Integrating top–down and bottom–up approaches to design a new framework to assess crop diversification sustainability

Christian Bockstaller

DiverIMPACTS

Diversification through Rotation, Intercropping, Multiple Cropping,
Promoted by Actors and Value Chains towards Sustainability

Integrating top-down and bottom-up approaches to design a new framework to assess crop diversification sustainability

F Angevin ±[1], C Bockstaller*[1], P M Curran[2], I Iocola[4], A Messean[1], C Schader2, D Stilmant[3], F Van Stappen[3], S Canali[4]

[1]INRA, France, [2]FIBL, Switzerland, [3]CRA-W, Belgium, [4]CREA, Italy

FSD 2019

Montevideo Uruguay

August 20th 2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727482 (DiverIMPACTS)

Introduction

- Diversification: a key lever for sustainability of farming systems (Bommarco et al. 2013 TREE)
- Still a lack of knowledge on synergies and trade-offs between sustainability themes
- Need of sustainability assessment
- … to avoid that “a solution generates new problems”

H2020 project DiverIMPACTS (2017-2022)

- to promote diversification through rotation, intercropping, multiple cropping, etc.

Space
(mixture,
intercropping,
strip cropping)

Time
(within/between years)

- with Actors and value-Chains

Overview of the project DiverImpacts

Consortium

34 partners, 11 countries
Academic to farmers organisations
Leader: A Messéan (INRA)

Structuration

9 WPs
e.g.
WP2: case studies, co-innovation
WP3: field experiments
WP4: sustainability assessment

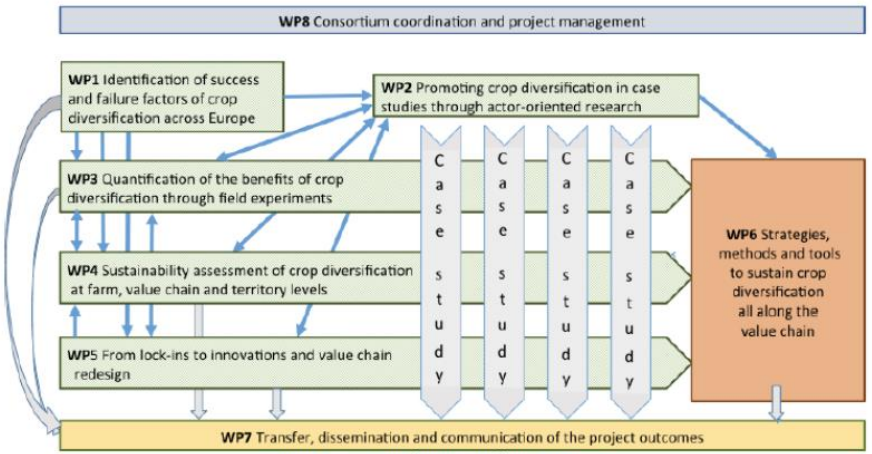


Figure 1. Operational structure of DiverIMPACTS

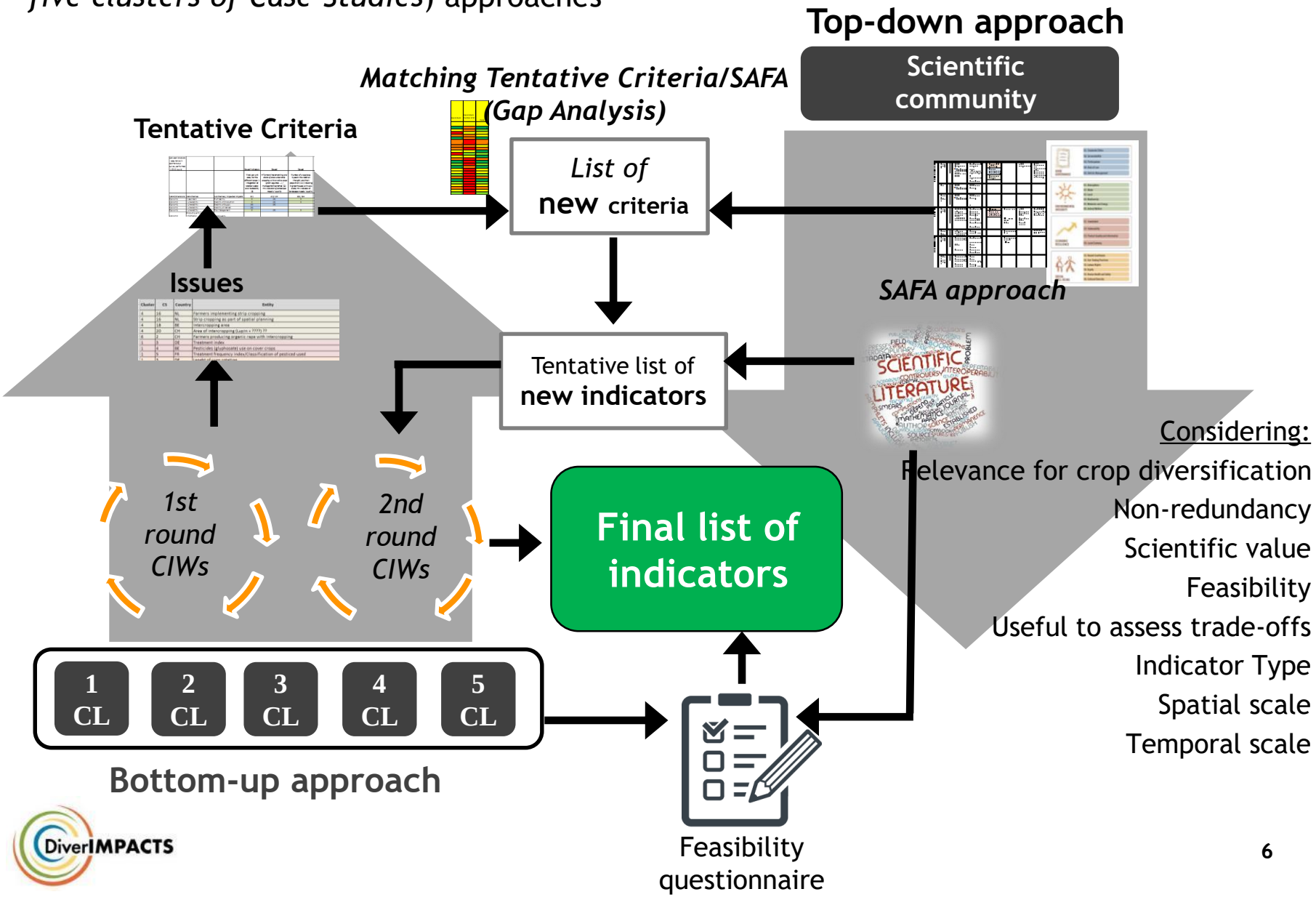
DiverIMPACTS

Aim of the WP4

- Analytical framework of indicators
  - sensitive to crop diversification
  - able to evaluate potential synergies and trade-offs at different scales
- Evaluation of the sustainability performance of the diversified agricultural strategies
  - in 25 Case Studies (CSs) located across Europe
  - at different spatial scales (field, groups of fields, farm, territory).

Methodology *(implementing multi-actor approach)*

Integration of **top-down** (*scientific community*) and **bottom-up** (*actors involved in the five clusters of Case Studies*) approaches



Results

The DiverIMPACTS framework - 29 indicators -

Final list of indicators

Dimension

8 Econ
19 Env
2 Social

N.	Criteria	ID	Indicators	Spatial Scale
Economic dimension				
1	Productivity	1.1	Energetic yield (EY)	CS
		1.2	Land Equivalent Ratio (LER)	F
2	Stability of production	2.1	Yield Coefficient of Variation (YCV)	F/CS
3	Profitability	3.1	Average gross or semi net margin at rotation level (RGM or RSNM)	CS
4	Dependency on external inputs	4.1	Total input/turnover (DEI)	CS
			equired by the sector/market (PSQ)	CS
			d local distribution (PSC)	FM
			ution to profitability (SCCP)	SC
			tal dimension	
				FM
			SNH)	T/FM
				CS/FM
			)	CS
			D)	CS/FM
16	GHG balance	16.3	Total fuel consumption at far	
		16.4 (11.1)	C input during the rotation (	
17	Non-renewable resources (Fossil energy and mineral P)	17.1	Total fuel consumption at far	
		17.2	Mineral Nitrogen Use for foss	
		17.3	Mineral Phosphorus use (MPU	
Social dim				
18	Famer and public health	18.1	Treatment frequency index (	
19	Farmers' quality of life	19.1	Work overload (WOL)	

Spatial scale

1 Field (F)
12 Cropping System (CS)
2 Farm (FM)
1 Supply Chain (SC)
1 FM/Territory (T)
4 F/CS
7 CS/FM
1 CS/FM/T

Temporal scale CS/FM

- Length of the rotation, or
- Multiannual

Three pragmatic approaches for feasibility

- use of literature values for data that are not available (e.g., energetic contents of crop yields);
- use of indirect indicators or proxy-indicators (e.g., C input as a proxy of SOC content);
- use of qualitative information. (e.g. Product quality with a focus on the risk of not achieving the level of quality requested by the market)

DiverIMPACTS

Indicators- CS Relevance (8 CSs out of 25)

N.	Criteria	Indicators	Relevance
1	Productivity	Energetic yield (EY)	75%
		Land Equivalent Ratio (LER)	50%
2	Stability of production	Yield Coefficient of Variation (YCV)	88%
3	Profitability	Average gross or semi net margin at rotation level (RGM or RSNM)	88%
4	Dependency on external inputs	Total input/turnover (DEI)	75%
5	Product quality	Product standard quality required by the sector/market (PSQ)	63%
6	Local valorisation	Short food supply chain and local distribution (PSC)	50%
		Supplier/customer contribution to profitability (SCCP)	63%
7	Ecosystem/landscape Diversity	Crop Diversity Index (CDI)	100%
		% Semi Natural Habitat (%SNH)	25%
		% Ecological Focus Area (%EFA)	13%
8	Crop diversification	Temporal and spatial Crop-Species Richness (CSR)	88%
		Crop Diversity Index (CDI)	63%
		% Legume in rotation (LEG)	100%
9	Genetic diversification	Crop-cultivar diversity (CCD)	63%
		Number of crop in the rotation with cultivar mixture (CCM)	63%
10	Soil degradation (compaction, erosion)	Proportion of crops harvested in wet conditions (NWHC)	50%
		Bare soil during erosion risk period (BSO)	75%
11	Soil quality	C input during the rotation (ACI)	75%
12	Water withdrawal	Relative available water remaining (RWAR)	63%
		Water irrigation system and source (WISS)	38%
13	Water quality (nitrate)	Surface nutrient balances (NBAI and PBAL)	88%
		Bare soil during drainage period (BSO)	63%
14	Water quality (perticide)	Amount of leachable active ingredient (LeachAI)	38%
		Amount of active ingredients (QAI)	25%
15	Air quality	Amount of volatile active ingredients (VolAI)	25%
		Amount of active ingredients (QAI)	25%
16	GHG balance	Mineral Nitrogen Use for GHG balance calculation (MNUGHG)	50%
		Nitrogen Use Efficiency (NUE)	75%
		Total fuel consumption at farm level for global warming potential calculation (FCFGHG)	63%
		C input during the rotation (ACI)	63%
17	Fossil energy and mineral P use	Mineral Nitrogen Use for fossil energy use calculation (MNUNRJ)	63%
		Mineral Phosphorus use (MPU)	63%
		Total fuel consumption at farm level for fossil energy use calculation (FCFNRJ)	50%
18	Famer and public health	Treatment frequency index (TFI)	63%
19	Farmers' quality of life	Work overload (WOL)	50%

DiverIMPACTS

Indicators- CS Difficulties (8 CSs out of 25)

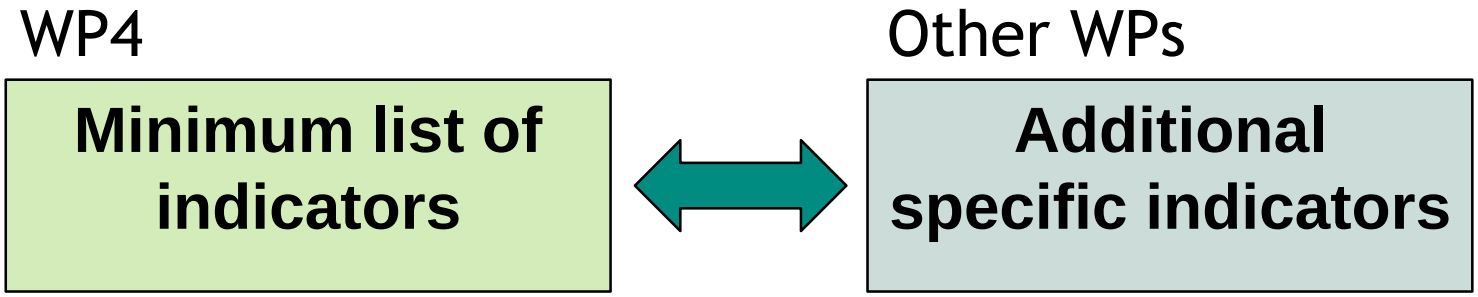
n.	Criteria	Indicators	Difficulties
1	Productivity	Energetic yield (EY)	29%
		Land Equivalent Ratio (LER)	29%
2	Stability of production	Yield Coefficient of Variation (YCV)	57%
3	Profitability	Average gross or semi net margin at rotation level (RGM or RSNM)	100%
4	Dependency on external inputs	Total input/turnover (DEI)	71%
5	Product quality	Product standard quality required by the sector/market (PSQ)	57%
6	Local valorisation	Short food supply chain and local distribution (PSC)	29%
		Supplier/customer contribution to profitability (SCCP)	43%
7	Ecosystem/landscape Diversity	Crop Diversity Index (CDI)	0%
		% Semi Natural Habitat (%SNH)	43%
		% Ecological Focus Area (%EFA)	14%
		Temporal and spatial Crop-Species Richness (CSR)	14%
8	Crop diversification	Crop Diversity Index (CDI)	0%
		% Legume in rotation (LEG)	14%
9	Genetic diversification	Crop-cultivar diversity (CCD)	29%
		Number of crop in the rotation with cultivar mixture (CCM)	0%
10	Soil degradation (compaction, erosion)	Proportion of crops harvested in wet conditions (NWHC)	0%
		Bare soil during erosion risk period (BSO)	0%
11	Soil quality	C input during the rotation (ACI)	57%
12	Water withdrawal	Relative available water remaining (RWAR)	29%
		Water irrigation system and source (WISS)	14%
13	Water quality (nitrate)	Surface nutrient balances (NBAI and PBAL)	71%
		Bare soil during drainage period (BSO)	0%
14	Water quality (pesticide)	Amount of leachable active ingredient (LeachAI)	0%
		Amount of active ingredients (QAI)	14%
15	Air quality	Amount of volatile active ingredients (VolAI)	0%
		Amount of active ingredients (QAI)	14%
16	GHG balance	Mineral Nitrogen Use for GHG balance calculation (MNUGHG)	14%
		Nitrogen Use Efficiency (NUE)	43%
		Total fuel consumption at farm level for global warming potential calculation (FCFGHG)	14%
17	Fossil energy and mineral P use	C input during the rotation (ACI)	29%
		Mineral Nitrogen Use for fossil energy use calculation (MNUNRJ)	14%
		Mineral Phosphorus use (MPU)	0%
		Total fuel consumption at farm level for fossil energy use calculation (FCFNRJ)	29%
18	Pesticide and public health	Treatment frequency index (TFI)	0%
19	Farmers' quality of life	Work overload (WOL)	0%

DiverIMPACTS

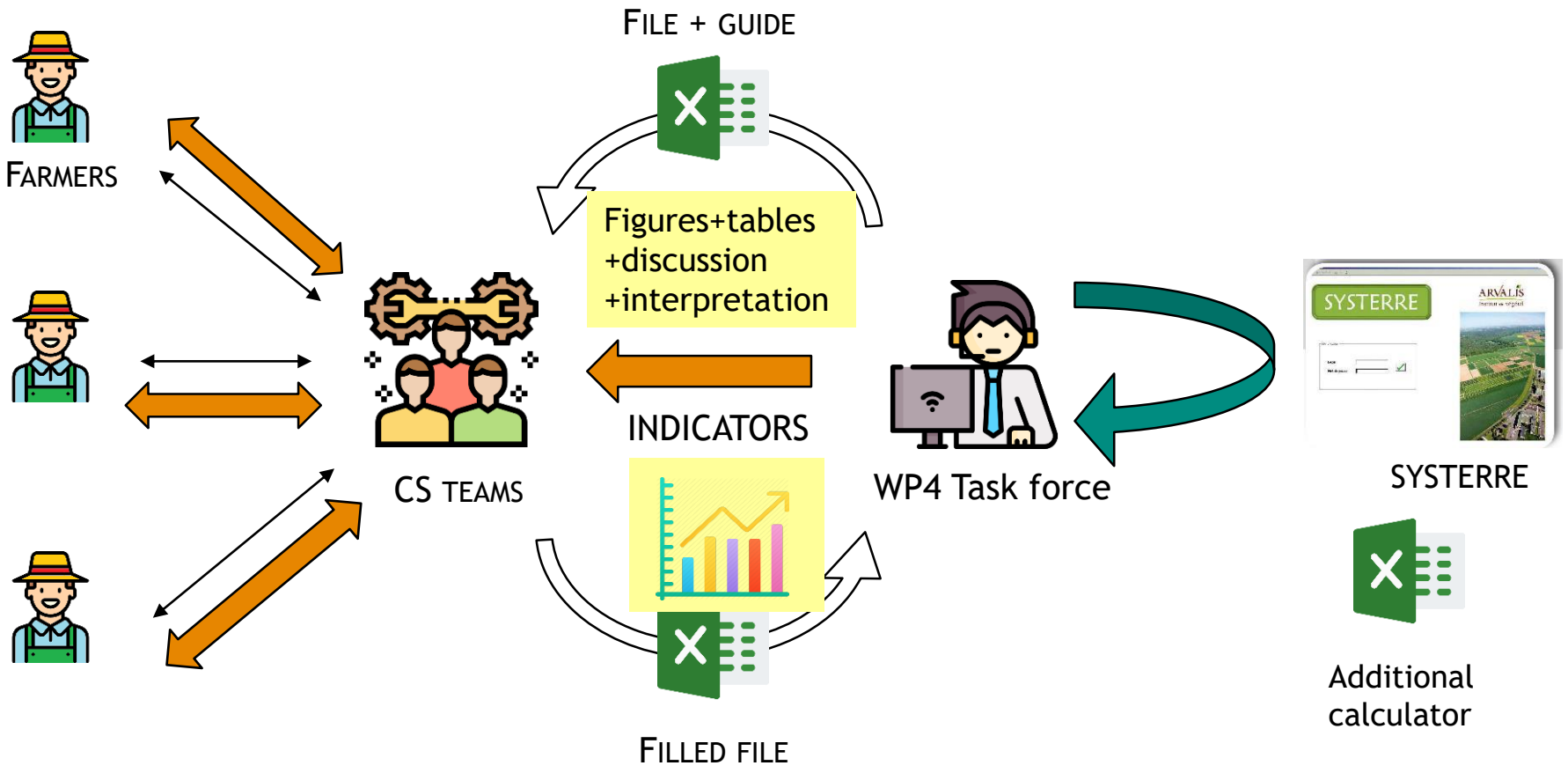
Request of additional specific indicators

Some examples:

- **auto-consumption for animal production;**
- **profitability at the agro food chain;**
- **proportion of gross margin** gained in **local value chain;**
- **farmers' satisfaction of working with diversification**
- decrease of **crop diseases;**
- **autonomy issues regarding the economical dimension**

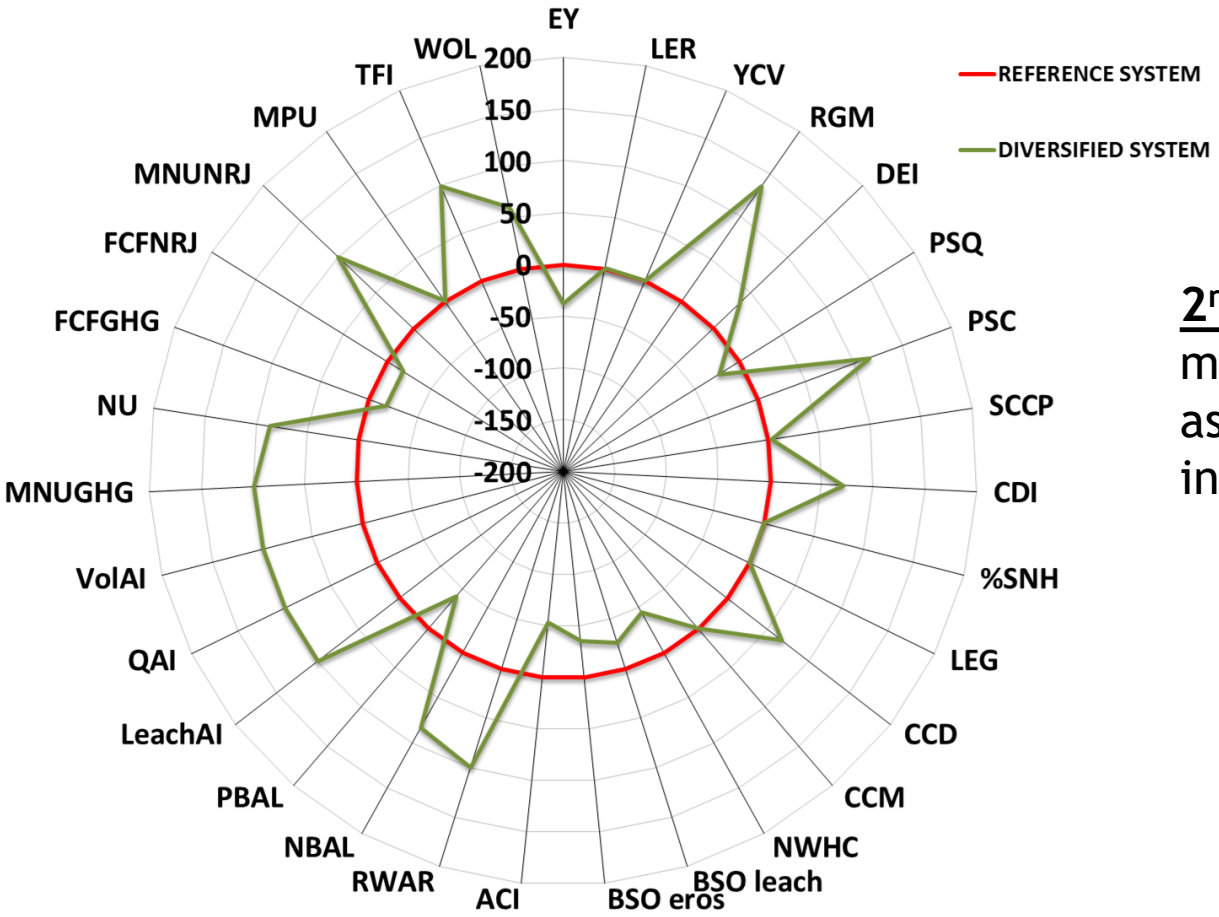


Methodological framework for implementation

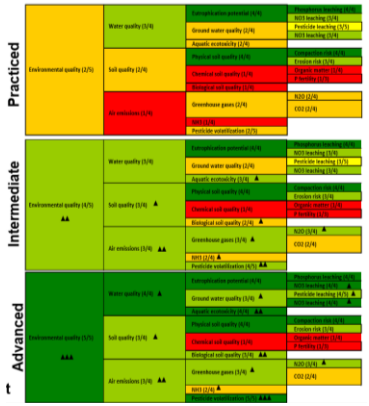


Expected results

1st step: Analysis of trade-offs and synergies (non aggregated indicators)



2nd step: Global multicriteria assessment (aggregated indicators)



DiverIMPACTS

Discussion - conclusion

- Outcome of project;
  - An indicator framework for diversified system assessment
  - A methodological framework for implementation
  - Ongoing test in CSs of the project

- Outlooks
  - Enhancement of both frameworks from
    - Feedbacks after 1st round of implementation
    - Analysis of the results
  - Assessment at farm level/territory level (Integrated MAELIA model)
  - Bottleneck for high diversified farms ?

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727482 (DiverIMPACTS)