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Review

Adoption and impact of integrated rice–fish farming system in Bangladesh

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A B S T R A C T

Like many other South and Southeast Asian countries, different national and international organizations are actively promoting integrated rice–fish farming system (IRFFS) as a potential technique to alleviate poverty, food and nutrition insecurity in different parts of Bangladesh, since 1990s. However, little rigorous empirical research exists on the determinants of adoption and welfare impact of such technologies, particularly in marginalized people's settings. This article addresses this research gap, using the case of indigenous small-scale IRFFS farm households cross-sectional survey data from northern and northwestern regions of Bangladesh. It employs double hurdle model for determining the factors affecting IRFFS adoption and intensity of adoption in the first stage and propensity score-matching (PSM) method to analyze the causal impact of IRFFS adoption on welfare of marginalized indigenous farm households in Bangladesh in the second stage. The findings of the first stage study indicate that among the key determinants of adoption are gender of the household head, access to irrigation, education and conflict with villagers. The results also show that farm size and access to credit play a significant role in the extent of adoption, implying land and credit constraints; hence, it can be difficult for land and credit constraint farmers to extend the adoption of the technology. In the second stage the study shows that IRFFS has a robust positive and significant impact on farm household welfare measured by household annual income, farm income, and quantity and frequency of fish consumption. Overall, the article provides evidence that promoting IRFFS technology is important to improve welfare of rural people especially for marginalized poor indigenous small-scale rural farm households in Bangladesh. But necessary interventions are needed to overcome the inhibiting factors for more widespread adoption of this promising technology.

Contents

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1. Introduction

In most developing countries (including Bangladesh), agriculture is the leading source of employment, income, food and nutrition security. Hence, sustainable increase in food production broadly to achieve food self-sufficiency and improve well-being (i.e. reduce poverty) of small-scale farmers under continuing rise in population, economic growth, changing food habit, rapid urbanization and severe climate change situation is crucial to economic growth and development. This increase in food production will have to be achieved by using less land, with less water, labor and chemicals (Doss, 2006; IRRI, 1998; Khush, 2001). As farmers intensify production through increased use of chemical inputs, concerns about the negative effects of such practices on human health and the environment are growing. Therefore, improved crop management practices that lead to productivity gains with minimum adverse effects on the quality of the natural resource base are needed (Laborte et al., 2009). Integrated rice–fish culture, an age-old farming system, is such a farming system technology which could produce rice (source of carbohydrate) and fish (source of high quality animal protein) sustainably at a time by optimizing scarce resource use through complementary use of land and water (Edwards et al., 1988; Frei and Becker, 2005). Although it's a very old farming system which has been practiced for many centuries by Asian farmers, the innovation may have potential to keep pace with the soaring demand for rice and fish in the developing world. Like in many other South and Southeast Asian countries, different national and international organizations have been actively promoting integrated rice–fish farming system (IRFFS) in different innovative ways as a potential technique to reduce poverty, food and nutrition insecurity in different parts of Bangladesh, since 1990s (Jahan et al., 2008). Different experimental and empirical research shows the potential of IRFFS in terms of productivity and efficiency increase, financial profitability, environmental and ecological benefits (Ahmed and Garnett, 2011; Ahmed et al., 2011; Berg, 2001, 2002; Frei and Becker, 2005; Giap et al., 2005; Gupta et al., 2002; Gurung and Wagle, 2005; Matteson, 2000; Ofori et al., 2005) in many parts of Africa and Asia, including Bangladesh. Bangladesh is a "poor" and a densely populated country with increasing demand for rice and fish. Rice monoculture is the dominant farming system with large irrigation coverage. Carrying capacity of this land and water are not utilized efficiently. Hence, there is a good scope to integrate aquaculture in those potential irrigated and rain-fed rice farming areas to increase rice and fish production by making efficient use of scarce land and water resources (Wahab et al., 2008). In spite of being actively promoted, IRFFS has not been widely adopted, and it remains a marginal farming system in Bangladesh due to socioeconomic, environmental, technological and institutional backdrops including the risk of flood and drought (Ahmed et al., 2011; Nabi, 2008).

IRFFS as a sustainable farming system technology, is gaining momentum in recent sustainable development paradigm. However, research on economics of rice–fish culture is insufficient (Ali and Mateo, 2007). There is a gap in knowledge regarding to what extent the IRFFS can increase the welfare of the smallholders and why this type of farming system technology is still marginal. Thus, assessment of the suitability of this technology for small-scale farmers is required. On the other hand, for policy makers, knowledge of suitability evaluations is essential, as that knowledge could support design of appropriate policies with respect to their adoption and impact. The experiences of marginalized indigenous farmers and different organizations promoting rice–fish culture in different parts of Bangladesh, therefore, give a different perspective to the emerging paradigm.

Against this backdrop, the objectives of this article are to: (1) assess the welfare impacts of adopting integrated rice–fish farming system on small-scale marginalized indigenous farm households in Bangladesh and (2) determine the major driving and inhibiting factors of integrated rice–fish farming adoption. However, as with other technologies, identifying and quantifying causal effect of integrated rice–fish farming system on welfare of marginalized indigenous farm households is not straightforward. Because, household welfare indicators such as household annual income are affected by a host of factors in addition to the integrated rice–fish farming adoption. Thus, there is a need to control these factors in estimating the impact of the integrated rice–fish farming on the outcome variable. In addition, adoption of integrated rice–fish farming may not follow a random process. The technology disseminators may in fact use certain selection criteria or households may self-select themselves into the adoption of integrated rice–fish farming system. As such, it might be that households who are adopters systematically differ from non-adopters of integrated rice–fish farming. Failure to properly account for the selection criteria or the self-selection issues in an impact evaluation exercise would lead to biased inferences about the impact of the technologies (Heckman et al., 1998). Further, adopters and non-adopters may differ in terms of unobserved characteristics. None of these issues have been taken care of in recent similar study by Pant et al. (2014), but in this article these problems are tested and accounted for.

Using a propensity score matching (PSM) and double hurdle model (DHM), this paper overcomes some of the above-mentioned challenges in measuring the factors affecting adoption and impacts of integrated rice–fish farming adoption on the welfare of marginalized and extremely poor indigenous households. To the best of our knowledge this study is the first of its kind to identify causal effect of integrated rice–fish farming system adoption on household's welfare and the factors affecting such adoption in marginalized extreme poverty settings in Bangladesh. In identifying factors affecting adoption and extent of adoption, the DHM estimates the likelihood and extent of IRFFS adoption by using probit and truncated regression models respectively. The PSM method was used in measuring the impact, and it involves pairing adopters and non-adopters of integrated rice–fish farming system who have similar observable characteristics. Our micro-econometric analysis is based on cross-sectional survey of 84 adopting and 148 non-adopting farm households from *Adivasi* Fisheries Project areas. The empirical data were collected at the end of the project in 2009. The outcome variables of our analysis for DHM include adoption of integrated rice–fish farming system and for PSM method outcome variables include annual household income, farm income, fish consumption quantity and frequency. The results of this paper provide valuable insights for other developing countries with similar agro-ecological, socioeconomic, and institutional settings for tackling extreme poverty and marginality situation.

The rest of this article is organized as follows: The next section briefly describes the review of relevant literature on integrated rice–fish farming system (IRFFS) in Bangladesh. The methodology section outlines the sampling, study area and data and econometric procedures of DHM and PSM methods. Subsequently, the results and discussion section provides and discusses the descriptive statistics and estimated results of the DHM and PSM methods. The last section summarizes the main findings, and draws some policy implications and outlook for future research.

2. Integrated rice–fish farming system in Bangladesh: a review

The agro-climatic and favorable resource conditions of Bangladesh are suitable for small-scale freshwater rural aquaculture (Ahmed et al., 2007b). The culture and consumption nature of fish also has important implications for fisheries and aquaculture development in Bangladesh (Belton et al., 2011). In Bangladesh, the total area under rice cultivation is about 8.0 million ha of which 2.834 million ha comprises inundated seasonal rice fields where water remains for 4–5 months. The carrying capacities of these lands and waters are not fully utilized, and there still exists potential scope for integrating aquaculture with agriculture (Ahmed and Garnet, 2011; DOF, 2010). ADB (Asian Development Bank) (2004) shows that about 280,000 ha of irrigated rice fields or 0.6% of the total irrigated land is suitable for rice–fish farming. Ahmed