

### Valuing the DEPHY network datasets to analyze relationships between crop diversity and pesticide use, to help the design of sustainable cropping systems

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# Valuing the DEPHY network datasets to analyze relationships between crop diversity and pesticide use, to help the design of sustainable cropping system

### 29th November 2022

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**PhD student**: Yaoyun ZHANG

# Content

- Context
- Research objectives
- Methodology
- Roadmap of the project
- Perspectives for further work

# Content

### Context

- Research objectives
- Methodology
- Roadmap-Arrangement of different components
- Perspectives for further work

**NATURE GEOSCIENCE** 



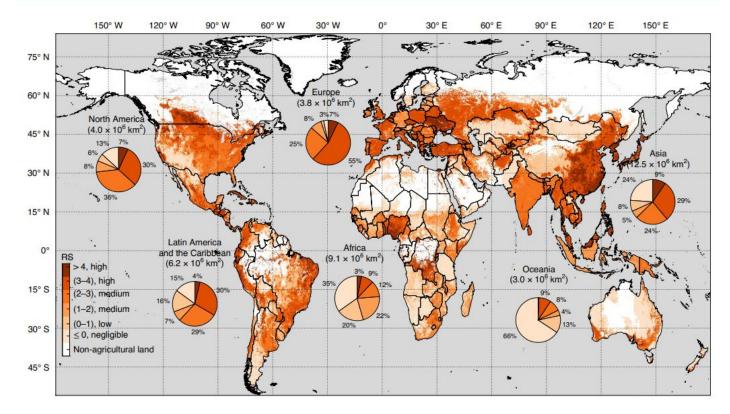


Fig. 1 | Global map of pesticide RS. The map has a spatial resolution of 5 arcmin, which is approximately 10 km × 10 km at the Equator. The pie charts represent the fraction of agricultural land classed under different RS in each region, and the values in parentheses above the pie charts denote the total agricultural land in that region.

- Understand the effects of agronomic practices on natural biological regulations in multiple environments
- Understand and manage the interactions among genotype, microbiome, soil and agronomic practices
- Design and manage intercropping to maximize both plant-plant interactions and pest regulations
- Develop strategic advice based on digital tools and experience-based knowledge within innovative networks
- Design public policies to support transition and pay for positive externalities
   based on natural
- Design the spatial organization of species and cultivars to limit the breakdown of resistance
- Develop digital tools and information networks for epidemiological surveillance and monitoring of natural regulation
- Understand the combined effects of agronomic practices, biocontrol, green infrastructure and natural reservoirs
- Analyze how to facilitate the use and effectiveness of biocontrol methods
   by enhancing their collective management
- Understand private initiatives and design public policies to support the coordination of landscape-management strategies

- Determine the factors that underlie the success of prophylaxis and that improve the effectiveness of biocontrol in multiple environments
- Understand how plant genotypes and soil management determine microbiome composition and functional traits in multiple environments
- Develop methods and tools for on-farm cultivar assessment in multiple innovative agroecological systems

cropping systems

that rely on

tailored practices

cropping systems

included in

renewed value,

chains

Pesticide-free

regulations

landscapes

enabled by the

- Design equipment and sensors adapted and adaptable to the variety of pesticide-free systems
  Pesticide-free
  - Determine the conditions for bridging farmers' experience and scientific knowledge
  - Develop traceability tools and labeling to enhance pesticide-free agri-food chains
  - Understand strategies of the biocontrol sector : regulations, business models and dynamics of firms
  - Understand agro-equipment firms' strategies and promote the development of new machines
  - Analyze how to implement participatory breeding methods by breeding companies and stakeholder networks
- Determine how to better articulate agricultural, health and food policies to enhance pesticide-free value chains

**Fig.7** Cross-cutting objectives and their related research topics. These objectives were designed collectively by the authors from the identification of complementary research topics that (1) belong to the

five strategies to achieve the pesticide-free goal and that (2) are characterized by similar targets, scales, or the stakeholders involved.

### 1. Agronomy

- 2. Genetics
- 3. Biological control
- 4. Machinery & digital
- 5. Economic & social

# **Current States**

### **Global production pressure**

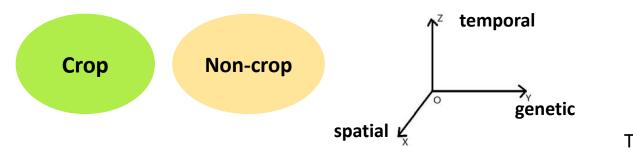
- Increasing population
- Climate change pressure
- Increasing vulnerability of conventional farming systems (FAO, 2020)

### On the pesticide use

- Health pressure, environmental leaching, biodiveristy reduce (Rani, 2021)
- Increasing reliance on pesticide (Glyphosate)

## What is agricultural diversification

- Diverse practice (reduced tillage, organic amendment)
- Diverse crop species (intercropping /crop rotation) crop diversification
- Non-crop species diversification (Flower strip, semi-natural habitat)
- Diversification of soil microorganism inoculation



Tamburini et al, 2020

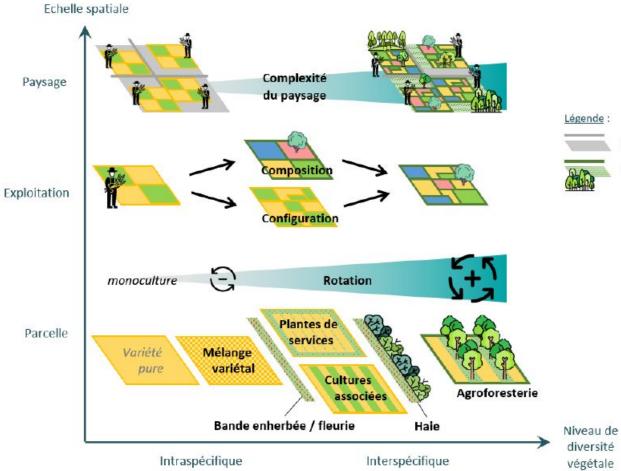


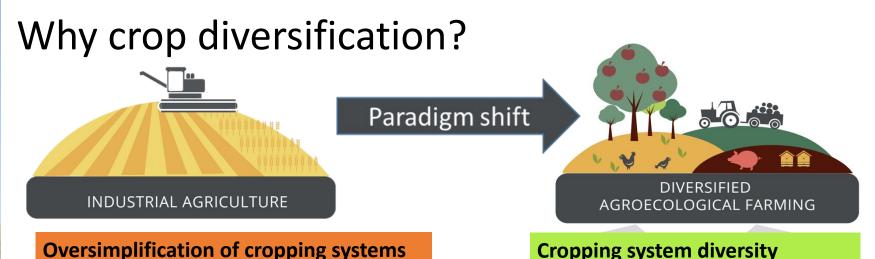
Figure 1. Représentation schématique des modalités de diversification végétale considérées dans l'ESCo

#### Légende :



Infrastructures artificielles

Eléments semi-naturels



### intensive pesticide use

- $\rightarrow$  Environmental pollution,
- **Biodiversity** loss,  $\rightarrow$
- → Human health issues concerns
- $\rightarrow$  Emergence selection of pest resistance

**Cropping system diversity** 

Less reliable on external inputs

- $\rightarrow$  Nutritional stability
- → Production stability at national scale
- → Provision of ecosystem services, e.g pest control

General strategy of system change

- 1. Efficiency- precision agriculture
- 1. Substitution- less hazardous pesticide
- 1. Redesign- system thinking

# Can crop diversification reduce pesticide use?

### Not so sure yet

### In some cases yes (Bonnet et al., 2021)

### But some cases no, (Alletto et al., 2022)

And they are both on experimental-site level.

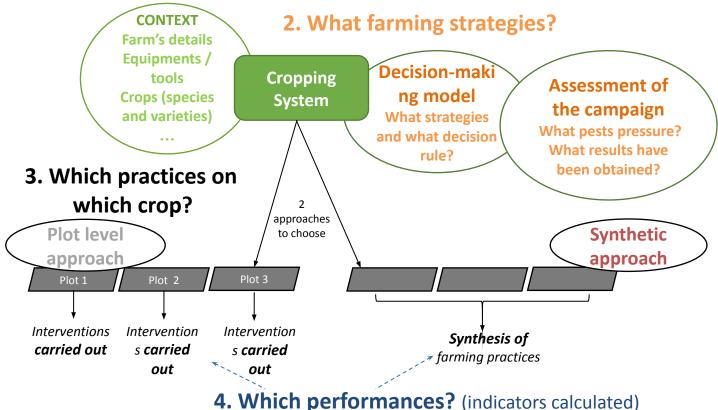
# Database DEPHY network

- A major action of the French Ecophyto National Action Plan.
- The DEPHY network coordinates 2000 voluntary farmers
- Farmers are engaged to demonstrate that reducing pesticide use is possible and cost-effective.
- Through a holistic approach of pest management



### AgroSYST

### 1. In which context?



13

### Farm description

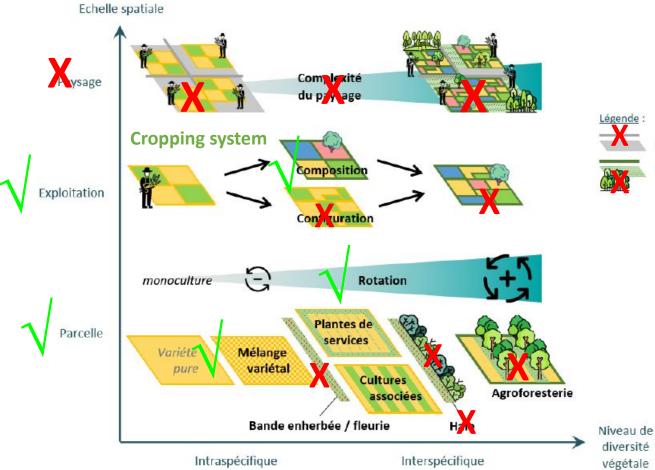
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• 2019 • 2018								
• 2016 Localisation	géographique du domaine							
Context & Characteristics	* Nom du domaine :	CBO_test	Livestock works	shop:				
Farm's détails: Name,	* Type de domaine :	Exploitation agricole	Animals, Size, Fee	eding,			~	
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#### RStudio

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Infrastructures artificielles

Eléments semi-naturels



# Content

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- Research objectives
- Methodology
- Roadmap-Arrangement of different components
- Perspectives for further work
- Time arrangement

# **Research Objective**

1. Test if there is a relationship between crop diversity and TFI with existing indexes

# 2. Define production situation which facilitate crop diversity

# Hypothesis

- Potential effects of crop diversification can reduce pesticide use
- Certain production situations could facilitate crop diversification strategy

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# Methodology

Part I: Compute exiting index vs TFI

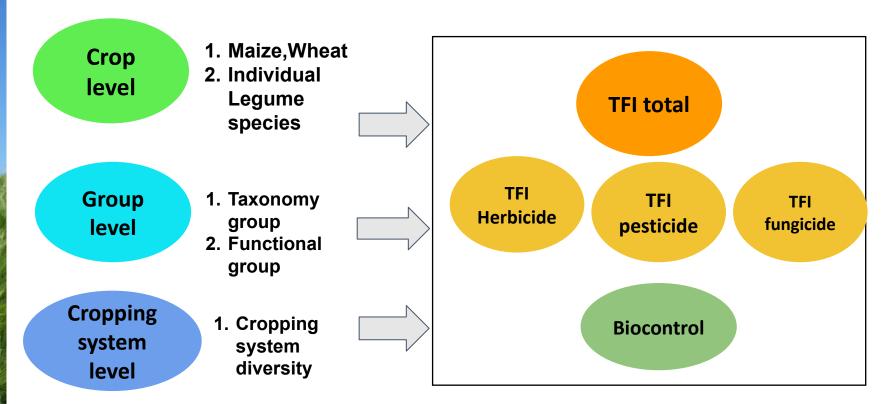
- A. Crop diversity
  - 1. Ecological Index (Shannon Index/ Simpson Index)
  - 2. Other Index (Crop species richness )(Bonnet et al, 2021)
- B. Functional group diversity
- 1. Soil coverage (growing season)
- 2. Other functions
- C. Cropping system diversity
  - 1. Rotation diversity index (Keichinger et al, 2021),
  - 2. Function crop diversity index (Nilsson et al., 2022)
  - 3. Crop functional diversity on spatial and temporal scale (Zhao et al, 2022)

## Methodology

### Part II: Expert knowledge to compose crop diversity index vs TFI Crop diversity = Nr/Species + Nr/family + Nr/mixture + Nr/Growing season + Nr/temporary grassland + (to be determined)

TFI: Total, herbicide, pesticide, fungicide biocontrol

### **Diversity on**



A transition from plant taxonomy to functional diversity

### Treatment Frequency Index (TFI) :

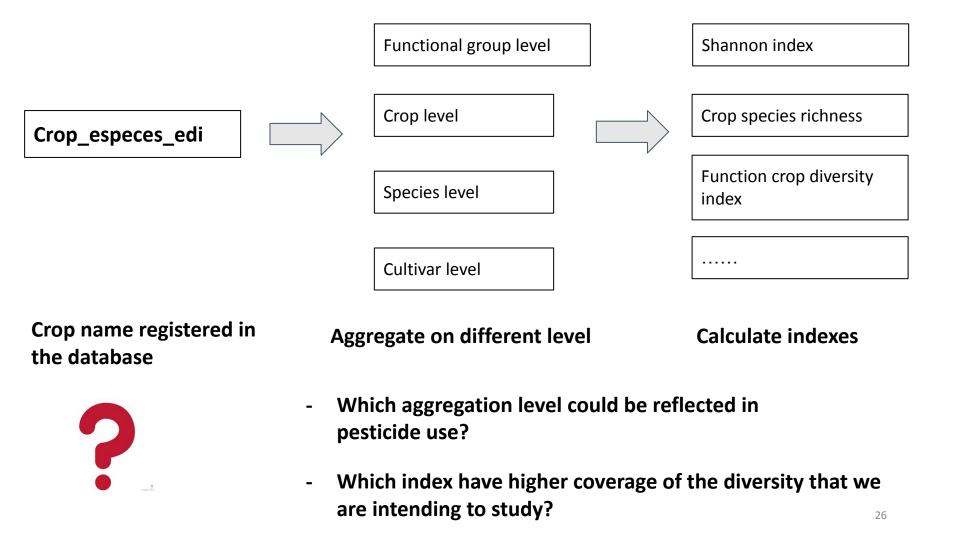
- A metric to quantify pesticides use
- Automatically compute by AgroSYS, information system of DEPHY network dataset

$$\mathsf{TFI} = \frac{\text{Dose applied}}{\text{Dose registed}} \times \frac{\text{Treatd surface}}{\text{Surface total}}$$

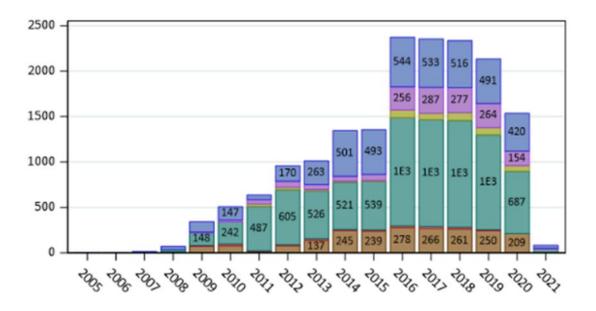
# **Existing diversity Index selected**

Index	Calculation	Strengths	weakness	Reference
Shannon	Shannon Index (H) = - $\sum_{i=1}^{i} p_i \ln p_i$	Able to calculate in AgroSYS data, representative of species diversity		
Shannon				
	Simpson Index (D) = $\frac{1}{\sum_{i=1}^{3} p_i^2}$			
Simpson	14 YOU			
	0.3 × Number of species grown per_rotation + 0.7 × Number_of_species_grown_p		Definition of crop number and	(Last et al. 2014), (Bonnet et al.,
Crop Specific richness	er_year		cropping system	2021)
Rotation diversity	To complex to put here			(Keichinger et al., 2021)
function crop diversity				
index	HF = − ∑k g=1 pg*ln( pg )			(Nilsson et al., 2022)
Crop Specific and fonctional diveristy on				
spatial and temporal scale	Crop diveristy= N species* N group *N Year			Zhao et al, 2022 (Nature communication)
The crop diversity index used by AgroSys dataset, by Nicolas Chantier	Diversité culturale= 1/Σ (Surface groupe de culture n/Surface développée du SdC)2			

25



# Data description-total



_	Filière	
VITICULTURE	CULTURES_TROPICALES	GCPE
ARBORICULTURE	MARAICHAGE	HORTICULTURE

DEPHY data volume also increases

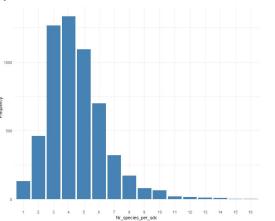
As of August 28, 2021, DEPHY farms includes:

17062 SdC (Cropping system)

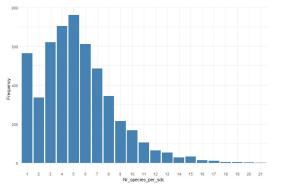
75% in Synthesized25% in Realized

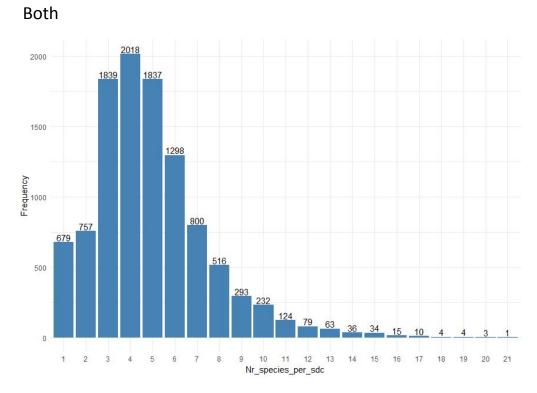
### Data description - Number of species per cropping system

Synthetise



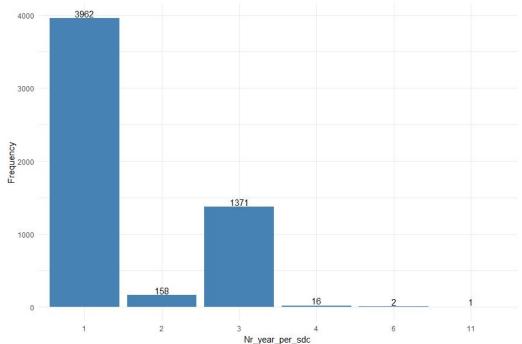
Realise



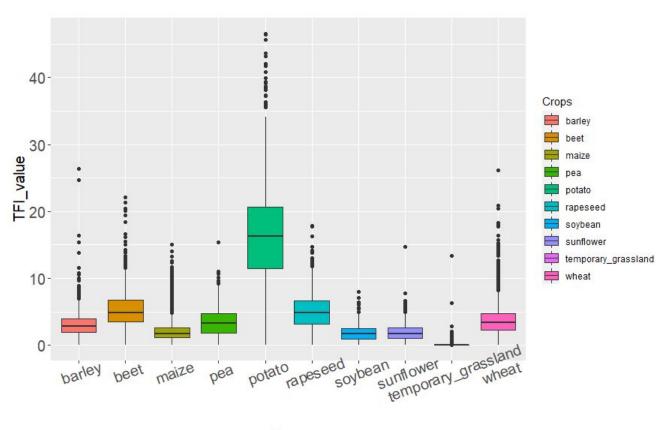


# Data description synthesis (a combined year)

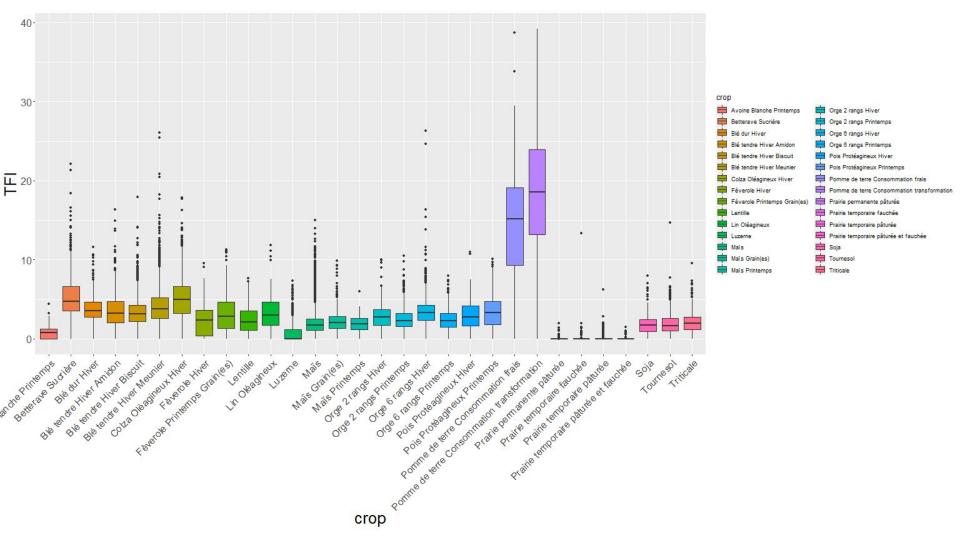
Number of year per sdc in synthtise: mostly one year and three years, also includes (2 years, 4 years, 6 years, 11 years)

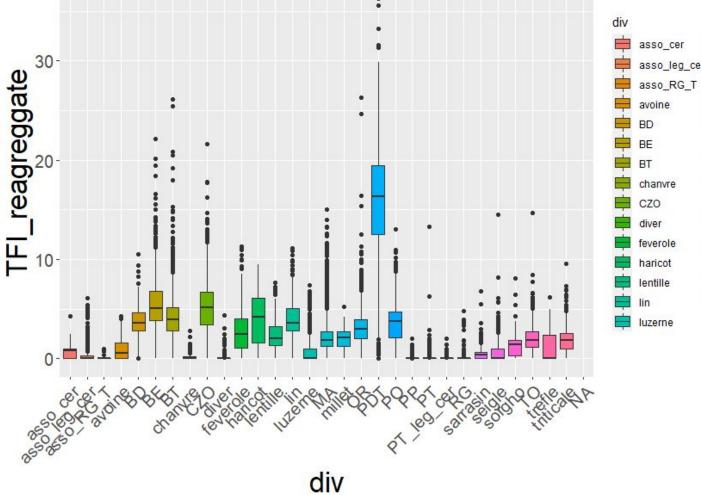


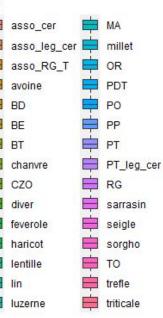
# TFI with crops



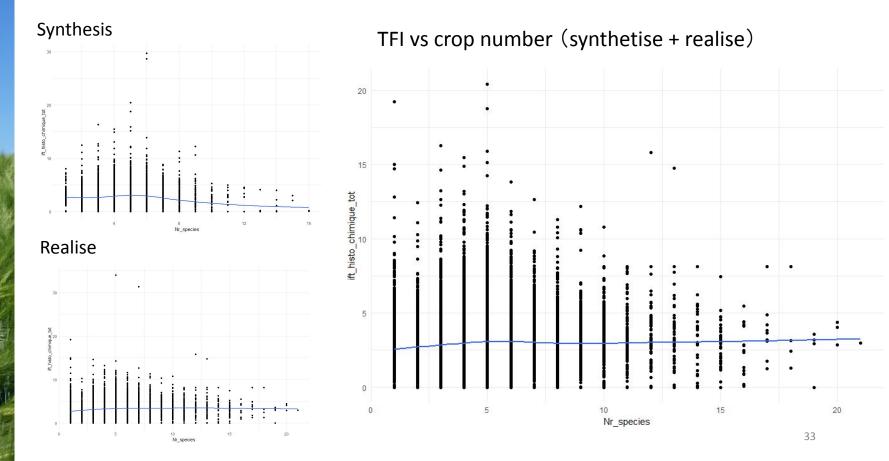
Crops







### Preliminary result-Treatment frequency index vs Number of species in each cropping system



## Methodology

- Define production situation
  - Soil : soil type, soil depth, organic matter content
  - Precipitation: annual precipitation
  - Temperature : annual average temperature, average temperature during summer
  - Radiation: length of daytime during summer, length of daytime during winter
  - Distant to natural infrastructure: river, natural habitat
  - Market: if 50km has same crop, we assume the market is available.

### To be determined

### Perspective

- Continue to work on the database to divide the crop on different level

Calculate crop diversity indexes based on different divisional method

• Thanks for your time