O.52 - A multiple criteria tool for on farm ex ante evaluation of the sustainability of innovative cropping systems with low pesticide use in viticulture

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Abstract

Innovative cropping systems designed by researchers must be evaluated with respect to their environmental impacts and to their economic and social adoptability by farmers. Using a Multiple Criteria Decision Aiding method appears to be relevant as it enables to integrate both quantitative and qualitative information. A hierarchical tree of criteria was designed for the evaluation of grape cropping systems, focusing on practices of crop protection and soil surface management. Indicators were identified to qualify the candidate cropping systems with respect to each criteria. Because of the high diversity of farming systems in viticulture, a special care was devoted to the context of the farm i.e. its economic situation, its natural environment and the farmer's priorities. The process of aggregation was then only partly determined with constant parameters, meaning that the stakeholders for whom the evaluation is performed must define the scale values of some indicators and the priorities among the economic and social criteria. This method of evaluation was tested by a panel of experts before being tested with farmers.

Introduction

Grape producers face an economic and environmental crisis, the latter being in relation with the generally high use of pesticides in vineyards. They are looking for innovations that could improve the global sustainability of their farming systems. To this end, novel cropping systems (e.g. integrated protection) should be evaluated ex ante with respect to both their environmental impacts and their economical and social adoptability by farmers. In Languedoc-Roussillon (south of France), farms producing grape are very diverse in terms of size, soils, availability of staff and equipment, and objectives of production (wine grade). In this context, we hypothesized that the evaluation of a candidate cropping system should be carried out in the farm context, taking into account information in relation with its adoptability. In the present research, we aimed at developing a tool that could be used by extensionists to discuss with farmers about a range of technical options at field scale.

To evaluate and compare cropping systems, Multiple Criteria Decision Aiding (MCDA) methodologies seem to be relevant (Sadok et al., 2008). Because some criteria cannot be quantified, the method must deal with qualitative criteria. A decision support tool called DEXi (Bohanec, 2008) was adopted; it enables to draw decision trees (based on hierarchy of attributes or criteria) and to aggregate the qualitative classes of criteria into a single note, which is in the present case the contribution of the cropping system to sustainable development.

Material and methods

In the present study, only components of cropping systems in relation with pesticide use i.e. crop protection and soil surface management have been considered. To evaluate their impact on environment, some criteria were derived from the list proposed by the ADD-Discotech project (MASC v.1.0) and adapted to viticulture. A consensus on the list of criteria to be retained was reached by four experts in design and evaluation of grape cropping systems. Each criteria took qualitative classes, such as 'low', 'medium' and 'good' for example.

Indicators were defined to provide information about each criterion; some have been chosen qualitative because it was not possible to quantify easily the impact of the cropping system on the concerned phenomena. It was needed to define scales to convert values of indicators into classes of criteria. The criteria were then aggregated by using 'if… then…' decision rules to obtain final classes for the overall criteria.

Three ways to contextualise the evaluation were identified: (i) some qualitative criteria can take values that reflect the opinion of the farmers or other stakeholders, (ii) the scale to convert an indicator value into a class of criteria can be fixed by them and reflect their objectives and constraints, (iii) the aggregation of the criteria can be modified in order to represent their priorities among the attributes.

Results

The impact of cropping systems on environment was evaluated through five attributes (fig 1): the pressure on biodiversity, the energy use and the impacts on the soil, water (both surface and below ground) and air compartments.

The economic adoptability of cropping systems was evaluated through (i) the satisfaction of production objectives on average, and the stability of production over the years, (ii) the cost of labour, inputs (fertilisers and pesticides) and fuel, and the level of investment that must be realised to implement the candidate cropping system. It indirectly reflects the efficiency of production and the productivity of labour.

For the social and human dimensions of sustainability, four attributes were considered: the difficulties to implement the candidate system (i.e. the level of technical competence needed), the task overlap (i.e. competition among tasks due to shortage of working time available), the health risk (i.e. the potential impact of practices on the farmer's or worker's health), the social recognition (i.e. the consideration of the society about the farmer's practices).

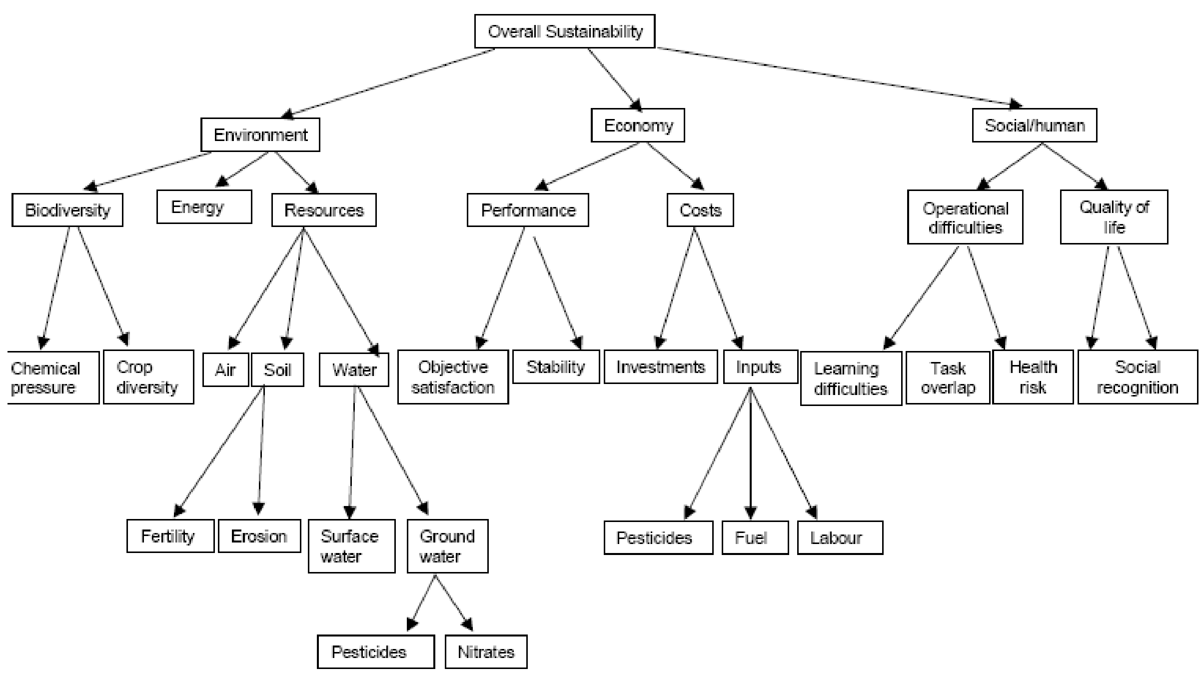

Fig 1: Decomposition of the sustainability of cropping systems into environmental, economical and social/human criteria.

Four of the environmental indicators were derived from calculations of the I-Phy indicators (van der Werf and Zimmer, 1998). The calculation was adapted to obtain four notes to qualify the impacts of the whole cropping system on the four compartments (one note per compartment: Air, Surface Water, Ground Water, Auxiliary insects). The other environmental indicators were in majority qualitative. They took into account the practices that have the highest impact known on the studied phenomena. For example, the indicator for erosion was the kind of soil surface management: if the soil was maintained with herbicides, the risk was high, if it was permanently covered with grass the risk was medium, and if the soil was covered by grass in winter and tillage was performed to destroy it at spring, then the risk was low.

The economical criteria about crop performance were estimated by using the approach developed by Pellegrino et al. (2006) that is based on the Fraction of Transpirable Soil Water (FTSW). There are correlations between the FTSW during some critical development stages of grapevine and its yield and quality of products, and an optimal trail of FTSW during the crop cycle could be defined, depending on the yield objective. The distance to this optimal trail of FTSW was estimated from simulations carried out with a water balance model. A degree of overall compatibility was the indicator of crop performance (between 0 and 1, the value 1 meaning that the cropping system always fitted the optimal trajectory of FTSW). The standard deviation of the degree of overall compatibility reflected the variability over the years.

For social indicators, three of them were qualitative and the classes were directly decided by the farmer. The indicator for health risk was the index of treatment frequency (IFT) calculated only for the toxic, highly toxic and harmful pesticides used.

The aggregation of criteria within DEXi could be done by setting manually all the decision rules, though it was a long task (there is a facilitating option in the software which allows defining the aggregation by attributing a certain weight to each criterion). We proposed that the aggregation of the environmental criteria should be constant for all evaluations, reflecting the fact that the farm context has no influence on performance requirements in terms of environmental impacts. As regards the economic and social/human criteria, the aggregation must be defined by the farmer in order to represent his opinions and priorities. For the same reason, the scale to convert economical indicator values into classes of criterion has to be defined by the farmer.

The indicators have been calculated for a field located in an experiment station (Domaine du Chapitre, close to Montpellier, France) where data were available for two different kinds of crop protection strategies and three different kinds of soil management strategies. It allowed a first evaluation of the method.

Discussion

Among all criteria of sustainability, the social ones were incomplete. Only the criterion of social recognition actually dealt with interactions among humans. The other “social” indicators related more to the adoptability of innovations.

The first test of calculation of the indicators gave relevant information about there suitability. The indicators of economic performance had three main drawbacks: (i) the calculation of crop performance is complex and there is a need to use a validated water balance for the specific fields where the evaluation is performed, (ii) the indicator has no transparency for the farmer, meaning that it is hard to interact with him about the value of the indicator, (iii) the validation of this indicator was not easy, and the correlation between FTSW and yield and quality has not been studied for the objective of high yield.

The calculation of the other indicators was easy if data about practices on the farm were available, i.e. if traceability was correctly managed.

Prospects

The test of the tool is still under process. The choices of contextualisation are currently discussed with experts of both grape cropping systems and multiple criteria evaluation.

The experts concerned with the choice of criteria are now expected to play the role of two farmers with different contexts and objectives. The results of the evaluation will be discussed and the difficulty to implement the tool will be observed. A second phase of test will be carried out with a second version and with the head of the experiment station. The last step will be to implement the method in different farms to get a more precise and statistical evaluation of the method.

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