Impact of the Targeted Extension Program on Rice Productivity in Tamil Nadu, India

Parijat Ghosh[1], Suresh Babu[2], Deepayan Debnath[3] and Khyam Paneru[4*]

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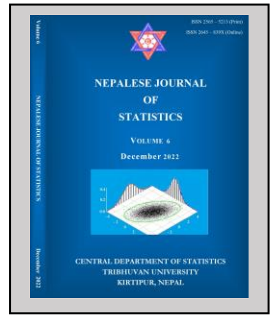

ABSTRACT

Background: Based on a randomized experiment by treating one group of farmers with an extension package and the other group as usual in Thanjavur district of Tamil Nadu, India, we examined the impact of the targeted extension package on farmers' rice yield.

Objective: The objective of the study was to investigate whether the chosen targeted extension package would significantly increase farmers' rice yields or not.

Materials and Methods: We estimated a multiple linear regression model to determine the effect of several independent variables, including plot size, amount of money borrowed, and farmers' income on the rice yield.

Results: We found that the rice yield among the farmers who received the extension package had increased compared to the group of farmers with no extension support. The regression coefficient of extension (1 = yes, 0 = no) is statistically significant (p-value = 0.063) at a 10% level of significance.

Conclusion: Assessing the impact of the targeted extension package on the farmers is important in utilizing good agricultural practices to increase rice productivity. We concluded that a targeted extension program is crucial for increasing rice yield among rural farmers in Southern India.

Keywords: Farm income, randomized control trial, rice yield, southern India, targeted extension.

Address correspondence to the authors: Family and Community Medicine, School of Medicine, University of Missouri – Columbia, Missouri, USA. Email: phool.ghosh@gmail.com[1]; Development Strategy and Governance (DSGD), International Food Policy Research Institute, Washington, DC, USA. Email: S.BABU@cgiar.org[2]; Food and Agricultural Policy Research Institute, University of Missouri – Columbia, Missouri, USA.
Email: deepayan.debnath@gmail.com[3]; The University of Tampa, Florida, USA.
Email: kpaneru@ut.edu[4*] (Corresponding author email)

INTRODUCTION

The World Development Report 2007 (World Bank, 2007) identified extension services as an important intervention for economic development and growth in the agricultural sector. Agricultural extension is crucial in improving farmers' knowledge (Maertens, Michelson & Nourani, 2021; Davis, 2009; Anderson & Feder, 2007). While adaption to new and improved technology leads to increasing yield, farmers need proper guidance and training through agricultural extension to utilize those technologies. Sharing information among farmers and educating them to use the technology properly, extension programs enhance the skills and human knowledge by meeting two broader goals: increase in agricultural production and adoption of sustainable management practices (Glendenning, Babu & Asenso-Okyere, 2010; Glaeser, Laibson & Sacerdote, 2002). Once farmers are exposed to improved technology, they should learn how to use it appropriately. To access the information and apply the knowledge correctly, farmers must have access to capital and other resources (Adhiguru, Birthal & Kumar, 2009). Therefore, supporting and promoting cost-effective agricultural extension is very important to increase the know-how of the farmers, which can ultimately lead to increasing crop productivity (Maertens, Michelson & Nourani, 2021).

Several methodological and data-related challenges have been reported in assessing the impact of extension programs on yield improvements. The productivity of farmers is highly driven by knowledge and reliable information provided through timely extension programs. At the same time, farmers are also influenced by other sources of knowledge, making it difficult to estimate the extension programs' contribution to farmers' productivity. Agriculture extension programs help farmers to obtain relevant information and knowledge to improve their livelihoods (Glendenning, Babu & Asenso-Okyere, 2010; Birner et al., 2009; Davis, 2009). However, it also found that accessing such information alone did not significantly change the production process due to the lack of knowledge to use the information correctly in farming activities (Conley & Udry, 2010). Mittal and Mehar (2016) showed that demographic factors such as age, education, and farm size influence farmers' behavior in adopting different agriculture-related information sources in India. Suvedi, Ghimire and Kaplowitz (2017) found that many socio-economics variables induced the participation rates in extension programs. Thus, delineating the impact of extension programs on yield improvements continues to be methodological and data-oriented.

The modern agricultural extension program in India began with loans from the World Bank in the 1970s and was limited to only training and visit types of extension until the 1990s (Ferroni & Zhou, 2012; Feder & Slade, 1986). However, more recently, it has become "pluralistic" (co-existence of private and public extension systems to facilitate learning and interaction) in nature (Ferroni & Zhou, 2012; Birner & Anderson, 2007; Christoplos & Kidd, 2000). These pluralistic approaches are cost-effective as they engage farmers in hands-on training programs (Anderson, 2007). These pluralistic extension services are offered by multiple (both public and private) agencies and are meant to provide access to various services and information as and when needed by farmers; therefore, each approach is contextual. As it is context-based, the services provided by the extension agents meet specific producer’s needs and offer the flexibility required to help the farmers (Raabe, 2008). For example, "Farmers-based extension organizations" provide available and used information in the context of the participants and the institution (Rajalahti, Janssen & Pehu, 2008). Although policy interventions like India's National Food Security Act can encourage farmers to produce more food to reduce hunger and poverty (Debnath, Babu, Ghosh & Helmar, 2018), investments in extension system development have been sub-optimal. The role of extension investments in improving agricultural development, productivity, and management of the resources has been well recognized in India for some time (Ferroni & Zhou 2012; Singh, 1999). However, the effectiveness of the agricultural extension depends on the range of extension models employed (Anderson & Feder, 2007; Maertens, Michelson & Nourani, 2021).

For years, developing countries, including India, did not pay much attention to extension and agriculture in an integrated policy framework (World Bank, 2008). Although extension services became available to both small- and large-scale farmers, it disproportionately affects the farmer's productivity (Ferroni & Zhou, 2012). Since extension services are not delivered directly but through agents who often face challenges in motivating and imparting knowledge to the farmers, their performances vary depending on the farmer's ability to learn (Anderson, 2007). As such, agricultural extension outcomes differ significantly from one region to another as diverse farming systems are spatial in nature, even within the country. In India, increasing population, water scarcity, reduced land area, and declining soil fertility remain the main threats towards maintaining current rice yields. However, growing technological innovations and various crop management systems have substantially offset the effects of these factors on rice yield. Despite existing efforts, there remains a wide gap in rice yield between large-scale and smaller subsistence farmers. Interventions in the form of targeted extension services to small and marginal-sized farm holders can help bridge this gap by increasing the productivity of rice in rural parts of India. Studies assessing the impacts of targeted extension services on crop yields are limited. While targeted extension services can contribute substantially to enhancing agricultural productivity by providing relevant, timely, and accurate information to the farmers (Mittal, Padmaja & Ajay, 2018; Lukuyu, Place, Franzel & Kiptot, 2012; Hailemichael & Haug, 2020), quantifying such impact is challenging and varies greatly across regions and commodities. In India, the agriculture sector, including rice production, is becoming increasingly knowledge-intensive, which relies heavily on targeted extension programs for further increases in yield levels (Babu, 2017). However, to our knowledge, previous studies did not determine the effect of extension programs on rice production in southern India.

In this study, we determine the impact of targeted extension services on rice yield in the Thanjavur district of Tamil Nadu, India. We develop and analyze a farm-level survey corresponding to the randomized control trial experiment comprising a structured response of 322 farmers in 64 villages in the Thanjavur district. Additionally, we examine the role played by extension services given to randomly selected farmers to increase their rice productivity. We tested whether the chosen extension package would significantly increase farmers' rice yields. The study consists of two groups of farmers: the 'control' group who did not receive the extension training and the 'treatment' group who received the training. This allows comparing the 'treatment' group's outcome with the 'control' group to determine the impact of the extension package on rice yield.

METHODOLOGY

Study design

India is one of the major producers, consumers, and exporters of rice. Since 1995, with the trade liberalization under the Uruguay Round Agreement on Agriculture, there has been a notable change in the rice trade in the international market; India has played a significant role as a major contributor (Debnath et al, 2018). In almost all states in India, rice is grown. However, it is concentrated mostly in the river valleys, the lowlands of coastal areas, and the Deltas of the Northeastern and Southern parts of India. Rice plays a significant role in addressing food insecurity in Tamil Nadu. Rice is a kharif crop that is sown at the beginning of the monsoon and harvested from September through October. In 2018-19, Tamil Nadu produced 6.13 million MT of rice in an area of 1.72 million hectares, and it continues to be the main growing crop there, with the production increase to 7.5 million MT in 2020-2021 in an area of 1.88 million hectares, which comprises 50% of the total irrigated land (Government of Tamil Nadu, 2020). The study area comprises rice farmers in Tamil Nadu, India. The study focuses on the rice productivity Thanjavur district. Thanjavur lies on the east coast of Southern India and is commonly known as the "Rice bowl of Tamil Nadu." Thanjavur district is located in the delta of the Kaveri river, with a population of 2.5 million. The deltaic region extends to the northern and eastern portions of the Kaveri river, thus the primary irrigation source. While the non-irrigated area or the upland area comprises the southern and the western region of the Thanjavur district, it received 1053 mm annual rainfall between 1970-2000; precipitation projections indicate a general decrease of 3.0% in the 2020s. The study region compromises the irrigated and non-irrigated areas as the district is in the deltaic plain. The most important season for rice in the Thanjavur district is the Samba season, with planting starting in August.

Survey sampling and data

The targeted population of the study was all farmers who cultivated rice in the Thanjavur district of Tamil Nadu, India, during the Samba season in 2011/12 crop year. The paddy cultivation season in August in Tamil Nadu is known as the Samba season. The survey was conducted from September 2011 until the end of February 2012. The survey includes socio-demographic and economic information, including credit and extension services expected to impact the rice yield. The survey was conducted in all the 64 villages in the Thanjavur district during the samba season, the most crucial season for rice production in the Thanjavur district. The survey covered randomly chosen 322 farmers. Even though this survey was done a few years back, the results were still novel and have never been used in any other studies. We also believe that farmers' behavior toward the extension activities would have been the same if it had been done in the current year, and the rice yield outcome would not be any different. The survey was prepared in the local Tamil language and distributed among those farmers. In addition to handouts, farmers were advised through targeted field visits with operation-specific and crop stage-specific knowledge sharing, village training, and mobile connectivity. Farmers were further frequently monitored on their adoption of the targeted extension packages. The survey questionnaires collect information on land use, land ownership, input use, including fertilizers and supplements application rates, rice production, extension services provided, credit borrowed by the farmers, agriculture equipment used, soil quality, as well as farmers' needs, assets, access to infrastructure and services. The sample comprised small landholder and marginal-scale farmers who had no exposure to agriculture extension activities earlier to increase their rice productivity. Villages (village or town is recognized as the primary area of habitation) were grouped under eight clusters. Each cluster consisted of five to seven villages, and four supervisors were allocated to eight villages under each cluster. The intervention using extension services was designed for the randomly selected farmers to determine whether that would increase their rice productivity. Our research is carried out on a randomized control trial with rice growers to test if the chosen targeted extension package significantly increases their rice yield and the net income of the farmers. We also have a group of farmers called the 'control,' who did not get extension support. We compare the treatment group with 'control' group to determine whether the extension package would increase the rice production or not.

RESULTS

We consider the input variables: extension service, walking distance, plot size, amount of money borrowed, farmers' income, and farmer's age to study their impact on rice yield. The unit of measurements and descriptive statistics of each of these variables are reported in Table 1. Although the study is based on 322 farmers, the sample size presented in Table 2 for some variables is less than 322 due to missing information. We use a t-test to determine the significance of a difference in average rice yields between the two groups of farmers. The test statistic, p-value, and confidence interval for the statistical inferences are presented in Table 2. Description and unit of measurement of each variable in Table 1 and Table 2 are given below.

Yield per Acre:	Total yield per acre in kilograms
Plot Size:	Size of the plot in acres
Distance:	Walking distance to the plot in minutes
Amount Borrowed:	Amount borrowed per acre in Indian Rupees
Income:	Household income in Indian Rupees

Table 1. Descriptive statistics.

Variable	n	Mean	SD	Minimum	Median	Maximum
Yield per Acre	309	2432.48	2378.32	300.00	1800.00	24000.00
Plot Size	319	4.09	4.59	0.50	3.00	47.00
Distance	319	17.43	11.60	2.00	15.00	60.00
Amount Borrowed	208	8792.10	6089.70	347.83	7500.00	10000.00
Income	319	73821.32	117834.24	10000.00	40000.00	1000000.00
Age	322	49.15	10.09	18.00	48.00	98.00

The standard deviations of total yield per acre, income, and borrowed amount suggest significant variability. Although we do not present data graphically, the data is highly skewed for these three variables. The average rice yield per acre for all the farmers is 2,432.5 kilograms. While the farmers' average income is Rs.7,3821, there is a considerable disparity in the annual income, where the lowest income is Rs. 10,000, and the highest income is Rs. 1,000,000. However, such an income gap may depend on different factors such as land availability and other sources of income. A similar gap is seen in the amount borrowed. Farmers have borrowed Rs. 348 to Rs. 10,000 with an average of Rs. 6,090 per acre during the rice-growing season. We conducted Mann Whitney U-test to compare the two groups of farmers; test statistic values and corresponding p-values are given in Table 2. Farmers who received extension services have lower incomes than those who did not receive extension services. The average age of the farmers who receive the extension services is higher than those who did not receive extension services. As shown in Table 2, there is no significant difference between the two groups of farmers for the remaining variables: plot size, walking distance to the plot, and amount borrowed.

Impact analysis

We estimate the effect of several independent variables on the yield by estimating a linear regression model. Considering that the rice yield is highly skewed, we transform it into the logarithmic form to smoothen the skewness in the data. We also transformed two independent variables into the logarithmic form: Farmer's income and amount borrowed. The regression model with the village fixed effect is

$$\ln Y_{ij} = \alpha_j + \beta_1 E_{ij} + \beta_2 D_{ij} + \beta_3 A_{ij} + \beta_4 \ln AB_{ij} + \beta_5 \ln IN_{ij} + \beta_6 AG_{ij} + \varepsilon_{ij}. \quad (1)$$

The intercept term α_j for the j^{th} village indicates that the model uses the village-level fixed effect.

Table 2. Mann Whitney U-test for the comparison of two groups of farmers.

Variables	Extension		No Extension		Test Statistic U	p-value
	n	Mean (SD)	n	Mean (SD)		
Yield per Acre	243	2522.72 (2553.69)	66	2100.21 (1542.96)	8760.5	0.119
Area	253	4.24 (4.83)	66	3.549 (3.49)	9157.5	0.1105
Distance	253	16.99 (11.06)	66	19.12 (13.43)	7830.5	0.213
Amount Borrowed	168	8954.15 (6394.49)	40	8111.50 (4599.30)	3448.5	0.396
Income	253	79162.06 (123969.18)	66	53348.48 (88378.12)	10306	0.002***
Age	253	49.62 (10.31)	66	47.43 (9.09)	9683	0.081*

* and *** are statistically significant at 10% and 1% levels, respectively.

Table 3. Variable description used in model (1).

Variable description used in the regression model (1)
Y_{ij}: yields per acre (kilogram) for the i^{th} farmer in j^{th} village
E_{ij}: extension services provided (1= Yes and 0 =No) for the i^{th} farmer in the j^{th} village
D_{ij}: walking distance (minutes) from the i^{th} farmer's home to the plot in the j^{th} village
A_{ij}: area: plot size (acres) for the i^{th} farmer in j^{th} village
AB_{ij}: the amount borrowed (Indian Rupees) per acre by the i^{th} farmer in the j^{th} village
IN_{ij}: income of i^{th} farmer in the j^{th} village
AG_{ij}: age of the i^{th} farmer in the j^{th} village (age of the household head)
ε_{ij}: error term for the i^{th} farmer in the j^{th} village

Table 4. Impact of extension service, socioeconomic characteristics of the farmers on the rice yield (Dependent variable: log yield).

Explanatory Variables	Coefficient	Standard Error	p-value
Extension (0 = No, 1 = Yes)	0.203*	0.108	0.063
Distance	-0.010*	0.003	0.002
Area of plot	-0.012	0.012	0.301
Log (Amount borrowed per acre)	-0.229*	0.070	0.002
Log (Income)	-0.029	0.048	0.535
Age of the farmer	0.0007	0.004	0.858
Village fixed effect: Yes Sample size: 199 R-squared: 44.94%			

* and ** statistically significant at 10% and 5% levels, respectively.

Regression coefficients, standard error of each coefficient, and corresponding p-value are listed in Table 4. We considered 199 farmers' data with complete information for all the variables in the regression analysis. We find that the impact of farmers walking long distances from their house to the field has a significant negative effect on rice yield. It means that the lower the walking distance (in minutes) from the farmers' home to the field, the higher the yield. This can be interpreted as diminishing farmers' productivity in terms of walking to their corresponding fields. The field size and rice yield are positively related as an indicator of the economics of scale. On the contrary, we find a negative impact of credit on yield. The reason behind the negative impact of credit on yield can be well explained by the fact that farmers who received money for agricultural purposes to increase their rice yield did not use the whole amount received for agricultural purposes, and many farmers may not use the money received at all for agricultural production. It can be argued that those farmers used the money received for their personal needs than using it for farming. The impact of extension service (farmers with extension service and farmers with no extension service) on the rice yield. We find a positive co-efficient in the extension group (0.203), which indicates that farmers with targeted extension services are more likely to increase rice yield. Hence, we concluded that extension services have significantly increased the rice yield among the participating farmers. However, we find that some independent variables do not significantly impact the yield.

Model diagnostics

We used the variance inflation factor (VIF) and tolerance to test the multicollinearity in the fitted model. Generally, tolerance < 0.1 and VIF > 5 might indicate multicollinearity. As shown in Table 5, tolerances are greater than 0.1, and all VIFs are less than 5. It indicates that the model does have an issue with multicollinearity. Similarly, the residuals vs. fitted values plot in Fig. 1 supports the model assumptions. However, it shows that some influential observations may exist, as presented in Fig. 2. After removing those few influential observations, we see only a small (insignificant) change in the regression parameters. So we presented the regression results without removing those influential observations.

Table 5. Tolerance and VIF to test multicollinearity in fitted model.

Variables	Tolerance	VIF
Extension	0.550	1.820
Distance	0.727	1.376
Area of plot	0.384	2.607
Log (Amount borrowed per acre)	0.357	2.800
Log (Income)	0.501	1.996
Age of the farmer	0.615	1.627

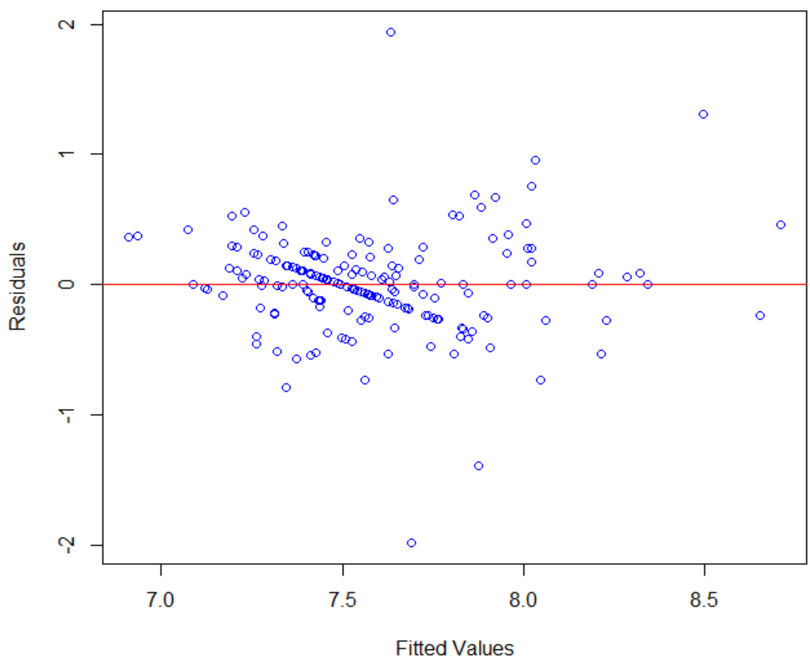

Fig. 1. Plot of residuals vs. fitted values of the regression model.

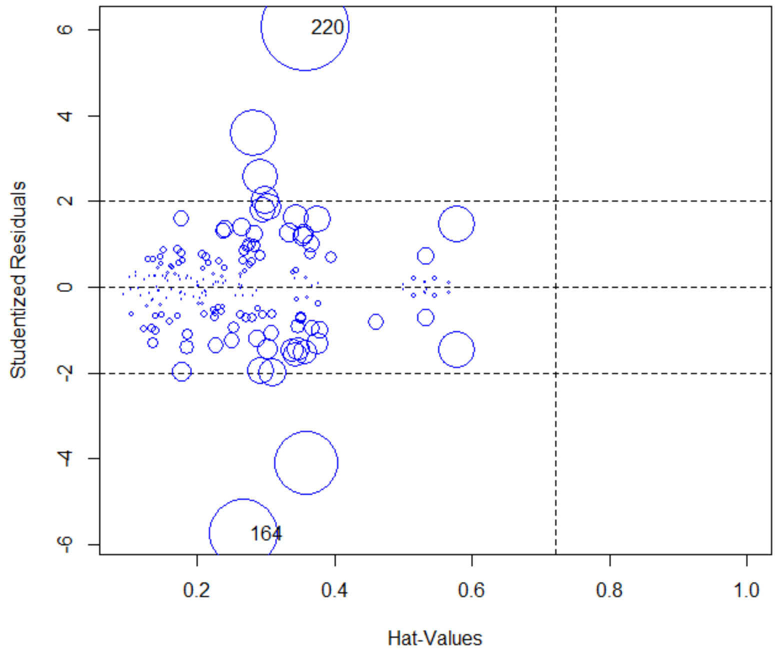

Fig. 2. Regression diagnostic plot for influential observations.

DISCUSSION

For a country like India with a growing population, it is important to craft policies that can significantly increase rice production to meet its food demand. While attempts have been made to improve the enabling environment for farmers through price policies and market reforms, it is equally important to focus on productivity and the production process. The information delivered to farmers to adopt new technologies would enhance production by increasing rice yield in the longer term. With the growing population and scarcity of land and water, it is becoming increasingly important for policymakers in India to not only look at different ways of encouraging farmers to increase rice yield but also to provide them with the necessary context-specific knowledge support needed to overcome constraints in the production process. Targeted intervention in the form of seed packages, credit, and time-specific extension services to the rice farmers in India can bring a positive change in the long run regarding increasing the rice yield. This paper sheds some light on the impacts of such targeted extension interventions, which, if implemented correctly, could substantially increase rice production among India's small and medium-scale farmers. India being a net exporter of rice, increasing rice productivity can help reduce its foreign exchange deficit. It will facilitate more public investment in rural development programs resulting in positive change in the quality of life of low-income rice-producing farmers.

It is generally agreed that targeting small and marginal rice-producing farmers in India is essential from both technological and policy perspectives. However, increased investments are needed to motivate and empower small landholding farmers to adopt new technology and sustainable management practices to increase the productivity of the agricultural sector. The results of this study provided evidence for this assertion.

CONCLUSION

Intervention in the form of targeted extension services to farmers is a way to encourage them to adopt new technologies and services to overcome constraints that can affect their crop production practices and yield. In this study, we evaluate the impacts of such extension services intervention on rice yield among 64 villages in Thanjavur district in Tamil Nadu, India, during samba season, a dominant rice-growing season. Rice farmers were randomly chosen from the villages and allocated into two groups – 1) group provided with extension and 2) with no extension. We find that there is an increase in yield in the group of farmers that received intervention in the form of extension services. The inherent strength of the data used in the study - yield was not calculated manually by researchers as is seen in other studies (Abate, Bernard, Brauw & Minot, 2018; Reynolds, Wulster-Radcliffe, Aaron & Davis, 2015), but we include this important rice yield variable in the survey questionnaire, thus limiting error in our calculations. Our findings support the existing literature that targeted time, and crop-specific extension education can significantly increase yield in developing countries (Abate, Bernard, Brauw & Minot, 2018; Glendenning, Babu & Asenso-Okyere, 2010).

The randomized control trial experiment used in this study illustrates the impact of extension and technology in the production of rice in Tamil Nadu. We find strong evidence for the hypothesis that targeted extension support will have a substantial impact on rice yield. In this study, we also compare the differences in rice yield among the treatment groups. The group of farmers who received extension service had higher rice production than 'control' farmers with no extension service. Credit borrowed by the farmers did make a significant difference, as this group of farmers who received the credit support may not use the money for agricultural purposes. It can be interpreted that the farmers spend the credit borrowed for agricultural activities on some other purposes rather than agriculture, making the effect of credit support negative on yield. The sample size used in this study is substantial for conducting such tests and convincing policymakers that encourage such interventions among small and marginal-size farmers in India. It can help them get better acquainted with new technologies and services that can make the farming practice sustainable while increasing rice yield.

Further research in this field is needed to address the effects of extension services interventions on the farming system in India. One drawback of the study is that the female farmer's participation is far less in numbers than their male counterparts. However, possible explanations for this difference can be that the male members are more likely to engage in farming than females in the households, or female farmers are less likely to be reached out by the extension agents. While the study is conducted in only one district of Tamil Nadu, such studies need to be conducted in multiple districts to demonstrate the changes in rice yield that can occur with the introduction of these types of interventions. This will make the results more robust.

CONFLICT OF INTEREST

The authors declared absence of conflict of interest.

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