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Impact of land fragmentation, farm size, land ownership and crop diversity on profit and efficiency of irrigated farms in India

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ABSTRACT

In this article, we analyze the impact of land fragmentation, farm size, land ownership and crop diversity on farm profit and efficiency of 90 groundwater irrigated farms in the hard rock areas of South India. As we hypothesize that these variables may impact both, farm profit and efficiency in alternative ways, we develop four different stochastic frontier and inefficiency effect models by shifting some of these variables from the inefficiency model into the profit function. The underlining reason is to know the impact of different combination of these structural variables on farm profit and efficiency. Our analysis shows that there exist high levels of inefficiency among the sample farms. Among the variables influencing efficiency, the most pronounced effects are observed with land fragmentation, land ownership and crop diversity. Land fragmentation is positively and significantly associated with inefficiency, whereas land ownership and crop diversity is negatively and significantly associated with inefficiency. In addition land fragmentation can also have a significant negative effect on farm profit. We further find that smaller farms appear to have lower inefficiencies than larger farms due to the more efficient use of inputs by the former category. Importantly, when a farmer owns a failed well, this also contributes to the inefficiency, since well failure increases cost of irrigation. Further the average profit efficiencies are higher for unfragmented farms, large farms, owner operated farms and farms with a diversified cropping pattern as compared with their counterparts. Knowledge on the factors influencing farm profit and efficiency is crucial for policy makers and extension agents for improving efficiency levels of the groundwater irrigated farms especially in water scarce regions of the country.

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Introduction

In agrarian economies, land reforms, especially land redistribution can play a pivotal role in reducing poverty and land inequity and India is no exception to this. The country's land redistribution policy has to some extent been successful in reducing the poverty and land inequity (Jha et al., 2005; Mearns, 1999). Overtime, in the process of land reform, there has been an increase in land fragmentation, a decrease in farm size, an increase in land degradation and redistribution of resource ownership (Jha et al., 2005; Mearns, 1999; Niroula and Thapa, 2005, 2007; Rahman and Rahman, 2008).

The seminal work of Schultz's on efficient peasants states that peasants in poor countries maximize returns from their input use since they are rational decision makers (Schultz, 1964). After this work, several scholars have researched on the impacts of land fragmentation and farm size on efficiency. Literature argues for three main factors for boosting up land fragmentation in India. These are law of inheritance of paternal property, absence of a progressive tax on inherited land and underdeveloped land market (Ghatak and Roy, 2007; Niroula and Thapa, 2005). As a consequence the country is inter alia experiencing a decline in farm size and an increase in the number of operational holdings. For instance, the agricultural land per capita declined from 0.41 ha in 1980 to 0.31 ha in 2009 (FAO, 2012). Between 1990–91 and 2000–01, the number of operational holdings increased from 106.64 million to 119.93 million, while the operational farm size has reduced from 1.57 ha to 1.33 ha (Government of India, 2010). This is the opposite from the trend in East Asian countries like Japan and South-Korea. In these countries the farm size is getting larger and the number of operational holdings are reduced. In these countries, a gradual shift of labor force from agriculture to non-agricultural sectors is experienced due to the availability of relatively attractive income opportunities outside

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the agricultural sector. This has resulted in land consolidation and encouraged commercialization, which has helped the farms towards more efficient utilization of labor and other inputs, thereby improving the farm efficiency (Niroula and Thapa, 2005). In contrast, in India, land fragmentation has discouraged commercialization, thus promoting inefficiency in agricultural production (Jha et al., 2005; Parikh and Nagarajan, 2004). Some of the contributing factors to inefficiency are: sub-optimal application of farm inputs, excess traveling time, loss of productive land due to bunding or hedging, difficulties in use of modern technology as well as problems with monitoring (Jha et al., 2005; Parikh and Nagarajan, 2004).

Land fragmentation could drive farmers towards intensive agricultural practices such as continuous farming and monocropping, resulting in deterioration of land quality. This increases production cost and lowers land productivity (McPherson, 1982; Ram et al., 1999). Land fragmentation might, however, also drive towards crop diversification, which may act as a risk reducing strategy especially in the areas suffering from labor scarcity, natural disasters and successive droughts (Niroula and Thapa, 2005; Tan et al., 2006). In addition diversification can contribute to improvements in soil fertility, if crops with different nutrient requirements use soil resources more optimally. Farmers also apply fertilizers differently to different crops and ultimately some sort of balanced application of fertilizer is ensured (Hazra, 2000).

Identifying options for improving efficiency of irrigated farms has become a challenging task for the policy makers and researchers. It is reported that, for example, the inefficiency of water use in agricultural sector is to the extent of 60–70% in India, indicating tremendous potential for increasing water use efficiency (Palanisami, 2009). In a densely populated country like India, the scope of increasing agricultural production by increasing total farm land and water use is costly and almost reached saturation and hence the most likely option here to meet the country's food requirement is to increase productivity by increasing efficiency. While most literature on efficiency analyzes the impact of land fragmentation, farm size, and land ownership on farm efficiency for a single crop (Bardhan, 1973; Lau and Yotopoulos, 1971; Ali and Flinn, 1989; Coelli et al., 2002; Rahman, 2003; Rahman and Rahman, 2008; Alam et al., 2011), this should be extended to multiple crops. In reality farmers grow one or more crops during a year or within a season depending on their available resources. They do not decide about resource allocation considering the profit from a single crop, rather they think about the whole farm and allocate their resources accordingly. This is widely discussed in literature about dynamic modeling of farm allocation decisions (Dogliotti et al., 2003; Miranowski and Orazem, 1994; Hopper, 1965). There are also studies on impacts of land fragmentation or land ownership or farm size or crop diversification on productivity or efficiency, but to our best knowledge there are no studies considering all these aspects together in a single region in a general way and particularly in India. In addition, there are no reported studies in India similar to our approach (profit frontier and inefficiency effect model) for analyzing the above mentioned issues. In this paper, we particularly focus on the impact of land fragmentation, farm size, land ownership and crop diversity on farm profit and efficiency, using farm level survey data from 90 groundwater irrigated farms in India. Four different stochastic Cobb–Douglas profit frontier and inefficiency effect models are developed, which is explained in detail in the next section. The remainder of the paper is organized in three sections: Section "Research methodology" describes the study region and data collection followed by the methodology of the stochastic profit frontier approach. Section "Results and discussion" provides research findings and analysis of those findings and the final section "Concluding remarks" offers conclusions and policy implications.

Research methodology

The study area and data collection

The present study was undertaken in one of the taluks[1] of the Eastern Dry Zone (EDZ) of Karnataka, which lies in the hard rock region of south India. The EDZ is a semi-arid region, characterized by insufficient rainfall (784 mm), lack of water recharge and lack of access to perennial rivers (Chandrakanth et al., 2004; Government of Karnataka, 2006). In this zone, groundwater supplies more than 90% of the total irrigated land. Overtime, effects of overdraft has led to well failure, decline in water tables and decline in groundwater outputs, thus constraining agriculture. Despite improvements in groundwater extraction and use of new technologies (Manjunatha et al., 2011), water scarcity is exacerbated by population growth and growing effective demand for groundwater intensive agricultural production. As a result of water overdraft, the region is declared as an over-exploited zone by the department of mines and geology, meaning that the extraction of groundwater exceeds more than 85% of recharge (Government of Karnataka, 2006).

Using multistage sampling techniques, primary data needed for the study were collected from 90 groundwater irrigated farms belonging to 10 villages of Malur taluk for the agricultural year 2007–08. The villages where water scarcity was most severe were purposively selected and this was done considering the secondary data on water availability from the Karnataka state water resources department as well as upon consultation with water resource experts. The total geographical area of the taluk is 645 km^2 with a population of 0.207 million. For their livelihood the residents here mainly rely on agriculture and wage employment (Government of Karnataka, 2006). Groundwater is the major source of irrigation in the taluk contributing approximately 99% (17,956 ha) to the total irrigated area (Government of Karnataka, 2006). In the study region, vegetable production dominates over cereals and other food crops. The main agricultural products of the region are tomato, potato, beetroot, carrot, beans, cauliflower, banana, flowers, etc. The vegetables produced are mainly sold at the local market. The remaining vegetables are supplied to the Bangalore city, which is only 46 km away from the region. Informal groundwater markets emerged in the region because of the low groundwater table, high initial investments necessary to construct bore wells and the high risk of well failure (Manjunatha et al., 2011).

Land fragmentation is a severe problem in the Malur taluk. For instance the number of operational holdings has increased from 38,627 in 2000–01 to 43,047 in 2005–06, while the per-capita operational holdings decreased from 1.15 ha to 1.07 ha during the same period (Government of India, 2012). Also, the region is experiencing soil degradation due to the intensive cropping activity (high value agriculture) throughout the year (personal communication). Unfortunately, there are no reported estimates for the degraded land as such, but some researchers have used proxies such as reduction in agricultural land and increase in waste land over the years to indicate the severity of degradation. The region experienced an increase of waste land to the total land from 27.88% in 1998 to 38.42% in 2002 as well as a decrease in usable agricultural land from 40.95 to 22.56% during the same period (Ramachandra and Uttam Kumar, 2004).

Considering the complexity of the interlinked issues and the competition for limited resources, especially land and water, the selected study region was regarded suitable to analyze the issue of land fragmentation, farm size, land ownership and crop diversification. Using a structured and pre-tested questionnaire, detailed

[1] A taluk is an administrative unit in India. A taluk consists of several villages.

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