RISK MANAGEMENT IN AGRICULTURE AND CROP INSURANCE: IMPLEMENTATION OF A METHOD FOR ESTIMATING REFERENCE YIELDS IN ORGANIC FIELD CROPS IN FRANCE

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STUDY CONTEXT

Agriculture in France is subject to numerous constraints, notably increasing meteorological risks in recent years due to climate change. Faced with natural disasters and pressure from bio-aggressors, farmers in both conventional and organic production are confronted with a multitude of risk factors leading to variability in their agricultural yields (Arora 2019; Malhi et al., 2021). Consequently, risk management is a key issue for the sustainability of agricultural activities. Crop insurance is considered an essential tool for safeguarding against these various risks and securing farmers' income (Folus et al. 2020; Frascarelli et al., 2021; Koenig et al., 2022).

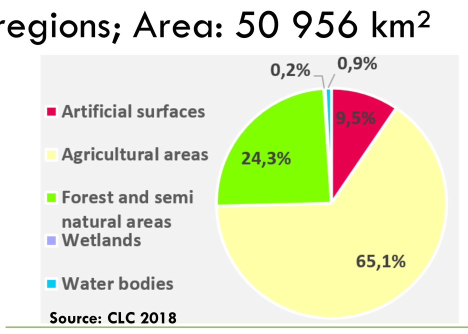
OBJECTIVE

Compared to conventional agriculture, there are not enough reference yields for organic farming in most agricultural regions of France. This lack of reference data makes it difficult for insurers to set up crop insurance contracts appropriate to agricultural, environmental, and climatic contexts of farmers.

The objective of this study is to develop a method for estimating reference yields in large-scale crops (winter soft wheat, maize, spring barley) in organic farming, using statistical models, in order to determine the conditions and parameters to be considered for crop insurance pricing and the contractualization of Groupama *Paris Val de Loire* (GPVL, French insurance company) members.

STUDY AREA

Groupama PVL: 4 regions, 10 departments, 84 small agricultural regions; Area: 50 956 km²



Crop	Area (km²)	Area (%)
Winter soft wheat	8 587	31%
Winter swede rape	2 386	9%
Winter barley	2 064	7%
Spring barley	1 865	7%
Permanent grassland	1 853	7%
Maize	1 689	6%
Others	9 251	33%
Total	27 695	100%

Source: RPG 2020

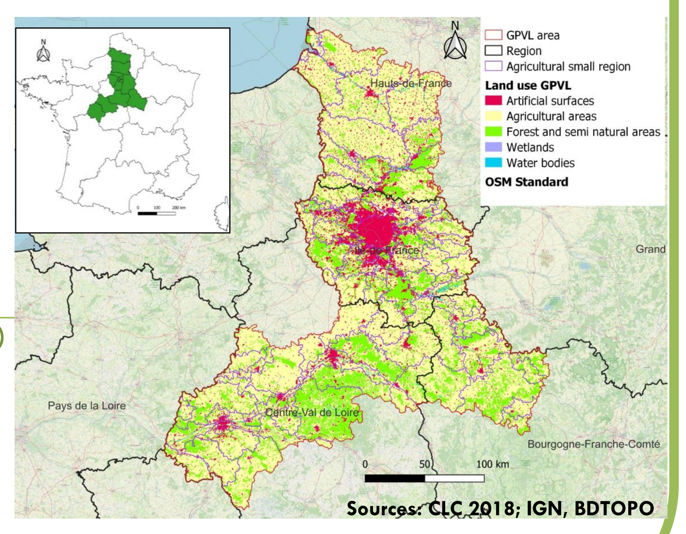


Figure 1. Land use of the GPVL zone

DETERMINANTS OF YIELD

To determine the reference yield, the first step is to study the determinants of yield in large-scale crops (winter wheat, spring barley, maize grain) to identify the factors that impact yield (Ponisio et al. 2015; Ben Zekri et al., 2019). Then, statistical regression analysis was used to explain the variability of yields among members based on the factors determining yield. These factors primarily include climate, soil properties, pressure from bio-aggressors, crop rotation, technical itinerary of the crop, as well as the farmer's expertise and landscape factors.

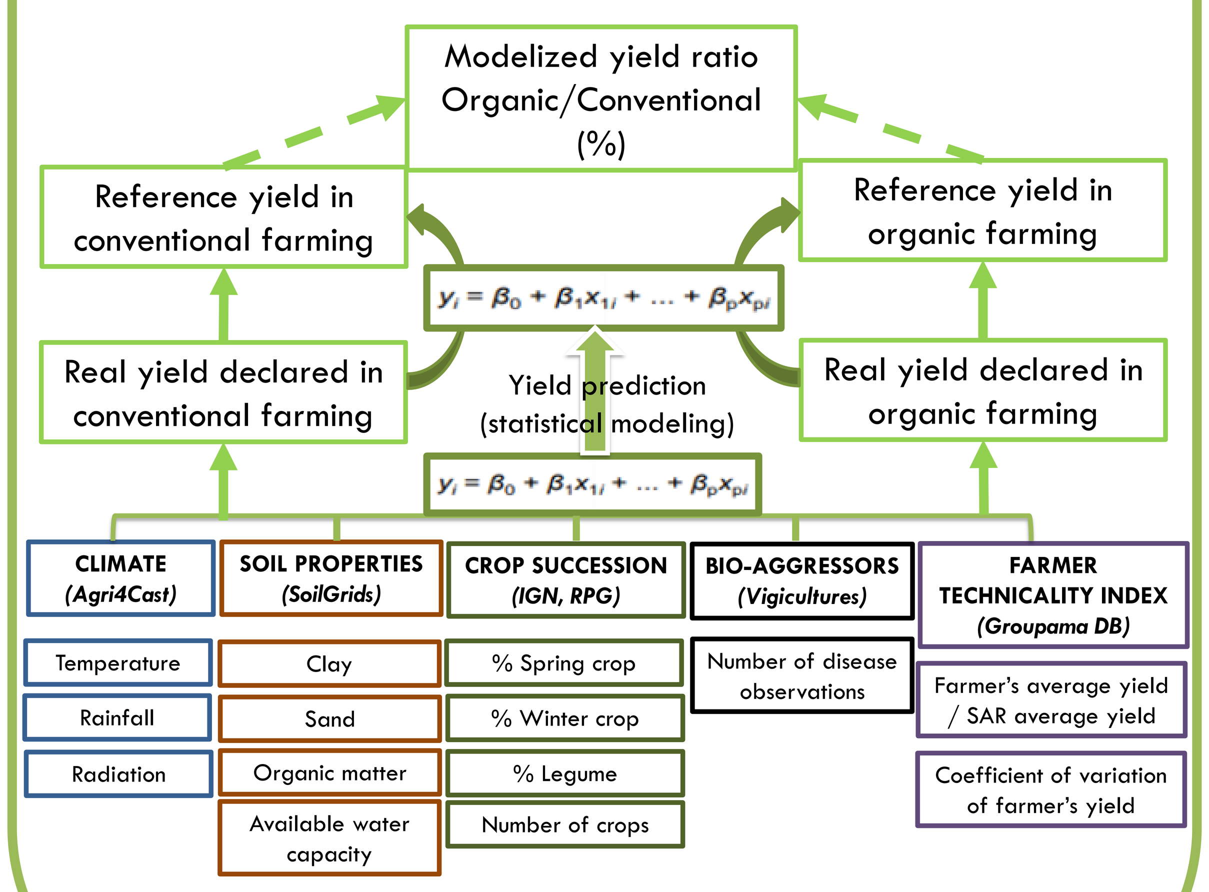


Figure 2. Crop yield determinants and yield prediction approach

CROP YIELD ESTIMATION

The analysis of yield variability based on yield determinants has enabled the development of a method for estimating reference yields in organic farming using regression and prediction models such as Generalized Linear Regression (GLM), Partial Least Squares (PLS), Ridge regression and stepwise backward. The PLS model is the most effective and suitable for yield estimation, as determined through comparison using metrics and criteria such as R² and RMSE (Table 1). The yield estimation model was applied to predict the yields of insured members of Groupama Paris Val de Loire based on their location and the spatial intrinsic characteristics of fields.

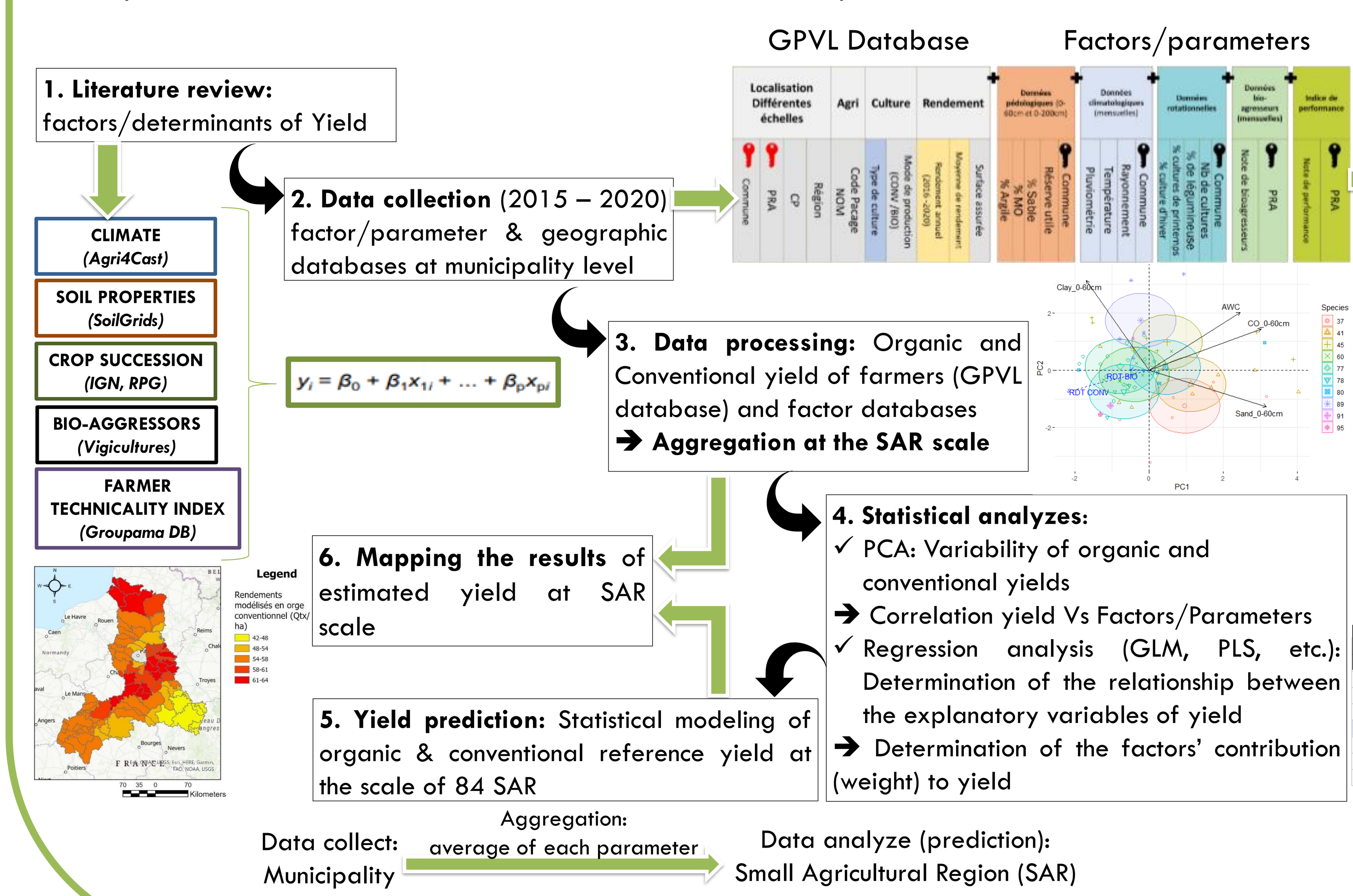


Figure 3. The approach to estimating wheat, maize and barley yield in organic and conventional farming

Table 1. Results of R² and RMSE of the different models tested in conventional (A) and organic (B) wheat, maize and barley

A

Model	Winter soft wheat		Maize		Spring barley	
	R²	RMSE	R²	RMSE	R²	RMSE
Lasso regression	0,695	1,108	0,555	2,107	0,504	1,282
LM	0,706	1,083	0,552	2,088	0,547	1,179
GLM	0,707	1,083	0,557	2,088	0,560	1,179
PLS	0,710	1,083	0,557	2,127	0,560	1,212
Stepwise backward	0,699	1,103	0,553	2,119	0,501	1,288
Ridge regression	0,697	1,107	0,555	2,090	0,505	1,296
Elastic net regression	0,697	1,105	0,546	2,130	0,494	1,295

B

Model	Winter soft wheat		Maize		Spring barley	
	R²	RMSE	R²	RMSE	R²	RMSE
Lasso regression	0,210	2,009	0,961	11,355	0,463	1,461
LM	0,390	1,640	0,572	1,580	0,398	1,279
GLM	0,501	1,640	0,735	1,580	0,588	1,279
PLS	0,509	1,851	0,735	2,439	0,588	1,644
Stepwise backward	0,410	1,906	0,949	11,936	0,597	1,505
Ridge regression	0,307	1,735	0,975	15,196	0,584	1,721
Elastic net regression	0,338	1,840	0,942	14,226	0,466	1,477

RESULTS & DISCUSSION

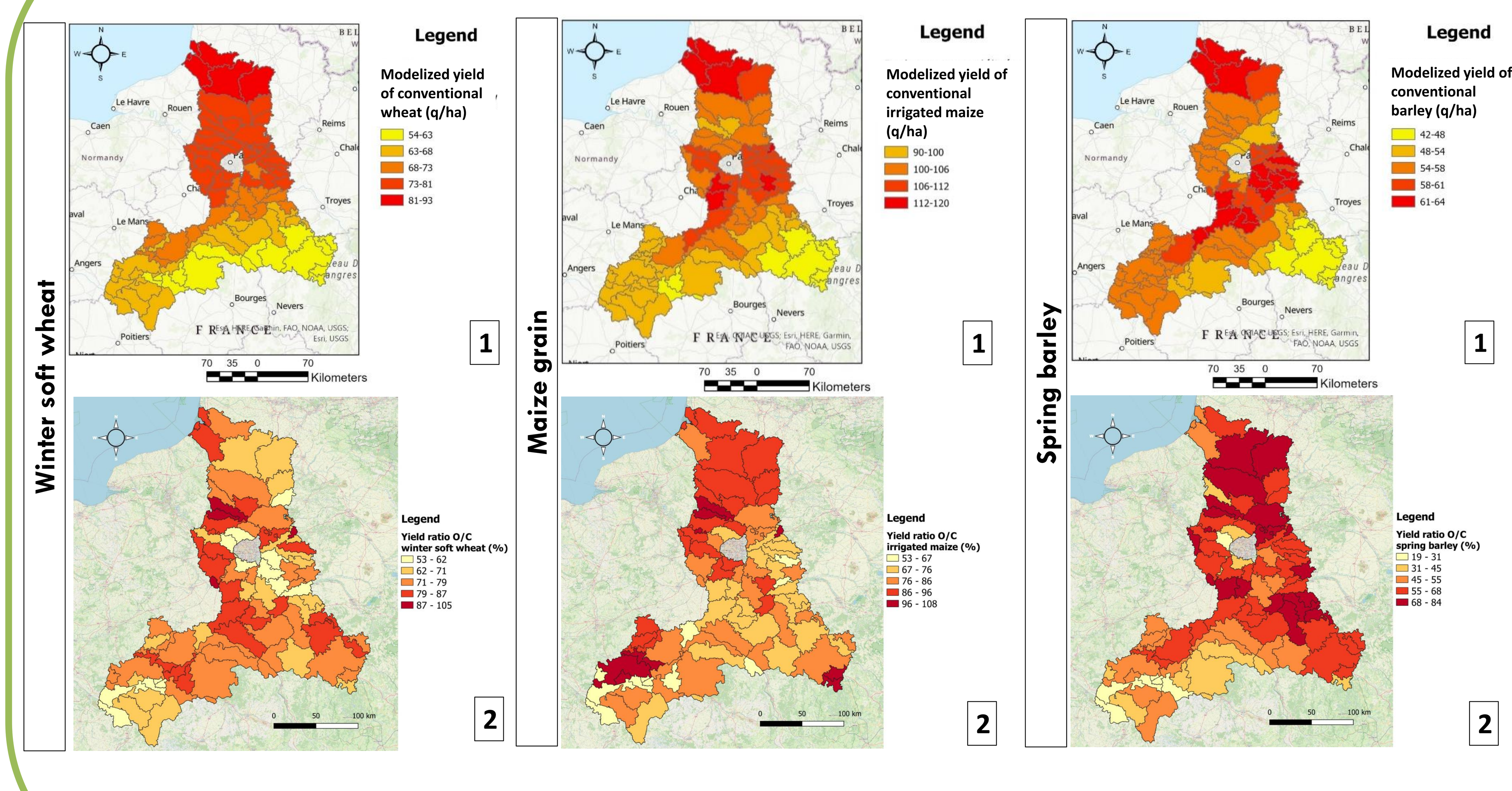


Figure 4. Spatial distribution of estimated yields (quintals/ha) at SAR scale for wheat, maize and barley in conventional faming (1) and the yield ratio organic/conventional (O/C) farming (2)

The estimated yield in organic farming at SAR scale, for winter soft wheat ranges from 3.3 t/ha to 7.8 t/ha, spring barley ranges from 1.0 t/ha to 5.1 t/ha, while maize grain varies from 5.1 t/ha to 11.3 t/ha (Figure 4). The yield ratio between organic and conventional farming varies between 53% and 105% for winter soft wheat, from 53% to 108% for grain corn and from 19% to 84% for spring barley. This ratio, which means the yield decline rate, shows a remarkable gap between organic and conventional yields which varies depending on the small agricultural regions. The climate, particularly rainfall, represents the main factor which explains this yield variation.

CONCLUSION

Each factor has its limitations and leads to a lack of precision regarding results. Several other factors have not been studied and may impact yields, including biodiversity index, sowing date, bio-aggressors management, nitrogen management, soil cover, varieties used, and rotation duration. The statistical modelling yield approach will facilitate a better assessment of factors affecting yield and more precise crop insurance pricing depending on reference yields in organic and conventional farming, thereby helping to support farmers in the face of increasing uncertainty resulting from current climatic, agronomic, and environmental challenges.

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