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Agricultural biodiversity and farm level technical efficiency: An empirical investigation

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ABSTRACT

Land degradation with deforestation and loss of biodiversity has been considered one of the most serious environmental problems for developing countries. The lower level of agricultural productivity resulting in the inability to obtain a sufficient level of production in agriculture leads rural communities to exert pressure on forest resources while damaging the ecological services provided by them. Promotion of economic efficiency as well as achieving environmentally sustainable farming practices can help maintain a sustainable agricultural sector while reducing land degradation and pressure on forests in rural communities. In this context this study investigates the relationships between different indicators of agricultural biodiversity (crop diversity, livestock diversity and agro-diversity) and farm level technical efficiency (TE). A survey conducted covering 723 farms in Sri Lanka is used for the analysis. The results show that crop diversity, livestock diversity and agro diversity are positively related with farm level TE. Hence, it is clear that maintaining more diverse farming systems is crucial to reducing farm level inefficiency and thereby improving the welfare of rural households while reducing the pressure on extensive agricultural practices which has increased global deforestation. Such diversity is especially important for subsistence agricultural practices which are still widespread in most Asian countries.

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Introduction

The agriculture sector which includes agriculture, fisheries and forestry is a substantial contributor to the Sri Lankan economy. This sector which depends intimately on the environmental and natural resources accounted for about 8% of the country's GDP in 2015. At present approximately 34% of the total land area is under agriculture which is the dominant source of livelihood in rural areas for nearly 70% of the country's population. At present land degradation with deforestation and loss of biodiversity has been considered one of the most serious environmental problems in Sri Lankan rural agriculture. Key causal factors responsible for land degradation have been identified as land clearing, poor land management practices, over exploitation of land due to fragmentation, shifting cultivation, insecure land tenure, loss of biodiversity, the growing of erosive crops as well as extensive cultivation practices due to lower level of farm productivity.

Agricultural production has been increased mainly through expanding the area under cultivation. Natural forests have been the victim of this type of unplanned agricultural expansion activities. The growing body of literature on the role of forests and agricultural productivity (Reddy and Chakravaty, 1999; Pattanayak and Sills, 2001; Delacote, 2010) shows that lower levels of productivity in agriculture leads rural communities to exert increased pressure on forest resources. This typically takes the form of clearing and extraction that helps them smooth their consumption patterns and cope with agricultural risk. This implies that increasing agricultural productivity and efficiency can decrease the pressure on forest resources while decreasing deforestation.

Technological innovation and the efficient use of production technologies are the main strategies for achieving productivity growth in agriculture (see, for example, Idiong, 2007). However, in developing countries most new agricultural technologies have only been partially successful in improving productivity. This is often due to a lack of ability or desire on the part of producers to adjust input levels to those required by the new technology. This in turn reflects their attachment to traditional agricultural systems and/or because of the presence of institutional constraints (Latruffe et al., 2005). These considerations suggest that the best option available

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to assist developing countries to increase productivity is to increase farm efficiency using current technologies.

Biodiversity conservation on agricultural land is one of the objectives that has received considerable attention from policy makers in recent years (Winters et al., 2005). Agricultural biodiversity is a sub-set of general biodiversity[1] which is essential for global food production, livelihood security and sustainable agricultural development (Van Dusen, 2005). It includes all forms of life directly relevant to agricultural production. In addition to providing direct benefits to farmers, agricultural biodiversity improves ecological processes by regulating climate, maintaining soil quality, providing protection from erosion, storing nutrients and reducing pollution. Some societies also values biodiversity for cultural reasons as it maintains the aesthetic values of the landscapes (Nagarajan et al., 2007). It is evident then, that agricultural biodiversity can play an important role in maintaining environmentally friendly farming systems in the long run.

In terms of TE agricultural diversity can increase farm level TE in three ways. First, farmers have the scope to utilise family labour optimally when they maintain a diverse agricultural system (Brookfield et al., 2002). For example, different crops may require labour in different time periods. Thus family labour can easily be distributed among different crops and/or livestock in order to obtain maximum benefits. Second, diverse farming systems minimise the external risk that farmers often face. For example, having crops and livestock is likely to minimise a farmer's risk from, say, disease or drought. This is because, for example, whilst a disease can devastate crops, a farmer is still able to obtain some income from his livestock. Third, a biologically rich farming system can improve soil fertility and minimise input costs in the long run.

However, it appears that enhancement of biodiversity is not explicitly recognised as a valid target or as a positive output when production efficiency is measured in practice. We therefore hypothesis that this lack of knowledge may cause biases in traditional efficiency calculations and leave agricultural areas open to environmental degradation. As well, discrimination against environmentally benign technologies may result.

This paper provides empirical evidence on the links between TE and agricultural biodiversity by analysing farm level data collected from 723 farmers in three agricultural districts in Sri Lanka. The specific objectives of this study include: (i) identify the role of different indicators of agricultural biodiversity in determining farm level TE (ii) estimate input–output relationships in more diverse farming systems; and (iii) identify socio-economic factors influencing TE in a diverse farming system. This study is the first attempt to investigate the link between farm level TE and agricultural biodiversity. We use a stochastic frontier production function (SFPF) approach to estimate farm level TE in small scale farms in Sri Lanka. The results of the study are designed to assist in developing policies needed to maintain a sustainable farming system and provide improved environmental as well as ecological benefits for society.

The remainder of the paper is set out as follows. Section "Literature review" discusses the relevant literature on farm level TE while Section "Research method and data collection" describes the research method and data collection. Section "Stochastic frontier production function" describes the economic model that use to investigate the relationship between different components of agricultural biodiversity and farm level TE. Section "Results of the study" reports the empirical results of the study while Section "Discussion" provides a discussion of the results. The final section concludes and explains the policy implications of the study.

Literature review

It is now well known that agricultural biodiversity has positive impacts on overall productivity and soil quality (Heisey et al., 1997; Meng et al., 2003). Agricultural biodiversity can also affect farm level efficiency through management of scarce resources in a diverse farming system. Belbase and Grabowski (1985) as early as the 1980s investigated the TE in Nepalese agriculture. The average TE level of the main agricultural crops was found to be 80%. Their analysis showed that nutritional levels, income, and education were significantly related to TE, while no relationship was found for farming experience. Parikh and Shah (1995) presented a review of the various approaches to efficiency measurement and conducted empirical analyses of cross-sectional data from 397 sample farmers in the North-West Frontier Province of Pakistan.

Burki and Shah (1998) presented new evidence on TE and its sources by examining the cost behaviour of 387 farms in five irrigated districts of Punjab. They concluded that farm efficiency is positively related to formal schooling of farm operators, the abundance of canal water and negatively related to farm size. The age of farm operators was shown to have no effect on efficiency. Dairy farms were the subject of a paper by Hadri and Whittaker (1999) where the efficiency of a small panel of dairy farms in the southwest of England was considered in the context of their use of potentially polluting agrochemicals.

Sherlund et al. (2002) investigated the efficiency of smallholder rice farmers in Côte d'Ivoire while controlling for environmental factors that affect the production process. Apart from identifying factors that influence technical efficiencies, the study found that the inclusion of environmental variables in the production function significantly changed the results: the estimated mean technical efficiencies increased from 36% to 76%. Binam et al. (2004) examined factors influencing the TE of groundnut and maize farmers in Cameroon. They concluded that access to credit, social capital, distance from the road and extension services were important factors explaining the variations in technical efficiencies.

Hadley (2006) estimated stochastic frontier production functions for eight different farm types (cereal, dairy, sheep, beef, poultry, pigs, general cropping and mixed) for the period 1982 to 2002. The result showed that factors such as farm or herd size, farm debt ratios, farmer age, levels of specialisation and ownership status were significant variables in the efficiency function. Idiong (2007) provides estimates of TE and its determinants using data obtained from 112 small scale rice farmers. The results showed that rice farmers were not fully technically efficient with a mean efficiency of 77%. The result also showed that farmers' educational level, membership of cooperative/farmer associations and access to credit significantly and positively influenced the farmers' efficiency.

Bozoglu and Ceyhan (2007) measured the TE of a sample of vegetable farms and explored the determinants of technical inefficiency in the Samsun province of Turkey. Farm managers from 75 randomly selected farms were interviewed to collect farm level data in the 2002–2003 production periods. Results revealed that the average output of vegetable farms in Samsun could increase by 18% under prevailing technology. The TE of the sample vegetable farms ranged from 0.56 to 0.95 (0.82 average). The variables of schooling, experience, credit use, participation by women and information were shown to reduce technical inefficiency. However, age, family size, off-farm income and farm size showed a positive relationship with inefficiency.

[1] The FAO (1999) defines agricultural biodiversity as the variety and variability of animals, plants and micro-organisms which are necessary to sustain key functions of an agro-ecosystem, its structures and processes for, and in support of, food production and food security.

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