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Incentives for Experimenting with Sustainable Intensification: Can Direct Payments to Farmers Help Diversify the Cropping Systems in South India?

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ABSTRACT

The sustainable intensification of cropping systems with legume species enhances the system resilience to climate change, maintains soil health, and increases food production and income from existing farmland while lowering the environmental footprint. However, the production of many nutritious legume crops has been stagnant in India. How can farmers be incentivized to include legume crops in their farming system? Local agro-ecological and institutional factors and household characteristics determine farmer adoption of sustainable intensification practices and legume cultivation by shaping the perceptions and awareness of the farmers. The present study examines the factors determining farmers' willingness to cultivate legume crops, using data from 596 randomly selected farmers from 40 villages of Andhra Pradesh and Telangana. We constructed a Transition Probability Matrix (TPM) to understand the land-use changes across crops in the study districts and followed a contingent valuation approach to analyse the heterogeneity of farmers' preferences and willingness to cultivate legume crops. It was found that agricultural land use patterns in the study districts moved toward monoculture over time. The interval regression estimates of farmers' willingness to cultivate legume crops suggested a dire need to couple external financial incentives with conventional extension activities, at least in the initial stages of project intervention. However, carefully selecting the legume species and changing the nature of intervention based on local preferences could lower farmers' need for financial incentives and thus the total project cost, while increasing the probability of the success of interventions.

Keywords: Sustainable intensification, cropping system, legume species, financial incentives, willingness to accept.

JEL : O33, Q12, Q18.

I

INTRODUCTION

Increasing hazards and risks of climate change threaten the viability of agricultural production systems, farmer livelihoods, and food security worldwide (Ortiz-Bobea *et al*., 2021; Thiede and Strube, 2020). At the same time, agriculture is also a major source of Greenhouse Gas (GHG) emissions (Rao *et al*., 2019). Therefore, strategies toward mitigation and adaptation to climate change have become inherently crucial while aiming to build a resilient food production system (Aggarwal *et al.*, 2018). There are several options to reduce the negative impacts of climate change on agricultural systems, make them resilient to climate change, and

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reduce emissions – ranging from improved crop management (e.g., adjusting the sowing time of crops) to a change in cropping systems and crop types. Several technologies and practices developed by CGIAR and national R&D institutions, under the umbrella of Sustainable Agricultural Practices (SAP), can enhance and maintain crop yields, soil fertility, farm income, and input-use efficiency while reducing GHG emissions (Khatri-Chhetri *et al.*, 2017). Among SAP, crop diversification is arguably one of the most rational and cost-effective approaches to coping with the vagaries of climate change (Singh et al., 2018). Crop diversification is vital for ensuring continued availability of production resources (e.g., soil nutrients, water, land) for future generations, promoting diverse diets, improving soil fertility and input use efficiency, suppressing pest outbreaks, creating healthy agroecosystems, and securing rural livelihoods of the Global South (IPES-Food, 2016).

The economic and ecological effects of a cropping system diversification process depend on the complementarity (synergy) of the individual crops. In this connection, grain legumes gain popularity in India for contributing to farm profitability, human and animal nutrition as a cost-effective source of protein. There is also a significant market demand as the country is a net importer (Palai *et al*., 2019). Furthermore, from the farming system perspective, grain legumes are valuable for being a rich source of plant nutrients. Due to their ability to fix biological nitrogen and indirect supply of manure-based nitrogen inputs when included in the cropping systems such as intercropping and crop rotation, legume species can reduce the use of inorganic fertilizers for cereal crops (Snapp *et al*., 2018; Teshome, 2018). Nevertheless, despite its widely documented private benefits and positive externalities, legume production faces several constraints in India.

India realised a 3.3 per cent average annual growth in legume production between 2000 and 2020, reaching a record production of 25.5 million tons in 2018 (FAOSTAT, 2022). A downside is that most legume production growth is due to expanding cropland. Since 2000, the productivity has remained near-stagnant, with an average increase of only 4 kg/ha/year between 2000 and 2020 (0.3 per cent per annum; estimated from FAOSTAT, 2022). At the same time, India imports a large share of its domestic pulse requirement (Palai *et al*., 2019). Smith *et al*. (2018) identified several barriers to legume production in India: lack of technical know-how, unreliable seed supply, lack of processing units, financial constraints, water scarcity, limited fertiliser supply, etc. Overcoming these constraints and motivating farmers to engage in legume production by developing regionally appropriate climate-smart technology options have high importance in agricultural R&D initiatives. Understanding farmers' knowledge and preferences is the first step in this direction. Considering the high public good values of legume crops – such as increased protein availability for consumers, soil health improvement, reduction of nitrogenous fertiliser uses and resulting reduction of negative environmental externalities, etc. – might qualify their inclusion in the Payments for Agrobiodiversity

Conservation Services (PACS). Although PACS focuses on in situ/on-farm agrobiodiversity conservation with threatened plant and animal genetic resources, the incentive mechanism structure can be experimented with to popularise legume species also. Piñeiro *et al*. (2020) observed that programmes linked to short-term economic benefits could generate a higher adoption rate than those aimed solely at providing an ecological service. There is no mechanism in place now to incentivise the farmers to adopt more environment-friendly farming practices, and there is a lack of feasibility studies in this direction.

We to contribute to this literature on technology dissemination and direct farmer payments for sustainable agriculture by exploring farmers' willingness to include legume species in cereal-based crop production systems. We used a stated preference method applied at the individual farm-household level to elicit farmers' preferences and hypothetical compensation levels to accept the cultivation of legume crops on 0.50 ha. The feasibility of a direct payment scheme is examined for the incorporation of legumes along with cereal crops (rice and maize) using household data from two contrasting agro-ecosystems of southern India. The next section of the paper describes the sampling strategy and analytical methods. Section 3 explains the major findings, and the last section concludes the study.

II

MATERIALS AND METHODS

The present paper is developed from a baseline survey dataset as part of an ongoing R&D project on popularising climate-smart agricultural practices in South India. The study districts were selected purposively. One is from Andhra Pradesh (Srikakulam) and another from Telangana (Nalgonda). They form the target geographical area for implementing the project interventions.

2.1 Sampling Strategy and Sample Size

The field surveys were conducted between November 2021 and January 2022. We followed a multistage random sampling approach to select respondents. From the village census of the purposively selected CD (community development) blocks, 40 villages were selected randomly. Twenty were from Ranastalam block of Srikakulam and another 20 from Thripuraram block of Nalgonda. The project team selected these blocks as the intervention area to start R&D activities after the completion of baseline surveys. First, we obtained information on village characteristics for constraint analysis and resource mapping and cropping system preferences through gender-segregated focus group discussions (FGDs). Each FGD comprised about 5 to 8 farmers.

In the second round of field visits, a household survey was conducted. After a household census, farmers were randomly selected from each of the 40 study villages. Data were collected using a pre-tested, structured questionnaire. About 15 farm households involved in agriculture were interviewed per village, making the total sample size 600. For the household survey, the heads (or, in their absence, the most senior family member knowledgeable about agriculture) were approached. The information collected from farmers included household composition, landholding, cropping systems, cultivation practices in major seasons, adoption of climate-smart agricultural practices, assets and amenities, and household food (in)security status. In addition, to examine whether one can incentivise farmers financially to start legume crop cultivation on farm, we elicited their willingness to accept (WTA).[1] After omitting the observations with measurement errors, the details of 596 farm-households were compiled for the analysis (298 from each district).

2.2 Analytical Tools

The Transition Probability Matrices (TPM) were estimated through Markov chain analysis to understand the temporal agricultural land-use changes in study districts. For the purpose district-level secondary data were used for the 25 years (1993-2017) from ICRISAT meso-level datasets. The TPM is well suited to examining land-use shifts among different crops. This method helps summarise how land use has changed over time and what paths they are likely to take in future periods. In TPM, a population at time t has the distribution S^t over the discrete states, S_1, S_2,.., S_{ij}, and the probability P_{ij} moving from state S_i at one point in time to state S_j and not on any prior state. The transition probabilities P_{ij} form the matrix P, where $\sum_j^i P_{ij} = 1 \; and \; P_{ij} \geq 0$ for all ‘i’ and ‘j’ states.

To further understand the farmers' willingness to accept sustainable intervention to cope with climate change and for better nutrition, we used the contingent valuation technique. Sustainable technologies are often constrained by the lack of access to agricultural inputs (particularly improved varieties of different crops) and production technologies at affordable rates. Hence, this study estimated farmers' WTA to include legumes in the cropping system through a stated preference method. The WTA mode was more suitable than the alternative willingness-to-pay (WTP) mode for value elicitation because the property rights of cultivated land rest with the farmers. We used the double bounded dichotomous choice (DBDC) approach to elicit WTA to incorporate legume crops on a minimum of 0.50 ha of their farmland. The DBDC model is statistically more efficient than the single bounded approach *(Hanemann et al*., 1991).

During the household survey, we elicited farmers' willingness in a dichotomous yes-no response to participate in a hypothetical programme to intensify the existing farming systems with legume crops against random bids representing potential financial incentives. A total of seven possible follow-up bids were formulated. The lowest bid was Rs. 1000, and the highest Rs. 7500. Farmers who responded negatively to the initial bid were allocated higher bids, and those who responded positively with lower bids. Farmers who responded positively to the first or second bids were asked about the legume species they would select to cultivate and their preferred type of incorporation (intercropping, fallow intensification, or crop replacement). About 60 per cent of the farmers responded positively to the initial bid amount (Table 1). Of the farmers who responded positively to the initial bid, 38 per cent were from Srikakulam and 22 per cent from Nalgonda. Srikakulam farmers were more willing to cultivate legume crops because their farming systems were already diversified and were more likely to cultivate black gram following fallow intensification (crop rotation in fallow land). In contrast, Nalgonda farmers were more willing to cultivate red gram by following inter-cropping with other traditional cereal crops. Further, the bids were converted to WTA ranges and analysed using an interval regression model based on the responses.

TABLE 1. BID STRUCTURE, PREFERRED LEGUME CROP AND CROPPING SYSTEM BY SAMPLE FARMERS

Initial bid presented [Rs.]	Share of positive responses [initial bid]			Willingness to cultivate black gram among the positive responses [share of households]			Preferred cropping system among the positive responses [share of households]		
	Overall	Srikakulam	Nalgonda	Overall	Srikakulam	Nalgonda	Overall	Srikakulam	Nalgonda
1000	15.79**	0.00	15.79	0.00	0.00	0.00	[0.00;0.00;100.00]	[0.00;0.00;0.00]	[0.00;0.00;100.00]
2000	47.42	28.87	18.56	73.91***	58.70	15.22	[43.48;45.65;10.87]	[30.43;28.26;2.17]	[13.04;17.39;8.70]
3000	62.03	40.11	21.93	74.14***	61.21	12.93	[52.59;36.21;11.21] ***	[41.38;18.97;4.31]	[11.21;17.24;6.90]
4000	53.97	39.68	14.29	73.53***	67.65	5.88	[52.94;26.47;20.59]	[44.12;20.59;8.82]	[8.82;5.88;11.76]
5000	77.54	50.00	27.54	64.49***	53.27	11.21	[42.99;47.66;9.35] **	[32.71;28.04;3.74]	[10.28;19.63;5.61]
6000	53.57	25.00	28.57	40.00***	40.00	0.00	[33.33;60.00;6.67]	[26.67;20.00;0.00]	[6.67;40.00;6.67]
7500	57.81	39.06	18.75	67.57***	54.05	13.51	[43.24;45.95;10.81] **	[37.84;27.03;2.70]	[5.41;18.92;8.11]
Overall	60.07	38.42	21.64	68.44***	56.98	11.45	[46.37;41.62;12.01] ***	[36.31;23.74;3.91]	[10.06;17.88;8.10]

Note: Figures in parentheses indicate the share of sample households preferred cropping system [fallow intensification; intercropping; crop replacement]. ** and *** indicate significant differences between the districts at 0.05, and 0.01 levels, respectively.

III

RESULTS AND DISCUSSIONS

3.1 Farmer Characteristics

The socio-economic attributes of farm households that could influence farmers' willingness to cultivate legume crops on farm are shown in Table 2. Significant inter-district differences were noted for most variables. The average years of schooling of sample farmers is 3.82 years (lower primary school). The Nalgonda farmers had more education on an average (5.21 years) than Srikakulam farmers (2.43 years). The average age of household head was 50 years, and more than 85 per cent of sample households were male headed. Household heads in Srikakulam were older (53 years) than in Nalgonda (47 years). On an average, the sample households contained three adult members. Most households belonged to the Other Socially Marginalised Castes (OSMC or OBC as per the government documents). About 37 per cent belonged to

TABLE 2. DESCRIPTIVE STATISTICS OF SAMPLE FARMERS

Variables	Description		Mean (Std. deviation)			
			Overall (n=596)	Srikakulam (n=298)	Nalgonda (n=298)	Sig.
(1)	(2)		(3)	(4)	(5)	(6)
HHH Education	Formal education of the household head (years)		3.82 (5.19)	2.43 (4.44)	5.21 (5.52)	***
HHH Age	Age of the the household head (years)		49.83 (13.73)	52.65 (13.11)	47.01 (13.77)	***
HHH Gender	Gender of the household head (1 = If household head is male, 0 = otherwise)		0.87	0.85	0.89	
Adult members	Number of adult members in the household		3.30 (1.22)	3.43 (1.21)	3.18 (1.22)	***
Boys <15 years	Number of boys below age 15 in the household		0.38 (0.64)	0.31 (0.60)	0.46 (0.68)	***
Girls <15 years	Number of girls below age 15 in the household		0.38 (0.70)	0.34 (0.65)	0.42 (0.74)	
Caste categories	SC	1 = If household belongs to Scheduled Castes, 0 = otherwise	0.06	0.11	0.01	***
	ST	1 = If household belongs to Scheduled Tribes, 0 = otherwise	0.37	0.01	0.74	***
	OSMC	1 = If household belongs to Other Socially Marginalize Castes (also known as OBC in India), 0 = otherwise	0.47	0.72	0.21	***
	NMC	1 = If respondent belongs to Non-Marginalised Castes, 0 = otherwise (*reference dummy in the regression analysis*)	0.09	0.15	0.04	***
Cultivated land	Hectare		1.06 (1.01)	0.99 (0.98)	1.13 (1.04)	*
TLU#	Tropical livestock unit (index)		0.98 (1.30)	0.73 (1.37)	1.23 (1.17)	***
Share of irrigated land	Percentage of cultivated area under irrigation (per cent)		95.50 (20.56)	91.44 (27.87)	99.55 (6.10)	***
Share of farm income	Percentage of income from farm activities (per cent)		82.01 (30.25)	79.61 (31.59)	84.41 (28.71)	**
Household food security scale	1=If household is food deficit, 0=otherwise		0.31	0.47	0.16	***
Credit access	1 = If household accessed credit from any source, 0 = otherwise		0.76	0.74	0.78	
Group membership	1 = If household member to any group, 0 = otherwise		0.70	0.62	0.78	***
Extension access	1 = If household accessed farm Information any source, 0 = otherwise		0.45	0.60	0.30	***
District	1=Nalgonda, 0=otherwise		0.50	0.00	1.00	

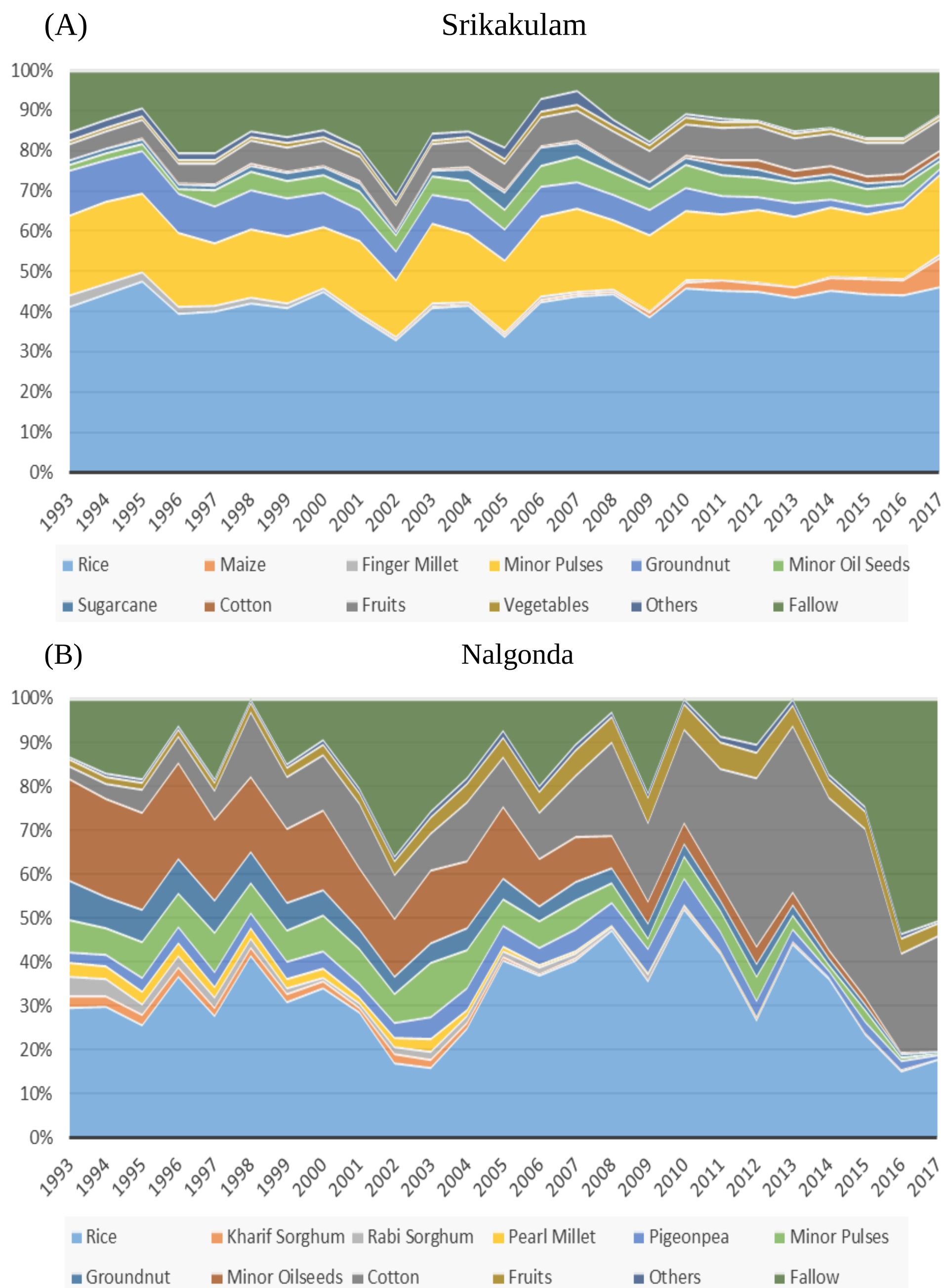
Note: #TLU was determined following (FAO, 2011) whereby cattle and buffalo, sheep & goat, pigs, and chickens have a TLU of 0.50, 0.10, 0.20 and 0.01, respectively. Afterwards, the TLU was summed for each household. *, ** and *** indicates significance difference between districts at 0.10, 0.05, and 0.01 levels, respectively.

Scheduled Tribes (ST) and 6 per cent to Scheduled Castes (SC) – the two caste groups covering the most underprivileged sections of the Indian society. Srikakulam villages had OSMC dominance in population, while Nalgonda had ST. The average cultivated land was 1.06 ha (0.99 ha in Srikakulam and 1.13 ha in Nalgonda). The households kept 0.98 TLU livestock on average. More TLU were in Nalgonda (1.23) than in Srikakulam (0.73). Nalgonda farmers had about 100 percent cultivated land under irrigation, and 84 per cent of their income was from farming. Slightly less area (91 per cent) was under irrigation, and 80 percent of income was derived from farming in Srikakulam. About 47 per cent of sample households from Srikakulam but only 16 percent of farmers of Nalgonda reported as food insecure during the survey. There was no significant inter-district difference with credit access, with about three-fourth of farmers accessing credit in the previous 12 months in both districts. The percentage of farmers participating in group activities was higher in Nalgonda (78 per cent) than in Srikakulam (60 per cent). However, agricultural extension access was poor in Nalgonda (30 per cent of farmers accessing the formal extension networks) than in Srikakulam (60 per cent).

3.2 Agricultural Land-Use Changes in the Study Districts

The aggregate land use by crops in the Srikakulam district during the 25 years (1993-2017) appears stable with respect to the area averages (Figure 1A). Crop diversity index increased in the first 15 years and then declined. During 2007-2017 period, the evenness index reduced from 0.70 to 0.62. Rice remained the dominant crop, while maize gained importance after 2010. Groundnut and finger millet cultivation has subsided significantly over time. There is still a large area devoted to the cultivation of minor pulses. The share of fallow land had reduced after 2002. The Transition Probability Matrix (TPM) analysis indicates a story of frequent conversion between crops (Table 3A). Some of the rice area (26 per cent) was converted to minor pulses and minor pulses to rice (91 per cent minor pulse area). A large share of rice area (25 per cent) was fallowed temporarily, and fallow land was brought back to rice and minor pulses. Cotton gives way to maize, but maize area is rarely converted into other crops. A large share of the vegetable area (65 per cent) is converted for rice. About 24 per cent of the area is kept fallow for longer term.

In Nalgonda, rice maintained its importance as the major crop, although periodic fallowing has become more common in the recent past (Figure 1B). The evenness index reduced throughout the study period and reached at the lowest (0.38) in 2016 from its peak value of 0.76 in 1998. Fallowing is the main factor responsible for the crop diversity reduction. According to TPM, about 70 percent of the rice area has been unconverted during the study period (Table 3B), and about 24 per cent of the rice area has gone to fallow. On the other hand, 11 per cent of fallow land was brought under rice. More and more rice areas were put under fallow after 2013. Sorghum and minor pulses area had subsided significantly. Cotton crop has gained



Data source: ICRISAT District Data (1993-2017). Fallow land is calculated as the difference between the maximum area under cultivation before a given year (after 1990) and the total cropped area in that year. If the difference is negative, fallow area of zero is provided.

Figure 1. Temporal Changes in Agricultural Land Use (1993-2017)

TABLE 3. TRANSITION PROBABILITY MATRIX

(A) SRIKAKULAM

	Rice	Maize	Finger millet	Minor pulses	Groundnut	Other oilseeds	Sugarcane	Cotton	Fruits	Vegetables	Others	Fallow
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Rice	0.48			0.26					0.01			0.25
Maize	0.09	0.91										
Finger millet			0.73	0.04	0.14						0.09	
Minor pulses	0.91			0.08					0.01			
Groundnut					0.84		0.02			0.01	0.14	
Other oilseeds	0.06	0.01				0.78	0.06	0.01	0.04	0.05		
Sugarcane	0.09			0.12		0.07	0.53		0.11	0.08		
Cotton		0.11						0.89				
Fruits	0.16								0.84			
Vegetables	0.65									0.35		
Others				0.79	0.12						0.09	
Fallow	0.34		0.01	0.28	0.03	0.05	0.02		0.01	0.01		0.24

(B) NALGONDA

	Rice	*Kharif* sorghum	*Rabi* sorghum	Pearl millet	Red gram	Minor	Groundnut	Other oilseeds	Cotton	Fruits	Others	Fallow
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Rice	0.70				0.01	0.02			0.02		0.01	0.24
Kharif sorghum		0.21						0.79				
Rabi sorghum			0.27	0.16				0.56				
Pearl millet		0.22		0.62			0.16					
Red gram	0.24				0.65					0.11		
Minor pulses	0.70					0.30						
Groundnut	0.17	0.08					0.75					
Other oilseeds			0.06		0.01	0.16	0.04	0.73				
Cotton									0.87			0.13
Fruits									0.17	0.83		
Others	0.34									0.19	0.47	
Fallow	0.11				0.05	0.08	0.01	0.04	0.10	0.01	0.01	0.58

Note: Estimated from ICRISAT District Data (1993-2017). The crops with less than 1 per cent area share are included in the category "Others".

importance over time in the region, especially in uplands and fallow lands. To sum, the cropping system of Nalgonda was highly diverse in the 1990s, with sorghum, pearl millet, minor pulses, groundnut, other oilseeds, etc., but now only a small share of farmers cultivate these crops. A significant area of these crops has been converted to rice. About 58 per cent of the area kept fallow for longer term.

These results indicate that the cropping system followed in the study district appeared less and less diverse over time, especially in Nalgonda. The FGD data indicated that only negligible (>2 per cent) farmers, especially from Srikakulam, were cultivating legume crops. Most of the agricultural areas were covered with rice-rice crop rotation in Nalgonda and maize-fallow in Srikakulam. The other cropping systems were rarely adopted by farmers in both districts. Waterlogging was cited the main reason for the predominance of the rice-rice system in Nalgonda. Farmers from Srikakulam district reported that the rice-maize-fallow system has been declining recently due to the lack of price support and low profitability of the system, as compared to the plantation crops. In some villages of the Srikakulam district, farmers view maize-maize-fallow systems positively due to high market demand. Nevertheless, irrigation water scarcity is affecting this system.

3.3 Farmers' Willingness to Include Legume Crops in the Existing Cropping Systems

The study estimated three WTA models employing interval regression framework. Model [I] is for the overall sample, Model [II] is for respondents from the Srikakulam district, and Model [III] is for respondents from the Nalgonda district (Table 4). Results from the three models varied widely with respect to coefficient signs and level of significance. As expected, the region dummy is positive and significant in Model [I]. Srikakulam district is comparatively more diversified, and a significant percentage of farmers are willing to cultivate legumes with lower financial incentives. As expected, WTA is comparatively higher for the Nalgonda district than in the Srikakulam district (Figure 2a). The coefficient of household gender (male = 1) is statistically significant and negatively associated with the WTA for legume crops. Male-headed households were willing to start cultivating legumes at lower financial incentives than female-headed households (Figure 2b). During the field survey, many farmers were willing to cultivate legume crops even without any external incentives, had improved varieties supplied.

The coefficient of the size of cultivated land is negative and significant, indicating that large farmers were more willing to participate in the compensation program. The WTA coefficient for intercropping is positive and significant,

TABLE 4. WILLINGNESS TO ACCEPT INTERVAL REGRESSION ESTIMATION RESULTS

(1)	Model I: Overall (2)	Model II: Srikakulam district (3)	Model III: Nalgonda district (4)
Model intercept	1,328.28*	1,791.78**	933.72
	(744.79)	(721.60)	(2375.34)
HHH Education	3.11	25.51	-35.77
	(19.20)	(20.92)	(37.27)
HHH Age	11.15	12.75*	7.81
	(7.26)	(7.29)	(16.33)
HHH Gender	-825.28***	-860.93***	-999.77
	(246.20)	(229.16)	(669.11)
Adult members	-59.58	-163.38**	103.51
	(70.24)	(72.95)	(146.23)
Boys <15 years	254.55**	31.54	727.51***
	(127.74)	(138.93)	(228.82)
Girls <15 years	-45.20	-97.20	131.95
	(119.74)	(128.19)	(218.23)

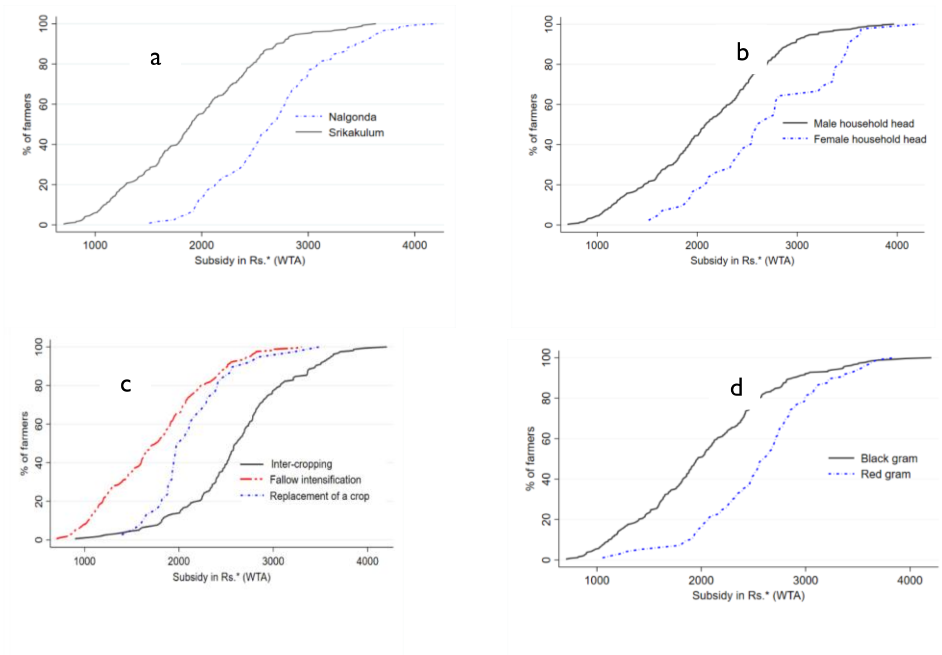
(*Contd*.)

TABLE 4 (CONCLD.).

(1)		Model I: Overall (2)	Model II: Srikakulam district (3)	Model III: Nalgonda district (4)
Caste categories (dummy, NMC is the reference category)	SC	52.07	533.95	-842.71
		(379.69)	(339.19)	(1,408.61)
	ST	-476.70	5,860.00***	-249.40
		(376.75)	(1,215.04)	(856.92)
	OSMC	64.48	140.01	667.20
		(260.58)	(233.15)	(905.48)
Cultivated land		-197.50**	-136.58	-185.28
		(91.01)	(92.30)	(203.50)
TLU		9.93	-40.13	18.37
		(64.21)	(71.32)	(123.85)
Share of irrigated land		3.81	1.49	9.25
		(3.77)	(3.26)	(16.25)
Share of farm income		-0.50	-0.88	2.08
		(2.78)	(2.88)	(5.74)
Likely cultivating legume crop (dummy)		13.26	-201.79	361.08
		(221.90)	(300.40)	(333.10)
Cropping system (dummy, crop rotations in fallow is the reference category)	Intercropping	779.04***	499.21***	1,601.29***
		(179.18)	(177.36)	(442.28)
	Replacement of a crop	-14.40	557.96*	59.74
		(275.24)	(335.80)	(532.69)
Household food security status (dummy)		450.45*	370.07	725.33
		(268.43)	(230.79)	(1,652.41)
Credit access (dummy)		-69.29	99.46	-226.91
		(195.69)	(211.99)	(389.95)
Group membership (dummy)		59.14	132.55	-190.39
		(187.74)	(189.27)	(421.24)
Extension access (dummy)		583.10***	691.09***	395.94
		(168.28)	(177.72)	(365.50)
District (dummy)		1,230.59***		
		(314.55)		
Number of observations		360	242	118
Log likelihood		-507.71	-280.48	-192.87
LR $\chi2$ [df]		75.60***	76.68***	37.47***
Insigma		7.20***	6.98***	7.30***
		(0.04)	(0.05)	(0.07)

Notes: Dependent variable is the range in which household WTA would fall in and is measured in Indian rupees (Rs.; 1 US$=Rs. 76.59) for cultivating 0.50 ha of legume crop. Coefficients are shown with standard errors in parentheses. *,**, and *** indicates that the coefficients are statistically significant at 0.10, 0.05, and 0.01 levels, respectively

indicating farmers were reluctant to cultivate legume crops as intercropping compared to other legume inclusion methods, such as intensification in fallows and crop replacements (Figure 2c). Further, WTA for cultivating black gram as an option was higher than red gram (Figure 2d). It could be because of the long duration of red gram (250-270 days) as compared to black gram (70-85 days). Other factors that positively influenced the WTA for legume crops were household food insecurity and extension access. Food and nutrition literature reports a positive correlation between socio-economic status and household food security. Change in crop cultivation may further increase food anxiety of already food insecure households. Hence, food insecure households were more reluctant to adopt legume crops or accept legume cultivation at higher financial incentives. Further, farmers with better extension access were less willing to cultivate legume crops, which need further exploration.



Notes: It is measured in Indian rupees (Rs.; 1 US$=Rs. 76.59) for cultivating 0.50 ha of legume crop.

Figure 2. Distribution of WTA to Cultivate Legume Crops by, (a) Regions, (b) Household Head Gender, (c) Preferred Cropping System, and (d) Preferred Crop.

IV

CONCLUSION

Resource-based, context-specific optimisation of cropping systems for higher efficiency, income, and lower carbon footprints is critical for the sustainability of agriculture, but market access and extension inclusivity are crucial for their adoption by farmers. External financial incentives could increase the short-term attractiveness of new technological interventions that have signficant social value (public good) associated with it. The present study analysed the land-use changes and farmers' willingness to accept legume crop cultivation in South India. The results showed that the cropping system was becoming gradually less diverse in recent decades, which is a sign of unsustainable agricultural growth process. It is pertinent that financial incentives are necessary at least at the beginning of the project intervention and to realise the potentials of legume crop cultivation and fallow land utilization. With some financial incentives, more than 60 per cent of surveyed farmers were willing to include legume crops on farm for fallow intensification or inter-cropping. The cost of such incentive mechanisms depends on the crop species and type of intervention. Incentives could be offered in many ways, such as supplying higher yielding legume crop varieties at subsidised rate, coupling with awareness creation about the public and private benefits of cultivating legume crops, creating easy-to-access output markets for legume products etc. The effectiveness of these mechanisms has to be examined through further empirical research.

NOTE

1. The WTA format is less popular as a stated preference approach for value elicitation due to the widespread belief that it is not incentive compatible. In the present study, a competitive bidding was introduced to overcome this limitation. Respondents were informed that, due to the budget constraints, only a limited number of farmers from each village would be selected for participation in the scheme of subsidized production of legume crops. The selection shall be based on the lowest WTA value demanded.

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