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Developing and quantifying indicators of organic farming using analytic hierarchy process

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ABSTRACT

Although regulations and criteria relating to organic farming are clearly defined by the relevant agencies, especially by IFOAM, some have been overshadowed by attention to others and have lost their significance over time. The aim of this study was to develop and quantify organic farming indicators to determine the relative importance of each. The desired indicators were collected during a literature review of scientific resources about the principles of organic farming. These indices were classified into four categories and their weights were determined through interviews with experts on organic agriculture, including university professors, agroecology students, Ministry of Agriculture experts, organic farming inspectors and organic farmers. The analytic hierarchy process (AHP) was used for this purpose. The results showed that pest and disease management, yield, soil nutrient management, water consumption rate, chemical fertilizer consumption rate and the use of transgenic materials having weights of 0.16, 0.098, 0.096, 0.08, 0.071 and 0.059, respectively, and are the most important indicators for development and assessment of organic farming. In this as well as similar studies, the weight of indicators associated with consumption of chemical fertilizers and pesticides were relatively high. This indicates the importance of rules related to the use of chemicals in organic farming; however, each index has a certain weight and none can be overlooked. All indicators should be considered as an inseparable set and all should be used in the development of organic farming. The results of this study can be useful for both inspection bodies and organic farmers. Farmers can reduce the risks associated with transitioning to organic farming and minimize the probability of failure by monitoring these indicators in their fields.

1. Introduction

Achieving the development goals of organic farming requires dedicated compliance with the diversified principles of organic farming. These principles and regulations are classified into different social, economic, ecological and agricultural categories. The International Federation of Organic Agriculture Movements (IFOAM) defines the four principles of organic agriculture as health, ecology, fairness and care. These principles should be integrated and considered as a whole when applied to the development of organic farming (Luttikholt, 2007).

The principle of health emphasizes that organic agriculture should sustain and enhance the health of the soil, plants, animals, humans and the planet as one and indivisibly. Based on the principle of ecology, organic agriculture should focus on ecological systems and cycles and work with them, emulate them and help sustain them. The principle of fairness states that organic agriculture should build on relationships that ensure fairness toward the common environment and life opportunities. Under the principle of care, organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Each principle has a specific definition and specified subsets; ignoring any of these subsets and elements could jeopardize the objectives of organic farming (Lockeretz, 2007). Several sets of indicators have been proposed to interested users to achieve organic farming standards. Despite the differences that exist between these sets, all have the same goal–to achieve the principles of organic farming.

After a few decades of experience in monitoring and inspection of agroecosystems and certification of organic agroecosystems, the system continues to have weaknesses that should be taken into consideration. A small set of criteria for certification of organic agroecosystems must

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Table 1
AHP applications in agriculture (Bhatta and Doppler, 2010; Houshyar et al., 2014; Karami, 2006; Lu and Zhao, 2007; Mohammadian et al., 2010; Montazar and Behbahani, 2007; Okada et al., 2008; Setiawan et al., 2014; Srdevic et al., 2011; Toledo et al., 2011; Veisi et al., 2016).

Research field \ Researcher	Mohammadian et al. (2010)	Bhatta and Doppler (2010)	Srdevic et al. (2011)	Karami (2006)	Montazar and Behbahani (2007)	Okada et al. (2008)	Toledo et al. (2011)	Setiawan et al. (2014)	Veisi et al. (2016)	Lu and Zhao (2007)	Houshyar et al. (2014)
Assessment of agricultural sustainability										■	
Evaluation of risk factors							■				
Irrigation project improvement						■					
Determining priorities of conversion of unused land to food land								■			
Developing an ethics-based approach to indicators of sustainable agriculture									■		
Development of an optimized irrigation system selection model					■						
Appropriateness of farmer adoption of irrigation methods				■							
Decision-making in ranking loan applicants for purchasing irrigation equipment			■								
Farming differentiation in rural-urban interface		■									
Choosing a potential crop pattern	■										
Sustainability analysis of silage corn production											■

be monitored and approved. In recent years, the importance of some indicators has increased significantly, while those of others have decreased or disappeared. The present study determined and weighted a comprehensive set of indicators to be applied to the organic agriculture monitoring and certification system. Also, farmers can use these indicators to monitor their farms. The use of such self-monitoring systems can reduce the risks of transitioning to organic agriculture and minimize the risk of failure in this regard.

The tool used to quantify and weight the indicators was the analytic hierarchy process (AHP). It was developed by Saaty (1980) and has been widely applied in application domains, including to determine research priorities (Braunschweig, 2000), credit evaluation (Xu and Zhang, 2009), assessment of environmental sustainability (Kara and Köne, 2012), decision support for spatially targeted policies (Gerber et al., 2008), product project screening (Chin et al., 2008), selecting a biological indicator for a river flow restoration (Huang et al., 2013), Water quality assessment (Carbajal-Hernández et al., 2013), ranking the indicators of building performance and the users' risk (Khalil et al., 2016), systemic comparative assessments (Parra-López et al., 2008) and strategic decision-making (Bhushan and Rai, 2007). Table 1 shows the application of AHP to agriculture.

2. Methodology

2.1. Choosing a target population and explaining organic farming

Given that decisions about organic farming require expertise in the field, the target population in this study cannot be selected randomly from the entire community. Purposive sampling must be used in such studies. Expert sampling is a type of purposive sampling used when the research must glean knowledge from individuals with a particular expertise (Trotter, 2012). This expertise may be required during the exploratory phase of qualitative research to highlight potential new areas of interest or open doors to other participants. A survey of experts is required at two important stages: (1) to determine a comprehensive set of indicators and; (2) to weight them.

The first step of the present study was determination of a comprehensive set of organic farming indicators. The respondents were 50 individuals active in scientific fields related to organic farming (university professors, agroecology students and Ministry of Agriculture experts). In the second step, for pairwise comparison and weighting of indicators, 60 participants were selected from university experts, organic farming inspectors, Ministry of Agriculture experts and organic farmers. Selection of respondents was based on a combination of their expertise and experience relating to organic agriculture. The scoring method of indicators was clearly explained for all respondents to prevent errors caused by lack of understanding of the AHP. All pairwise comparison matrices were completed through face-to-face interviews and the data was prepared for analysis.

2.2. Meta-analysis and collecting indicators

A comprehensive set of organic farming indicators was first collected during a literature review. The indices of the ecosystem services and agroecosystem health models were used to ensure the comprehensiveness of the indicators. According to the ecosystem services