African Journal of Agricultural Research Vol. 5(23), pp. 3185-3190, 4 December, 2010
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR10.301
ISSN 1991-637X ©2010 Academic Journals

Full Length Research Paper

The partnership models of agricultural sustainable development based on Multiple Criteria Decision Making (MCDM) in Iran

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Accepted 28 July, 2010

Sustainable development and the definition of indicators to assess progress towards sustainability have become a high priority in scientific research. The purpose of this study was two-fold: first, to determine agricultural sustainability criteria; second, to determine optimum partnership models for agricultural sustainability. This study was conducted in Ilam Province of Iran. The populations of the research were 30 farmers, who were interviewed to determine the sustainable agricultural development criteria. A discussion of the nine criteria was developed. Through an interview we were able to determine how they perceived the relative importance of these criteria. A questionnaire was developed based on analytical hierarchy process (AHP). Each question consisted of a pair-wise comparison of two criteria. Therefore, the nine criteria and four alternatives resulted in a total of 72 questions. First the respondents were asked to indicate the relative importance of the two criteria with respect to the overall goal. Finally, the farmers were asked to indicate the relative importance of the two alternatives (partnership models) with respect to each criterion. The results indicated that reducing farmers migration, sharing with agricultural engineer, land consolidation, increasing farmers awareness, crop rotation, using less amount of chemical fertilizer, using less amount of chemical pesticide, fertilizer recommendation and allocation efficiency are the most important criteria for sustainable agriculture in Iran. A sensitivity analysis was carried out to determine the critical factors that affected the priority of alternatives. Also, results of application of AHP indicated that private and cooperative partnership models are the most useful partnership models in the agricultural sustainability. The results of this study demonstrated that the private partnership model for agricultural sustainability is imperative.

Key words: AHP, partnership, Iran, sustainable agricultural development.

INTRODUCTION

In recent years, sustainable development has become an important issue round globe (Tsai and Chou, 2009). Sustainable development and the definition of indicators to assess progress towards sustainability have become a high priority in scientific research and on policy agenda (Cauwenbegh et al., 2007).

According to the Brundtland Committee's report ''Our Common Future" sustainability is defined as the ability to ''meet the needs of the present without compromising the ability of future generations to meet their own needs" (Tsai and Chou, 2009).

Humans are quick and careless in destroying and polluting water, soil, forests, jungles and other manifestations of nature. Environmental destruction may slow economic growth in addition to threatening the health and well-being of the local population (Denier and Takahashi, 1999). Sustainability as a concept has emerged to address environmental challenges that are facing development planners (Rezaeimoghaddam and Karami, 2008).

Since the 1980s, new concepts and social demands have begun to emerge in relation to agricultural

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production. Sustainable agriculture, environmental friendly agricultural practices and responsible management of natural resources are ideas that refer to ecological, technological and socioeconomic dimensions of the broader concept of sustainable development (Harwood, 1990). These concepts point out the multifunctional nature of agriculture. This multifunctional role was not explicitly recognized by the European Union (EU) until in the 1992 Common Agricultural Policy (CAP) Reform, which was consolidated in the "2000 Agenda" and the Mid-Term 2003 Reform. At this time, new functions were attributed to agriculture in addition to the traditional productive role. These new functions were related to the conservation of the environment, the creation of employment, and the preservation of rural life. This function is named sustainable agriculture that is desirable because it is supposed to better satisfy the social demand for multiple functions of agriculture. In the case of wheat production, lack of dependable studies is even more apparent. One of the agricultural sustainability is defined as successful management of the resources of agriculture to satisfy changing human needs, to conserve the environment, and increase biological resources (Chikwendu and Arokoyo, 1997). Agricultural sustainability simply means the ability of agriculture to sustain. Various terms have been attributed to sustainable agriculture, e.g., organic, regenerative, ecological, alternative, bio-dynamic, natural and low-input, contrasting high input, maximum-production, and intensive agriculture (Rahman et al., 1999). Agricultural sustainability is a philosophy based on human goals and an understanding of the long-term impact of our activities on the environment and on other species (Rezaeimoghaddam and Karami, 2008). The three main goals of agricultural sustainability are economic efficiency, environmental quality, and social responsibility (Fairweather and Campbell, 2003). The goal of sustainability is to sustain a desirable quality of life. To sustain the sacredness in farming, there must be harmony found economically, socially, and ecologically among the personal, interpersonal, and the spiritual. The current crisis in conventional, commercial agriculture arises from its lack of sustainability. Much of the research effort in (adoption of) sustainable agriculture has been fragmented, with little coordination and integration. Little substantive research has investigated the beliefs and motivations that drive farmers' decisions about adoption of sustainable agricultural practices (Karami and Mansoorabadi, 2008).

At the Rio Summit in 1992, the United Nations further expanded the above definition and adopted a set of principles to guide future sustainable development. The Declaration on Environment and Development defines the rights of people toward development, and their responsibilities to safeguard the common environment (Quaddus and Siddique, 2001). From then on, environmental and sustainable development issues have been pushed to a higher priority on social agenda. In taking a note from the ''3 Ps" of Marketing, sustainable development can be said to have its own version of the ''3Ps", that is People, Planet, and Profit. All three aspects have to be satisfied before an entrepreneurial activity is labeled as sustainable (Crals and Vereeck, 2005).

Agricultural development has been based on modernization theory in the late decades especially in third world. The beginning of modernization of Iranian agriculture was most marked by the land reform of 1962. The land reform was perceived as prerequisite to any effort to modernize the traditional, prominently rural society of Iran. However, analysis of development policies shows that this theory has produced negative impacts such as uneven development, poverty and environmental degradation (Malakouti, 2000). The concern for environmental problem was the major contributing factor to loss of faith in this path to development. The conventional development strategies are fundamentally limited in their ability to promote sustainable agricultural development of Iran (Rezaeimoghaddam and Karami, 2008).

For agriculture to be considered sustainable, certain economic, environmental and social criteria need to be met. Moreover, a sound decision making tool is essential if we are to decide on the most appropriate partnership models in order to reach agricultural sustainability.

The purpose of this paper is to introduce a multi criteria decision making model(MCDM) and use analytic hierarchy process (AHP) for selecting the most appropriate partnership models (including private, rental, sharing and cooperative) from a number of alternatives for an individual farmer. The objectives of the study are

1) Determination of agricultural sustainability criteria.
2) Determination of optimum partnership models for agriculture.

MATERIALS AND METHODS

This study was conducted in Ilam Province of Iran. The populations of the research were 30 farmers interviewed to determine the sustainable agricultural development criteria. A discussion of the nine criteria developed in this stage is presented in the next section. A questionnaire was developed based on the AHP. Each question consisted of a pair-wise comparison of two criteria. Therefore, the nine criteria and four alternatives result in a total of 72 questions. First, the respondents were asked to indicate the relative importance of the two criteria with respect to the overall goal. Finally, the farmers were asked to indicate the relative importance of the two alternatives (partnership models) with respect to each criterion.

All criteria and alternatives were qualitative measures in this study. The scale used for comparison of two qualitative measures was a bipolar scale (Table 1). There were two types of Pair-wise comparisons; first, a comparison of criteria with respect to goal; and second, some pair-wise comparisons of alternatives with respect to criterion. These comparisons were shown in matrix structure named

Table 1. Measurement scale of AHP.

Intensity of relative importance definition
1 = Equal importance
3 = Moderate importance
5 = Strong importance
7 = Very strong importance
9 = Absolute importance
2, 4, 6 and 8 = Intermediate values between
Two adjacent judgments

Source: Satty (1997).

decision matrix. Therefore, the result decision matrixes included a decision matrix for criteria comparisons and some decisions matrices for alternatives comparisons.

The Consistency Ratio (CR) is measured for each decision matrix. CR shows the precision of judgments in comparing criteria and alternatives. In other words, the Inconsistency Ratio (IR) shows the possible error (s) in judgments. Inconsistency ratio for each matrix should be less than 0.1, otherwise the decision maker(s) should re-evaluate the judgments for the related matrix until the ratio is finally less than 0.1.

The analytic hierarchy was programmed in Expert Choice. We first calculated the geometric means of the marked responses in each question from each of the participants. Then, the comparison matrix was inputted into Expert Choice to produce local weights at each level of the hierarchy. These were then combined using an additive value model to produce a set of global weight or priorities for the alternatives. Finally, a sensitivity analysis was performed to determine the critical evaluation criteria that affect the selection strategy.

DISCUSSION

Belton and Stewart (2002) define multi criteria decision analysis (MCDA) as, ‘‘an umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or group explore decisions that matter”. MCDA approaches have been classified in a number of ways. One of the first categorizations makes a distinction between multi-objective decision making (MODM) and multi- attribute decision making (MADM). The main distinction between the two groups of methods is based on the number of alternatives under evaluation. MADM methods are designed for selecting discrete alternatives while MODM is more adequate to deal with multi-objective planning problems, when a theoretically infinite number of continuous alternatives are defined by a set of constraints on a vector of decision variables (Belton and Stewart, 2002).

The AHP, developed by Saaty (1977), is a decision making method for prioritizing alternatives when multiple criteria must be considered. This approach allows the decision maker to structure problems in the form of a hierarchy or a set of integrated levels, such as, the goal, the criteria, and the alternatives. The primary advantage of the AHP is its use of pair-wise comparisons to obtain a ratio scale of measurement. Ratio scales are a natural means of comparison among alternatives and enable the measurement of both tangible and intangible factors. An AHP analysis uses pair wise comparisons to measure the impact of items on one level of the hierarchy on the next higher level. For example, the criteria are pair wise compared in terms of their ability to achieve the goal, and the alternatives are pair-wise compared in terms of their ability to achieve each of the criteria. At each level, the pair-wise comparisons are organized into a matrix and the weights of the items being compared are determined by computing the maximum weight value of the matrix.

A weighted averaging approach is used to combine the results across levels of the hierarchy to compute a final weight for each alternative. In cases where many alternatives need to be evaluated, the AHP ratings approach is often used. This approach requires that a series of ratings or intensities be developed for each criterion (Table 1). These intensities must be pair-wise compared to each criterion, and then alternatives are evaluated by selecting the appropriate intensity for each criterion. Another important advantage of the AHP is that it allows for inconsistency in judgment. However, the AHP also measures the degree to which the judgments are inconsistent and establishes an acceptable tolerance level for the degree of inconsistency. Other advantages and disadvantages of the AHP have been extensively described and debated elsewhere (Harker and Vargas, 1990; Saaty, 1990).

The AHP process was developed to solve a specific class of problem that involves the prioritization of potential alternative solutions. The AHP is based on three major components (Karami, 2006).

Stage one: Selection of criteria

At this stage of building, the model faced the crucial question of who should determine the criteria of agricultural sustainability. Sustainable criteria were determined from literature review and library research.

In all, 30 farmers were interviewed. Furthermore, existing literature was considered an important source for mining the criteria of sustainable agriculture. End results of this stage were selection of nine criteria for agricultural sustainability development.

Stage two: Pair wise comparison of criteria

At this stage the participants were involved in pair-wise comparison of the nine criteria. Many methods can be used to accommodate the views and judgments of participants in the priority setting process. In a common objective context where all participants share the same objectives, there are four ways to set the priorities: consensus, vote or compromise, geometric mean of the individuals’ judgments, and separate models or players (Lai et al., 2002). Consensus refers to the achievement of a consensus of group participants in constructing a hierarchy and making judgments. If a consensus cannot be reached, the group may then choose to vote or compromise on a judgment. If a consensus cannot be achieved and the group is unwilling to vote or to compromise, then a geometric mean (average) of the individuals’ judgments can be calculated. The geometric mean is an appropriate rule for combining individual judgments to obtain the group judgment for each pair-wise comparison. In this study we first calculated the geometric means of the marked responses in each question from each of the respondents. Then, the comparison matrix was inputted into Expert Choice to produce local weights at each level of the hierarchy.

Stage three: Pair-wise comparison of alternatives with regard to criteria

At this stage, pair-wise comparisons on the alternative partnership models with respect to the nine criteria were performed. Consensus method was used to set the priorities at this stage of the research.

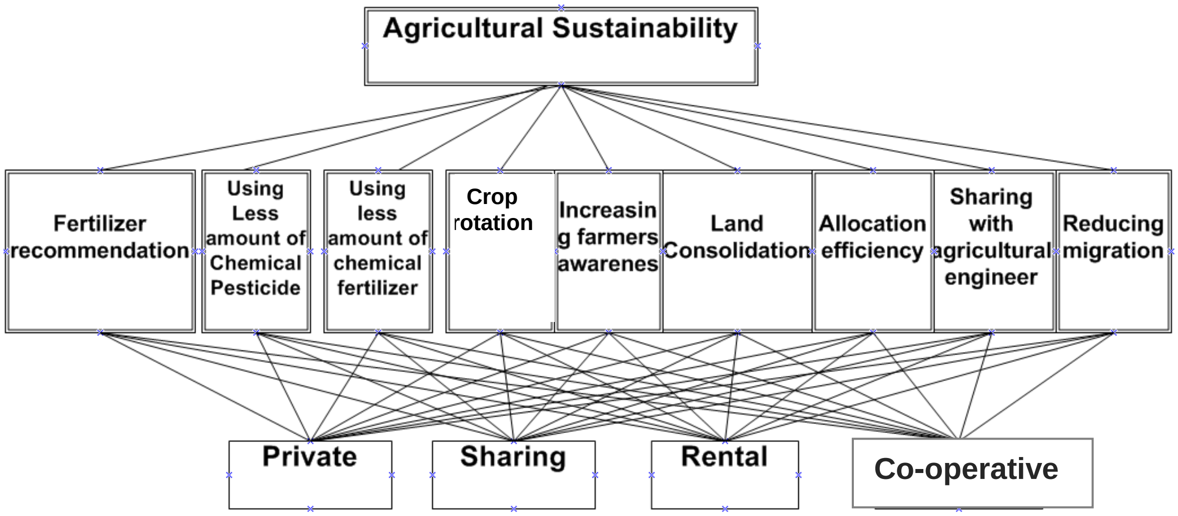

Figure 1. Hierarchical model for selection of agricultural sustainability.

Table 2. The priority of partnership models.

Criteria	priority of partnership models 1	2	3	4	IR
Reducing farmers migration	P	C	S	R	/09
Sharing with agricultural engineer	C	P	R	S	/07
Land consolidation	C	P	R	S	/06
Increasing farmers awareness	C	P	R	S	/07
Crop rotation	P	C	S	R	/07
Using less amount of chemical fertilizer	P	C	S	R	/05
Using less amount of chemical pesticide	P	C	S	R	/02
Fertilizer recommendation	P	C	S	R	/07
Allocation efficiency	R	S	C	P	/06

P: Private, R: rental; S: sharing; C: cooperative and IR: inconsistency.

Figure 1 shows the relation between ultimate goal, criteria and alternatives in a hierarchy framework.

The AHP can be used by a team to enhance the quality of group decisions by bringing structure to the decision making process and by synthesizing different points of view (Lai et al., 2002). The application of the AHP to support group decisions has proven to be contributive in several research studies (Byun, 2001; Chen and Huang, 2004; Solnes, 2003). Lai et al. (2002) report the results of a case study where the AHP was employed to support the selection of MAS in a group decision environment. Byun (2001) has applied the AHP for deciding on car purchase between 13 managers as a group of decision makers. The AHP has been used between seven experts to evaluate the risks and benefits associated with three alternative mission architecture scenarios for the human exploration of Mars (Tavana, 2004). Their findings have validated the AHP as an effective and flexible tool for group decision making because it can form a systematic framework for conducting structured group sessions.

RESULTS

Determination of sustainable criteria by literature review showed nine criteria including:

a) Reducing farmers migration
b) Sharing with agricultural engineer
c) Land consolidation
d) Increasing farmers awareness
e) Crop rotation
f) Using less amount of chemical fertilizer
g) Using less amount of chemical pesticide
h) Fertilizer recommendation and
i) Allocation efficiency

are very important, although most studies view the context of sustainability in terms of "socio-cultural", "economic-technical" and "environmental" aspects.

The results of partnership models prioritizations are presented considering the criteria. Table2 shows these results.

Figure 2 shows the results of sensitivity analysis for partnership models. Sensitivity analysis allows us to verify the results of the decision. A sensitivity analysis was formed to see how sensitive the alternatives are to change with the importance of the criteria. The Expert Choice implementation of AHP provides four graphical sensitivity analysis modes: dynamic, gradient, performance and two- dimensional analysis (Expert Choice, 2000). Here performance sensitivity analysis is employed. It depicts how well each alternative (Private, rental, sharing and cooperative models) performs on each criterion by increasing or decreasing the importance of the criteria.

Conclusion

Agriculture is unique and most essential activity in every society. Beyond its primary role of producing food and

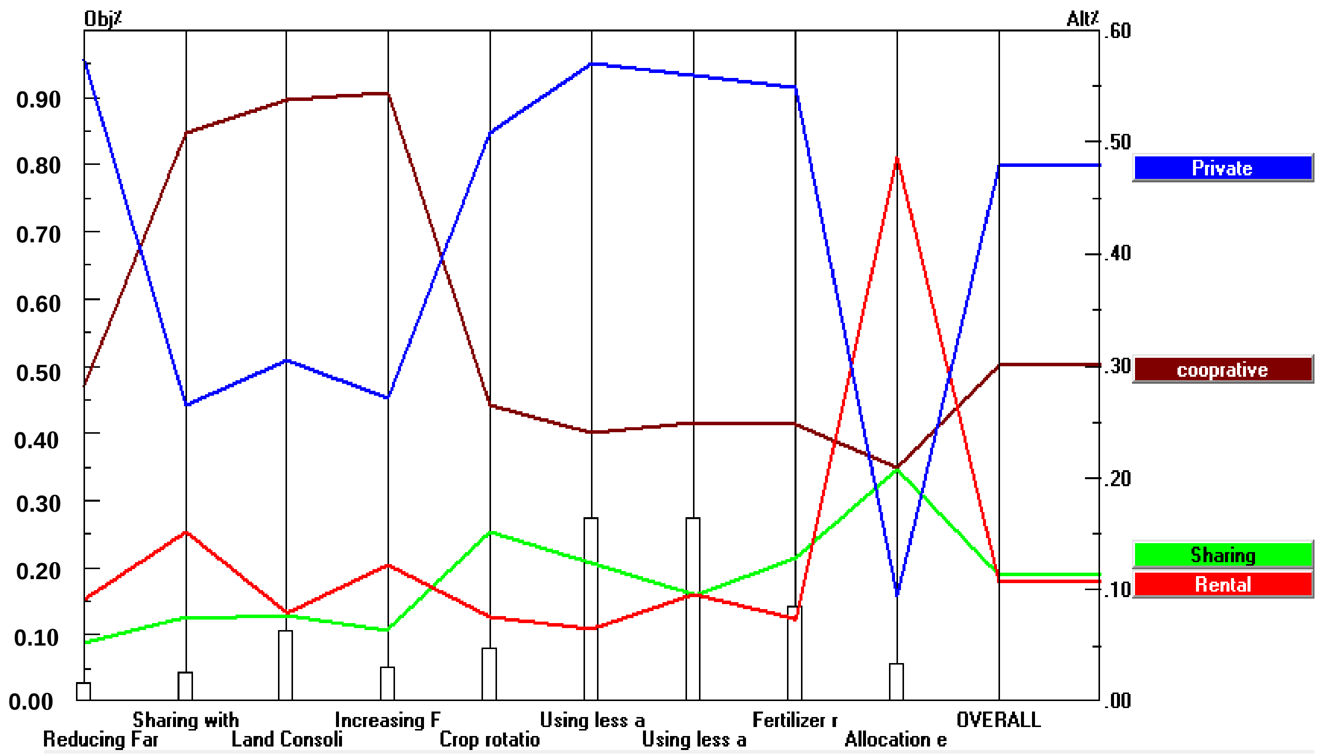

Figure 2. Results of sensitivity analysis for partnership models.

fiber agriculture, it also contributes to the viability of rural areas, food security, the cultural heritage and environmental benefits such as agricultural landscape, agro-biological diversity, land conservation and high standards of plant, animal and public health.

Agricultural development in Iran has been based on modernization theory in the late decades. The consequences of implementation of modernization based agricultural development policies, particularly with regard to environmental impact, have been negative. Iran's agriculture is facing serious environmental pollution and degradation problems (Rezaei-Moghaddam and Karami, 2008). Agricultural development decision-making is becoming more pluralistic. There is a felt need for alternative partnership models. Four competing partnership models have been developed based on general tenets of private, rental, sharing and cooperative.

This paper argues that AHP is a useful tool to reach a decision regarding commitment to a theoretical base for agricultural sustainable development among stakeholders of agriculture. 30 farmers are the stakeholders of Ilam Province agriculture and they were involved in AHP decision process. The stakeholder's identified nine criteria for agricultural sustainability including: reducing farmers migration, sharing with agricultural engineer, land consolidation, increasing farmers awareness, crop rotation, using less amount of chemical fertilizer, using less amount of chemical pesticide, fertilizer recommendation and allocation efficiency. Although there were differences between stakeholder regarding the magnitude of priority of private over another partnership models, all participants and the aggregate analysis of decisions confirmed the priority of private partnership model for Ilam Province, Iran.

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