

Multi-Attribute Assessment of the Sustainability of Innovative Banana Cropping Systems in Guadeloupe: Adaptation and Implementation of the MASC Method

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Introduction

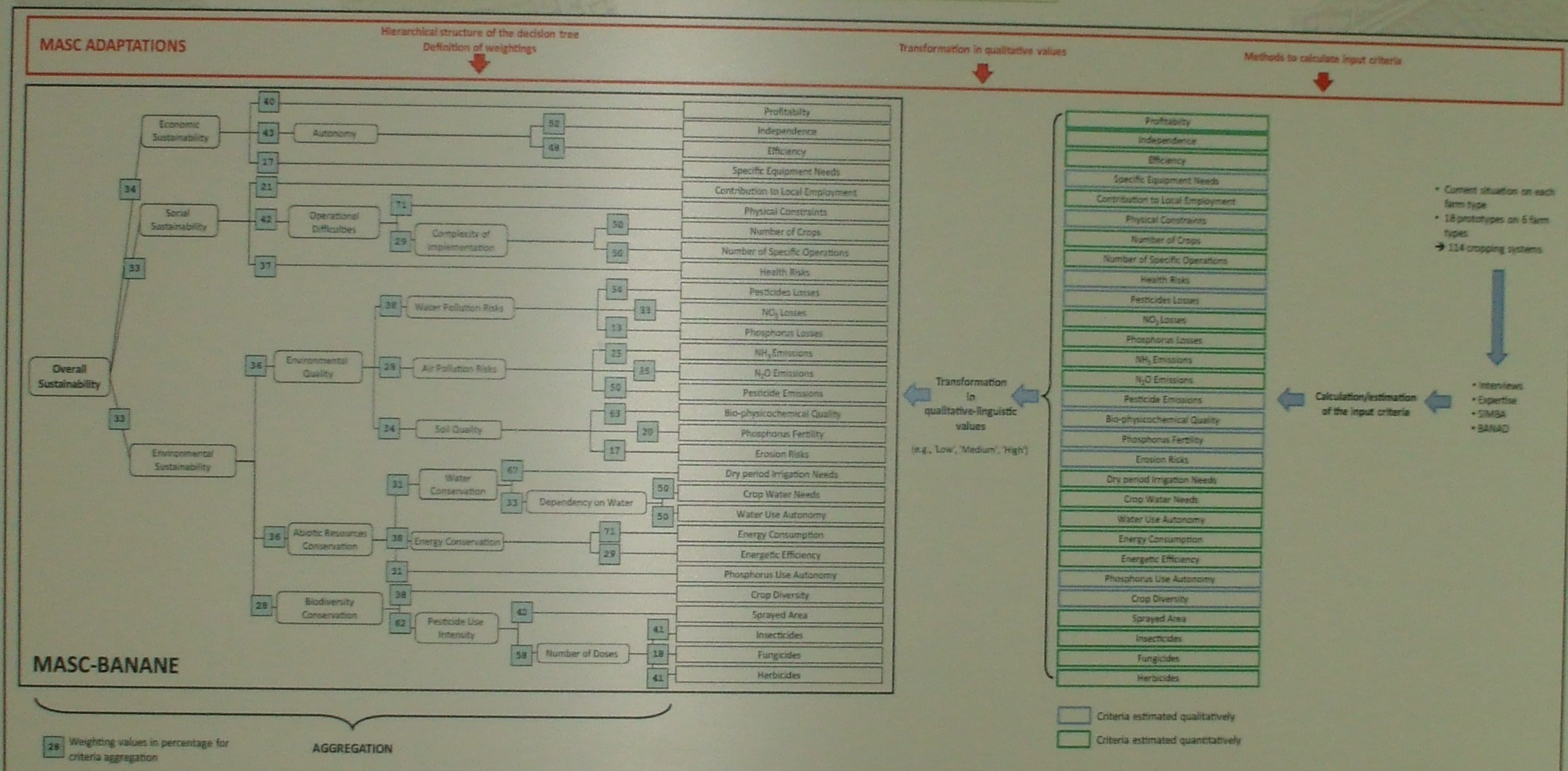
Currently, banana's production in Guadeloupe is cutting through an economic and an environmental crisis. Facing with this crisis, solution possibility lies in proposing sustainable innovative cropping systems. The research unit *AgroSystèmes Tropicaux* of the French National Institute for Agricultural Research has developed a program to design banana innovative cropping systems. A panel of experts designed 18 agro-ecological cropping systems. The *ex ante* assessment is an important step because it allows to quickly identify the best sustainable cropping systems.

Materials and Methods

The MASC (Multi-attribute Assessment of the Sustainability of Cropping systems) method (Sadok *et al.*, 2009) was used to assess the innovative cropping systems. MASC is implemented within a decision support system called DEXi (Bohanec, 2003). MASC has to be adjusted to the context of growing bananas in Guadeloupe. Because benefits of innovations depend on the farming context, innovative cropping systems was assessed through six types of farms. The data needed come from interviews, the mechanistic model BANAD (Blazy *et al.*, 2010) and the crop model SIMBA (Tixier *et al.*, 2008).

Typical innovative system	#	Description
Regulation of pesticide use	1	No use of nematocides
	2	No use of herbicides (manual or mechanical weeding)
	3	No use of nematocides and herbicides (manual or mechanical weeding)
Rotations	4	Rotation with <i>Crotalaria juncea</i> (8 months)
	5	Rotation with fallow chemically controlled (12 months)
	6	Rotation with Pineapple (24 months)
Integrated systems	7	Integrated system 1: rotation with <i>Brachiaria decumbens</i> (12 months) + intercropping with <i>B. decumbens</i>
	8	Integrated system 2: rotation with fallow chemically controlled (12 months) + intercropping with <i>Impatiens sp.</i>
Intercropping	9	Organic system: rotation with <i>C. juncea</i> + intercropping with <i>Canavalia ensiformis</i> + organic manure
	10	Intercropping with <i>C. ensiformis</i>
Conditional application	11	Intercropping with <i>B. decumbens</i>
	12	Intercropping with <i>Impatiens sp.</i>
	13	Treatment nematocides according to a monitoring of nematodes
Resistant cultivars	14	Herbicide based on a threshold of land cover in weeds
	15	Contributions of chemical fertilizers as needed
Resistant cultivars	16	Variety 91X
	17	Variety 91Y
	18	Variety 91Y in organic system rotation with <i>C. juncea</i> + intercropping with <i>Canavalia ensiformis</i> + organic manure

Type of crop/rotation	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Banana field management	Banana field replanted every 5 to 8 years			Perennial banana		
System area (ha)	4.2	8	92	28	6	5
Average altitude (m)	90	12.5	123	258	509	390
Type of soil	Wetland	Ferrallitic	Wetland	Andosol	Andosol	Andosol
Surface mechanized	100%	100%	100%	75%	0%	0%
Average yield (t/ha/yr)	21.4	22.5	45.2	38.5	17.3	18.6
Percentage of family labor	74%	42%	2%	9%	37%	70%
Selling Price banana (€/kg)	0.56	0.54	0.57	0.57	0.45	0.46



Results

Compared to the current situation (No Innovation), the Global Sustainability score is:

- increased by two levels in 3 cases
- increased by one level in 23 cases
- remained the same in 77 cases
- reduced to a level in 5 cases

Overall, innovative cropping systems do not reduce the sustainability of the current situation.

Global Sustainability score achieved, is:

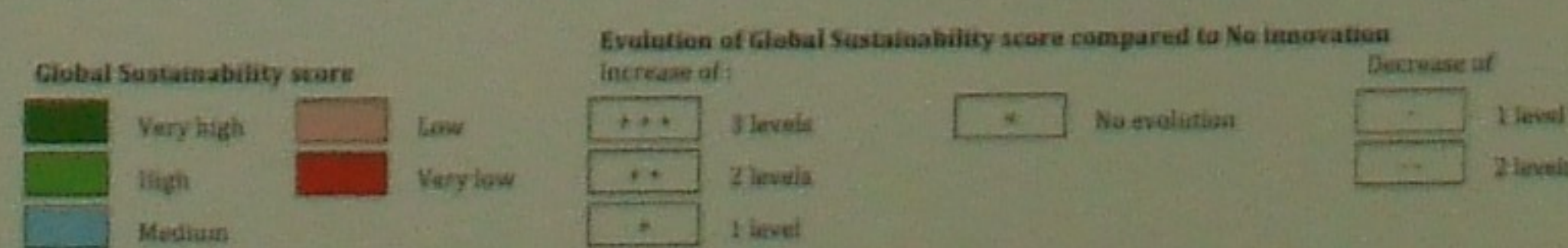
- low in 51 cases
- medium in 54 cases
- high in 3 cases

Innovative systems lead to a low to medium Global Sustainability score.

Identification of relevant systems by type of farm (increasing Global Sustainability score):

- Type 1 → 6 innovative systems
- Type 2, 3 and 6 → 7 innovative systems
- Types 4 and 5 → no innovative systems

	# Innovation	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
No Innovation	0	Low	Low	Low	Medium	Medium	Low
Regulation of pesticide use	No Nematocides	1	=	+	=	=	=
	No Herbicides	2	=	=	=	=	=
	No Nematocides + No Herbicides	3	+	=	+	=	=
Rotations	<i>Crotalaria juncea</i>	4	=	+	=	=	+
	Fallow	5	+	=	=	=	=
	Pineapple	6	=	=	=	=	=
Integrated systems	Integrated system 1	7	+	+	+	=	+
	Integrated system 2	8	+	+	+	=	=
	Organic system	9	++	++	+	=	+
Intercropping	<i>Canavalia ensiformis</i>	10	=	=	=	=	=
	<i>Brachiaria decumbens</i>	11	=	=	+	=	=
Conditional application	<i>Impatiens sp.</i>	12	=	=	=	=	-
	Nematocides	13	=	=	=	=	+
	Herbicides	14	=	=	=	=	=
Resistant cultivars	Fertilizer	15	=	=	=	=	=
	91X	16	=	=	=	=	=
	91Y	17	=	=	+	=	+
	91Y in organic system	18	++	+	+	=	-



Conclusions

Our results show that, for a given innovation, the Global Sustainability score varies widely with different farm types.

We identified 27 pairs 'Farm type*Innovative system' more sustainable.

The more relevant systems are the Integrated System 1 and the Integrated Organic System.

Prospects

Involvement of stakeholders in setting the weights and the structure of the hierarchical tree.

Taking into account other criteria: potential for adoption of cropping systems (motivation and constraints).

Test *in situ* of the relevant systems.

Evaluation of cropping systems at other scales (landscape, watershed).

Blazy, J.M., Tirolien, J., Thomas, A., Guez-Cabanne, H., Salazar, J., Wery, J., 2010. BANAD: a decision model for ex ante assessment of agro-ecological innovations and its application to banana farms in Guadeloupe. *Agricultural Systems*, Volume 103, Issue 4, May 2010, Pages 222-230.

Sadok, W., Anguiano, T., Dreyer, J.E., Beckwith, C., Oubach, B., Oubach, L., Bass, S., Minner, A., Diaz, I., 2009. MASC: a qualitative multi-attribute decision model for ex ante assessment of the sustainability of cropping systems. *Agroecology and Sustainable Development*, Volume 29, Issue 1, Pages 447-462.

Tixier, P., Mollat, E., Dorel, M., Wery, J., 2008. SIMBA, a mechanistic crop growth model for banana-based cropping systems. *Agricultural Systems*, Volume 97, Issue 3, June 2008, Pages 159-170.

