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Environmental sustainability indicators for cash-crop farms in Quebec, Canada: A participatory approach

Marie-Noëlle Thivierge[a], Diane Parent[a], Valérie Bélanger[a], Denis A. Angers[b], Guy Allard[a], Doris Pellerin[a], Anne Vanasse[a,*]

[a] Faculté des sciences de l'agriculture et de l'alimentation, Université Laval, Québec, QC, Canada G1V 0A6
[b] Soils and Crops Research and Development Centre, Agriculture and Agri-Food Canada, 2560 Hochelaga Boulevard, Québec, QC, Canada G1V 2J3

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ABSTRACT

On-farm environmental assessment, with consideration to the specificity of the farming system and the geographic zone, can enable farmers to include the environmental aspect in their management decisions. In the province of Quebec, Canada, 45% of the cultivated land is dedicated to grain production and among the 13,800 farms that sell grains, 3975 are specialized in this production. Cereal-based systems have their own constraints and realities and could benefit from a specific tool to assess their environmental sustainability. The objective of this research was to adapt and further develop a set of indicators of environmental sustainability at the farm level for cash-crop farms of the province of Quebec, in order to provide a self-assessment and decision-aid tool to farmers. Using a methodology based on focus groups of experts (researchers, stakeholders, and farmers), several indicators developed for dairy farms were adapted to cash-crop farms. Then the set of indicators was tested on cash-crop farms across the province through interviews with 31 farmers. The indicators were weighted according to their contribution to four sub-objectives of environmental sustainability (soil, water, air, and biodiversity conservation). A new type of chart was designed to help farmers understand and interpret the scores obtained from the set of indicators. Finally, a questionnaire was sent to the 31 farmers for end-use validation. A total of 16 indicators emerged from this research. The weighting reveals that, out of a total of 177 points, the indicators that contribute the most to environmental sustainability of cash-crop farms are "integrated pest management" (21 points), "crop diversity" (19 points), "riparian buffer strip" (18 points), and "incorporation of manure into the soil" (16 points). In comparison with a radar chart and a conventional bar chart, a new bar chart revealed to be a better decision aid tool, allowing the majority of farmers to identify the sustainability weaknesses of a fictive farm. However, the graphic design of this chart could be improved for easier understanding. The end-use validation confirmed the interest of farmers in this decision-aid tool.

1. Introduction

Environmental sustainability can be defined as the maintenance of natural capital, which comprises the resources providing sink and source functions in ecosystems (Goodland, 1995; Van Cauwenbergh et al., 2007). Many attempts to address sustainability have been made since the Rio Earth Summit of 1992, through efforts from several countries to establish indicators for measuring progress (Rigby et al., 2001). Indicators are variables that provide information on other variables that are less available (Gras et al., 1989). They simplify the information (Andersen et al., 2013; Girardin et al., 1999; Mitchell et al., 1995; Rigby et al., 2001; Singh et al., 2012) and serve as a benchmark to make a decision (Gras et al., 1989) or to quantify the degree of compliance with environmental objectives (Van der Werf et al., 2007).

In agriculture, on-farm assessment is essential to guide farmers with their management decisions (Häni et al., 2003; Pacini et al., 2003; Van Cauwenbergh et al., 2007). The use of a set of indicators constitutes a holistic approach that takes into account all agricultural practices within the system (Bockstaller et al., 1997).

* Corresponding author. Tel.: +1 418 656 2131x12262; fax: +1 418 656 7856.
E-mail addresses: Marie-Noelle.Thivierge.1@ulaval.ca (M.-N. Thivierge), Diane.Parent@fsaa.ulaval.ca (D. Parent), Valerie.Belanger@fsaa.ulaval.ca (V. Bélanger), Denis.Angers@agr.gc.ca (D.A. Angers), Guy.Allard@fsaa.ulaval.ca (G. Allard), Doris.Pellerin@fsaa.ulaval.ca (D. Pellerin), Anne.Vanasse@fsaa.ulaval.ca (A. Vanasse).

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One of the first sets of indicators at the farm level was the *Farmer sustainability index* of Taylor et al. (1993), with 33 weighted indicators designed for cabbage farmers in Malaysia. Their methodology included a panel of experts as well as interviews with farmers. Bockstaller et al. (1997) and Girardin et al. (2000) went one step further by linking their indicators with sustainability sub-objectives or components. Their AGRO*ECO method for cash-crop farms was validated in France and Germany, and the results were presented to farmers using a radar chart. Since its first edition in 2000, the IDEA method (Vilain et al., 2008) moved the focus to the educational aspect of assessing the sustainability at the farm level. The EVAD method (Rey-Valette et al., 2008), inspired by IDEA's principles, improved and documented the methodology to help farmer groups to construct their own set of indicators using a participatory methodology. The MOTIFS method (Meul et al., 2008) contributed to the user-friendliness of this kind of tool with an improved version of the radar chart. Other indicators and methods for on-farm sustainability assessment were developed within the European Union, as the Common Agricultural Policy (CAP) reform under Agenda 2000 made of sustainable development a priority (Commission of the European Communities, 1999). Recently, in the province of Quebec, Canada, Bélanger et al. (2012) developed agri-environmental indicators to specifically assess the sustainability of dairy farms.

Indicators at the local production level have to reflect site-specific characteristics (Sattler et al., 2010), including the climatic and natural conditions of the site (Commission of the European Communities, 1999), and the particularities of the farming system under study (Meul et al., 2008). The climatic and natural conditions prevailing in Quebec differ from those of Europe, mostly regarding the length of the growing season, the water regime, and the nature of arable soil. As those factors have a strong influence on crop production, it appears relevant to offer farmers a tool adapted to their specific conditions. Moreover, in Quebec, grain production has increased by 25% between 1998 and 2007 (BPR, 2008), and 47% of the cultivated land is now dedicated to this production (ISQ and MAPAQ, 2013). Cash crops in Quebec mostly include grain maize (corn), wheat, oats, barley, canola (colza), and soybeans. Among the 13,800 farms that sold grains in 2010, there were 3975 for which it accounted for more than half of the farm income (ISQ and MAPAQ, 2013; Statistics Canada, 2012). Therefore, this specific farming system deserves some attention.

The objective of this research was to adapt and further develop a set of farm-level indicators of environmental sustainability for Quebec cash-crop farms, in order to provide a self-assessment and decision-aid tool to farmers. Complementary objectives were to improve the methodology to allocate weights to such indicators, and to design a new type of chart leading to a better interpretation of the scores resulting from the sustainability assessment.

2. Methodology

The conceptual framework of the methodology is illustrated in Fig. 1 and will be detailed in Sections 2.1–2.5.

The steps in the construction of indicators are interactive: the results from one step could lead to some modifications in previous ones (Rey-Valette et al., 2008). Those feedbacks are illustrated by the arrows in Fig. 1. Furthermore, this methodology can be described as adaptive and iterative (Meul et al., 2009; Rey-Valette et al., 2008).

2.1. Adaptation of indicators from dairy farms to cash-crop farms

The original set of indicators from Bélanger et al. (2012) had been developed using the Delphi method (Delbecq et al., 1975) to inquire 25 experts through anonymous individual questionnaires,

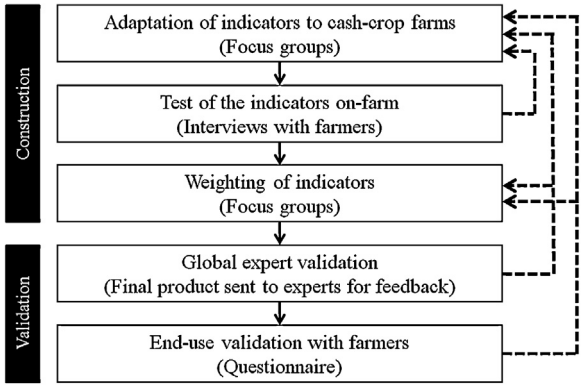

Fig. 1. Conceptual framework of the methodology developed to adapt a set of indicators of environmental sustainability to cash-crop farms of the province of Quebec. The arrows illustrate the many feedbacks, making it an adaptive and iterative process.

for several rounds of questions. Thereafter, 12 experts (researchers, stakeholders, and farmers) were gathered to discuss the results in a panel, also referred to as a *focus group*. See Bélanger et al. (2012) for the detailed methodology regarding the Delphi method and the focus group. This participatory approach is named co-construction of indicators (Rey-Valette et al., 2008) or bottom-up approach (Fraser et al., 2006; King et al., 2000; Singh et al., 2012). According to Rey-Valette et al. (2008), it is important to bring together different stakeholders, including farmers, in the process of indicator construction. The inputs of farmers, often neglected in such processes, increase the likelihood of the indicators being accepted by the users (Dalal et al., 1999; Fraser et al., 2006; King et al., 2000).

Thus, to adapt the dairy farm indicators from Bélanger et al. (2012) to the reality and constraints of cash-crop farms, the same type of methodology based on the consultation with experts was chosen, though with a smaller panel of eight experts (researchers, stakeholders, and farmers). The evaluation criteria described by Bélanger et al. (2012) were being sought during the adaptation process and must be seen as guidelines. Thereby, selected indicators should aim at being: (1) easy to implement, (2) immediately understandable, (3) reproducible, (4) sensitive to variations, (5) adapted to the objectives, and (6) relevant for users (see Bélanger et al., 2012, for a detailed description of these evaluation criteria). The discussions among experts were recorded for future references.

2.2. Testing of the indicators on cash-crop farms

After a first focus group with the panel of experts, the selected indicators were tested on 31 cash-crop farms across eight areas of the province of Quebec (Table 1). A cash-crop farm can be defined as a farm where cash crops production accounts for 50% or more of its income (Statistics Canada, 2012). The objectives of these tests were to validate the calculations for each indicator, verify if the indicators fulfilled some of the criteria (criteria 1, 3, and 4 of Section 2.1), establish their suitability for all cropping systems, and determine whether the questions were understandable to all farmers. The farms were recruited with the help from several Agri-Environmental Advisory Clubs across the province.

For each farm, a one-to-one interview with the farmer was conducted. During this 2-h interview, a questionnaire was filled with the farmer. The agri-environmental fertilization plan of the farm (AOR, 2002) was also used as a data source. To be easy to implement, on-farm indicators must take advantage of the information already available that is credible (Bockstaller et al., 1997; Halberg, 1999; Meul et al., 2009; Mitchell et al., 1995; Rigby et al., 2001). Feedbacks from farmers were collected to improve the indicators.