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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

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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

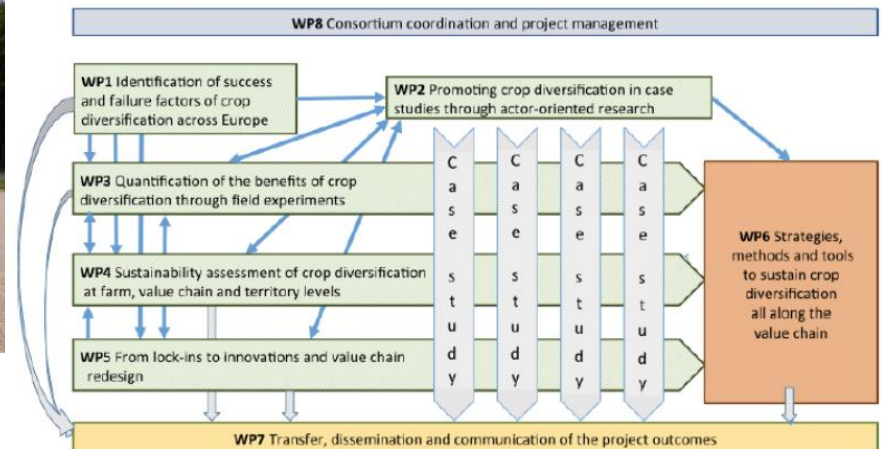


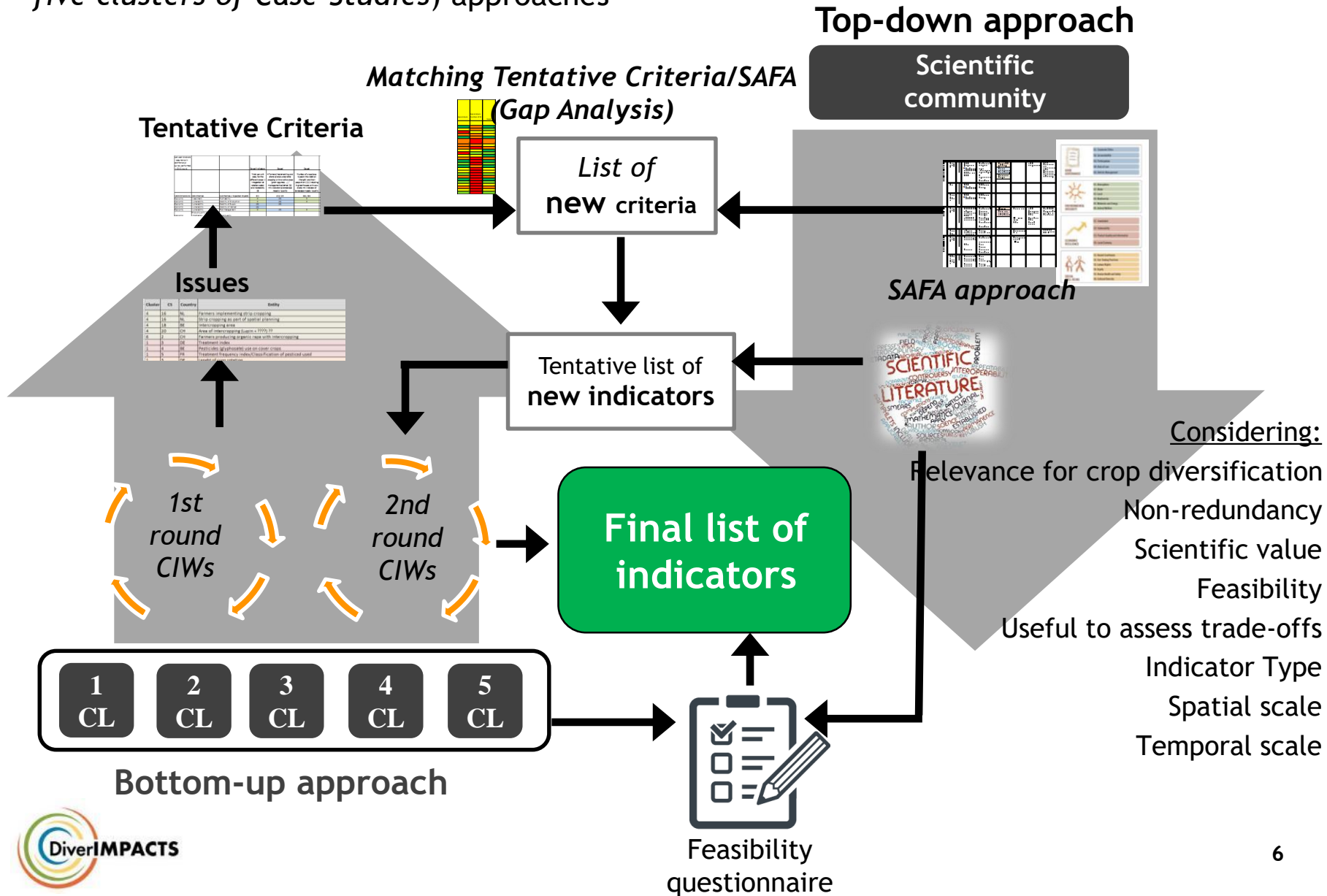
Figure 1. Operational structure of DiverIMPACTS

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
			Required by the sector/market (PSQ)	CS
			Local distribution (PSC)	FM
			Contribution to profitability (SCCP)	SC
Environmental dimension				
				FM
				T/FM
				CS/FM
				CS
				CS/FM
				CS

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

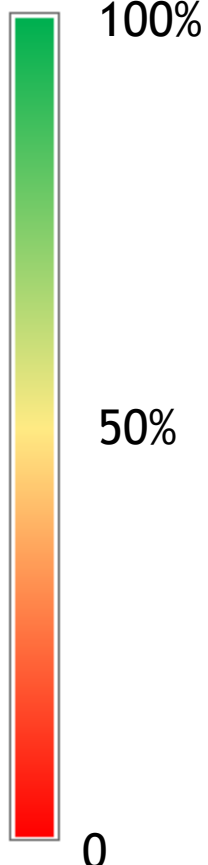
- Length of the rotation, or
- Multiannual

16	GHG balance	16.3	Total fuel consumption at farm level	
		16.4 (11.1)	C input during the rotation (t/ha)	
17	Non-renewable resources (Fossil energy and mineral P)	17.1	Total fuel consumption at farm level	
		17.2	Mineral Nitrogen Use for fossil fuels	
		17.3	Mineral Phosphorus use (MPU)	
Social dimension				
18	Famer and public health	18.1	Treatment frequency index (TFI)	
19	Farmers' quality of life	19.1	Work overload (WOL)	

Three pragmatic approaches for feasibility

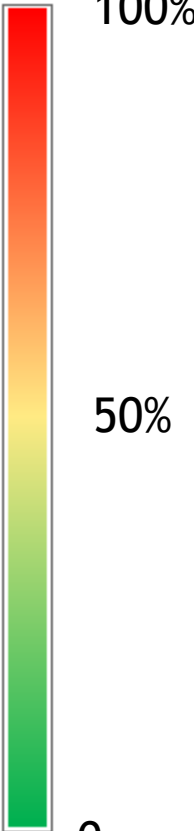
- use of literature values for data that are not available (e.g., energetic contents of crop yields);
- use of indirect indicators or proxy-indicators (e.g., C input as a proxy of SOC content);
- use of qualitative information. (e.g. Product quality with a focus on the risk of not achieving the level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

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 valorization	Short food supply chain and local distribution (PSC)	50%
		Supplier/customer contribution to profitability (SCCP)	63%
		Crop Diversity Index (CDI)	100%
7	Ecarytorm/landscape Diversity	% Semi Natural Habitat (%SNH)	25%
		% Ecological Focus Area (%EFA)	13%
		Temporal and spatial Crop-Species Richness (CSR)	88%
8	Crop diversification	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%
		Relative available water remaining (RWAR)	63%
12	Water withdrawal	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 (pesticide)	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%
		Mineral Nitrogen Use for GHG balance calculation (MNUGHG)	50%
16	GHG balance	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%
		Mineral Nitrogen Use for fossil energy use calculation (MNUNRJ)	63%
17	Fossil energy and mineral P use	Mineral Phosphorus use (MPU)	63%
		Total fuel consumption at farm level for fossil energy use calculation (FCFNRJ)	50%
18	Farmer and public health	Treatment frequency index (TFI)	63%
19	Farmer's quality of life	Work overload (WOL)	50%

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	Dependence on external inputs	Total input/turnover (DEI)	71%
5	Product quality	Product standard quality required by the sector/market (PSQ)	57%
6	Local externalities	Short food supply chain and local distribution (PSC)	29%
		Supplier/customer contribution to profitability (SCCP)	43%
		Crop Diversity Index (CDI)	0%
7	Ecosystem/landscape Diversity	% 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	Grassland 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%
		C input during the rotation (ACI)	29%
		Mineral Nitrogen Use for fossil energy use calculation (MNUNRJ)	14%
17	Fossil energy and mineral P use	Mineral Phosphorus use (MPU)	0%
		Total fuel consumption at farm level for fossil energy use calculation (FCFNRJ)	29%
18	Farmer and public health	Treatment frequency index (TFI)	0%
19	Farmer's quality of life	Work overload (WOL)	0%

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

WP4

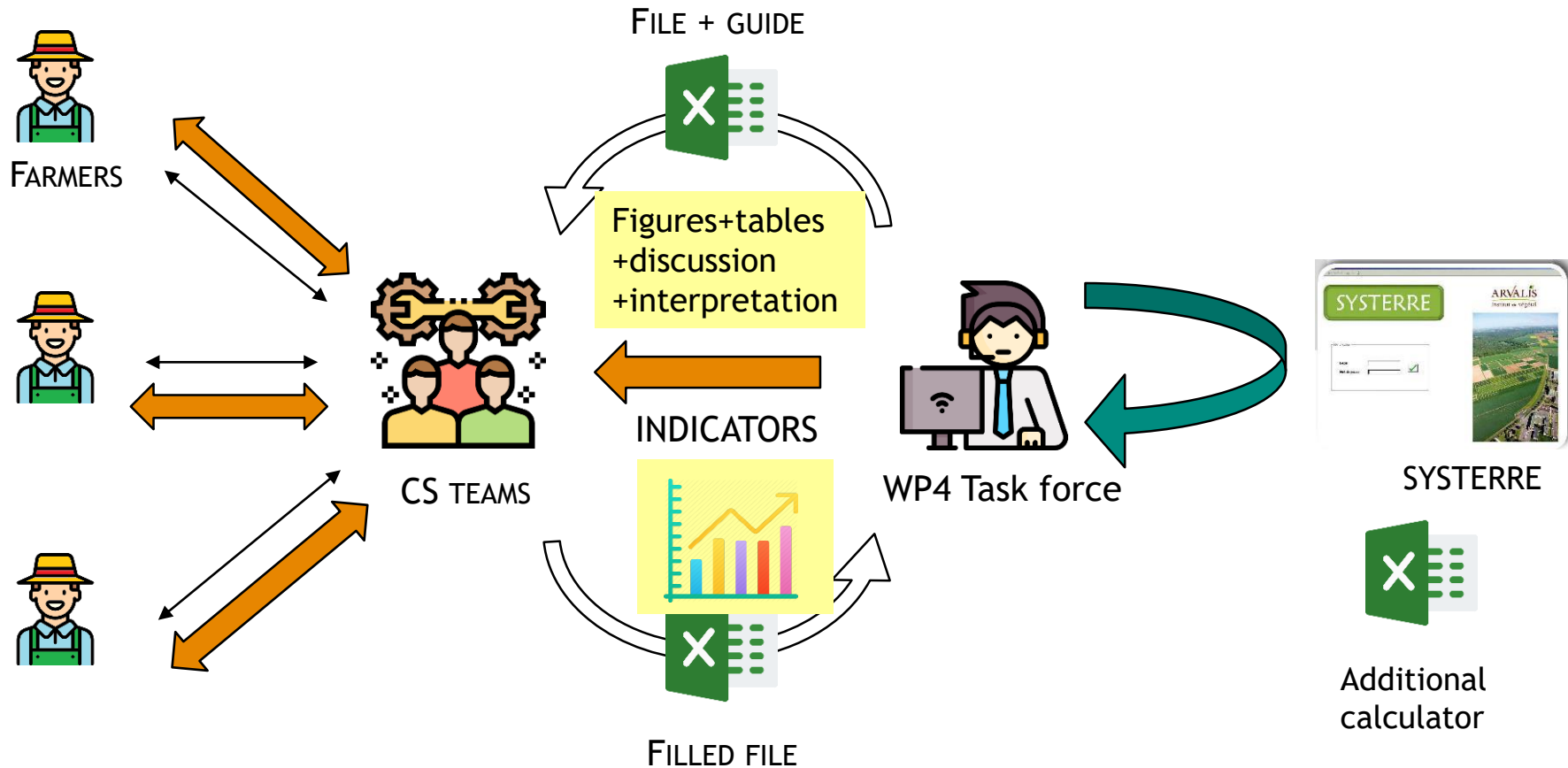
**Minimum list of
indicators**



Other WPs

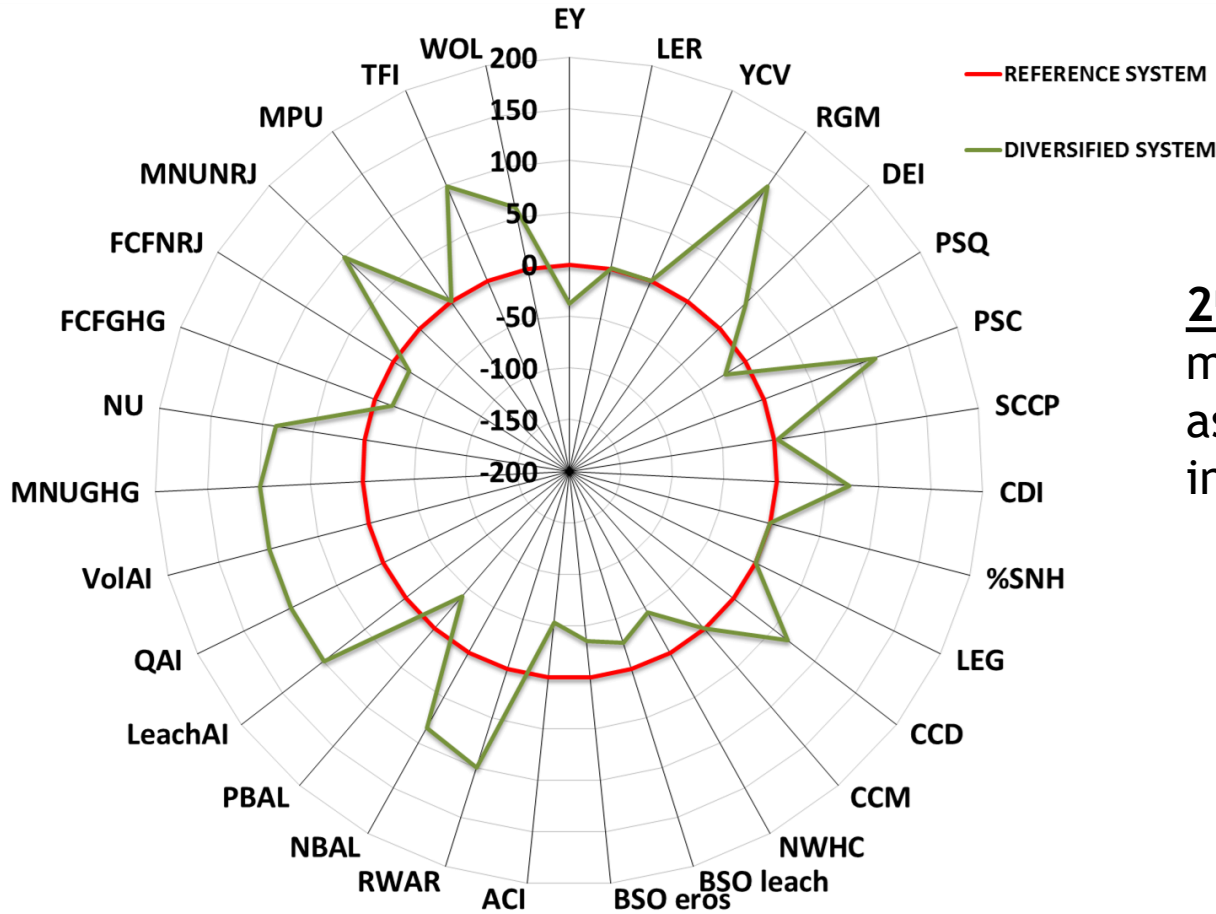
**Additional
specific indicators**

Methodological framework for implementation



Expected results

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



2nd step: Global multicriteria assessment (aggregated indicators)

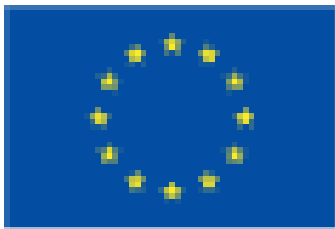
System	Water quality (2%)	Ground water quality (2%)	Residue washing (1%)	Residue recovery (1%)	Energy (1%)	CO2 emissions (1%)	Greenhouse gases (2%)	SO2 (1%)	NOx (1%)	Residue valorization (1%)
Practiced	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Intermediate	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Advanced	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲

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 ?



Thank you for your attention!



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