DIVERFARMING

Crop diversification and low-input farming across Europe: from practitioners' engagement and ecosystems services to increased revenues and value chain organisation

Innovations to reduce and remediate farm soil pollution.
A contribution to the EU Soil Strategy

DIVERFARMING
H2020: 728003

WP8

Economic assessment
at farms and value chains

Integrated and cross-case study comparative economic analysis of diversified cropping systems in Europe

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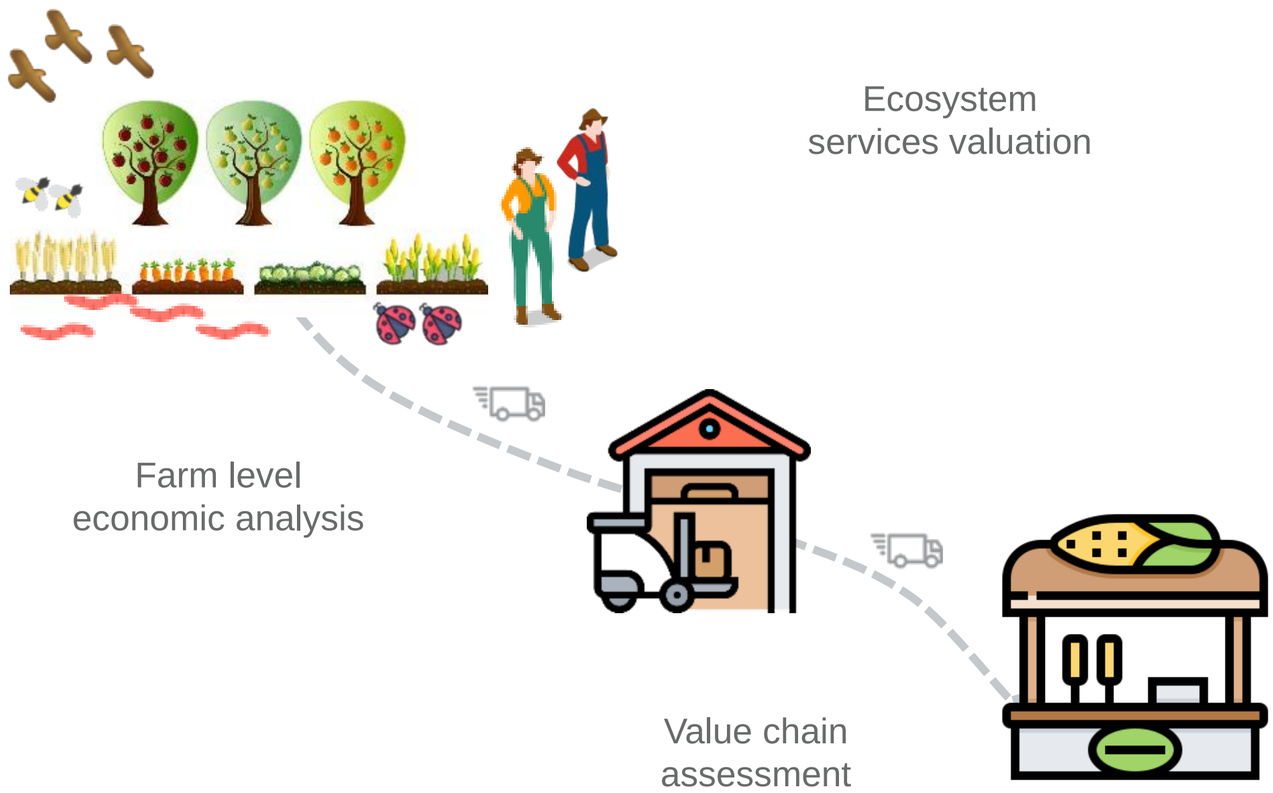
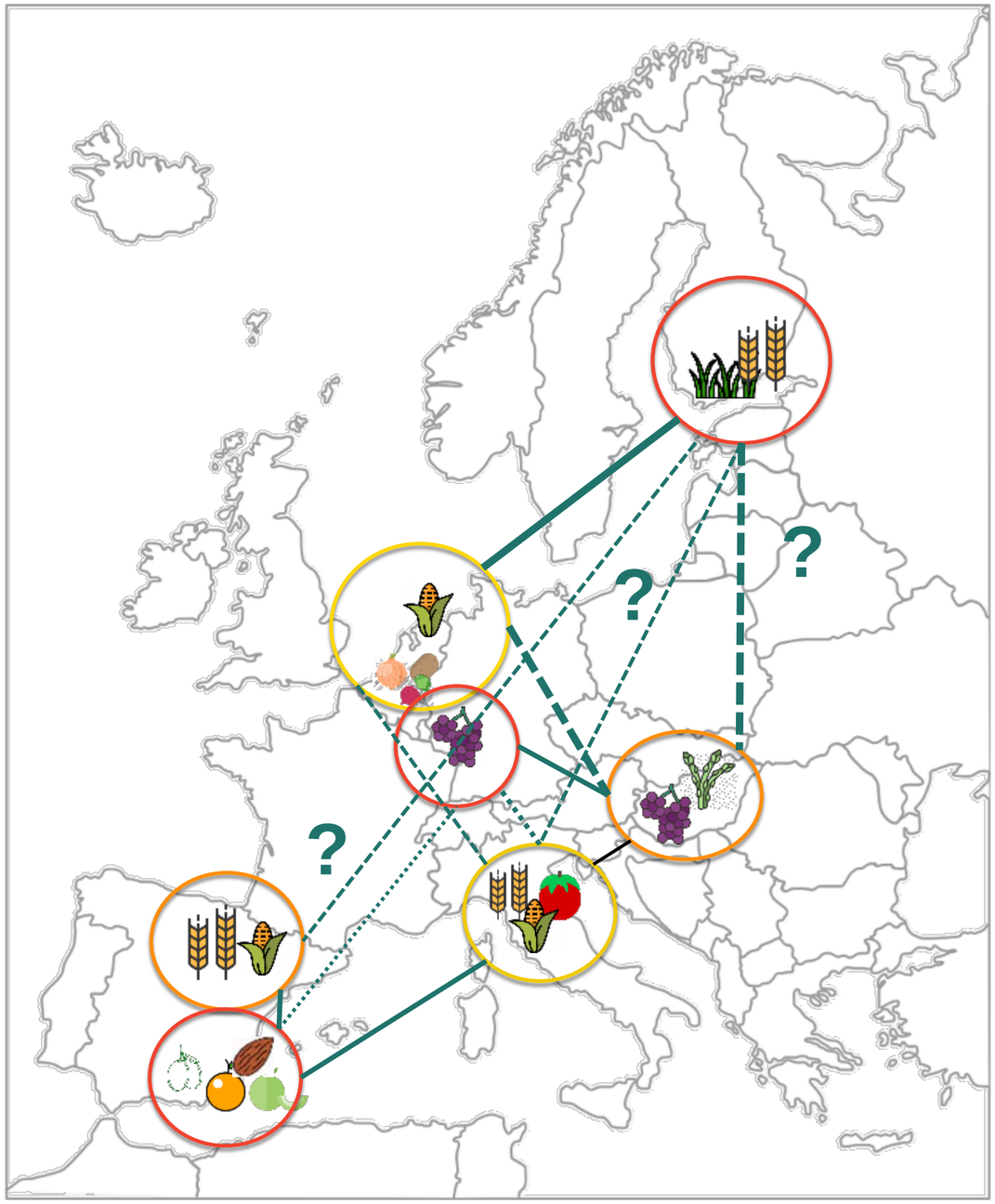
Rationale and motivation





The **objective** is to analyze and define **economic patterns** in the results of **crop diversification across Europe** for establishing guidelines and recommendations to increase **the socioeconomic impact of crop diversification.**

Diversified cropping systems in Europe

South Mediterranean pedoclimatic region

CS1

Intercropping

MC: **Almond**
+
D1: Capper
D2: Thyme

CS2

Intercropping

MC: **Mandarin**
+
D1: Vetch/Barley + Fava bean
D2: Fava bean + Purslane + Cowpea

CS4

Intercropping

MC: **Olive**
+
D1: Oat
D2: Saffron
D3: Lavender

Diversified cropping systems in Europe

South Mediterranean pedoclimatic region

CS3a

Rotation

MC: **Wheat / Barley**
+
D1: Wheat + Barley + Pea
D2: Wheat + Barley + Vetch

CS3b

Multiple cropping

MC: **Maize**
+
D1: Maize + Pea
D2: Maize + Barley

CS16

Intercropping

MC: **Melon**
+
D1: Cowpea

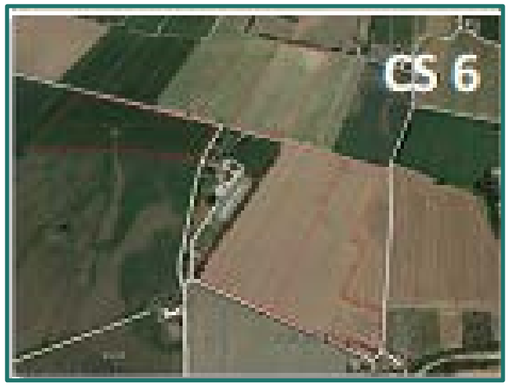
Diversified cropping systems in Europe

North Mediterranean pedoclimatic region

CS5

Rotation

MC: **Maize**
vs
D1: Tomato + Pea/Tomato
+ Durum wheat



CS6

Rotation

MC: **Durum wheat-Barley rotation**
vs
D1: Tomato + Pea/Tomato
+ Durum wheat

CS7

Rotation

MC: **Tomato-Durum wheat rotation**
vs
D1: Tomato + Pea/Tomato
+ Durum wheat

Diversified cropping systems in Europe

Atlantic pedoclimatic region

CS8

Intercropping

MC: **Biodynamic maize**
+
D1: Beans

CS15

Rotation

MC: **Biodynamic vegetable rotation**
vs
D1: Onion + Pea + Potato + Spelt + Red beet + Grass clover
D2: Onion + Red beet + Pea + Onion + Potato + Spelt
D3: Red beet + Onion + Pea + Red beat + Potato + Spelt

Diversified cropping systems in Europe

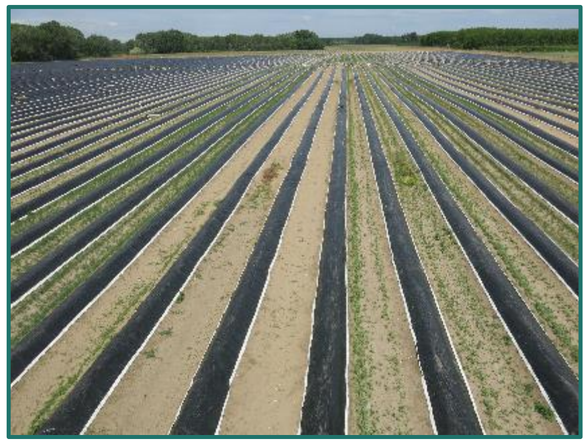
Continental pedoclimatic region

CS9

Intercropping

MC: **Grapevine**
+
D1: Thyme
D2: Oregano

Pannonian pedoclimatic region



CS10

Intercropping

MC: **Asparagus**
+
D1: Pea
D2: Oat

CS11

Intercropping

MC: **Grapevine**
+
D1: Yarrow
D2: Grass

Diversified cropping systems in Europe

Boreal pedoclimatic region

CS12

Rotation

MC: **Barley**
+
D1: Oilseed rape

CS13

Rotation

MC: **Fodder rotation**
vs
D1: Barley + 30% Grass ley + Barley

Cross-case study on farm level economic analysis

Materials and methods

Farm level economic analysis

+ Revenues

- Variable costs
  - Raw material
  - Irrigation
  - External labour

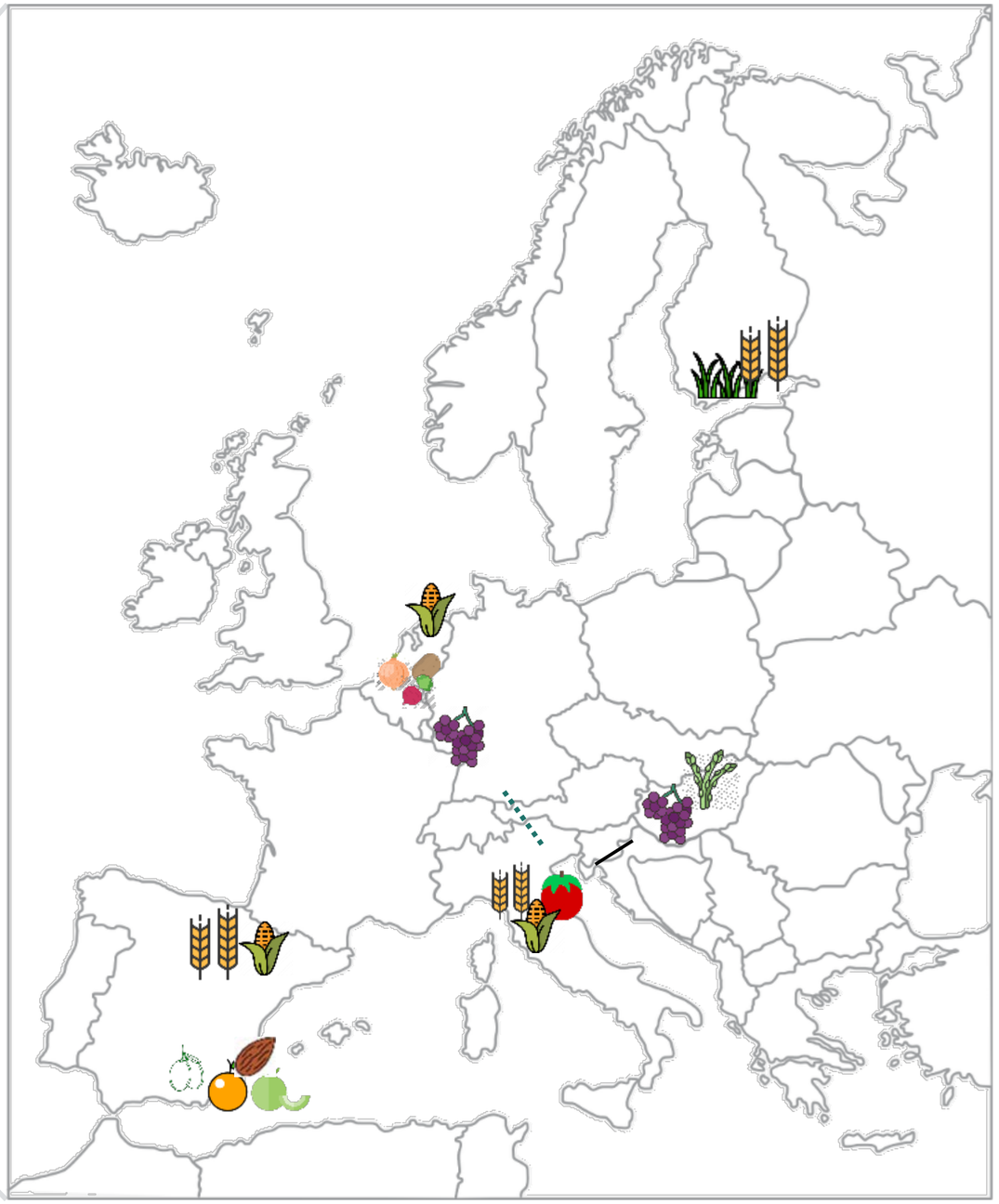
= *Gross margin A*

- Family labour

= *Gross margin B*

- Fixed costs

= *Gross margin C*



Note: $€_{EU\text{-}PPP}$/ha/year

Cross-case study on farm level economic analysis

Materials and methods

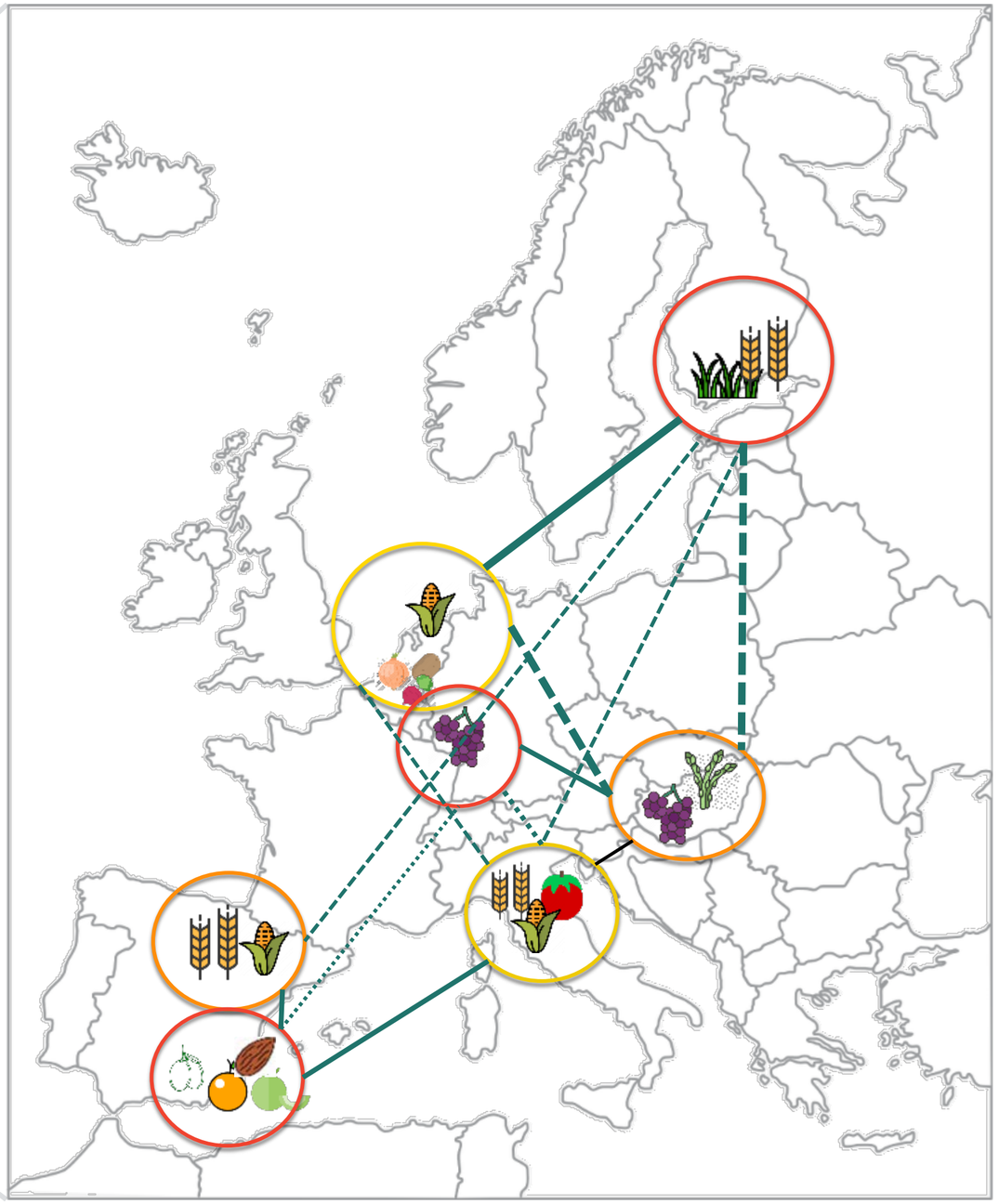
Cluster analysis

k-means

16 case studies

27 crop diversifications

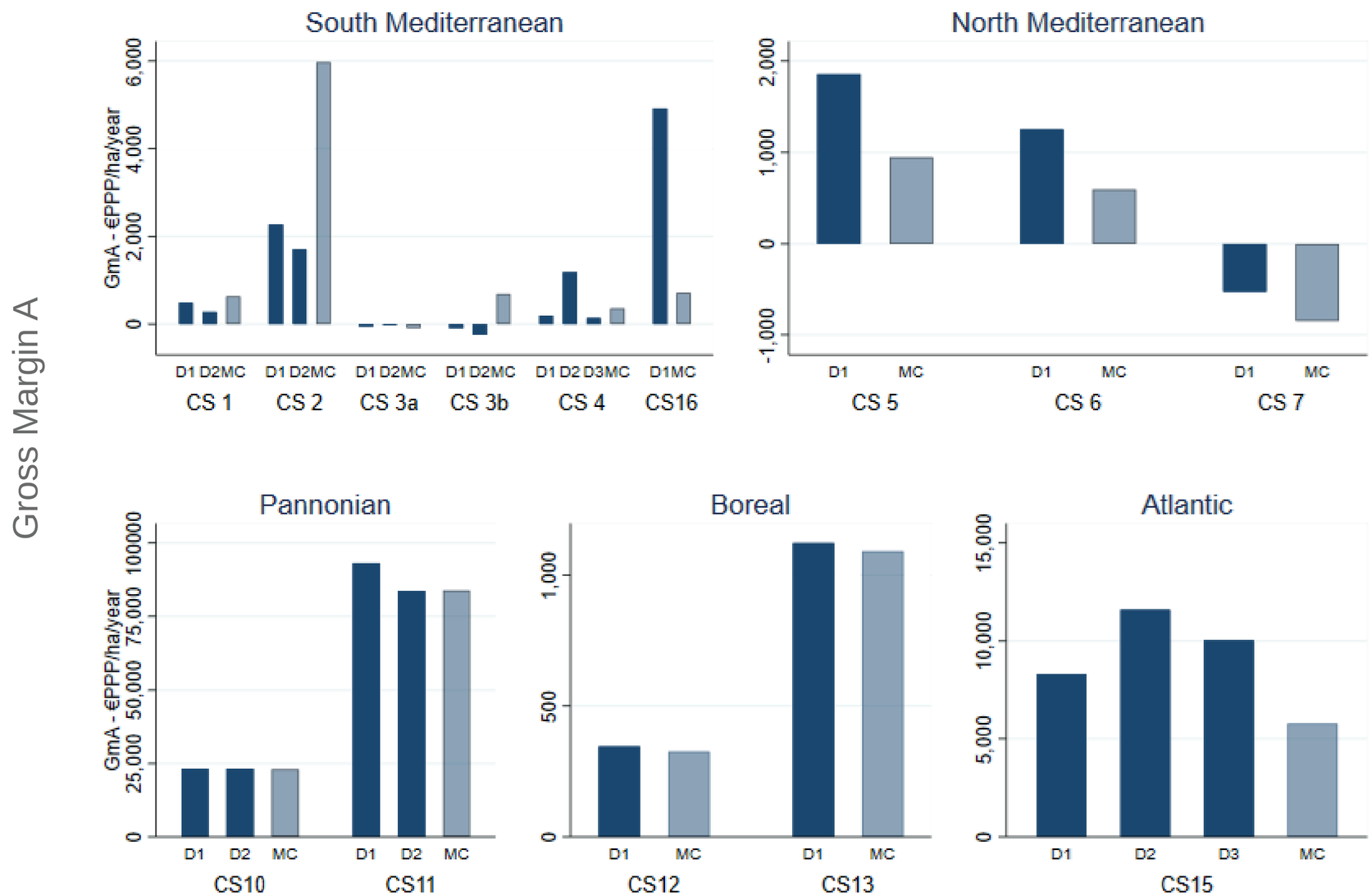
Gross Margin $A_{(i)}$
+
Δ Gross Margin Diversification$_{(i)}$



Cross-case study on farm level economic analysis

Results

Farm level economic analysis



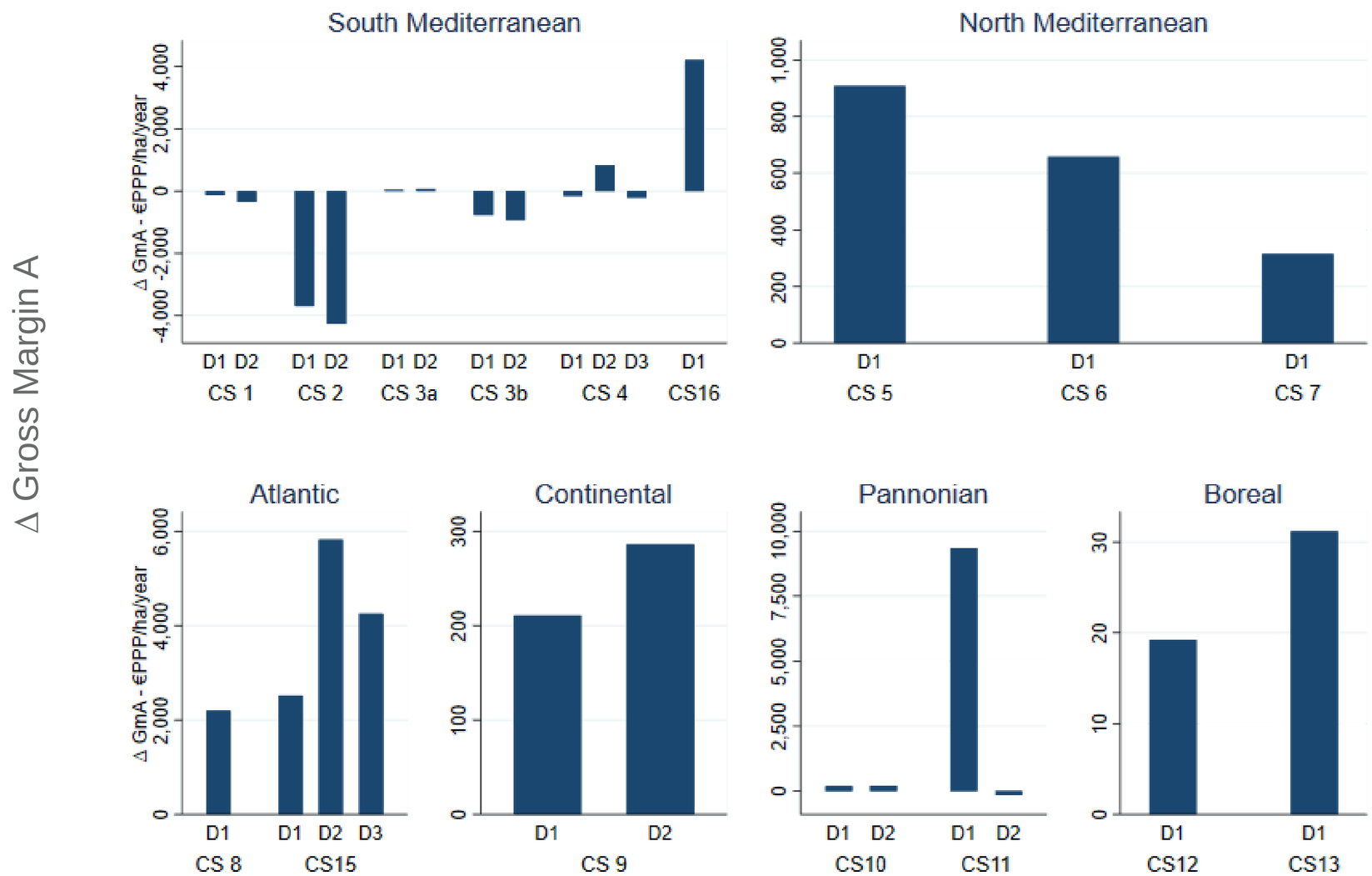
Wide dispersion of the farm level economic results within and across case studies/regions

A priori, there is no a clear pattern among the economic results

Cross-case study on farm level economic analysis

Results

Farm level economic analysis



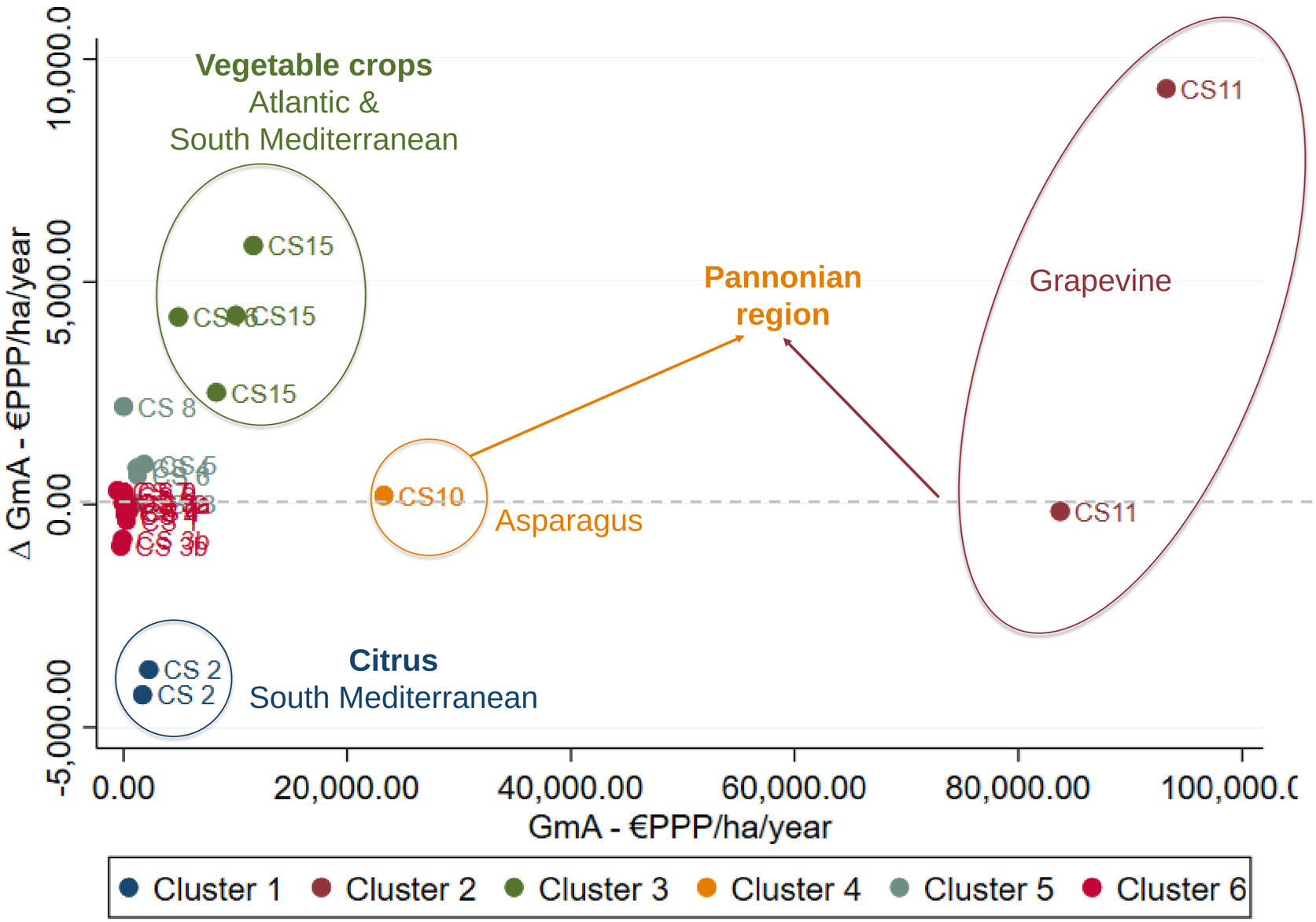
Wide dispersion of the farm level economic results within and across case studies/regions

In most cases, there is a positive impact of crop diversification on gross margins, although some increments are low

Cross-case study on farm level economic analysis

Results

Cluster analysis



Some economic patterns arise from farm level economic results

The impact of diversification on farm level economic results depends more on the crop type than on the type of crop diversification

Great concentration around low gross margins with low economic impact (Clusters 5 & 6)

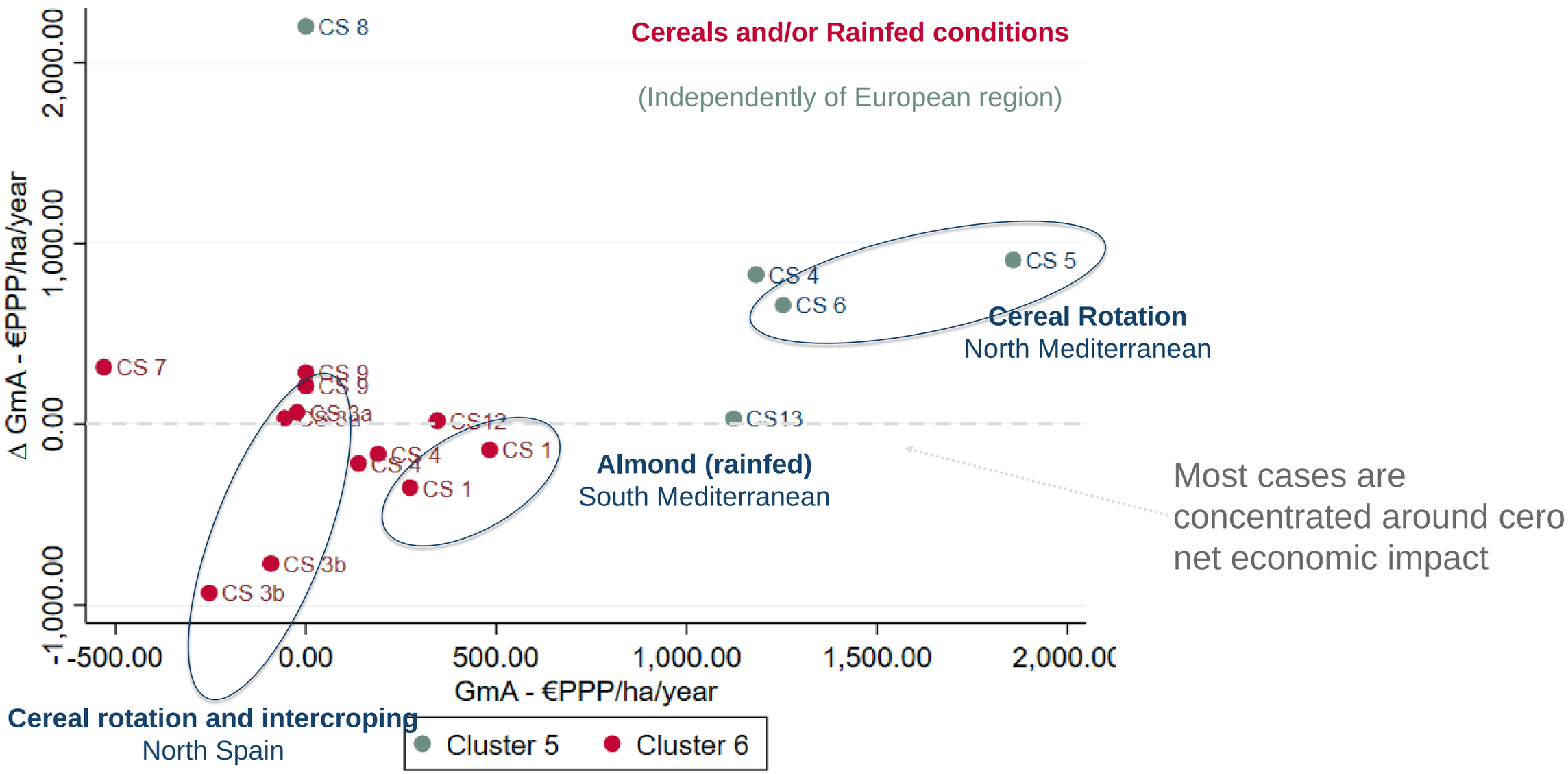
Great likelihood that crop diversification provides positive farm level economic results, or at least, no significant impact

*Preliminary results

Cross-case study on farm level economic analysis

Results

Cluster analysis



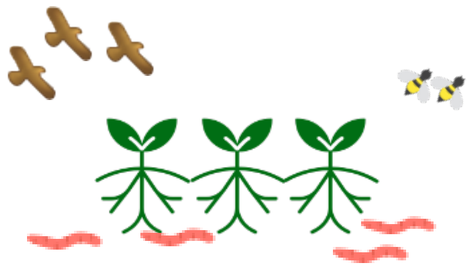
*Preliminary results

Cross-case study on integrated economic analysis

Materials and methods

Non-market valuation

Crop diversification → Ecosystem services → Environmental & Socio-cultural benefits



Ecosystem services

South Mediterranean

Scenario 1.1	Diversification A	Diversification B	Monocrop (SQ)
Biodiversity	High	Low	Low
Soil loss	High	Low	High
CO_2 net balance	High	Medium	Low
Cultural heritage	Low	High	Low
Landscape	Diversification	Diversification	Monocrop
Monthly overrun	40 €	20 €	0 €
Choose an option			

Choice experiment

North Mediterranean

Scenario 1.1	Diversification A	Diversification B	Status quo
Biodiversity	High	High	Low
CO2 net balance	Medium	Low	Low
Water Pollution Risk	Low	Low	High
Agriculture Landscape	Diversification	Diversification	Monoculture
Cost	30 €	22,5 €	0 €
Choice			

Choice experiment

Boreal

Attribute	Description	Symbol	Change
Organic	The share of organic milk production is about 3%. Organic crop production covers 11% of the total arable area in Finland.		The share of organic milk and crops produced is increasing.
Low-input production	Fertilizers and feeds bought outside the farm are used in abundance. Cows are mainly high-yielding. Limited opportunities for crop rotation.		Cows feed is produced using less inputs purchased outside the farm, such as fertilizers, plant protection products and purchased feed. Cows are not necessarily high yielding.
Grazing cows in the landscape	Grazing cows are rarely seen.		Grazing cows are visible in the landscape.
Crop diversification (biodiversity)	In extensive fields, only a few crop species are cultivated or the same crop is grown on the same site year after year.		Arable landscape is more diverse and lively. Clovers and pea plants bring variation in plant biodiversity, and oilseed rape cultivation brings yellow colour to the landscape.
Regionality	Milk production has concentrated on the middle and northern part of the country. Milk processing is done only larger units.		Local cheese guarantees milk production to survive also in the southern part of the country. Small cheese factories are economically viable.
Rural jobs	In Finland, we have a few dozen small-scale cheese processing factories which usually are located in rural areas.		Cheese is made by domestic, small-scale cheese company. Cheese-making offers jobs in rural areas.
Tradition	Cheese and local products have strong meaning in the Finnish food culture.		Cheese making skills, knowhow and traditions are maintained in different parts of the country.
Cost	Monthly increase in foodstuff expenditures per household	€	

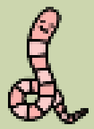
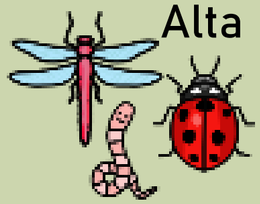
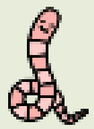
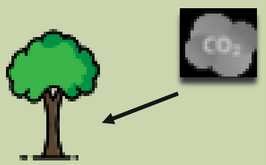
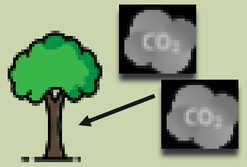
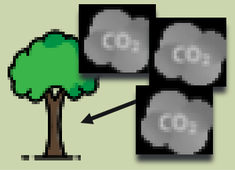
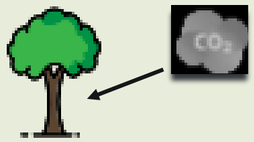
Contingent valuation

Cross-case study on integrated economic analysis

Materials and methods

Non-market valuation **Spanish case study**

Attributes and levels definition

ES group	Attribute	Description	Levels			Current situation (sq)
Biodiversity		Expected % of soil microbial richness increment over monocropping	Baja 	Media 	Alta 	Baja 
Regulating ES	Soil erosion	Expected % of soil erosion rates reduction over monocropping	Alta 	Media 	Baja 	Alta 
	CO_2 net balance	Expected % of soil organic carbon per hectare and year increase over monocropping	Baja 	Media 	Alta 	Baja 
Cultural ES	Cultural heritage	Maintenance of traditional agricultural practices				
	Landscape	Perception of agricultural landscape beauty				

Cross-case study on integrated economic analysis

Materials and methods

Non-market valuation

Intensive food production can provide environmental impacts that can be alleviated through crop diversification practices. Crop diversification allows environmental risk reduction through an increase in biodiversity, erosion control, higher CO2 balance, and also provides a more heterogeneous landscape and the conservation of traditional knowledge and practices.

The following are proposed cropping system benefits combinations that would come with an ***increase in the monthly foodstuff expenditure****. Please indicate your preferred option. You can also choose neither of the two proposed options. If you choose 'monocrop', you will not have to pay increased foodstuff expenditure, nor will you be avoiding current agricultural monocropping impacts. Please consider your level of disposable income before answering this question.*

Scenario 3.3	Diversification A	Diversification B	Monocropping (SQ)
Biodiversity	High	Low	Low
Soil loss	Low	High	High
CO_2 net balance	Low	Media	Baja
Cultural heritage conservation	High	Low	Low
Landscape			
Monthly overcost	40 €	30 €	0 €
Select an option	☐	☐	☐

Example of a choice set included in the survey

Cross-case study on integrated economic analysis

Non-market valuation

Compensating surplus can reach an increase of 92.86 €/month per family in food expenditure when Ecosystem Services provision and biodiversity are in the best situation.

Considering 539,000 households within Region of Murcia…

… 600.62 M€/year of increase in food expenditure

Scenario	Brief description	Compensating surplus (€/household/month) Average [95% CI]	TEV (M€/month) Average [95% CI]	TEV (€/ha/year) Average [95% CI]
RIS	Rainfed intercropping system	64.09 [66.14;62.05]	34.55 [35.65;33.44]	939.83 [969.84;909.81]
LEIIS	Irrigated intercropping system throughout the establishing period	78.26 [81.06;75.47]	42.18 [43.69;40.68]	1,147.62 [1,188.60;1,106.63]
HEIIS	Irrigated intercropping system established in the long term	92.86 [96.53;89.19]	50.05 [52.03;48.07]	1,361.62 [1,415.47;1,307.78]

Cross-case study on farm level economic analysis

Materials and methods

Integrated market and non-market valuation – Social gross margin

Market valuation

+ Revenues

- Variable costs

= *Gross margin A*

- Family labour

= *Gross margin B*

- Fixed costs

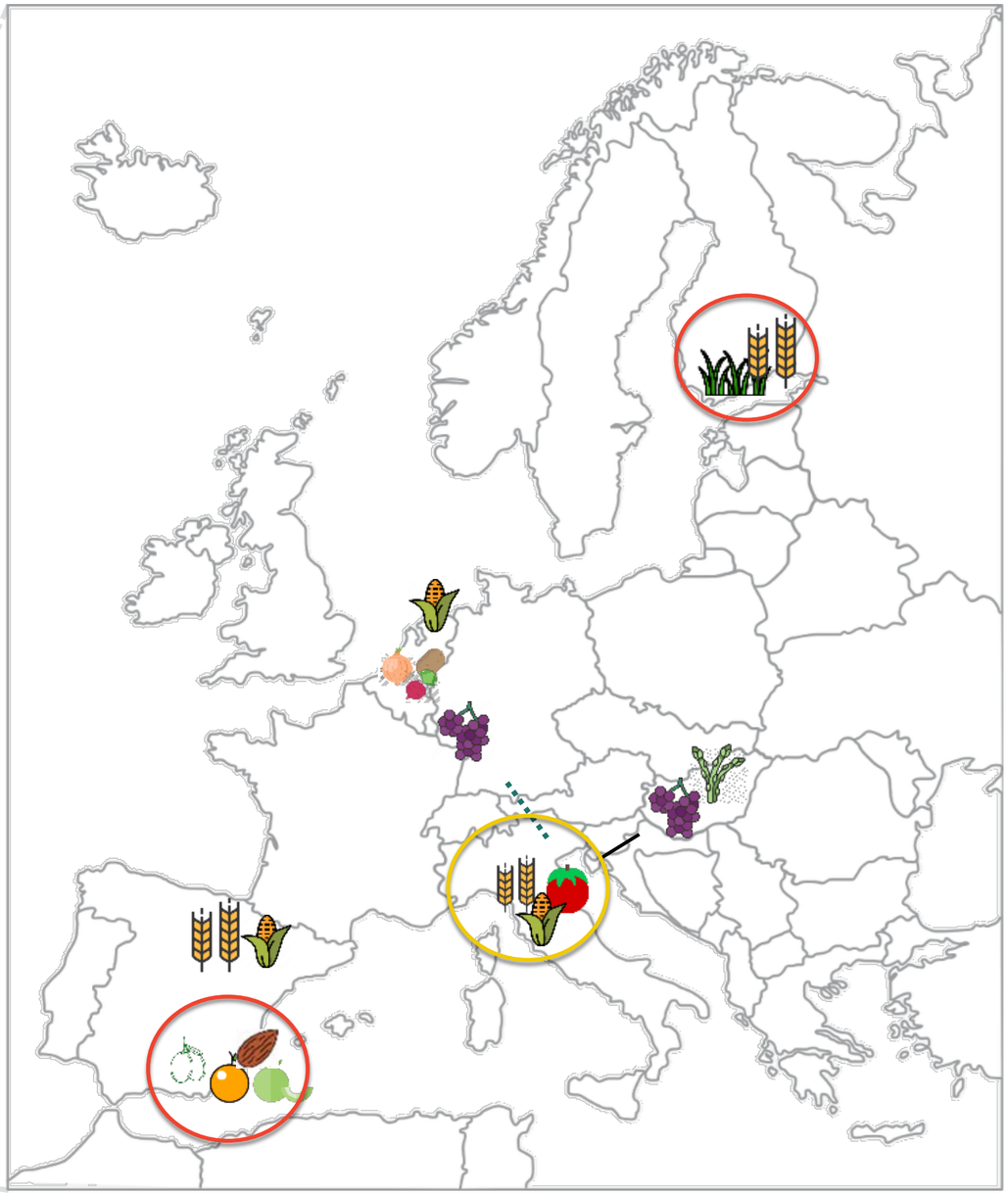
= *Gross margin C*

Non-market valuation

+ Environmental benefits

+ Socio-cultural benefits

= Social gross margin



Short term

Note: $€_{EU\text{-}PPP}$/ha/year

Cross-case study on integrated economic analysis

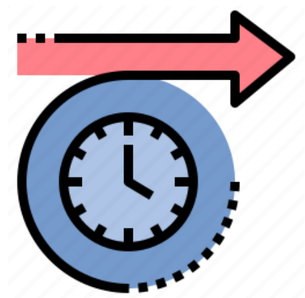
Materials and methods

Integrated market and non-market valuation – Cost-benefit analysis

A decision-making tool for investment evaluations considering financial/private and economic/social benefits and costs

Farm benefits & costs

Socioeconomic Benefits & costs



Long term

Profitability indicators

$$\boldsymbol{NPV} = -K + \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t} + \sum_{t=1}^{T} \frac{B_t^e - C_t^e}{(1+r)^t}$$

$$\boldsymbol{IRR} \rightarrow NPV = -K + \sum_{t=1}^{T} \frac{B_t - C_t}{(1+IRR)^t} + \sum_{t=1}^{T} \frac{B_t^e - C_t^e}{(1+IRR)^t} = 0$$

Assumptions

$T = 25\ years$

r =3,5%

Long term

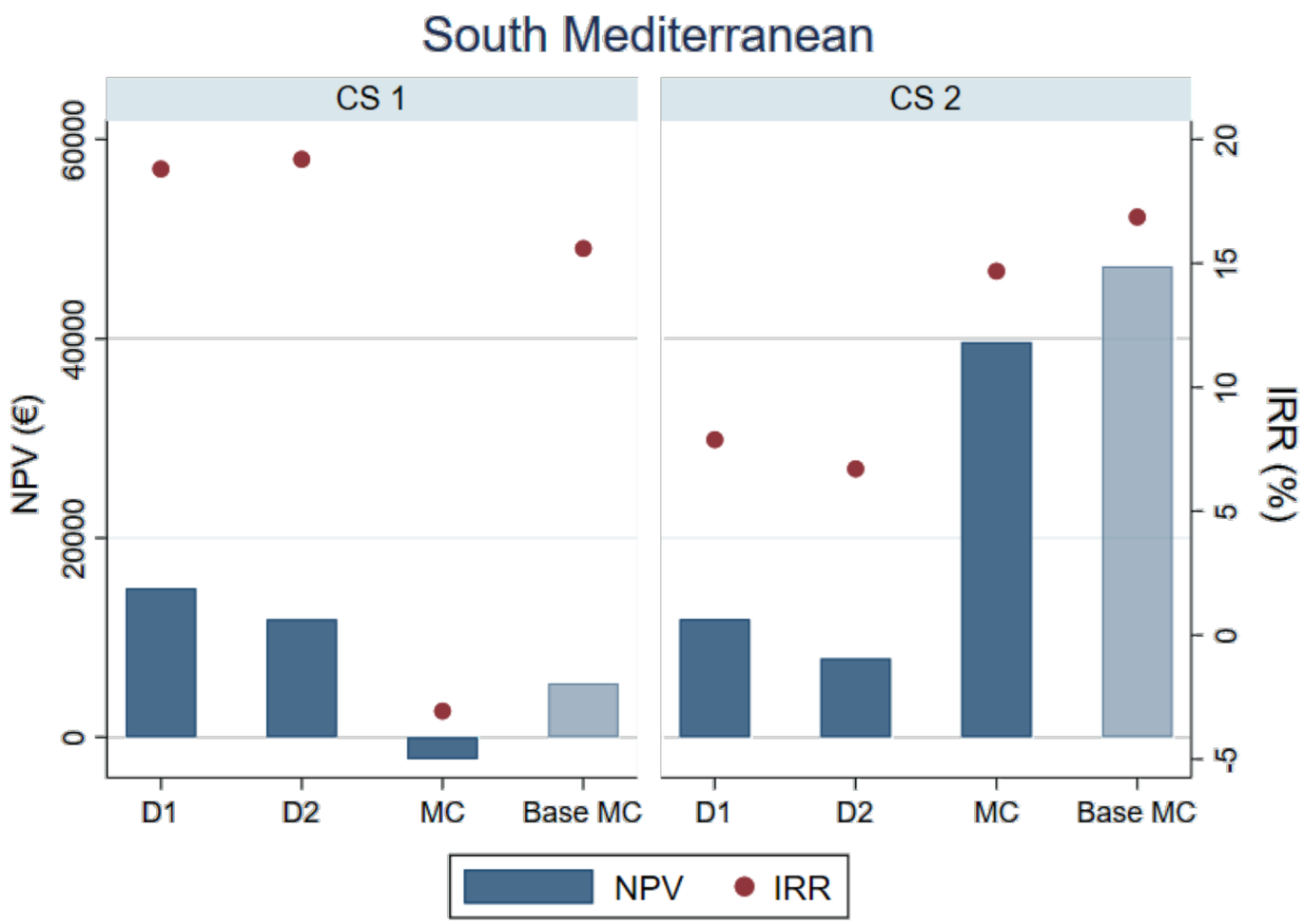
↑ Environmental benefits

↑ Socio-cultural benefits

Cross-case study on farm level economic analysis

Results - Spain

Integrated market and non-market valuation – Cost-benefit analysis



Notes:
D1, D2, MC → Market and non-market benefits/costs
Base MC → Only market benefits/costs

Again, the expected economic results in the long term depends on the crop assessed.

Market values are quite significant in cash crops such as mandarins.

However, in rainfed crops there is a significant gap of increment given the relatively high non-market benefits crop diversification provides in such agroecosystems.

*Preliminary results

Mandarin value chain analysis

Traditional mandarin value chain

Farmer → Horticultural Plant → Wholesaler supplier → Wholesaler dealer → Retailer

Modern mandarin value chain

Farmer → Horticultural Plant → Distribution platform → Super/Hiper market

- Increase biodiversity
- Reduce soil erosion
- Increase sequestered CO2
- Maintenance of cultural heritage
- Improve landscape quality

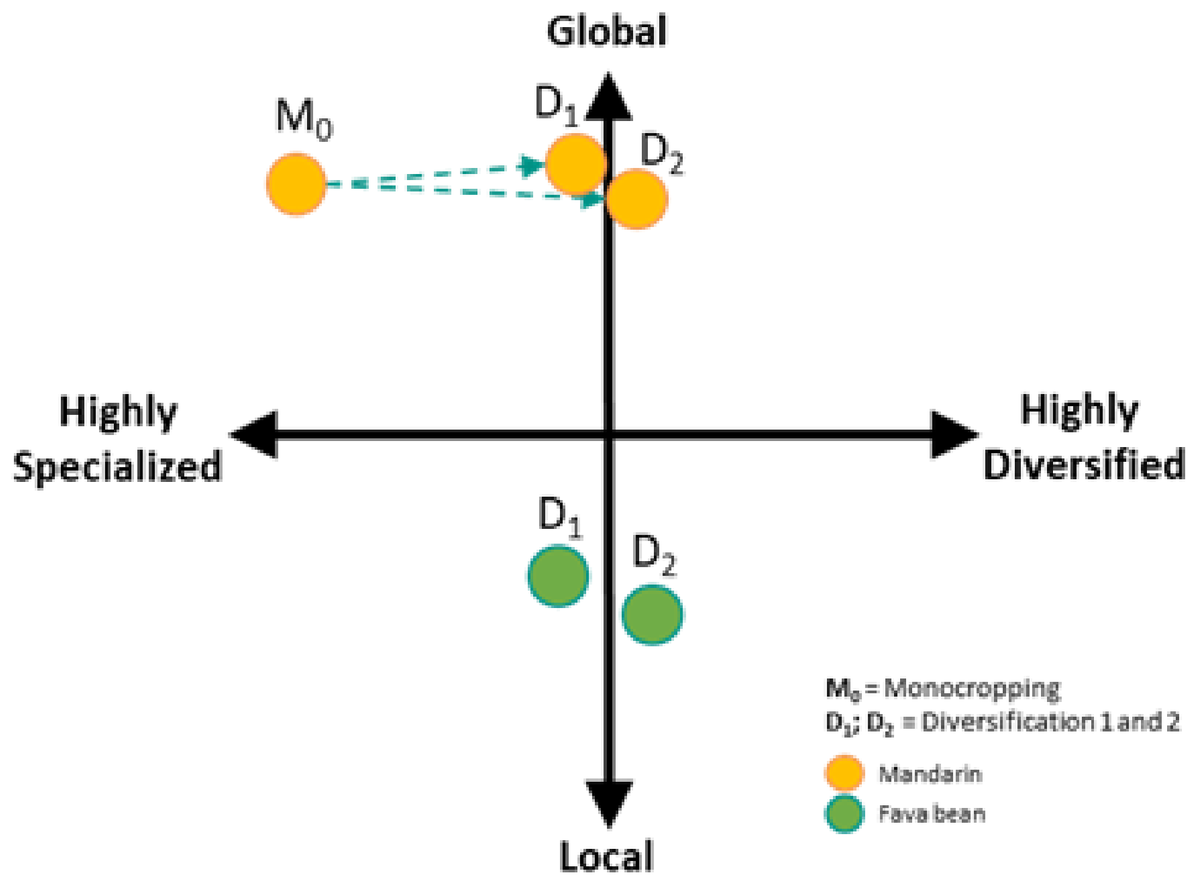
KPI	u.m.	M_0	D_1	D_2	Δ_{0-1}	Δ_{0-2}
GMa	€/ha	6289	4566	3613	**-27%**	**-43%**
GMb	€/ha	5792	2199	1655	**-62%**	**-71%**
GMc	€/ha	4607	1060	570	**-77%**	**-88%**
$\Delta_{19-20}CO_2$(TOC)	gr/kg	0.58	0.60	0.68	**+3%**	**+17%**
Soil erosion	t/ha	16.7	8.95	-	**-46%**	-
Pollinators	-	-	-	-	↑	↑

Mandarin value chain analysis

Expected moving from value chain perspectives

Business model alternatives

- Labelling product cropped with diversification practices by a certified organism by using a new label based on environmental benefits of diversification (**Labelling**)
- Subside farmers that adopt diversification practices (**Subsidies**)
- Include diversification practices as legible environmental practices withing the operational programmes that the producer organizations made (**Operational funds**).

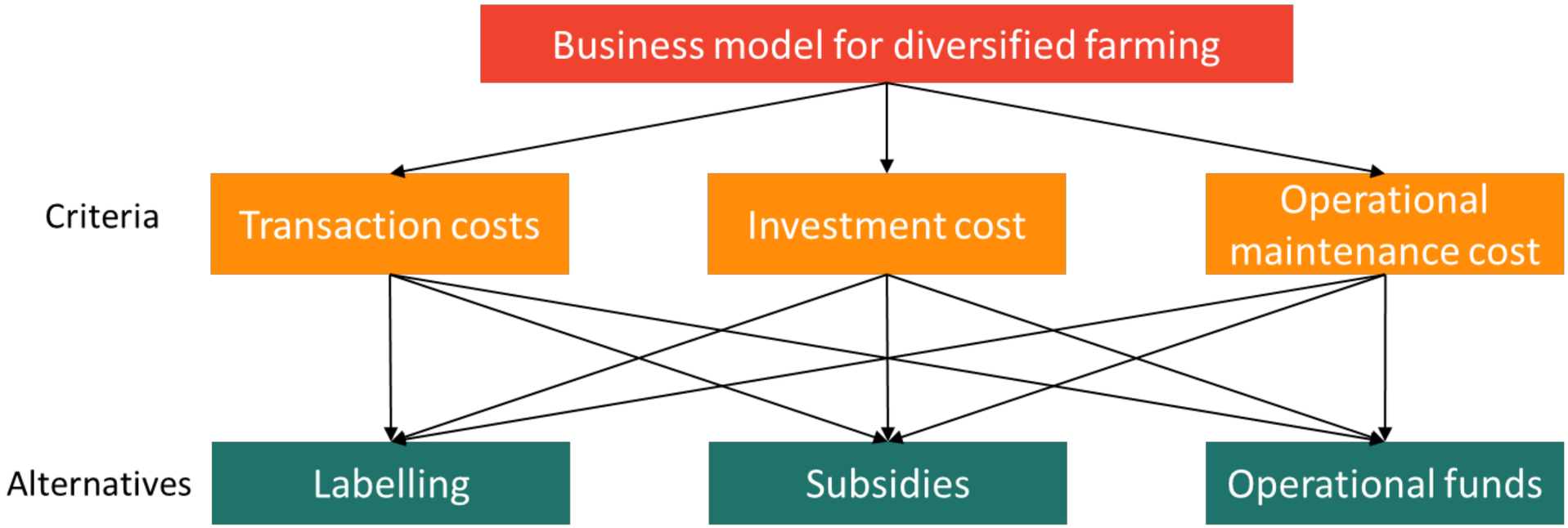


Mandarin value chain analysis

Method

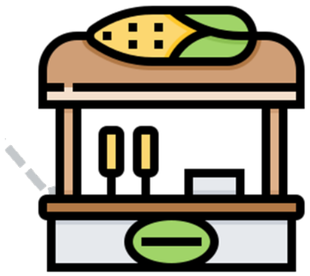
Multicriteria method

Analytic Hierarchy Process



Farmers

Cooperatives and producers associations



Ratailers

Public Administration

Researchers

Mandarin value chain analysis

Results

Stakeholders preferences

Analytic Hierarchy Process

AHP preferences by stakeholders' group

Stakeholders group	Label	Subsidies	O. Funds
Farmers	0.07	0.32	**0.58**
Cooperatives and producer's associations heads	0.16	0.32	**0.52**
Retailers	0.32	0.33	**0.34**
Public administration representativeness	0.09	**0.45**	0.44
Researchers	**0.37**	0.34	0.28
Global	0.20	0.35	**0.43**

Mandarin value chain analysis

Results

Canvas Business Model for Operational Funds in Citrus intercropping (fava bean)

Key Partners

- Fertlizer suppliers
- Herbicide suppliers
- Machinery supplier
- Irrigation communities
- **Producer organizations** Wholesalers and retailers
- **Public regional administration in charge of agricultural matters**
- **Public national ministry in charge of agriculture**

Key Activities

- Mandarins farming activities
- **Intercropping practices with alley crops**
- **Fava beans farming activities**

Key Resources

- Factors of production
- Irrigation water
- **Fava beans irrigation network**
- **Alley crops seeds**
- **Knowhow about intercropping practices**

Value Proposition

- **Environmentally friendly and more sustainable quality mandarins** at good price
- **Reduction of agriculture's main impacts on natural resources**:
- Increase carbon sequestration
- Improve soil health and retention
- Increase biodiversity

Customer Relationships

- Transactional — Business to business (from Farmer to local wholesalers or distribution platforms)
- No changes expected

Channels

- Traditional and modern national value chains for mandarins
- Export channels to EU and UK mainly via road transport for mandarins
- Local traditional value chains for fava beans

Customer Segments

- Local and national mandarins consumers
- EU and UK mandarins consumers
- Local fava bean consumers in winter time as cultural traditions

Cost Structure

- Fixed costs: Machinery, mandarins plantation and irrigation infraestructure, **Operational programmes application and maintenance costs**
- Vairable costs: Inputs, fuel, water and labour
  - **Labour is specially increased with the adoption of intercropping practices**

Revenue Stream

- Mandarins and **fava beans sales**
- **Operational programmes incomes**
- **Farm costs reduction in the long term**

Concluding remarks

The impact of crop diversification on the farm level economic results depends on the **crop type**

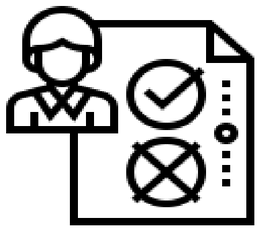
There are **not** any case study where crop diversification supposes a significant **negative impact** on farm level economic results

The most likely event is that crop diversification do **not imply a significant impact on farm gross margins,** and it case it does, it is expected to be positive (mainly when the main crop is vegetable)

The **integration of environmental and socio-cultural benefits** from crop diversification, together with the respective farm benefits, makes the case for supporting crop diversification both in the short and long term. This is of particular interest if the environmental costs of monocropping systems are considered.

*Preliminary results

Transition needs



Training and promotion of intercropping

Technical support

Financing operational programmes in agreement with farmers

Possible Solutions

Farmer and public administration consensus

Support from producer organizations

Socially valued ecosystem services

*Preliminary results

Innovations to reduce and remediate farm soil pollution.
A contribution to the EU Soil Strategy

Thanks

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