

***Ex ante* evaluation of cropping systems for co-design with farmers**

A case study of farmers involvement with the MASC model

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Outline

1- The MASC Model:

Assessment of sustainability at the level of cropping systems (CS)

2- Case Study:

Farmers participation in the use of the MASC model for co-designing a CS that reduces greenhouse gas emissions

3- Conclusion

Advantages, drawbacks and synthesis

The MASC Model: The Rationale

People in the field of agriculture are looking for innovative systems that address:

A growing number of challenges in agriculture

- Production of raw material
- Preservation of environment
- ...

The pedo-climatic & socio-economic local context

- Soil fertility
- Local market opportunity
- ...

Different perceptions about the performances reached

- Consumer preferences
- Farmer preferences
- ...

A need of method to assess the sustainability able to handle:

- a wider range of knowledge *via* the use of **qualitative and quantitative information**
- a larger **diversity of context and of decision-makers**
- operational scales for farmers such as the **cropping system (CS) level**

Cropping System = crop sequence at the field scale + management of each crop

The MASC Model:

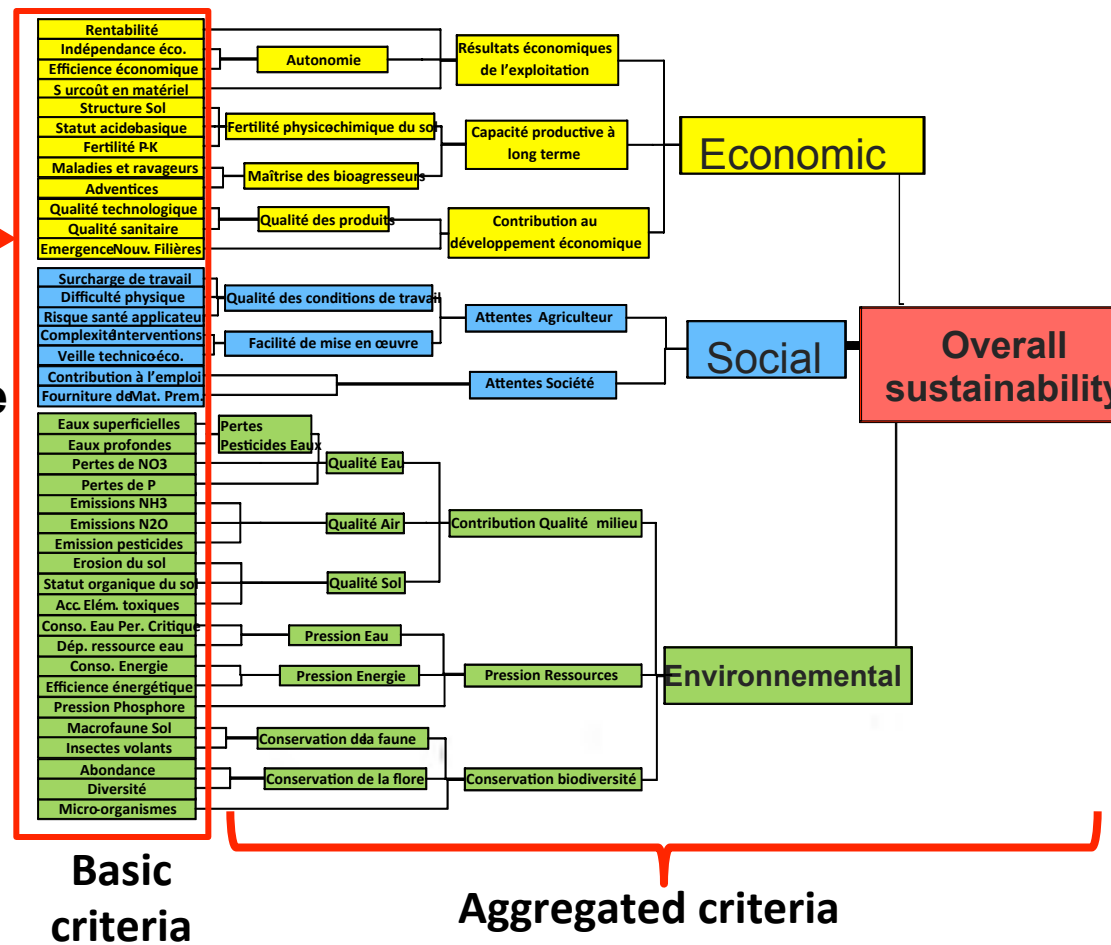
Multi-attribute Assessment of the Sustainability of Cropping Systems

- Implemented with DEXi DSS, (M. Bohanec - JSI, Slovenia).
- MASC 1.0 published in 2009 (Sadok *et al.*)
- Structuring & breaking down the assessment problem of sustainability into sub-problems

Each dimension is split up into a set of “basic criteria”
(e.g.: profitability, NO3 losses)

MASC decision tree all criteria are qualitative
(e.g.: low, medium, high)

MASC aggregates information towards overall sustainability
(through Utility Functions)



The MASC Model: Principles of Utility Function

Utility functions permit aggregation of information through the decision model

Manual method:

By according a value to upper-level criterion for each combination of the possible values of the lower-level criteria.

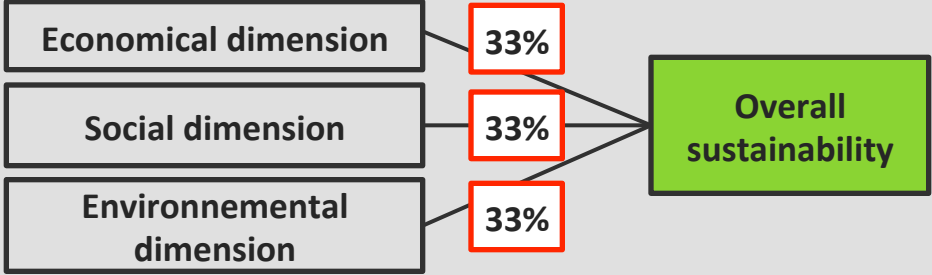
	Economical dimension	Social dimension	Environmental dimension	Overall sustainability
30	low	low	low	very low
35	low	low	medium	low
34	low	low	high	low
25	low	low	very high	rather low
30	low	medium	very low	very low
37	low	medium	low	low
30	low	medium	medium	rather low
38	low	medium	high	rather low
40	low	medium	very high	medium

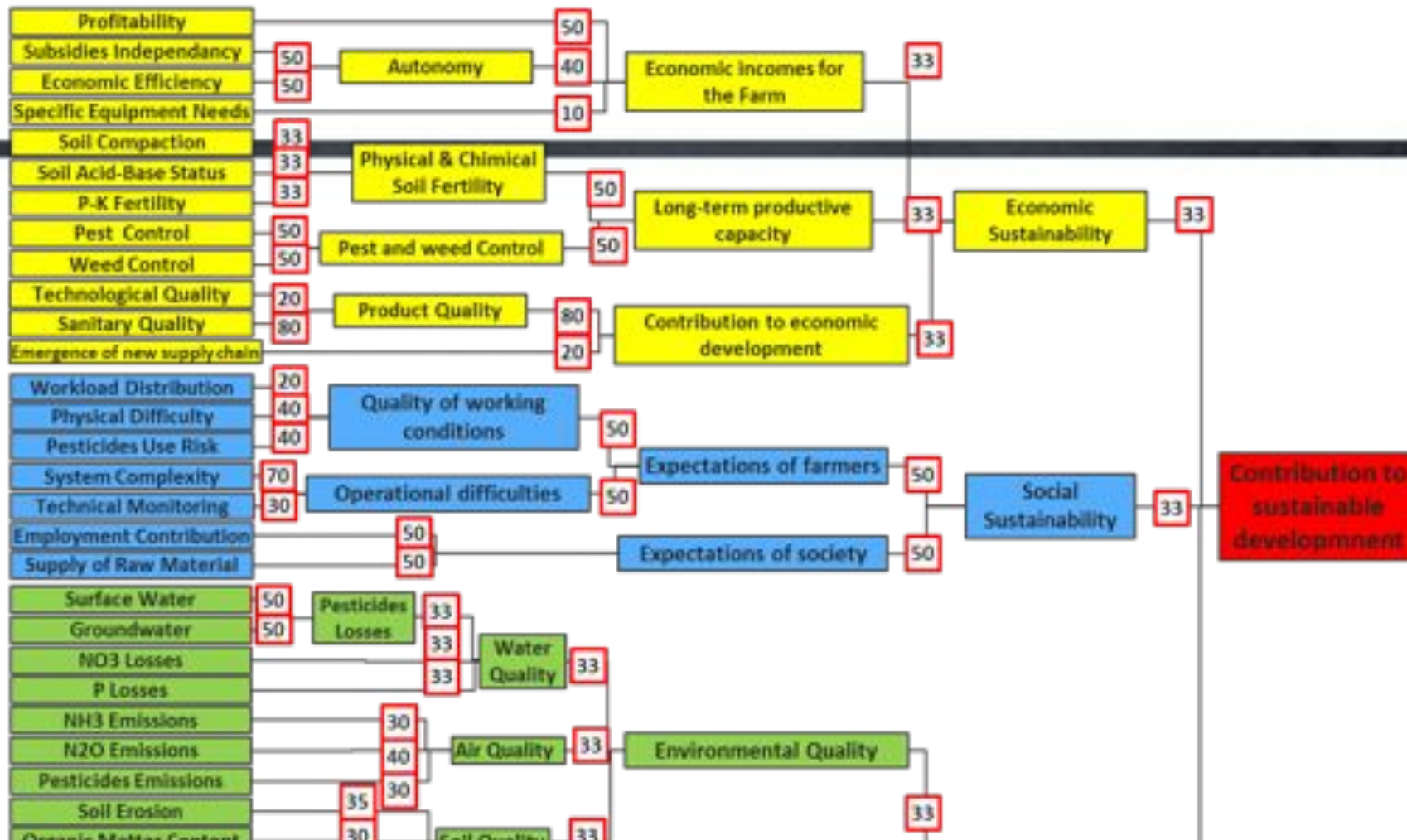


Feedback performed by DEXi

Automatic method:

By according weights (%) for the lower-level criteria





Users can modify weights to introduce:

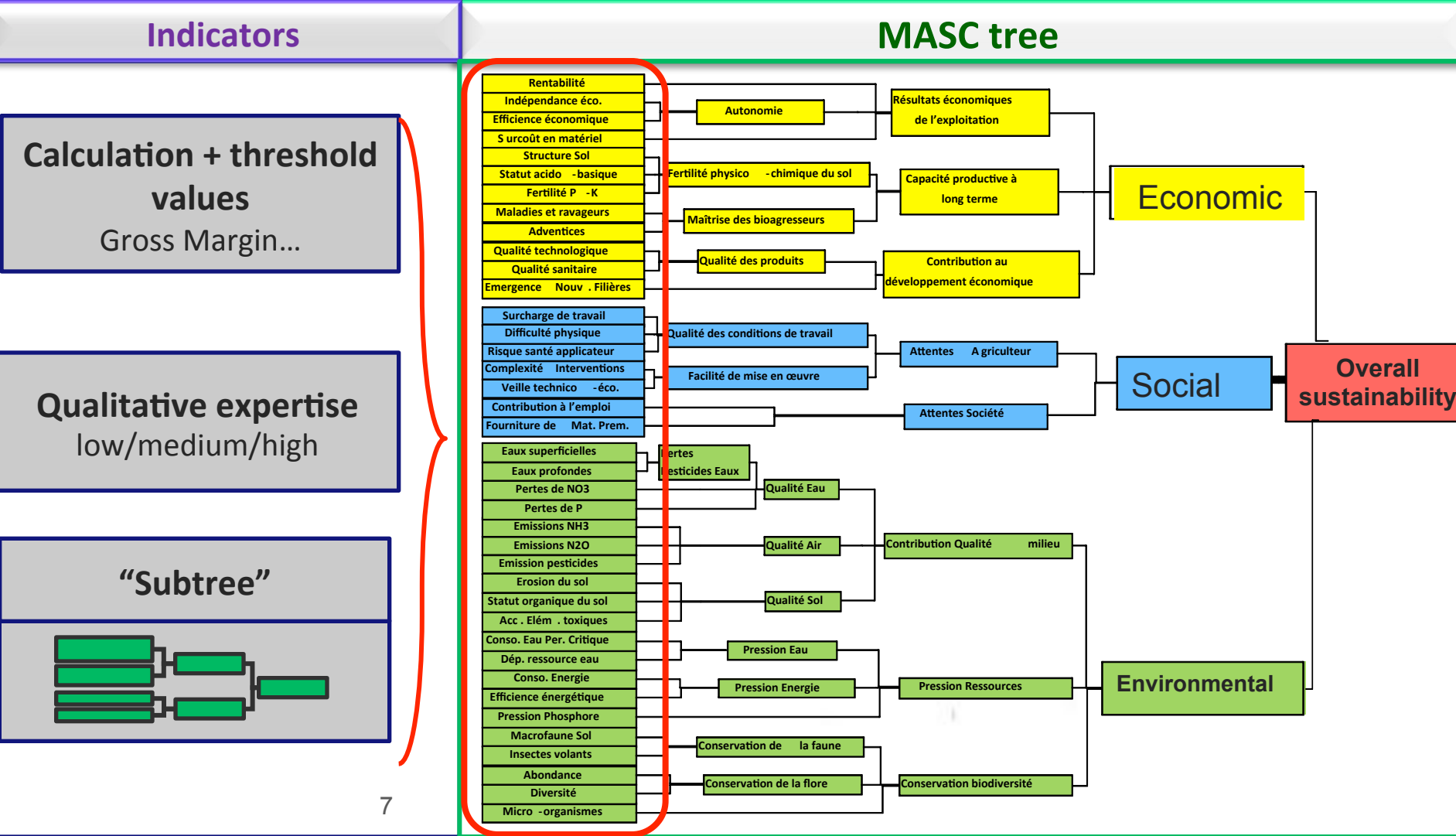
- Local issues
- Personal perception of sustainability

%

The MASC Model:

Multi-attribute Assessment of the Sustainability of Cropping Systems

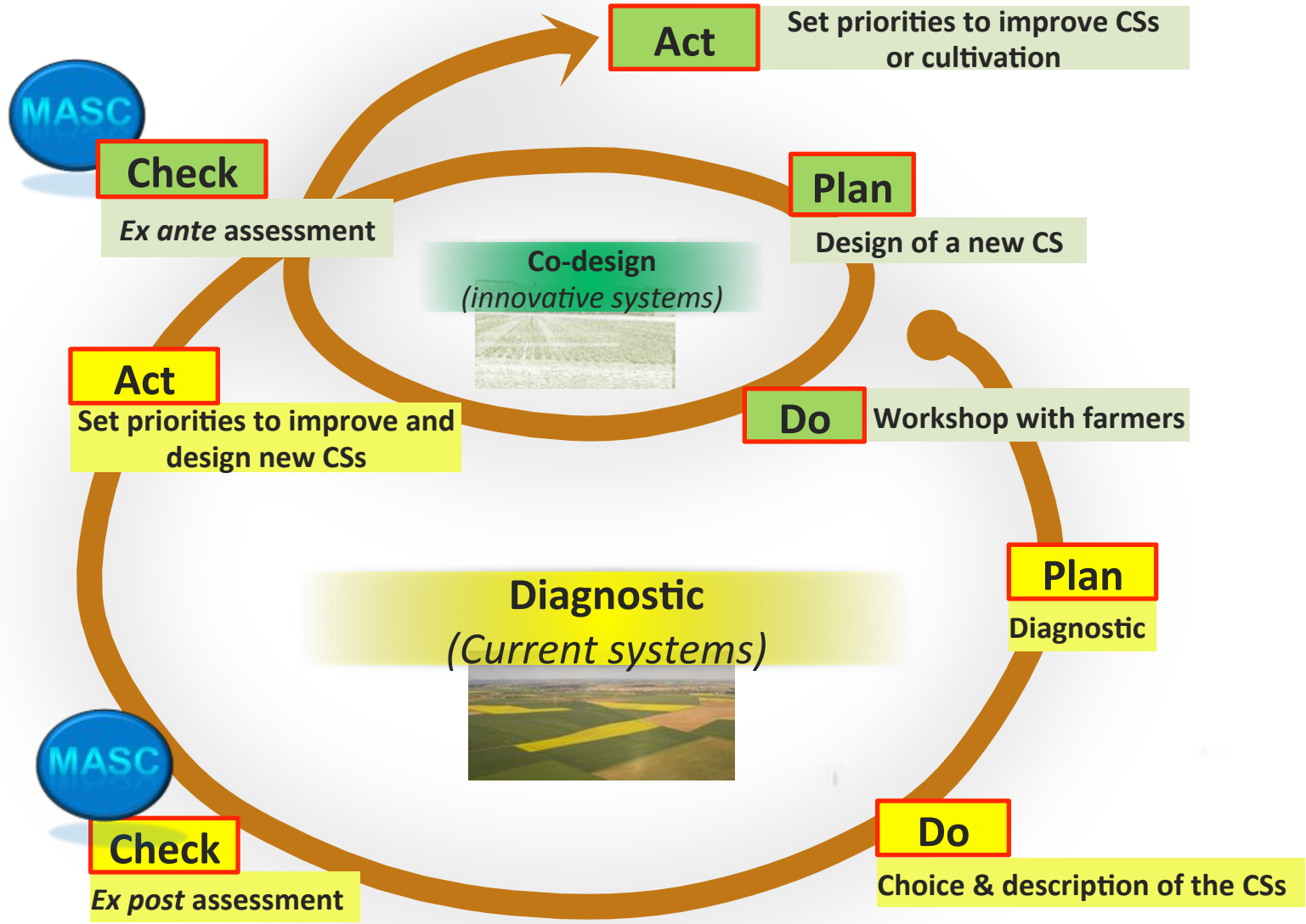
Three different indicators to fill in basic criteria



The MASC Model: use in a process of co-design of innovative systems



The Deming Wheel



PLAN: the SYSCLIM project

Project conducted in partnership with...



Public financing body



Agricultural research



Agricultural cooperative

Set of priorities

Design innovative CSs that
reduces greenhouse gas emissions

- By taking into account farmers expectations
- By taking into account the sustainability requirements



DO: Set priorities to improve CSs

Workshop to identify the farmers expectations

- **Should be done very early in the participative process**
(to keep them involved and interested)



- **Should be conducted with ice-breakers**
(i.e. effective process to make easier farmers participation)



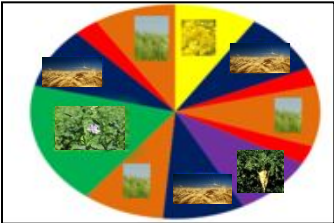
Main objectives assigned to CSs by farmers:

- Enhance profitability
- Maintain soil fertility
- Reduce workload
- Reduce dependency on external inputs (fertilizers, pesticides, oil)

Case study

CHECK: Diagnostic to identify sustainability issues

Identify and describe a representative CS with farmers & advisors



Strengths & weaknesses were analysed by small groups of farmers (supervised by an organizer)

3 / 4	Profitability							
2 / 4	Subsidies Independancy	Autonomy	2 / 4	Economic incomes for the farm	Economic Dimension	4 / 5		
2 / 4	Economic efficiency							
1 / 3	Specific Equipment Needs							
3 / 4	Soil Acid-base Status							
4 / 4	Soil compaction	Physical & Chmical Soil Fertility	4 / 4	long-term productive capacity				
4 / 4	Phosphorus & Potassium Fertility							
3 / 4	Pest control	Pest and Weed Control	4 / 4	Contribution to economic development				
4 / 4	Weed control							
3 / 3	Sanitary Quality	Product Quality	4 / 4	Expectations of society	Social Dimension	4 / 5		
3 / 3	Technological Quality							
2 / 3	Emergence of new supply chain							
3 / 4	Employment contribution							
4 / 4	Supply of Raw material							
3 / 4	System complexity	Operational difficulties	3 / 4	Expectation of farmers				
2 / 3	Technical monitoring							
1 / 3	Workload distribution	Quality of working conditions	1 / 4		Environmental Dimension	2 / 5		
1 / 4	Pesticides use risks							
3 / 3	Physical Difficulties							
2 / 4	Surface Water	Pesticides Losses	3 / 4	Water quality				
3 / 4	Ground Water							
3 / 4	NO _x Losses							
2 / 4	Phosphorus losses							
3 / 4	NH ₃ Emissions							
3 / 4	N ₂ O Emissions	Air Quality	3 / 4	Environmental Quality				
3 / 4	Pesticides Emission							
4 / 4	Accumulation of Toxical Elements	Soil Quality	3 / 4					
2 / 4	Organic Matter Content							
4 / 4	Soil erosion							
3 / 4	Dry Period Irrigation Needs	Water Conservation	4 / 4	Abiotic Ressource Conservation				
3 / 4	Dependency on Water							
1 / 3	Energy consumption	Energy Conservation	2 / 3					
3 / 3	Energy efficiency							
2 / 4	Phosphorus Conservation							
3 / 4	Flying Insects	Fauna Conservation	2 / 4	biodiversity Conservation				
2 / 4	Soil macrofauna							
1 / 4	floristic abundance	Flora conservation	2 / 4					
2 / 4	Floristic diversity							
3 / 4	Soil micro-organisms							
				Overall sustainability			4 / 7	
							Very Low Low Medium High Very High	

Farmers sought to pinpoint which of their agricultural practices have led to these results.

PLAN: Set priorities to improve CSs

Collective analysis of the compatibility between issues



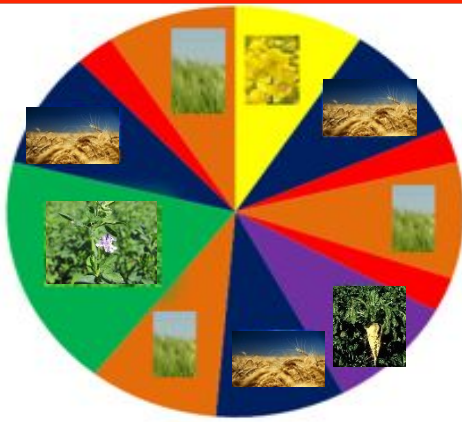
Reduce greenhouse gas emissions (Strategies)	Farmers expectations	Weaknesses identified (criteria of MASc)
Reduce the use of mineral N	Reduce dependency on external inputs	Economic efficiency
Reduce fuel consumption <i>(i.e. reducing soil tillage)</i>	Reduce the working time	Woarkload distribution Pressure on fossil energy
Increase soil carbon storage	Maintain soil fertility	Soil Macrofauna conservation

❑ Important step to get the farmers involved and to guide the design

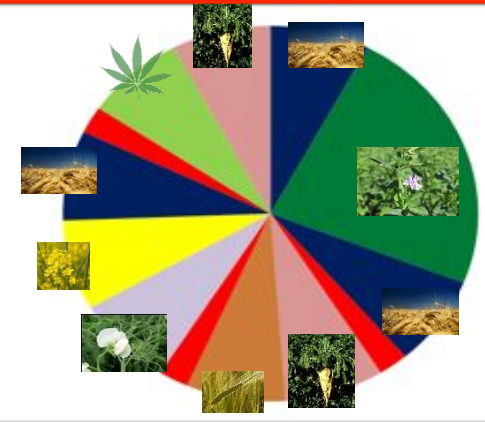
DO: Co-design a new cropping system

Workshop to co-design in a participative process

Current CSs



Newly co-designed CSs



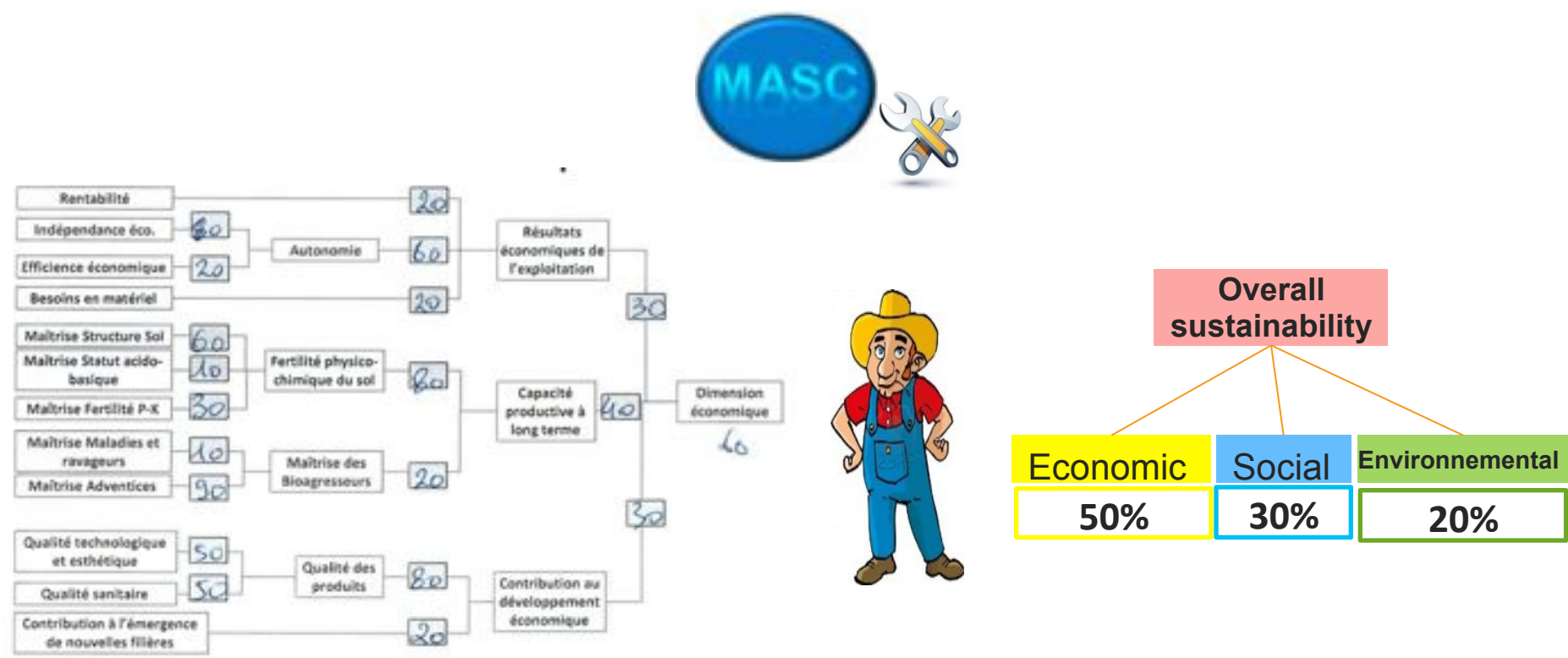
Strategies proposed by farmers

- Increase the proportion of legume crops
- Reduce the nitrogen mineral fertilizer,
- Increase the use of organic matter
- Reduce the frequency of plowing
- ...

Case study

CHECK: Co-design a new cropping system

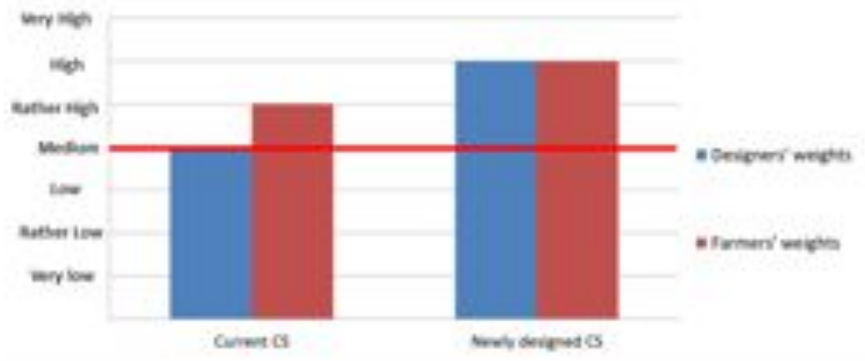
Introduce farmers vision of sustainability into parameter settings



- Farmers expressed their concerns individually or collectively

CHECK: Collective interpretation of results

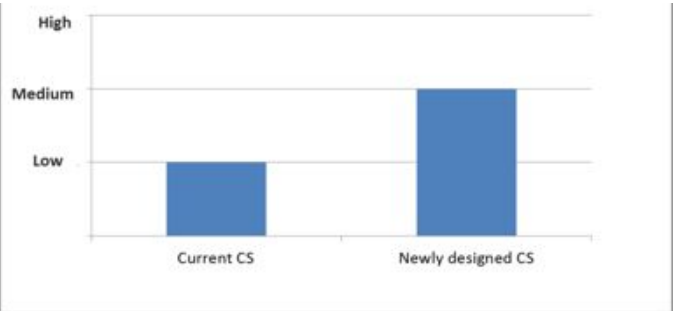
Overall sustainability



... According to their overall performance

- With designer's weights
- With the farmers' weights

Consumption of fossil energy sources



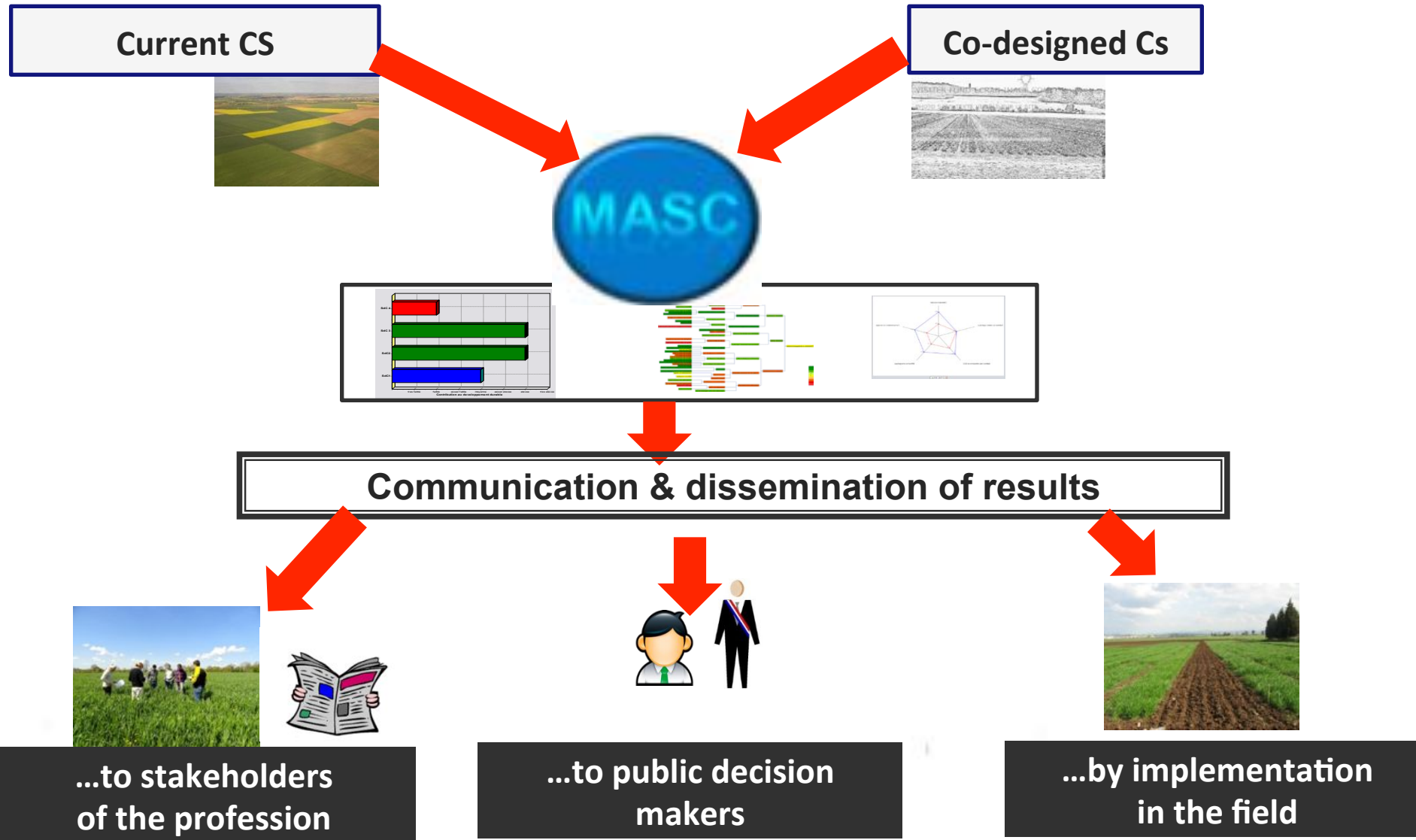
... According to specific goals

1-14 Profitability	27-4	Autonomy	32	Economic income for the farm	Economic Dimension	3-4-17
1-22 Resource efficiency	32					
1-23 Specific Equipment Needs	24	Physical & Chemical Soil Fertility	24	long-term productive capacity		
1-24 Fuel consumption	24					
1-25 Phosphorus & Potassium Fertility	24					
1-26 Pest control	24	Pest and Weed Control	24	Contribution to economic development		
1-27 Sanitary Quality	24	Product Quality	24	Expectations of society		
1-28 Technological Quality	24					
1-29 Emergence of new supply chain	24					
1-30 Equipment condition	24					
1-31 Supply of Raw material	24					
1-32 Pasture condition	21	Operational difficulties	21	Expectation of farmers	Social Dimension	
1-33 Technical monitoring	21					
1-34 Technical maintenance	21					
1-35 Pesticides and risks	1	Quality of working conditions	1			
1-36 Physical difficulties	1					
1-37 Surface Water	1-3	Pesticides	1-3	Water quality	Environmental Quality	
1-38 Liquid Water	1-3	Leakage	1-3			
1-39 Soil erosion	1-3					
1-40 Phosphorus losses	1-3					
1-41 NH ₃ emissions	1-3					
1-42 N ₂ O emissions	1-3	Air Quality	1-3			
1-43 Pesticides Emission	1-3					
1-44 Accumulation of Pesticide Elements	1-3	Soil Quality	1-3			
1-45 Organic Matter Content	1-3					
1-46 Soil erosion	1-3					
1-47 Soil fertility	1-3	Water Conservation	1-3	Abiotic Resource Conservation	Environmental Dimension	
1-48 Soil water retention	1-3					
1-49 Dependency on Water	1-3					
1-50 Energy consumption	1-3	Energy Conservation	1-3			
1-51 Energy efficiency	1-3					
1-52 Phosphorus Conservation	1-3					
1-53 Energy efficiency	1-3	Fauna Conservation	1-3	Biodiversity Conservation		
1-54 Plant diversity	1-3					
1-55 Insect abundance	1-3					
1-56 Fauna diversity	1-3					
1-57 Soil micro-organisms	1-3					

...according to their strengths and weaknesses

Case study

ACT: Communication & dissemination of results



Conclusion & perspectives

Advantages & Drawbacks of this approach to involve farmers

Advantages

- **Targets an operational scale** for farmers
- **Does not focus solely on environment** (+ social & economical impacts)
- Includes **farmers perception by modifying the** parameter settings

- ❑ **Considers both preferences & issues** farmers deal with

Drawbacks

- **Calculation of basic criteria remains a bit laborious**
- **A lot of basic criteria which means dedicating time to become familiar with the means of evaluation**
- **2 or 3 meeting at least with farmers are necessary to conduct the whole process**

- ❑ **Necessary to remember that assessing sustainability takes time**

Involving farmers in the assessment of sustainability is promising...

- ❑ Useful support for sharing knowledge between researchers, advisors and farmers
- ❑ Farmers expressed their concerns which could guide the action of advisors
(e.g., pesticides toxicity, workload distribution and soil erosion)
- ❑ Farmers proposed some realistic improvements of their CSs



Thank you for your attention

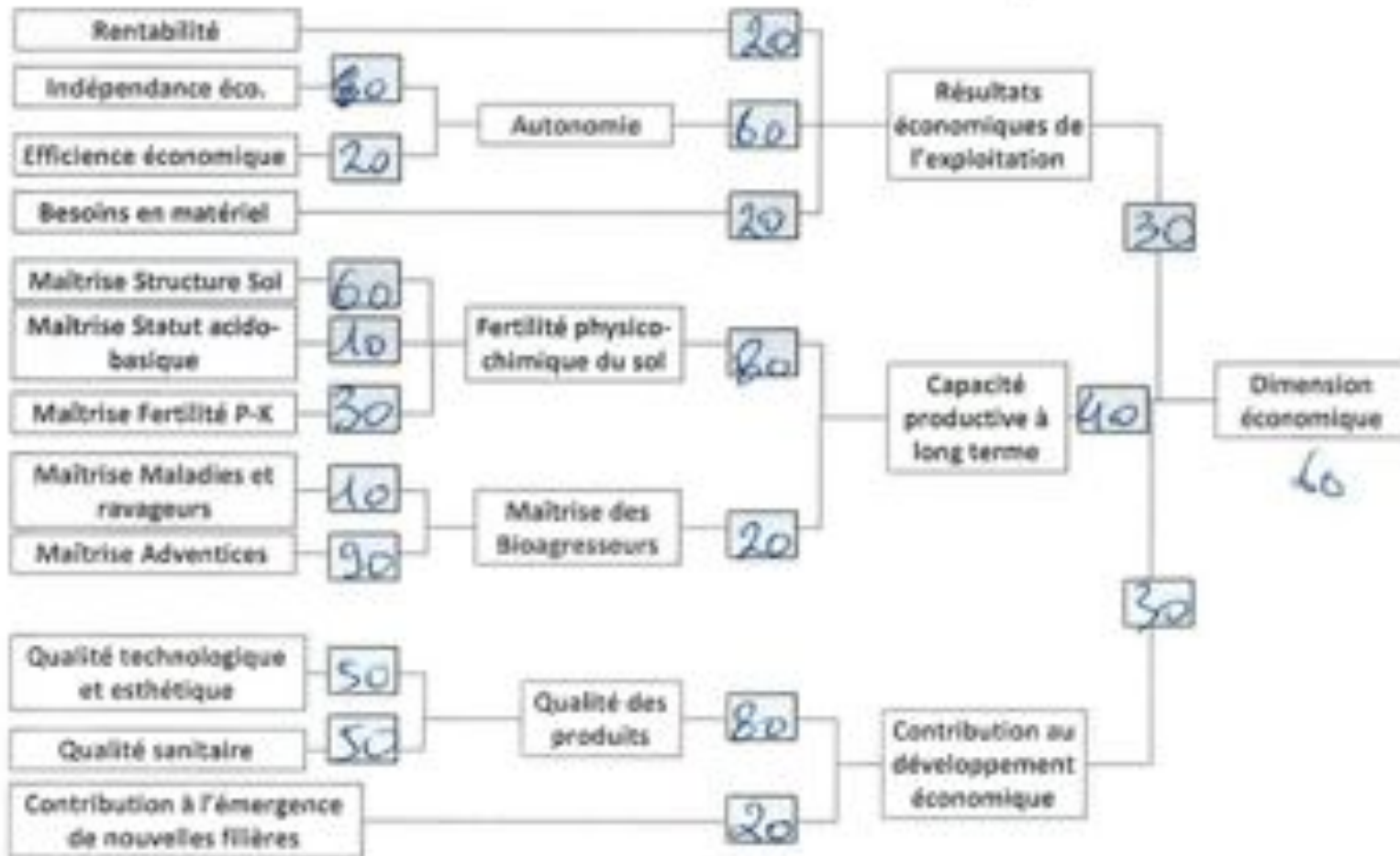
Correspondance: masc@grignon.inra.fr

To download the MASC model

https://www5.versailles-grignon.inra.fr/agronomie/Productions/logiciels_et_modeles/MASC/Modele-MASC

Act : Set priorities to improve CSs

- Modifying weights (collectively or individually)

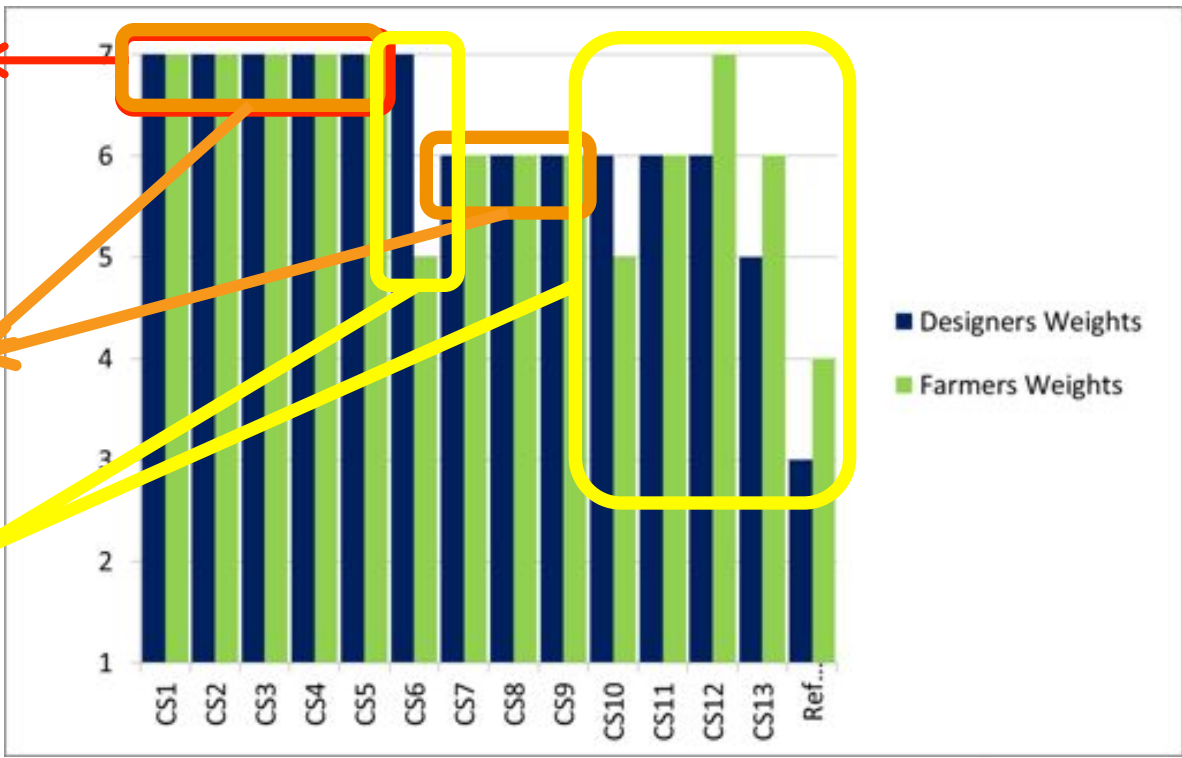


Results

Global analysis of the performances of the CS by simulation of different sets of weights

Collective interpretation of results

Results of the overall sustainability



Characteristic of the best CSs :

- Long/diversified rotations
- Grassland
- Green manure crops

Robustness against weights

Differences explain by weights given to economic and agronomic criteria

Propriété attendue du modèle

- **Flexibility**

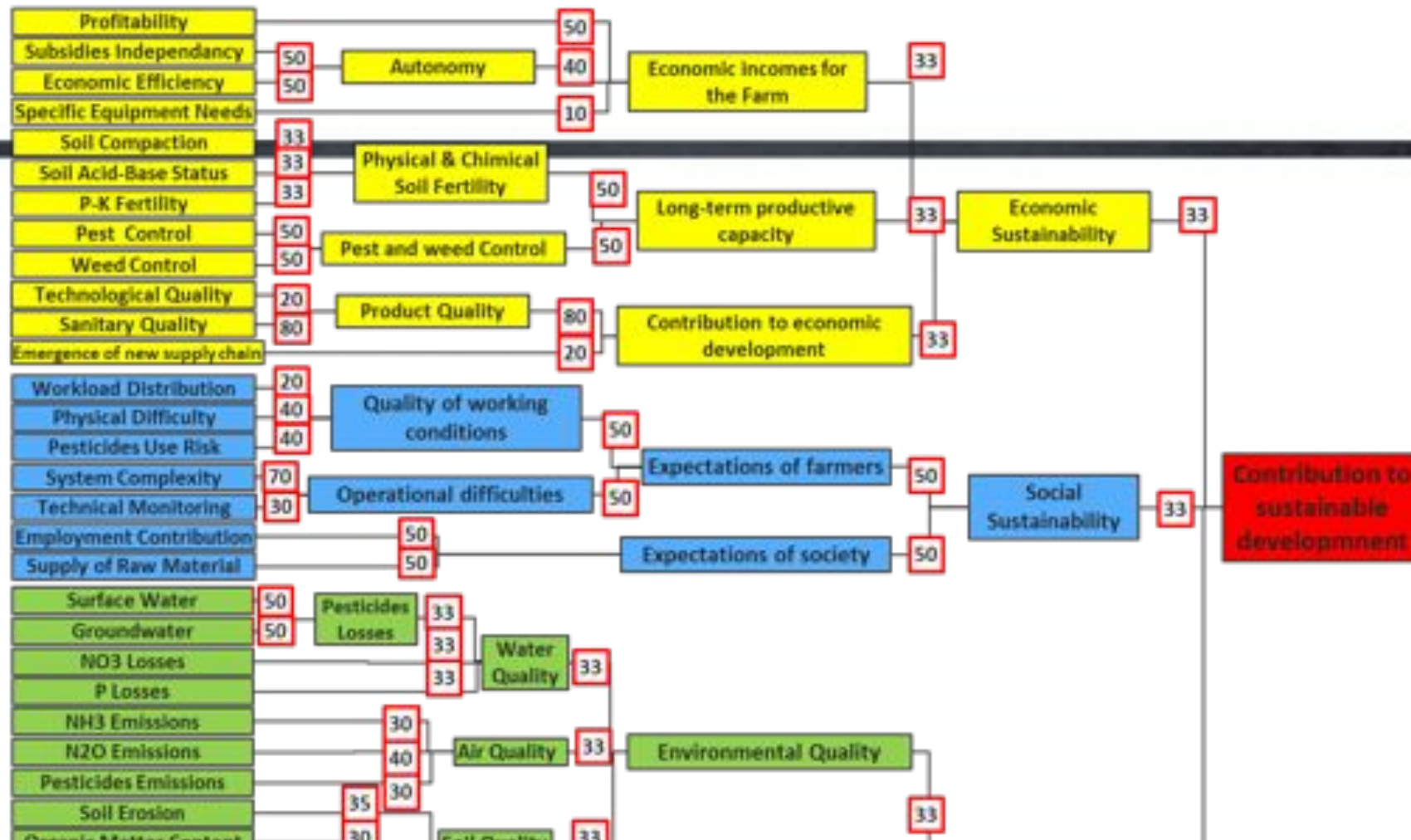
- pour considéré des préférences
- Des différences de contexte pédoclimatique
- Une utilisation en ex post et en ex ante

Transparence

- pour faciliter compréhension et l'interprétation
- Eviter les effet boîte noir qui diminue la confiance des utilisateurs

Viser un échelle et un objectif pratique

- Targets an operational scale for farmers
- Mettre les performances économiques avec les performances sociales.



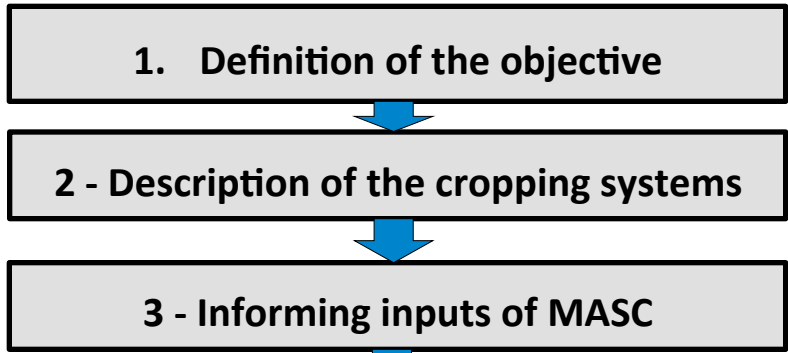
Users can modify weights to introduce:

- Local issues
- Personal perception of sustainability

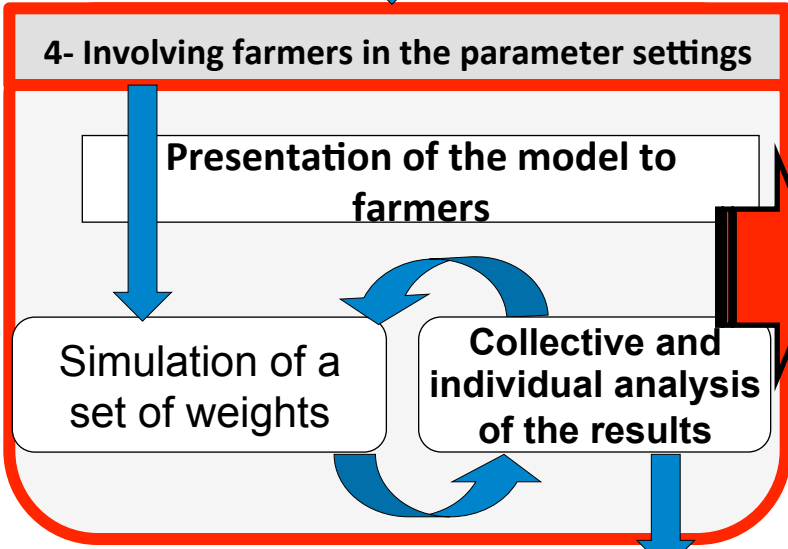
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Results:

A methodological approach in 5 steps



Preparatory work



A half day meeting with farmers

- Discussion about the sustainable dvpt at CS level
- Two sets of weights simulated
 - **Model designers' proposal**
 - **Adapted set of weights defined by farmers**
- Collective analysis of the results

Results

Analysis of the Individual cropping systems under assessment

Strengths & weaknesses were analysed by small groups of farmers (supervised by an organizer)

↑ 4 / 4	Profitability			↑ 4 / 4	Economic incomes for the farm	↑ 2 / 5	Economic Dimension	↑ 5 / 7	Overall sustainability
↑ 4 / 4	Subsidies Independancy	↑ 4 / 4	Autonomy	↑ 4 / 4					
↓ 3 / 4	Economic efficiency								
↑ 3 / 3	Specific Equipment Needs								
↑ 3 / 4	Soil Acid-base Status								
↑ 3 / 4	Soil compaction	↔ 2 / 4	Physical & Chemical Soil Fertility	↔ 2 / 4	long-term productive capacity				
↓ 1 / 4	Phosphorus & Potassium Fertility								
↔ 2 / 4	Pest control								
↑ 3 / 4	Weed control	↔ 2 / 4	Pest and Weed Control						
↓ 1 / 3	Sanitary Quality								
↑ 3 / 3	Technological Quality	↓ 1 / 4	Product Quality	↓ 1 / 4	Contribution to economic development				
↓ 1 / 3	Emergence of new supply chain								
↔ 2 / 4	Employment contribution								
↑ 4 / 4	Supply of Raw material			↔ 3 / 4	Expectations of society				
↑ 4 / 4	System complexity	↑ 4 / 4	Operational difficulties						
↑ 3 / 3	Technical monitoring								
↑ 3 / 3	Workload distribution			↑ 4 / 4	Expectation of farmers				
↑ 3 / 4	Pesticides use risks	↑ 4 / 4	Quality of working conditions						
↑ 3 / 3	Physical Difficulties								
↑ 4 / 4	Surface Water	↑ 4 / 4	Pesticides Losses						
↔ 3 / 4	Ground Water	↔ 3 / 4	Water quality						
↑ 4 / 4	NO ₂ Losses								
↓ 2 / 4	Phosphorus losses								
↔ 3 / 4	NH ₃ Emissions			↑ 4 / 4	Environmental Quality				
↔ 3 / 4	N ₂ O Emissions	↑ 4 / 4	Air Quality						
↑ 4 / 4	Pesticides Emission								
↑ 4 / 4	Accumultaion of Toxical Elements								
↑ 4 / 4	Organic Matter Content	↔ 3 / 4	Soil Quality						
↓ 2 / 4	Soil erosion								
↑ 3 / 4	Dry Period Irrigation Needs	↑ 4 / 4	Water Conservation						
↑ 3 / 4	Dependancy on Water								
↔ 2 / 3	Energy consumption	↑ 3 / 3	Energy Conservation	↑ 4 / 4	Abiotic Ressource Conservation				
↑ 3 / 3	Energy efficiency								
↑ 4 / 4	Phosphorus Conservation								
↔ 3 / 4	Flying insects								
↑ 4 / 4	Soil macrofauna	↑ 4 / 4	Fauna Conservation						
↓ 2 / 4	floristic abundance	↔ 2 / 4	Flora conservation	↔ 3 / 4	biodiversity Conservation				
↓ 2 / 4	Floristic diversity								
↑ 4 / 4	Soil micro-organisms								



Farmers seeking to pinpoint which of their agricultural practices have led to these results.

A case study of farmer involvement thanks to the MASC model

Involving farmers in the assessment of sustainability is promising...

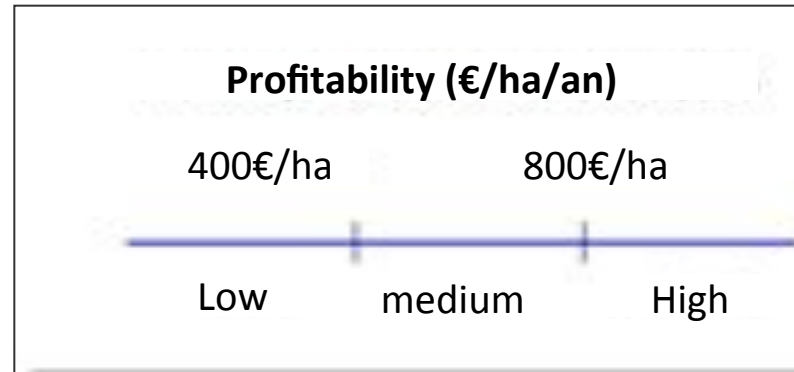
- Sharing knowledge
- Expressing concerns to help draw up advisor guidelines
- Giving rise to realistic improvements of CSs

Title of my intervention
intra
name

Only for calculated Data...

- ❑ Conversion into qualitative data is necessary:
(compatibility with the DEXi Software)

- Using threshold value
Example→



Threshold-values are **proposed** by designers and **could be adapted**:

- ❑ To express **personal preference** on the calculated value
- ❑ To adapt assessment to the **socio-economic and pedo-climatic context**
- ❑ To **discriminate the assessed cropping systems** on their performances