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A DELPHI STUDY TO DETERMINE SUSTAINABILITY FACTORS: THE CASE OF RICE FARMING IN BANGLADESH

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Abstract: Sustainable farming is a growing concern of agricultural policy agenda. The concept of 'farming sustainability' has a broad appeal but little specificity. Therefore, to bring in a wide spectrum of knowledge, experiences, and mental models, a multidisciplinary and multi-stakeholders collaborative research approach was adopted to determine important factors promoting rice farming sustainability. To cope with this challenge of stakeholders' participation, a modified Delphi technique was employed to capture the views of stakeholders. Based on a review of published and grey literature as well as informal discussion with experts, an 'initial list' of factors was prepared, and a panel of academic experts, researchers, extension workers, policy makers, NGO workers, agro-business leaders, and farmers provided input in the form of close and open questions. After administering two rounds survey, a fair consensus of experts score was achieved, and accordingly, a set of 21 factors: economical (3), social (9), ecological (7), and political (2) was determined. Based on the findings from this study these factors can be contributed substantially to promote and manage rice farming sustainability at the local level. The results highlighted that stakeholders' participation is an empirical way of generating straightforward inputs for coherent strategy formulation that are imperative for achieving sustainability.

KEYWORDS: Sustainable farming, Delphi technique, natural resource, development, Bangladesh.

Introduction

In the context of climate change, 'farming sustainability' has become a vital issue of agricultural policy agenda. A number of reports of the World Bank (2008) and FAO (2010) underscores due to food insecurity, negative environmental impact of intensive cultivation, and the grave threat of climate change. The issue of 'farming sustainability' is widely discussed and viewed by the international body as indispensable for water, food, and livelihood security of the world. However, this issue is both ambiguous and ambitious and entails embedded ideological positions as it has multi-dimensional and multi-functional attributes. In addition, the diverse factors and priorities at different levels influence its attainment and assessment.

Rice is a vital crop for achieving households and national food security and staple food for about half of the world population (FAO, 2010). Agriculture is the foundation of economy in Bangladesh, and rice remains its main driver. It occupies about 77% of the total cropped area, contributes to about 10% of GDP, and employs about 65% of labour forces of this country (BARC, 2011). In reality, "rice is life" for the millions of resource-poor farm families not only in Bangladesh but also in Asia and the Pacific.

Since the last few decades, the world has made notable progress in agricultural production, specifically in Asia, the food production increased by 280% over the last four decades (Pretty, 2008). Bangladesh has made remarkable progress in rice production over the last three and a half decades; it increased from about 17 million tons in 1970 to about 48 million tons in 2009 (BBS, 2009). Several studies (World Bank, 2000; Shahid & Behrawan, 2008; Alauddin & Quiggin, 2008; Rahman *et al.,* 2008; Roy *et al.,* 2013) have paid a significant attention on sustainable agriculture issue for socio-economic development. Consensus from these studies suggests that due to many reasons, for instance, depletion of organic matter, declining and degrading land resources, agro-biodiversity erosion, and land defragmentation the current production systems are not environmentally sound and economically viable in the long run.

The land productivity is slowly declining due to intensive cultivation of high yielding varieties (HYVs), indiscriminate use of agrochemicals, and deterioration of soil properties (Robbani *et al.,* 2007). Similarly, literature on the negative consequences of injudicious use of fertilizers and pesticides are quite rich (Chowdhury, 2009). Uddin & Kurosawa (2011) reported the application of nitrogen fertilizer seems to have a positive effect on the Arsenic (As) concentration in groundwater, which is an emerging threat of this country. Moreover, land fragmentation and river bank erosion are perennial problems. Given the present state of a weakened natural resource base, increasing adverse ecological conditions of cultivation, and the realisable impacts of climate change, farming systems require better management, monitoring and evaluation to promote productive and profitable, socially equitable and environmentally sound production systems, by adopting sustainable intensification of resources, technologies, social and human capitals.

Presently, Bangladesh is not a food self-reliant country and in this context of food insecurity and resource constraint, the country has to address two challenges: (i) increasing food production for the need to feed ever-increasing populations, and (ii) taking necessary initiatives to improve agri-environment for sustainable production. Realising the situation, the Government has been implementing several projects for increasing rice production and agri-environmental development. In this connection, it is significant to determine essential factors that provide a complete description of the state of satisfaction of rice farming sustainability issue. There is no single most common definition of sustainable farming; however, most of the studies emphasize on satisfying human foods, enhancing environmental quality, sustaining the economic viability of farming, and improving the quality of life for growers (e.g. NRC, 2010). In our view 'sustainable farming refers to the application of farming practices that maintains and improves the natural resources as well as enhances economic resilience, social, and governmental condition of farmers'. Sustainability factors are significant not only in the sense that they help diagnosing problems and understanding their underlying causes, but also they help prioritizing sustainable solutions, and play a key role in monitoring, management, and decision-making for sustainable agriculture development. Taking these issues into consideration, the purpose of this study is to determine the factors to promoting and managing rice farming sustainability.

Methodology

Multi-stakeholders' participation approach was adopted in this study. The selected stakeholders were from varied professions and geographic locations; therefore, it was difficult to gather all contributors in one place at the same time to discuss and achieve a consensus on the factor of sustainability. Thus, considering geographical, financial and temporal obstacles, this study employed the Delphi method for exploring potential factors of sustainable rice farming. Studies stated that it was a good research method for (i) deriving consensus among experts from the wider geographical areas on a particular topic (Imang & Ngah, 2012) and (ii) achieving an overall consensus on a complex problem from experts where knowledge is limited (Hauck *et al.*, 2007). The Delphi methods have been used in a plethora of cases and its application to determining factors in diverse fields is also established (Rasouli *et al.,* 2009; Chatterjee, 2012). In our view, it is a method for consensus-building by using a series of questionnaires delivered to experts, conducting repeated rounds, opportunities for expert to reconsider their responses, anonymity of experts, and using a range of statistical calculations for discussion and drawing conclusion.

Table 1: Rules for Analysing the Scores from Multiple Experts using the Delphi Technique.

Round 1	Round 2
Mean score Factor f ≥ 3.5	If Mean score Factor f ≥ 3.5 and SD ≤ 1 and Soundness score ≥ 50% then Factor f is accepted
Mean score Factor f < 3.5	If Mean score Factor f < 3.5 and SD > 1 and Soundness score < 50% then Factor f is accepted
Based on Choi & Sirakaya (2006)	

Note: Mean and standard deviation (SD) computed on a scale between: 1 = Least Important and 5 = Most Important and Soundness score either Sound (1) or Not Sound (0).

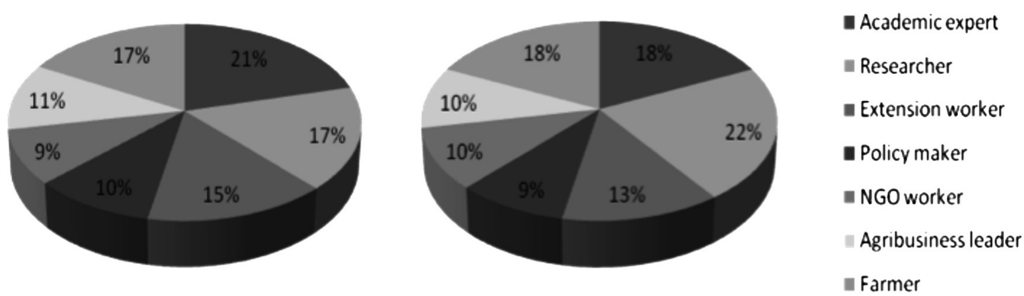

Figure 1: Multi-stakeholders Participation in the Delphi Survey.

Traditionally, the Delphi process begins with an open-ended questionnaire. However, several studies (Kuo & Chen, 2008) substantiated that the first-round should be started based on a review of literature to precisely capture the respondents' attention about the whole gamut of the issue. Similarly, our initial-round was a thorough review of literature and another two rounds Delphi surveys were conducted to achieve experts' consensus, and each round was based on the results of the preceding ones. The rules of Choi & Sirakaya (2006) were used for analysing the scores of factors yielded by the survey (see Table 1).

Participants

Researchers were diversified in taking the size of participants in the Delphi process. Hsu and Sandford (2007) state that there is no consensus about what the best number of participants is for a Delphi study. It depends on several factors, for example, the type of investigation, and participants' selection process. Many studies (e.g. Kuo & Chen, 2008) used the participant number of below twenty. Taking these lessons into account, 61 and 53 respondents were selected for the first- and second-round Delphi survey, respectively. Limiting the size of experts fulfilled two objectives: (i) it was easier to manage the whole work in a convenient way, and (ii) it helped to overcome the possibility to bury good data, as too much input makes it complicated. With the consultation of academicians, three criteria for experts' selection were defined: (i) individuals who have fifteen-years relevant professional experiences; (ii) individuals who have at least twelve years of direct involvement in rice research, extension, management, and marketing; and (iii) individuals who have ten years of involvement in agricultural policy making or consultancy. Moreover, a purposive approach was applied to select few participants, particularly farmers and their long farming experiences (above 20 years), literacy levels, and technical knowledge were considered (Figure 1).

Table 2: The 'Initial List' of 20 Issues/Factors/Indicators of Sustainable Agriculture Compiled Based on a Review of Literature.

Issue/factor/indicator	The issue/factor/indicator is a(n)
Education [1-4, 26]	key quality of farmers to manage a farm sustainably
Family annual income [5, 6]	capacity of the farmers' for adopting agricultural innovations
Input self sufficiency [5, 7-9, 26]	measure of farmers' ability and determine the ratio of local inputs cost to the total input cost
Land productivity [5, 7, 10, 26]	measure of the physical yield of rice per unit area
Crop diversity [11, 12, 26]	description of the number of crops grown per year
Adequacy of extension services [1, 5, 13-15]	indication of the frequency of extension personnel contact with necessary farm information
Equity [7, 10]	idea of moral equality, describes farmers thinking how to distribute farming goods and services across society, especially for the day labourers.
Social involvement/capital [3, 15, 26]	description of farmer's involvement with diverse organizations, frequency of contact and trust to them
Net farm return [7, 10, 16, 26]	indication of economic viability of a farm
Benefit cost ratio [7, 10]	measure of financial viability of production
Soil quality status [1, 7, 8, 15, 17-19, 26]	measure of major soil properties by chemical analysis
Pest and disease management [7, 20-22, 26]	proportion of land farmers used mechanical, cultural, biological, and chemical methods.
Depth of groundwater table [6, 15, 19, 23]	indication of overexploitation of the groundwater, the unique source of water for all purposes
Water pollution [5, 7, 8, 15, 23]	core issue of sustainability, which affects human and animal health and damages ecosystems indirectly
Nutrient management [7, 9, 26]	illustration of a approach to manage the amount, form, placement, and timing of the application of nutrients
Health hazards impinged by agriculture [2, 15, 20, 22]	indication of the casualties for injudicious use of pesticides, fertilizers, and others
Disaster management [5, 6, 17, 19]	arrangement of the Government's plan, programme, policy and initiatives for managing disaster risks
Agricultural credit [24, 25]	indication of GOs and NGOs financial supports for agriculture under certain terms and conditions
Agricultural subsidy [13, 24]	indication of Govt. financial assistance for agricultural inputs, e.g. irrigation and fertilizers.
Infrastructure e.g. rural roads [5, 14]	illustration of roads, culvert, market, deep tubewells, etc. which helps directly and indirectly in development

Refer to text for details

[1] Asaduzzaman *et al.* 2010; [2] Parveen and Nakagoshi 2001; [3] Parveen 2010; [4] Robinson *et al.* 2007; [5] World Bank 2010; [6] MoA 2006; [7] Rasul and Thapa 2004; [8] Hassanullah 2008; [9] Basak 2011; [10] Rasul and Thapa 2003; [11] Majumder and Shivakoti 2001; [12] Rahman 2009a; [13] Asaduzzaman 2009; [14] Rahman 2003; [15] Pagiola 1995; [16] Rahman 2009b; [17] Rashid and Islam 2009; [18] Jahiruddin and Satter 2010; [19] Chowdhury 2009; [20] Dasgupta *et al.* 2004, [21] Hassan and Bakshi 2005; [22] Dasgupta *et al.* 2005; [23] ADB 2004; [24] Ahmed *et al.* 2009; [25] Sarkar *et al.* 2010; [26]Roy and Chan 2012.

Survey Instrument and Data Collection

The survey instrument was prepared based on a review of published and grey literature and informal discussions with experts.

The purpose of the initial stage was to document how previous researchers attributed and quantified issues, factors, and indicators of agricultural sustainability. With a view to determine these factors, the authors consulted relevant books, journal articles, reports, and books. An 'initial list' of potential factors was drawn up (see Table 2) and this list comprised of those issues/factors/indicators which were commonly used, mentioned, recommended in different published articles in defining, monitoring, and assessing agricultural sustainability. The first-round questionnaire comprised of two questions, including questions concerning experts' judgment on the initial lists, and another one was open ended. By providing open-ended question, the experts were allowed freedom to propose additional factors if they considered as well as judged this new factor in terms of importance. Panel members used five-point Likert scale for judging: 'most important', 'important', 'uncertain', 'less important' and 'least important' ('most important' anchored at 5 to 'least important' anchored at 1) and in the second-round, the experts assessed soundness of the factors.

The first-round instrument was sent by e-mail to 61 experts and 37 (61%) were returned. Before sending questionnaire we communicated with the experts for their consent, and a reminder was also sent to receive their support and cooperation. The replies were collated into 35 factors where a considerable number of new factors were added by experts in the first-round survey. Based on these scores given by experts, the mean and standard deviation of factors was calculated to select potential factors for the next round judgment (see the rules in Table 1). The second-round questionnaire was sent to 53 experts and 35 (66%) were returned. The mean scores from the prior round of each factor were included in the questionnaire to overcome the potential biases. The respondents were requested to rate the factors in terms of "sound" or "not sound" attribute. This question was designed to confirming experts' opinion. The Delphi survey was conducted from November 2011 to March 2012.

Results and Discussion

Twenty-one factors under four dimensions were identified; including four new factors were added by experts. Table 3 shows the results from the two rounds of the Delphi survey along with their mean, standard deviation, and soundness scores. The results of the survey deduced three factors of the economic dimension (Table 3), namely 'benefit-cost-ratio' (mean/SD/soundness: X = 3.77/0.95/0.90) [agreement mean/SD/Soundness mean, accordingly]; 'land productivity' (X = 3.66/0.98/0.82); and 'net farm return' (X = 3.58/0.62/0.71). The benefit-cost-ratio and net farm return is financial terms that describe and measure the farming profitability, an unequivocal attribute of farming sustainability. Gafsi & Favreau (2010) opined, first of all; a farm should be profitable without taking economic risk to be sustainable. Beets (1990) stated that sustainable development involved maximizing the net benefits of economic development, maintaining the services and quality of natural resources over time. Moreover, rapid population increase is one of the major problems of the country. The issue of land productivity is very crucial in the long run, because of the high population growth (1.26 % per annum) that reduces the availability of agricultural land in an alarming rate (declining 1% per annum) to meet the increased demand for non-agricultural purposes (FAO, 2000).

Nine factors of social dimension had developed by the survey (Table 3). The experts agreed that education is an important factor of rice farming sustainability. This is likely to the country's poor adult literacy rate, which was 56.3% in 2010. Studies (Dev and Hossain, 1995) illustrate that education is an essential component of socio-economic development. The research result shows farmer's educational level and effective farm management as well as timely adoptions of environment-friendly management practices were positively correlated (OECD, 1999). Moreover, FAO (2011) finds that public education, especially through the school curriculum, has proved to be an effective way to raise awareness and preparedness to deal with issues of sustainability and environmental management in Australia.

An important concern exists between the academicians, researchers, and policy makers about how to meet the demand of steadily increasing population when natural resources are dwindling. Moreover, the grave threat of climate change makes the situation worsen. Therefore, improved knowledge, skills, practices and technologies are inevitable to tackle these formidable challenges. There are diverse types of resource-conserving technologies such as conservation tillage and water harvesting and practices, for example, agroforestry and mixed cropping around the world. The make best use these technologies and practices would be appropriate and time-demandable, as these technologies and practices provide the principal means for sustainable natural resource management and improvement of productivity and biodiversity of agroecosystem.

Although technological progress accentuated the inequality in the distribution of rural incomes (Hossain, 1988), it has a significant positive effect on the efficiency in input use, employment of hired labor, and household incomes. Although different types of technologies and practices are currently being used, the total number of farmers is still relatively small. These technologies and practices can contribute to one hand sustainable farming systems and on the other hand, to increase cropping intensity, land productivity, and narrow the yield gaps. The yield gaps are one of the major challenges of agriculture as identified by BARC (2011). The World Summit on Sustainable Development provides one of the most elaborate articulations of the role of technological innovation in promoting sustainable development (UN Millennium Project, 2005).

Extension services provide effective and efficient scientific knowledge and necessary information to farmers, to enable them to judicious use of their resources, with a view to promote sustainable agricultural and socio-economic development. Anderson (2007) reported that many developing countries had reaffirmed the key role of agricultural advisory services for better production and development. The extension system is remained weak in Bangladesh (Assaduzzaman, 2009) and extension reform worldwide delineates public extension services of most of the countries are not being capable of solving farmers emerging farming problems. Hossain *et al., (*2007) illustrated that farmers get to know of the new technology less from the extension agents than through farmer to farmer informal contact. The results of this study found that two significant factors of extension services, namely ‘adequacy of extension services’ and ‘effectiveness of extension services’ for sustainable production systems.

As sustainable agriculture seeks an appropriation of local knowledge and resources, innovation, and technologies, which are locally available and accessible, fit and can contribute to the best solutions to sustaining farming system. Thus, social involvement as well as social capital and human capital were two vital aspects that require proper attention for building a sustainable agroecosystem. Several researchers substantiated that farmer’s high level of social and human assets are innovative means to face of uncertainty in agricultural systems (Olsson & Folke, 2001). Consensus from these studies suggests that as farmers in developing countries face serious social problems (e.g. limited scope for non-farm income, poverty, and lack of access to resources); thus, two inextricably linked components, namely social and human capital is significant for promoting farming sustainability. Pretty (2009) illustrates that sustainable agriculture is a social learning approach rather than a precise set of technologies.

Input self-sufficiency is an ability of farmers to manage and apply necessary inputs to the field

Table 3: Analysis of the Ratings Given By Experts in the Two Rounds Delphi Survey.

Dimension	Factors	Mean	SD	Soundness	Chosen factors
Economical	Land productivity	3.66	0.98	0.82	√
	Net farm return	3.58	0.62	0.71	√
	Benefit cost ratio	3.77	0.95	0.90	√
	Marketing channel*	3.55	0.96	0.46	X
Social	Education	4.29	0.86	0.64	√
	Family annual income	4.13	0.88	0.86	√
	Equity	3.19	1.13	-	-
	Input self sufficiency	3.97	0.95	0.61	√
	Adequacy of extension services	3.68	0.98	0.89	√
	Social capital	3.74	0.89	0.86	√
	Information self reliance*	3.58	0.96	0.47	X
	Risk and vulnerabilities in production*	3.87	0.80	0.35	X
	Effectiveness of extension services*	3.56	0.96	0.68	√
	Human capital*	3.61	0.84	0.86	√
	Pluriactivity*	3.52	0.85	0.68	√
	Use of resource-conserving technologies and practices*	3.52	0.96	0.68	√
	Willingness to grow crop*	3.03	0.95	-	-
Ecological	Emission of green house gases*	3.55	0.77	0.36	X
	Crop diversity	4.10	0.94	0.96	√
	Soil quality status	4.16	0.52	0.89	√
	Pest & disease management	3.93	0.86	0.82	√
	Depth of ground water table	3.80	0.40	0.36	X
	Water pollution	3.66	0.88	0.61	√
	Integrated nutrient management	4.45	0.68	0.75	√
	Health hazards impinged by ag	3.68	0.79	0.57	√
	Disaster management	3.77	0.96	0.86	√
	Cropping pattern*	3.52	0.72	0.46	X
	Soil erosion*	3.52	0.85	0.36	X
	Organic farming*	3.52	0.77	0.25	X
	Infrastructure e.g. rural roads	3.25	0.44	-	-
	Agro-biodiversity*	3.55	0.72	0.43	X
	Land use pattern	3.00	0.86	-	-
Political	Agricultural credit	3.55	0.51	0.64	√
	Agricultural subsidy	3.81	0.40	0.86	√
	Good governance*	3.51	0.93	0.21	X

Note: * Factors added in the first-round; Cutoff point: Mean ≥ 3.5, SD ≤ 1 and Soundness ≥ 50%;
Factors not listed in table those mean score was less than 3.

when necessary. It greatly influences cropping pattern, intensification and diversification, and contributes to increasing productivity. Taking declining soil organic matter, decreasing crop yield, and increasing the tendency of using agro-chemicals into account farmer's self-sufficiency in input management is urgent to keep the soil productive over the long periods. Moreover, minimization the dependency on external inputs is one of the principles of sustainable production.

Farmers' income and diversified income generation options help them to purchase necessary seeds, irrigation, and fertilizers, as well as it motivates them to adopt agricultural new technologies, ecological farming practices, and innovations, which all largely contributes to fostering environment-friendly production system. Innovation adoption always involves costs and associated risks; therefore, farmers simply cannot cut their existing practices and adopt a new one. To cope with this obstacle, learning is required for them (Chambers, 2005). Nowadays, farmers are puzzled by a number of new crop varieties (e.g. presently; sixty modern rice varieties exist in Bangladesh) and diverse solutions of emerging pests, diseases and soil-related problems; which all also signifies that farmers' investment in learning is very important. Otherwise, it will increase the existing informational and knowledge gaps of the farmers. Asenso-Okyere & Davis (2009) underscores that to fostering innovations in agriculture; policy makers must be scaling up investments in agricultural science and technology, research and extension, agricultural education and training, and farmer organizations and other local institutions.

Crop diversification is considered as a resilience mechanism as well as an effective means for crop risk management strategy. In elaborate sense, crop diversification is an effective tool for acceleration of agricultural growth, farmers' income, and employment opportunities; improving soil fertility; maintaining a balance of major crops and minor crops and biological species diversity that leads food and nutritional security, poverty alleviation, improvement and preservation of natural resources. Similarly, in the literature, the significance of crop diversity in agricultural and socio-economic development is quite rich (Haque, 2001). Considering the multidimensional importance of crop diversification, it is logistically realistic to include this factor for achieving rice farming sustainability.

Maintaining soil health is regarded as prime assessors of ecological sustainability and this can be achieved through properly maintaining the broad aspects of agricultural production, namely fertilizer, nutrients, disease, and pest management. The most common soil-related problems were the depletion of organic matter; increasing soil salinity, soil acidity, topsoil erosion, and water logging; and degrading rice soil (Jahiruddin & Satter, 2010) and these are the results of rice-based monoculture, excessive use of irrigation water, and fossil fuels as a source of energy. Therefore, taking the above prevailing situation into account, soil-quality status is a unique factor for farming sustainability and for that reason soil fertility and nutrient management also need to be considered.

With the introduction of many HYVs, the number and extents of pests and diseases infestations also have increased. Several studies report that integrated management is more sustainable than other crop management systems (FAO, 2010). In addition, disaster management, climate change and other related issues in agriculture are cross-cutting in nature. All the sub-sectors of agriculture are highly vulnerable to natural hazards. Drought is a recurrent problem of the North Western part of the country, and it adversely affects the rice cultivation. Since the independence in 1971, Bangladesh has suffered from major nine droughts with high magnitude (Paul, 1998). Bangladesh is a land of perennial floods. About 20% of the country is inundated regularly, and the frequency of flood is increasing over the time. Therefore, disaster management is vital issue for sustainable production.

There is no agriculture without water. However, water pollution due to Arsenic (As) is one of the severe environmental problems in the South Western part of the country, and it is a major concern of health hazards impinged by agriculture. Empirical research study acknowledges that the issue is a matter of great concern (Uddin & Kurosawa, 2011). The situation becomes graver with farmers limited knowledge as well as unaware of the negative effects of detrimental substances to health and environment. Worldwide water quality conditions appear to have been degraded in almost all regions with intensive agriculture and other developments (Molden & de Fraiture, 2004). Moreover, Parveen & Nakagoshi (2001) illustrates that considering the amount of used agro-chemicals, the unawareness of growers, and toxicity of few pesticides such as Furadon; the environment and farmers' health is at a high risk. This issue necessitates proper attention for sustainable agriculture.

Experts reached agreement on two political factors, namely agricultural subsidy and credit (Table 3). The population in Bangladesh is predominantly rural and small holders (>2 ha of farmland), and poverty is primarily a 'rural phenomenon', with more than half of its rural population classified as poor. Most of the farmers suffer shortage of hard cash during the rice planting season. Consequently, they face problems in purchasing recommended quantity of fertilizers, quality seeds, and irrigation, which significantly hampers the expected amount of production. Agricultural subsidy and credit can assist growers in diverse ways. Although agricultural subsidies exist, it does not helping small and marginal growers, considerably (MoA, 2006). The amount of subsidies is given by the government is much lower than the neighboring countries, namely India and Pakistan. Moreover, the systems of providing agricultural credit are needed to be reoriented with accountability and transferability. Innovating approaches are required in providing subsidies and credit for considering the ecological issues. For instance, India has implemented a new subsidy plan by giving farmers incentives for using a better mix of nutrients (Anand, 2010) and China has been providing a series of incentives, and subsidies aimed to guide the technology choices of the country's farmers (IFAD, 2010).

Conclusion

The study deals with one of the significant issues associated with 'increasing the productivity of rice farming, while at the same time keeping farming system profitable, maintaining farmers' quality of life and protecting the natural resource base over time', collectively these issues defined the sustainability of rice farming. Although a significant progress has achieved in production at the expanse of natural resources, high yielding varieties, and fossil fuels in the last few decades, there is no room to assume that these relationships will be remained linear in the present context. Scientists, policy makers have widely come to accept; specifically, natural resources are needed to be protected from destructed farming practices to keep the lands productive as well as to preserve the ability of land for future generations to meet their needs. Multi-stakeholder participation properly determines a list of 21 factors of four dimensions of sustainability that apparently essential for attaining and managing sustainable rice farming. However, it remains for policy makers to determine how these issues will be addressed. The results of this study provide an important insight into effective actions for attaining production in a sustainable way and applicable to other rice producing countries. The findings of this study are useful for formulating coherent rice farming development strategies, which are imperative for achieving sustainable agriculture and socio-economic development in Asia and the Pacific.

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