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Research Article

Climate resilient production practices: Extent of adoption and barriers faced by rice farmers in Telangana state of India

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Abstract

Improving farm level adoption of climate resilient rice production practices is essential to enable farm families to improve their household food security. The present study was undertaken to analyze the farmers' awareness, adoption and barriers to adoption of selected climate resilient rice production practices. Primary data were collected from 120 farmers from six villages based on random sampling in Nalgonda district of Telangana State, India. Visual questionnaire (photo elicitation) was used to assess farmers' awareness and adoption of selected climate-resilient practices *viz.,* System of Rice Intensification (SRI), Direct Seeded Rice (DSR), Green Manuring, Integrated Nutrient Management (INM), Leaf Color Chart (LCC), drought tolerant rice varieties and crop diversification. The findings of the study indicated that 50 percent of the farmers were aware of SRI practice but none of them were adopting it, similarly, 20 per cent of the farmers were aware of integrated nutrient management but only less than two percent had adopted the practice. A very low percentage of farmers were aware of the use of LCC (13.5%), drought tolerant paddy varieties (8.2%) with equally low adoption of these practices. Shortage of labor to adopt SRI, non-availability of drum seeder, small farm size, non-availability of seeds of green manure crops, formation of soil cracks in SRI, non-availability of LCC and drought resistant paddy varieties were the foremost barriers reported by farmers. The physical barriers reported by farmers need to be addressed to enhance adoption of climate resilient rice production practices. Similarly, training programs are to be organized to enhance the adoption of knowledge and skill intensive practices like SRI, DSR and LCC to overcome the non-physical barriers for adoption of climate resilient rice production practices.

Keywords: Adoption, barriers, climate resilient rice production practices, visual questionnaire

1. Introduction

Climate Smart Agriculture (CSA) seeks to achieve food security and sustainable agricultural development under impact of climate change (FAO, 2013). CSA provides triple benefits of increased agricultural productivity and incomes, building of adaptation and resilience against climate change and reduction in green house gases emissions (FAO, 2014). For the successful adoption and diffusion of CSA technological innovations, an understanding of farmers' awareness, adoption and specific barriers to adoption, which will aid the design and implementation of interventions that can overcome barriers.

A farmer's decision whether or not to adopt a particular CSA practice is influenced by many factors. These factors include but are not limited to the farmer's awareness of the practice, the availability of information about the practice, the financial, social and educational status, the farmer's attitude for risk, and the farmer's concern for environmental issues. An understanding of these factors plays an important role in the adoption and dissemination of CSA practices (Liu *et al.,* 2018).

James *et al.* (2015) identified the barriers or factors that prevent adoption of CSA practices in Africa and classified them under two broad categories. The first relates to the physical means or resources required to practice CSA. These can be considered as the physical barriers like land, human resources, equipment, infrastructure and finances. The second, referred to as the non-physical, relate to the institutional, cultural, policy and regulatory environments; information, knowledge and skills; technologies and innovations; and governance among others.

The adoption of climate- resilient practices by farmers may be influenced by a number of social, cultural, behavioral and financial factors. The implementation of certain practices may entail substantial financial cost which may be a deterrent to their adoption by farmers (Rochecouste *et al.*, 2015). Farmers' personal experience with climate change may also impact the adoption of climate-resilient agricultural practices (Niles *et al.,* 2016). According to the "Psychological Distance Theory" (Liberman *et al.*, 2007), the events perceived to be spatially, temporally or socially close or have a certainty of occurrence may greatly influence decisions of individuals (Spence *et al.*, 2012). Perceived financial benefits may be one of the most important drivers in the adoption of new agricultural and mitigation practices (Rochecouste *et al.,* 2015*)*. High adoption costs at the farm level, may act as a barrier for some farmers. Access to information and education form important factors in promoting awareness and adoption of climate-resilient measures in agriculture (Baumgart-Getz *et al.*, 2012).

Although, literature is available concerning the factors that affect the adoption of innovative practices and technologies in agriculture in developing countries (Cullen *et al.*, 2013; Eidt *et al.*, 2012), studies on factors affecting adoption of climate resilient rice production practices are limited. Therefore, this paper seeks to study the farmers' awareness, and adoption of climate resilient rice production practices and to identify barriers that prevent the successful adoption of climate-resilient rice production practices and also to enable the researchers and extension personnel to address these issues to help farmers overcome adverse impacts of climate change.

2. Materials and methods

The present study was undertaken during June, 2018 to analyze the farmers' awareness and adoption of selected climate resilient rice production technologies, and to elicit the barriers to adoption is required of these technologies. Data were collected from 120 farmers from six villages based on simple random sampling in Nalgonda district of Telangana State, India. One *Mandal* (an administrative unit under district comprising of several villages) was selected randomly for the study.

Visual methodologies including photography, film, video, painting, drawing and collage maybe used to collect data from respondents (Barbour, 2014). Photo elicitation is a technique used to generate verbal discussion and involves the use of visual images to record the responses based on visuals used (Thomas, 2009; Bigante, 2010) to create data and knowledge. Visual questionnaire was used to assess farmers' awareness and adoption of selected climate-resilient practices *viz.,* System of Rice Intensification (SRI), Direct Seeded Rice, Green Manuring ,Integrated Nutrient Management (INM), Leaf Color Chart (LCC), drought tolerant rice varieties, drought tolerant varieties of other crops and crop diversification. Barriers to adoption of these climate resilient practices were also elicited from farmers. An open-ended structured interview schedule was used to collect data from farmers and Focused Group Discussions (FGDs) were carried out to obtain relevant information. Data from the study were analyzed using descriptive statistics, frequency and percentage.

2.1. Climate resilient practices and interventions

Under the present study selected climate resilient practices and interventions for rice cultivation were identified and data was collected from farmers on the awareness and adoption of these selected interventions in rice cultivation (Table 1). A brief description of each practice was outlined along with the pictorial depiction/ photograph of the practice/intervention as shown in Table 1.

Yadav *et al.* (2015) opine, that the adoption of climate resilient rice production practices can improve yield potential of rice especially in rice growing areas facing water scarcity. The International Rice Research Institute (IRRI) has developed drought-tolerant varieties *viz., Sahbhagi Dhan* in India, *Sahod Ulan* in the Philippines, and *Sookha Dhan* varieties in Nepal which are being adopted by farmers (IRRI, 2019). The average yield advantage of drought-tolerant varieties over drought-susceptible ones is 0.8-1.2 tons per hectare under drought. Alternate wetting and drying (AWD), Direct Seeded Rice (DSR) and aerobic rice are being promoted as water saving practices in rice cultivation.

Detailed below are selected climate resilient rice production practices included in the study to analyze

Table 1: Climate resilient practices and interventions for rice cultivation.

Climate resilient practices and interventions for rice cultivation	
System of Rice Intensification(SRI)	7- to 10-days-old seedlings are transplanted at 20 cm spacing with 1–2 seedlings per hill
Direct-Seeded Rice (DSR)	Dry seeds are sown either by broadcasting or drilling in line
Green manure crops	Cultivation of legumes in a cropping system. This practice improves nitrogen economy and soil health/quality
Integrated Nutrient Management(INM)	Integrated use of organic and chemical fertilizers to partially (25 percent to 50 percent) reduce NPK requirements without affecting productivity and improve soil health
Leaf Color Chart(LCC)	Standardized color charts are used to identify nutrient deficiency to estimate fertilizer doses in different field locations
Crop insurance	Crop-specific insurance to compensate income loss due to vagaries of weather
Weather advisories	Information and communication technology–based forecasting about the weather.
Drought-tolerant varieties	Varieties those are tolerant to drought or dry weather conditions.
Crop diversification	Use of other crops on part of the land along with rice to economize on water use

Taneja *et al.* (2014.)

Table 2: Classification of practices and interventions for rice cultivation based on CSA categories.

Practice	CSA category	Adaptation/mitigation potential
System of Rice Intensification (SRI) Direct Seeded Rice (DSR)	Water smart	Practices that improve water use efficiency
Integrated Nutrient Management (INM) Leaf Color Chart(LCC) Green Manuring	Nutrient smart	Practices that improve nutrient use efficiency
Crop insurance Weather forecast	Weather smart	Interventions that provide income security and weather advisory services to farmers
Drought tolerant rice varieties Drought tolerant varieties of other crops Crop diversification	Knowledge smart	Use of science and local knowledge

Chhetri.*et al.* (2017).

the awareness, adoption and barriers to adoption of these practices.

2.1.1. SRI as climate-resilient practice

The aim of SRI is to lessen the water requirement of rice production, improve yields and increase farmers' income. The crop grown under SRI is more resilient under extreme weather events including, pests and diseases. The farmers were motivated to adopt SRI as it creates a triple-win situation for agriculture, climate security, and food security. The three benefits of SRI are: it sustainably increases rice production and farmer incomes, strengthens crops' resilience to climate change and variability and the SRI principle of keeping fields moist without flooding promotes mitigation of climate change. Economic evaluations revealed that SRI is more profitable and thus farmers can be motivated to adopt it as climate-resilient practice (Rama Rao, 2011; Dill *et al.*, 2013). The successful implementation of SRI depends on labor as it is mostly knowledge and skill based. SRI qualifies as climate-smart practice as it enables farmers to adapt their operations to various stresses of climate change and reduces the effect of global warming on rice cultivation (Thakur and Uphoff, 2017). SRI is one of the best options for increasing the production value per drop of water and for reducing agricultural water demand for rice cultivation (World Bank Institute, 2008). The need for higher labor inputs for SRI have been reported by Ly *et al.* (2012).

2.1.2. Drum seeding of rice

A drum seeder is an easy to use manual technology wherein pre-germinated paddy seeds are directly sown without growing a nursery and it helps in saving seed, water and labor requirement. There is an increase in productivity because of line sowing (spacing of 20 cm between rows) and early maturity of crop (by 7-10 days). This technique is being promoted as a contingency plan during delayed rainfall as direct sowing of rice is possible using irrigation water or immediately after receipt of the delayed monsoon rains (Prasad *et al.*, 2014). The drum seeder increases farmers' resilience against climate change as they can have more flexibility in their choice of planting time. In case of a natural disaster causing the loss of just planted rice, farmers can easily resow rice with drum seeder in a short time (FAO, 2018).

2.1.3.Drought tolerant paddy cultivars

The promotion of stress tolerant paddy varieties of shorter duration suitable for both transplanting and direct sowing is the need of the hour. Short duration and drought tolerant varieties are suitable for all types of farming situations but the yields of short duration varieties are slightly lower compared to long duration varieties. However, short duration varieties provide a significant yield advantage in drought years over the traditional long duration varieties (Prasad *et al.*, 2014). Drought-tolerant rice varieties have been developed by IRRI and have been released in several countries which includes *Sahbhagi Dhan* in India. These varieties provide an average yield advantage of 0.8-1.2 tons per hectare under drought over drought-susceptible ones Growing different varieties of rice with different traits helps to stabilize total crop output and reduce risk (Selvaraj *et al.*, 2010).

3. Results and discussion

3.1. Awareness and adoption of climate-resilient rice production practices

Visual questionnaire was used to assess farmers' awareness and adoption of selected climate-resilient practices *viz.,* SRI, DSR, INM, LCC, Green Manuring, drought tolerant rice varieties, drought tolerant varieties of other crops and crop diversification from farmers of six villages in Nalgonda district. Awareness of a particular climate resilient practice is considered as a pre-requisite to its adoption and in the present study high awareness of a practice did not result in to high adoption of the practices (Fig. 1). In the present study, nearly 50 per cent of the farmers were aware of SRI practice but none of them were adopting it. Similarly, 20 per cent of the farmers were aware of integrated nutrient management but less than two percent had adopted the practice. A very low percentage of farmers were aware of the climate resilient practices like direct sown rice with drum seeder (6.4%), and less than one percent of them had adopted it. Similarly 13.5% farmers were aware about use of LCC and about 10 per cent adopted it. In case crop insurance, awareness about drought resistant paddy varieties and drought tolerant varieties of other crop, the percentage of awareness and adoption was 70 to 61%, 8.2 to 0.00% and 37.3 to 25% respectively However, all the farmers were aware of and adopting crop diversification an important component of CSA.

3.2. Barriers to adoption of climate resilient practices

Barriers to adoption can be defined as factors, impediments or obstacles that may reduce the effectiveness of the farmers' adoption strategies and (Antwi-Agyei *et al.*, 2013) opine that the barriers interact at different levels to influence the adoption process. Barrier analysis as a rapid assessment tool was utilized to collect information from farmers on the barriers to adoption of selected climate resilient practices, and these ware classified under two broad categories, physical or hardware barriers and non-physical or software barriers.

3.3. Hardware or Physical barriers to adoption of climate resilient practices

The first relates to the physical means or resources required to practice climate resilient technologies and considered as the hardware barriers. Key constraints to adoption of climate resilient practices reported by farmers (Table 3) included non-availability of drought tolerant paddy varieties (100%), high cost and non-availability of drought resistant varieties of other crops (50.8%), non availability of drum seeder on rental basis (48.2%), shortage and high cost of labor for SRI (38.2%), non availability of farm inputs (23.6%), lack of finance(12.7%) for adopting INM and lack of finance for availing crop insurance (3.4%). Inadequate farm labor, lack of adequate knowledge, non-availability of seeds, and lack of funds to implement some of the

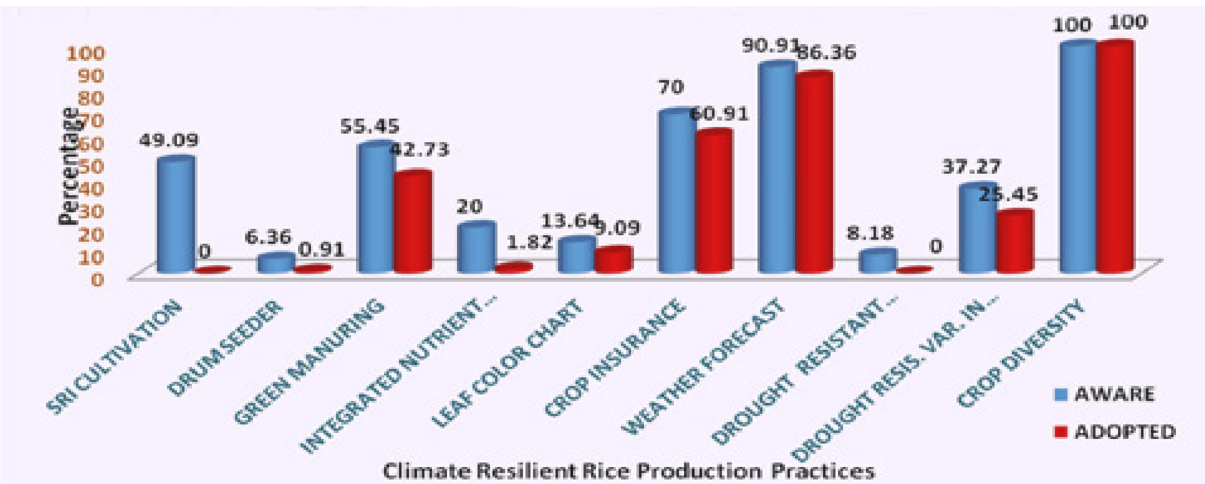

Fig. 1: Awareness and adoption of different climate resilient rice production practices.

Table 3: Barriers to adoption of climate resilient practices as perceived by farmers.

Intervention	Hardware barriers	Percentage	Software barriers	Percentage
SRI	Shortage of Labor and high labor cost	38.2	Lack of awareness, knowledge and skill	47.3
	High Weeds	4.5		
	Soil cracks	10.0		
Drum seeder	Non availability on rental basis and high cost	48.2	Lack of awareness and knowledge	50.89
Green manure crops	Non availability of seeds	17.27	Lack of information, knowledge and skill	29.9
Integrated nutrient management	Small farm size	10.0		
	Non availability of required farm inputs	23.6	Lack of awareness and knowledge	56.4
	Lack of finance	12.7	Lack of interest	5.5
Leaf color chart			Lack of information, knowledge and skill	90.91
Crop insurance	Lack of finance	3.64	Lack of awareness about crop insurance	35.45
Weather forecast			Lack of awareness and knowledge	13.7
Drought resistant varieties in paddy	Non availability of drought resistant paddy varieties	100.0		
Drought resistant varieties in other crops	High cost and non availability of seeds	50.91	Lack of awareness	23.64

Source: Survey data (2018) responses on non-adoption

improved practices were reported by Mutoko (2014). Capital inputs such as labor, finances and social capital are essential for the adoption of new technologies (Ellis, 1993). The adoption of CSA practices has been hindered by inadequate physical infrastructure, lack of finance and land tenure insecurity (CIAT, 2018). Lack of capital, high input cost, inadequate information about adoption practices and poor access to credit facilities were reported by Devkota *et al.* (2018). Non availability of drought tolerant varieties in the market was reported as one of the major technical constrains faced making them more prone to climate vulnerabilities (Satishkumar *et al.*, 2013). The lack of labor, finance, and lack of access to land were reported as physical barriers to adopt climate resilient strategies by Diiro *et al.* (2016). Barriers to adoption of CSA included lack of agriculture equipment, price constraints, borrowing constraints, and incomplete knowledge of adopting the practices (Daniel *et al.*, 2019).

3.4. Software or Non-physical barriers to adoption of climate resilient practices

Findings from the present study show that the non-physical or software barriers reported by farmers (Table 3) were lack of information, knowledge and skill to use LCC (90.9%), lack of awareness and knowledge about INM (56.4%), lack of awareness and knowledge to use drum seeder (51.8%), lack of awareness and skill to adopt SRI process (47.3%), lack of awareness to subscribe for crop insurance (35.4%), lack of knowledge and skill to grow green manure crop (29.9%), lack of awareness about drought tolerant varieties of other crops (23.6%) and lack of awareness and knowledge to access weather forecast information (13.7%). Access to information is a key element in the adoption of new technologies (Taneja *et al.*, 2014). Lack of information, technical knowledge and inadequate awareness about adaptation have been reported by Devkota *et al.* (2018). Resource-poor farm households need access to information about climate change, the available adaptation technology, timely access to the technology, complementary inputs and improving access to credit (Tambo; Abdoulaye, 2012). Social capital plays a significant role in adoption, and strengthening the local institutions for faster adoption is essential (Teklewold *et al.*, 2019).

4. Conclusions

Based on the findings of the study it is important to improve the farmers' access to drought tolerant paddy varieties. Large scale demonstrations and seed production efforts may be undertaken to provide these varieties to the farmers. Awareness generation and skill training programs are needed to enhance the adoption of knowledge and skill intensive technologies like SRI, DSR and use of LCC. Mixed farming and crop diversification is to be promoted while and increasing farmers' access to low-interest credit needs special attention to make climate-smart farming practices affordable for resource poor farmers. It is essential to popularize insurance as an effective adoption strategy among farmers through awareness generation and sensitization. Policymakers need to work towards the sustained cooperation among stakeholders at the local and national level to ensure successful adoption of climate resilient practices. Affirmative public policies are needed to scale up adoption through provision of financial and credit services. Strengthening social capital, collective action and farmer to farmer dissemination is to be promoted for faster and widespread adoption of climate resilient rice production practices.

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