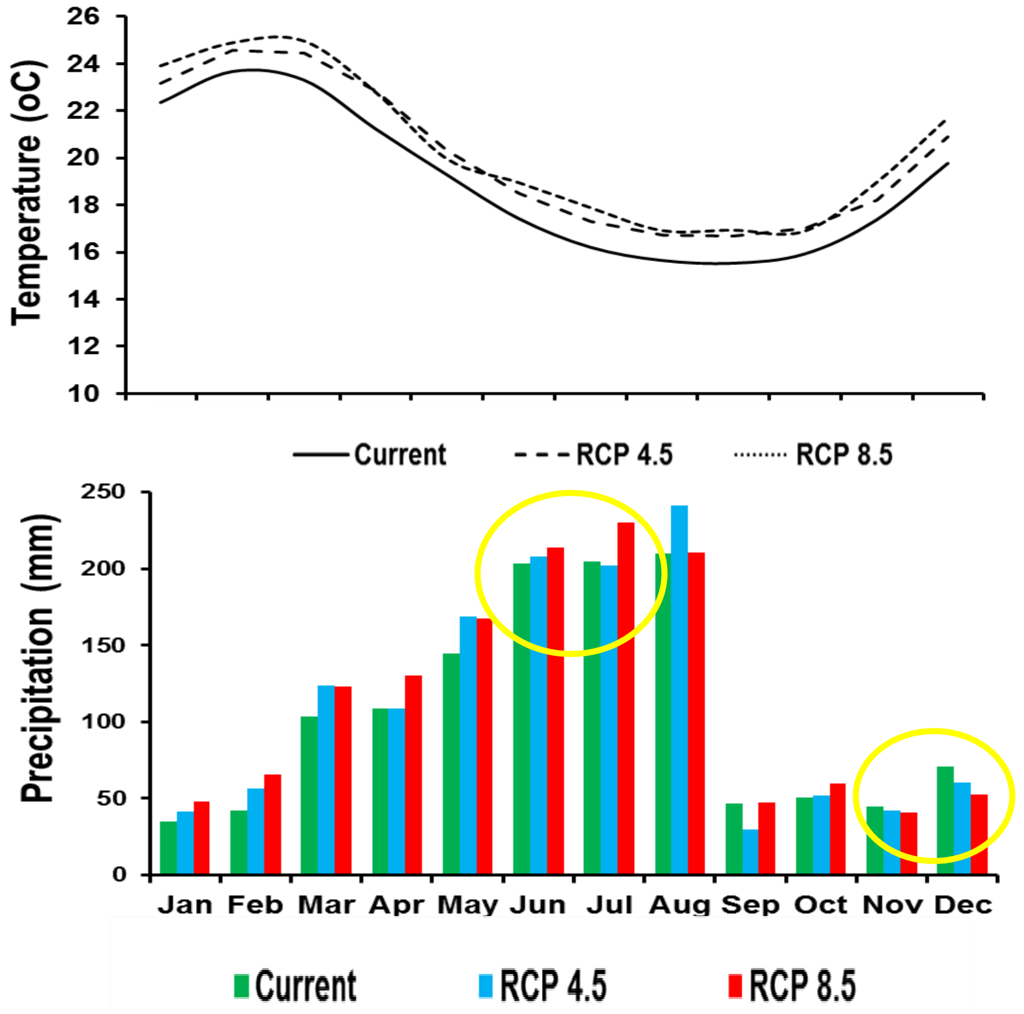


Fig 3. Current and two scenarios climate trends of Limu kosa district

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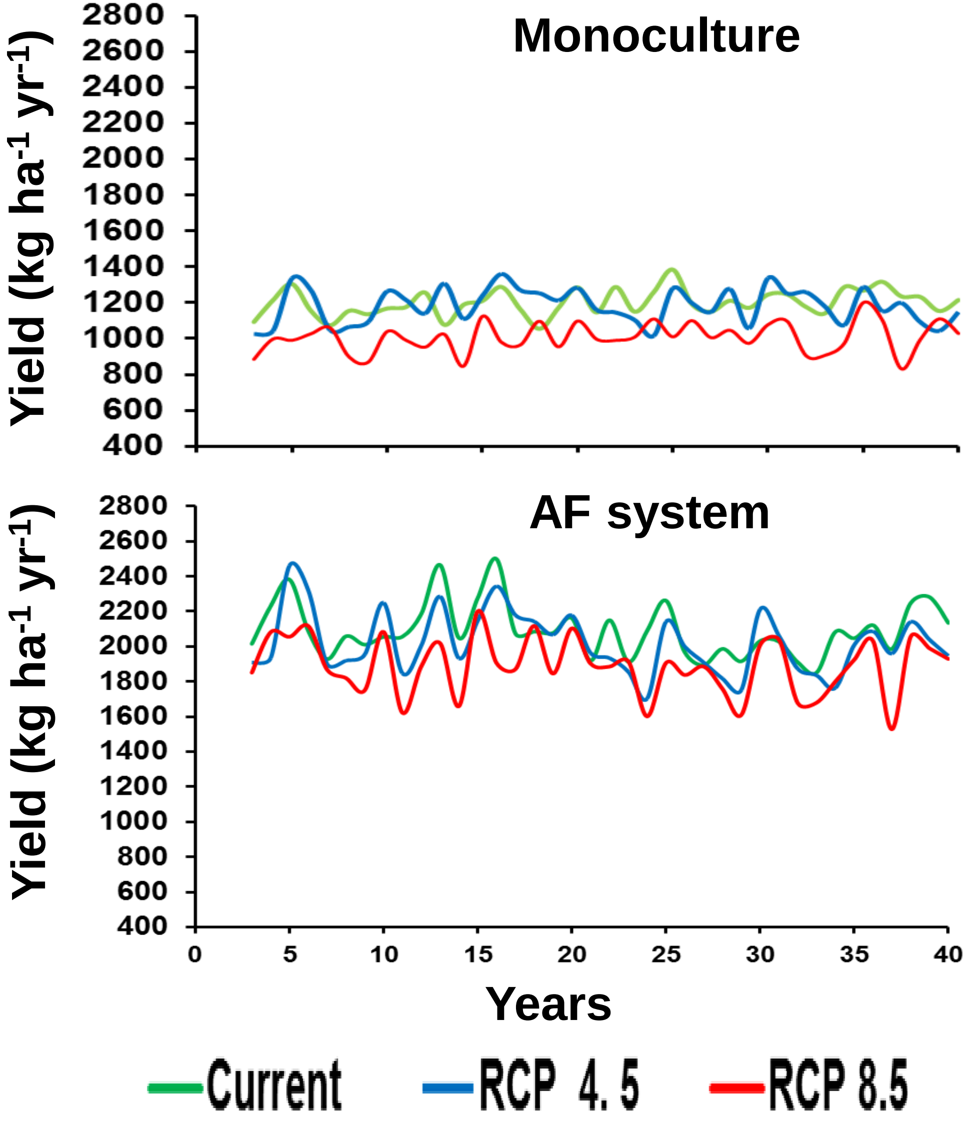
Impact of climate change on coffee yield

Using these climate, Yield-SAFE mode simulated yield of coffee as:



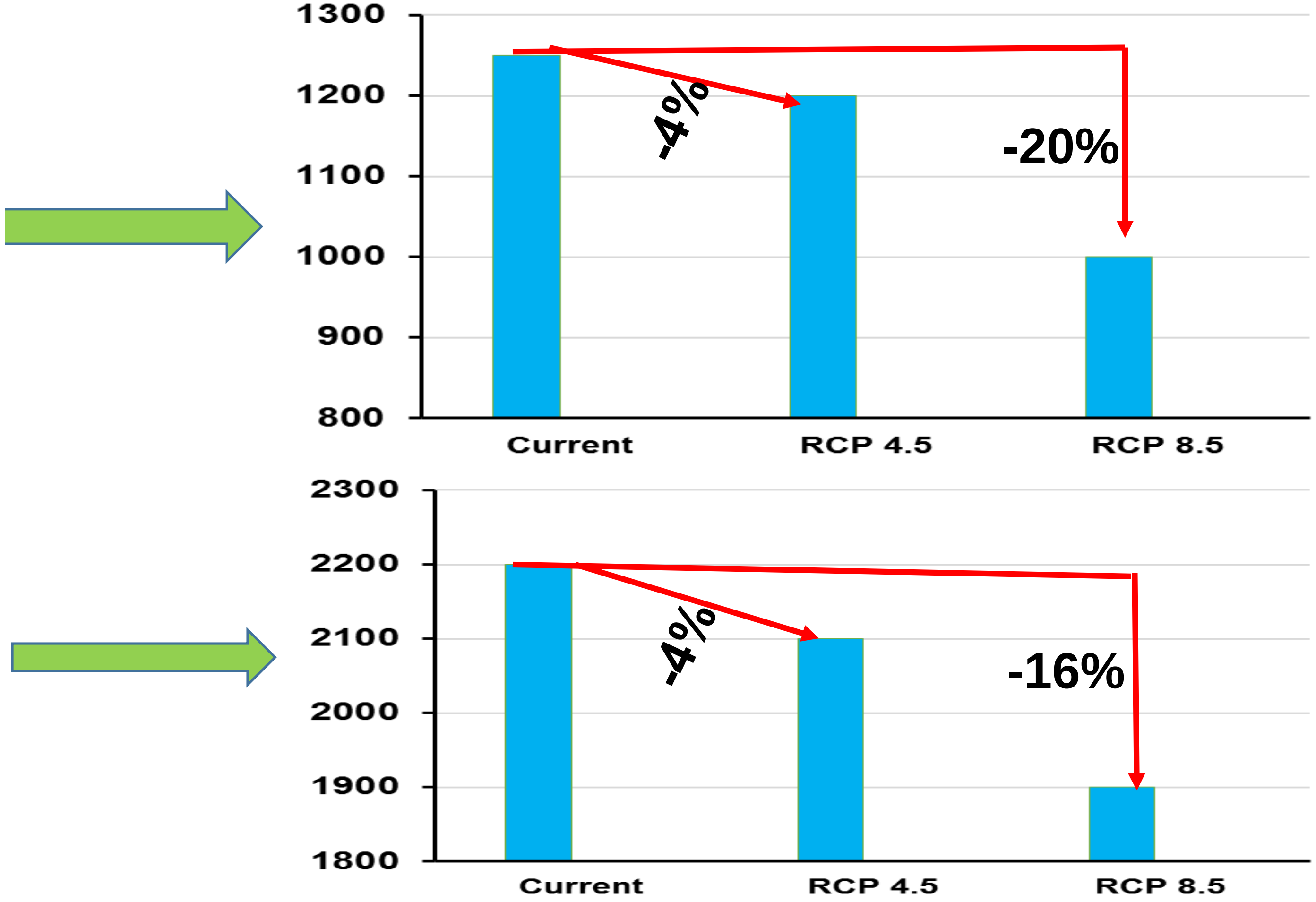


Fig 4. Predicted 40 years' average yield of coffee in monoculture and AF systems in Limu kosa district

Impact of climate change on coffee yield

Wonago distract

Table 4. Average of 20 years' monthly temperature & total annual precipitation in current and future scenarios- HadCM2 climate model

Temperature (ºC)			Precipitation (mm)		
Current	RCP 4.5	RCP 8.5	Current	RCP 4.5	RCP 8.5
20	**20.6 (+0.6)**	**20.8 (+0.8)**	**1136**	**1226 (+90)**	**1260 (+124)**

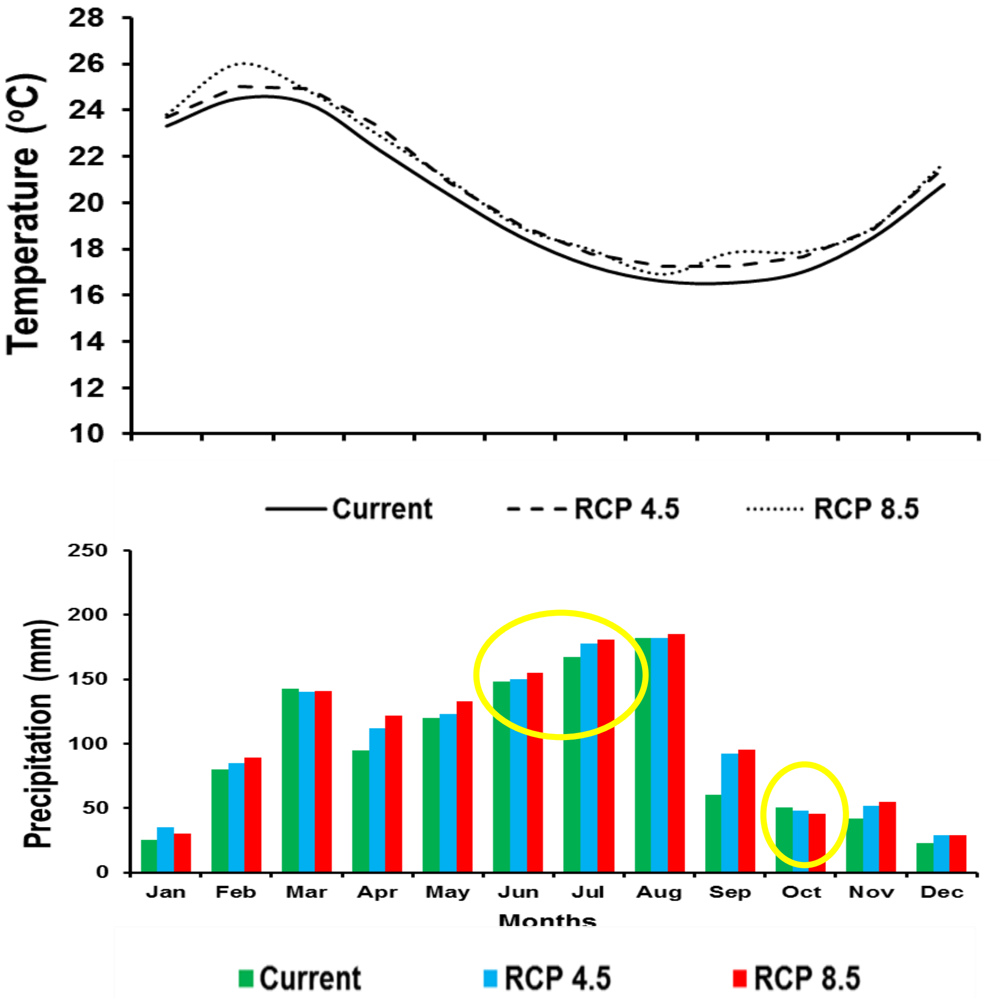
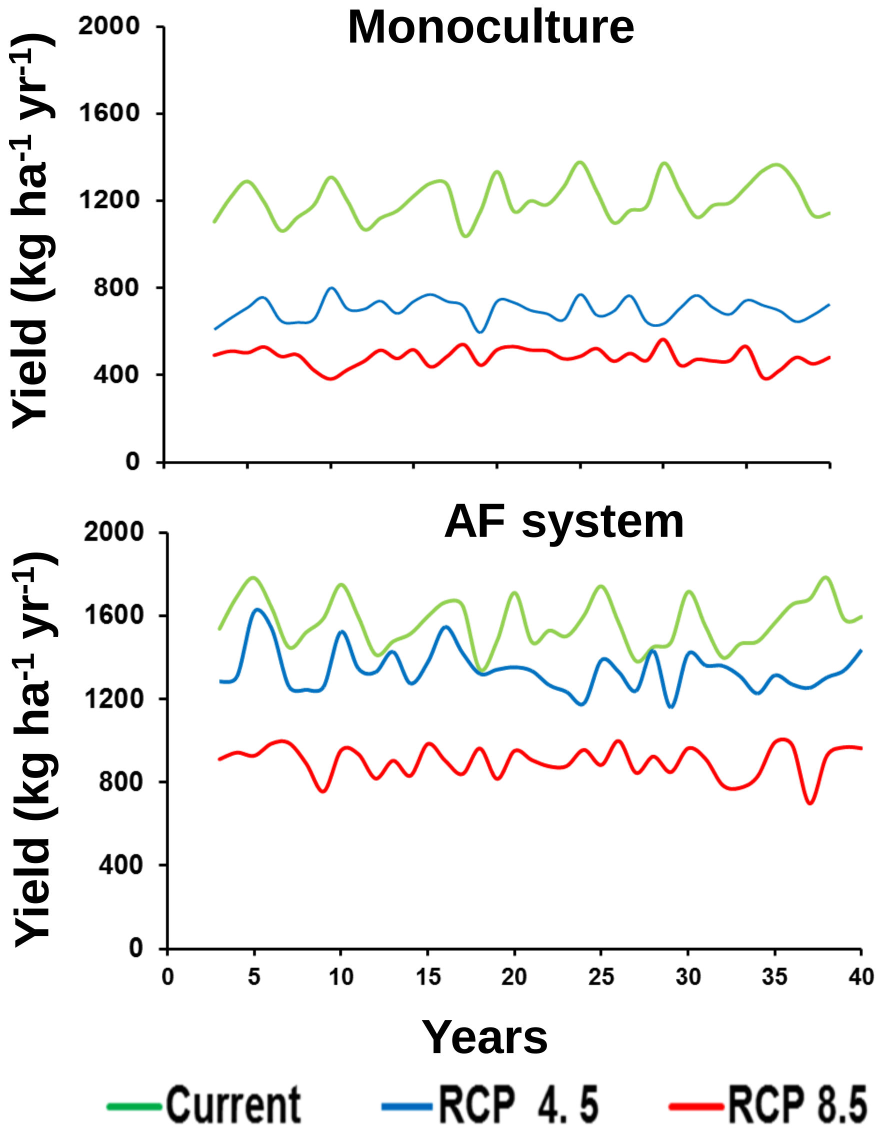


Fig 5. Current and two scenarios climate trends of Wonago district

Impact of climate change on coffee yield

Using these climate data , Yield-SAFE mode simulated yield of coffee as:



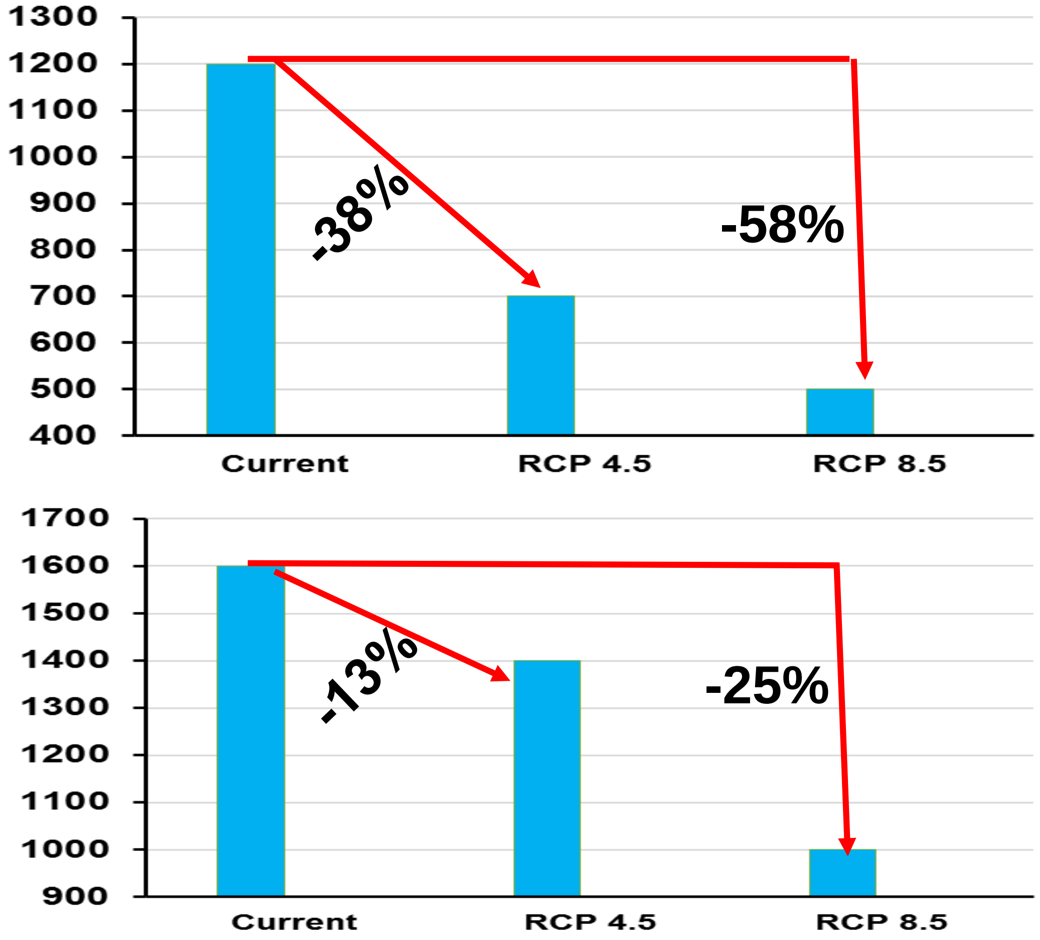


Fig 6. Predicted 40 years' average yield of coffee in monoculture and AF systems in Wonago district

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Impact of climate change on coffee yield

- Yield of coffee was estimated to decrease 4-25% under AF whereas 4-58% in monoculture in the future climate scenarios. The reasons are:

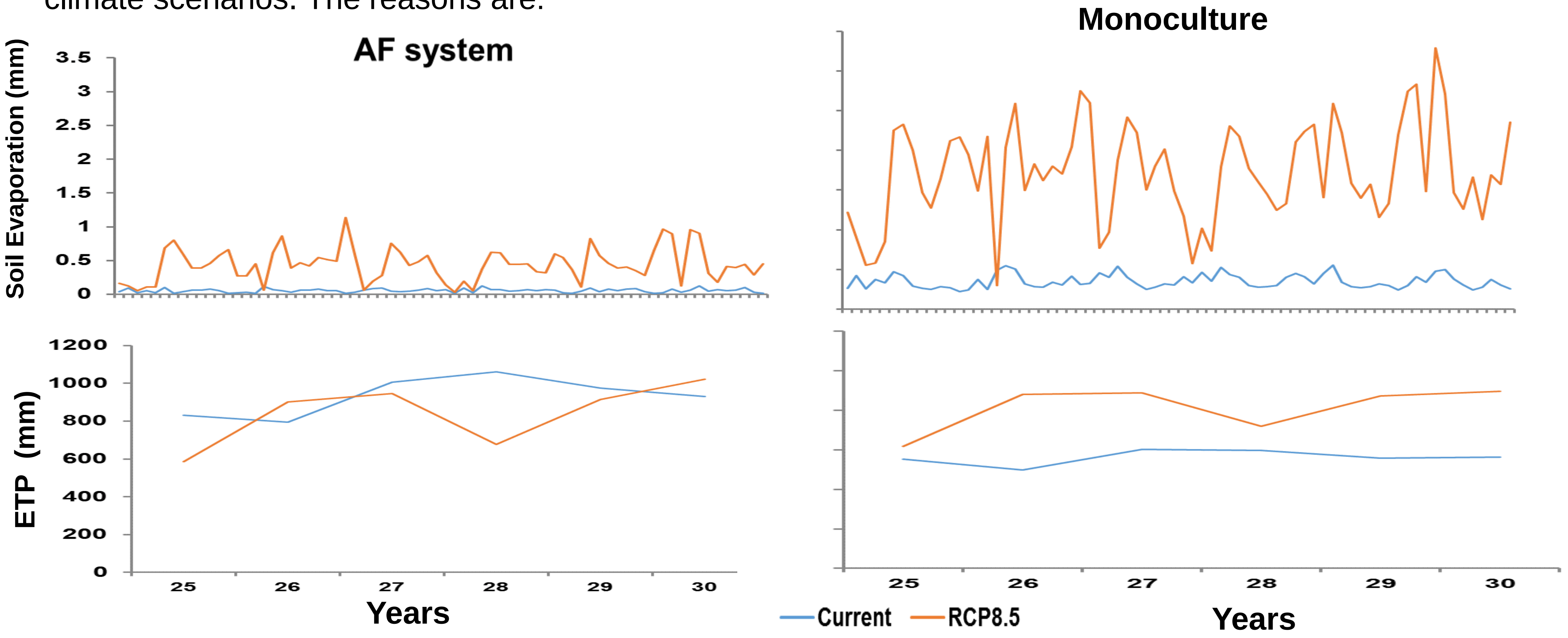

Fig 7. Comparison of water dynamics between AF and monoculture under current climate and in RCP 8.5 scenario in Wonago district

4. Conclusion and Future research

Conclusion and Future research

- This is the first time that was used Yield-SAFE model to predict effects of CC on *Coffee arabica* and the results are good

- The model is also helpful for the understanding the impacts of climate variables and soil dynamics on coffee productivity under climate change

- Yield of coffee in the Limu kosa (Southwest Ethiopia) is less impacted by CC compared to Wonago (South Ethiopia) district this due to it has higher current precipitation and soil depth

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Conclusion and Future research

- Coffee yield under agroforestry system seems to be more resilient when compared to monoculture in the future scenarios

- Therefore, coffee growing under agroforestry seems to be a key adaptation for mitigating the negative impacts of future climate in coffee production

- We also suggest coffee growth variables should be taken from permanent plots as model inputs, for better Yield-SAFE predictions

THANK YOU VERY MUCH!

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