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Determinants, profitability, and constraints of Crop diversification in Telangana

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ABSTRACT

Crop diversification is vital for alleviating soil pressure, enhancing sustainable production, and mitigating marketing challenges. This study aims to identify the drivers and profitability of crop diversification in Northern Telangana Zone (NTZ), influenced by the Telangana government's policy on cultivating alternate crops instead of paddy in the 2021 Rabi season. Monocropping degrades soil health; hence, the study was conducted to determine the most profitable crop to cultivate after paddy. A random sampling technique was used to collect data from 10 adopters (farmers who cultivated alternate crops) and 10 non-adopters (farmers who continued paddy) from each district of NTZ (a total of ten districts). Hence the total sample for the study is 200. The study employed cost concepts, logit regression, and Garrett ranking techniques for analysis. The findings revealed that cultivating maize in paddy fallows yielded comparable net returns (Rs. 47,544 per ha) to paddy cultivation in the Rabi season (Rs. 48,641 per ha). Logit regression analysis identified education, farming experience, landholding size, and contact with Agricultural Department officials as significant positive factors influencing crop diversification adoption. Among alternate crops, constraints such as high weed incidence in sesame (Garrett score: 63.65), paddy stubble regeneration in maize (64.95), insufficient and expensive seed supply in sunflower (70.71), post-harvest losses due to hailstorms in groundnut (61.75), and germination problems in pulses (64.88) were opined by the sample farmers. Effective strategies, including subsidized inputs, training programs on alternate crop cultivation, and improved storage and marketing facilities, are recommended to enhance crop diversification in the region.

Keywords: *Northern Telangana Zone, Crop diversification, Paddy fallows, adapters, alternate crops, strategies.*

Introduction

Agriculture plays a pivotal role in the Indian economy, serving as the backbone for over 70 per cent of rural households. It significantly contributes to the nation's economic and social well-being, accounting for 19.9 per cent of the GDP in 2020-21 and providing employment to 60 per cent of the population. Out of India's total geographical area of 328.73 million hectares, 197.32 million hectares are gross cropped areas, representing about 60 per cent in 2020-21. The country's food grain production has seen a remarkable increase from 51 million tonnes in 1950-51 to 308.65 million tonnes in 2020-21, showcasing the sector's critical importance (Agricultural Statistics at a Glance 2021). Despite a declining contribution to GDP, agriculture remains the third-largest sector after services and industry, contributing approximately 18.3 per cent to the GDP in 2022-23. This sector is essential not only for economic stability but also for ensuring food security and sustaining rural livelihoods. The nation's food security strategy emphasizes the adoption of sustainable agricultural practices.

Crop diversification (horizontal and vertical) has been acknowledged as an effective strategy for achieving the goal of food security, nutrition security, income growth, poverty alleviation, employment generation, judicious use of land and water resources, sustainable agricultural development, and environmental improvement. Crop diversification is a key ecological approach aimed at resource conservation and mitigating the environmental impacts of climate change. By promoting crop diversification, India seeks to enhance agricultural productivity to support its growing population. Crop diversification also aims to encourage technical advancements for sustainable agriculture and provide farmers with the option of selecting alternative crops for higher productivity and profitability.

Optimal utilization of resources through diversified cropping systems can effectively meet the increasing demand for agricultural production. In line with these goals, the Government of Telangana has advised farmers to adopt crop diversification, particularly during the *Rabi* season, by cultivating alternative crops in paddy fallows. This study aims to identify the drivers of crop diversification and suitable alternative crops for the *Rabi* season in paddy fallows.

Materials and methods

An ex-post facto research design was adopted for the study. In the state of Telangana, ten districts of Northern Telangana were selected purposively. Data was collected for the year 2021-2022. Ten villages that have the farmers cultivated alternate crops after paddy were selected from each Mandal of each district of Northern Telangana Zone.

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Ten adopter farmers and ten non-adopter farmers were selected randomly from each village. Hence, the total sample becomes 200 for the study.

The economics of diversified crop cultivation was done by categorizing costs into operational and fixed components and collecting detailed data on each component. For operational costs, data includes human labor, machine power, seeds, farmyard manure (FYM), fertilizers, plant protection chemicals, irrigation charges, miscellaneous expenses, and interest in working capital. For fixed costs, data includes the rental value of owned land, rent paid for leased-in land, depreciation of machinery and equipment, and interest on fixed capital. Operational and fixed costs were added get the total cost of cultivation. Gross returns and net returns per hectare were calculated to know the profitability of crops cultivated by adopter and non-adopter farmers.

Logit regression analysis was applied to determine the factors responsible for adopting crop diversification. The present study considered some significant quantitative explanatory variables based on the theory and literature. A logistic model is a univariate binary model. We used a binomial logistic regression model given that the dependent variable is dichotomous i.e., 0 when a farmer is a non-adopter of crop diversification and 1 when the farmer is an adopter of crop diversification. Predictor variables are a set of socioeconomic variables. Let P_j denote the probability that J^{th} farmer is an adopter of crop diversification. We assume that P_j is a Bernoulli variable and its distribution depends on the vector of predictors X, so that

$$P_j(X) = \frac{e^{\alpha+\beta x}}{1+e^{\alpha+\beta x}} \rightarrow a$$

The logit function to be estimated is then written as:

$$ln\,[Pj/\,(1-Pj)] \;=\; \alpha \;+\; \Sigma i\;\beta i\;Xij \;\rightarrow b$$

The logit variable $ln\,[Pj/\,(1-Pj)]$ is the natural log of the odds in favor of adoption. Equation (b) is estimated by the maximum likelihood method and the procedure does not require assumptions of normality and heteroscedasticity of errors in predictor variables.

Table 2.1: Description of variables used in the logit model

Variables	Variable measurement	Expected sign
Dependent variable		
Adopter/Non-adopter	Adopter of crop diversification = 1, Non-adopter of crop diversification = 0	
Independent variables		
Age	Number of years	+/-
Education	Years of schooling	+
Availability of human labour	Number	+
Experience in farming	Number of years	+
Size of land holding	Size of land in acres	+/-
Contact with State Agricultural Department officials	Have contact=1, No contact=0	+
Farm income	Actual amount (₹)	+

In the Garrett's ranking technique, the respondents were asked to rank the factors or problems and these ranks were converted into percent position by using the formula.

Percent Position (PP) = $\frac{100(Rij-0.5)}{Nj}$

Where,

R_{ij} = Ranking given to the i^{th} attribute by the j^{th} individual.

N_j = Number of attributes ranked by the j^{th} individual.

By referring to Garrett's table, the percent positions estimated were converted into scores. Thus, for each factor, the scores of the various respondents were added and the mean values were estimated. The mean values thus obtained for each of the attributes were arranged in descending order. The attributes with the highest mean value were considered as the most important ones and the others followed in that order.

Results and Discussion

The findings of the present study are summarized under the following headings:

Profile characteristics of sample farmers

The profile characteristics of sample farmers include age group, literacy level, family size, land holding size, and experience in farming, and the details of the same adopter and non-adopter farmers of crop diversification are presented in Table 1.

The results revealed that the majority of adopters (59 %) and non-adopters (51 %) belong to the middle age category with a secondary level of education (38 % and 42 %). adopters and non-adopters have small family size and semi-medium land holdings.

Table 1: Profile characteristics of sample farmers

Particulars	Adopters (%)	Non-adopters (%)
Age		
Young age (< 30 years)	13	25
Middle age (30 to 50 years)	59	51
Old age (> 50 years)	28	24
Education		
Primary level (0–5th)	36	39
Secondary level (6th-10th)	38	42
College level (>10th)	26	19
Family size		
Small family (< 4 No.)	49	59
Medium family (4 to 6 No.)	44	34
Big family (> 6 No.)	7	7
Land holding		
Marginal (<1 ha)	10	13
Small (1-2 ha)	23	42
Semi-medium (2-4 ha)	47	38
Medium (4-10 ha)	18	6
Large (>10 ha)	2	1
Experience in farming		
< 10 years	13	22
10 to 20 years	32	40
20 to 30 years	37	27
> 30 years	18	11

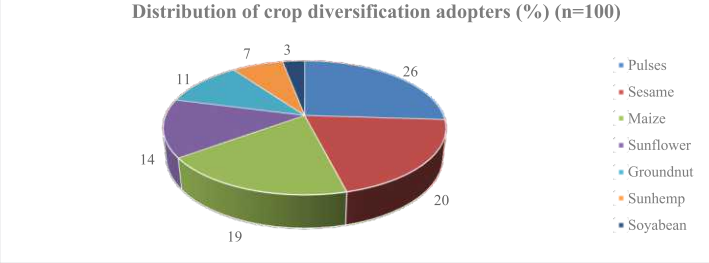
Overall, middle-aged, educated farmers from medium-sized families with semi-medium to medium landholdings and extensive farming experience are most inclined to adopt crop diversification. Supporting younger, less experienced farmers with smaller landholdings could enhance adoption and promote sustainable agriculture.

Distribution of crop diversification adopters

The information was collected on various crops cultivated by adopters of crop diversification in the *Rabi* season after paddy (Table 2). Among all, the majority of farmers cultivated pulses (26 %) as an alternate crop in the *Rabi* season in paddy fallows. It was followed by sesame (20 %), maize (19%), sunflower (14 %) and groundnut (11 %) (Table 2).

Table 2: Distribution of crop diversification adopters

Crop cultivated	Percentage of farmers
Pulses	26
Sesame	20
Maize	19
Sunflower	14
Groundnut	11
Sunhemp	7
Soyabean	3



Factors responsible for adopting crop diversification

The results of logit regression analysis to determine the factors responsible for adopting crop diversification are presented in Table 3.

Education: The coefficient of education was positive and statistically significant at 10 per cent indicating a one per cent increase in education increases the probability of adoption of crop diversification by 1 percent. This supports the results of (1 & 3).

Experience in farming: The coefficient of experience in farming was positive and statistically significant at 5 per cent. This study discovered that each additional year of experience increases the probability of adopting crop diversification by almost 1.0 per cent. This is most likely because as a farmer gets older, she accumulates more human capital in the form of experience which can be re-invested in the cultivation according to the changing conditions. Similar results were found in the study of (7).

Size of land holding: The coefficient of size of land holding was positive and statistically significant at 5 per cent. This study discovered that each additional acre of land owned increases the crop diversification adaptability by almost 4.0 percent. These findings were in confirmation with (6).

Contact with Agricultural Department Officials: The coefficient of contact with agricultural department officials was positive and statistically significant at 5 per cent. This study presents that with one per cent increase in contact with Agricultural Department Officials results in increased crop diversification adoption by 23.0 per cent. (8) The study was also in support of the finding that lack of knowledge transfer through public extension services is one of the critical reasons for the non-adoptability of crop- diversification by farmers.

Other variables like age, availability of human labor and farm income had an insignificant effect on the adoption of crop diversification.

Table 3: Factors responsible for adopting crop diversification

Variables	Estimate	Std. Error	Z – Value	Odds ratio	Marginal effects
Constant	-3.735**	1.388	-2.691	0.002	
Age	0.02015	0.0269	0.749	1.02	0.004
Education	0.05645*	0.03246	1.739	1.06	0.01*
Availability of human labour	0.0173	0.07163	0.242	1.02	0.004
Experience in farming	0.05332**	0.02277	2.341	1.05	0.01**
Size of land holding	0.06498**	0.03256	1.996	1.06	0.04**
Contact with state Agril. Department officials	1.073**	0.5177	2.072	2.93	0.23**
Farm income	-3.30E-08	1.43E-07	-0.229	0.99	-0.00001

Note: ****,** and * indicate significance at 1%, 5%, and 10% levels of probability.*

Cropping pattern and profitability of adopters of crop diversification (n=100)

Understanding the cropping pattern of sample farmers and their profitability is essential for identifying suitable crops for cultivation to maximize the net returns of farmers. The details of crops cultivated in both seasons, number of farmers cultivated, average holding, yield, cost of cultivation, gross returns, and net returns are presented below.

Table 4. Cropping pattern and profitability of adopters of crop diversification

S.No.	Season	Name of crop	No. of farmers	Average land holding (ha)	Average Yield (kg ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})
I	*Kharif*	Paddy (Bold)	58	2.31	6325	84607	134499	49892
		Paddy (Fine)	40	2.94	5800	86249	121566	35316
		Maize	11	0.71	4227	79593	81211	1619
		Turmeric	2	0.6	6750	277178	506250	229072
		Turmeric inter cropped with Maize	5	0.8	5800	286386	444000	157614
		Cotton	37	1.64	2094	93692	151852	58160
		Red gram	2	0.8	1750	62229	105000	42771
		Soy bean	11	2.64	1840	71690	78200	6510
II	*Rabi*	Paddy - Paddy (Bold)	29	2.6	6707	88136	136777	48641
		Paddy -Paddy(Fine)	14	2.99	4841	88762	133665	44903
		Paddy- Maize	19	0.81	6224	75843	123387	47544
		Paddy -Groundnut	11	1.2	1818	78078	81645	3567
		Paddy - Red gram	2	1	1028	63553	63651	98
		Paddy -Bengal gram	15	2.26	1742	66896	78800	11904
		Paddy - Black gram	14	0.9	875	52813	55674	2861
		Paddy - Green gram	5	0.3	500	65019	36000	-29019
		Paddy - Sun hemp	7	1.37	500	37987	51071	13084
		Paddy-Sunflower	14	2.26	1155	74017	76939	2922
		Paddy-Sesame	20	0.66	263	47414	23754	-23660
		Paddy - Soy bean	3	1.13	708	73021	36583	-36438
		Maize -Cowpea	3	1.33	1167	60248	60500	252
		Turmeric-Sesame	5	0.8	1075	45403	112350	66947
		Cotton -Sesame	1	0.6	625	46025	50000	3976
		Cotton - Cotton	2	2.8	1750	94683	178750	84067

During the Kharif season, Paddy-Bold was cultivated by 58 farmers with an average yield of 6325 kg/ha, generating net returns of Rs.49,892/ha. Paddy-fine, cultivated by 40 farmers, had a lower net return of Rs.35,316/ha. Maize, cultivated by 11 farmers, had a net return of only Rs.1619/ha, indicating lower profitability. Turmeric cultivation, practiced by 2 farmers, showed high net returns of Rs.229,072/ha, while Turmeric intercropped with Maize showed net returns of Rs.157,614/ha among 5 farmers. Cotton, Red gram, and soybean also showed varying net returns.

In the *Rabi* season, Paddy-Bold and Paddy-Fine continued to be popular with 29 and 14 farmers respectively, showing comparable net returns.

Maize cultivation in maize fallows practiced by 11 farmers yielded significant net returns of Rs.56,801/ha. Among all alternate crops cultivated, maize cultivation in the *Rabi* season in paddy fallows adopted by 19 farmers and yielded on par net returns with paddy cultivation Rs.47,544/ha and higher net returns when compared with other alternate crops cultivated (groundnut, Bengal gram red gram, black gram, sun hemp, and sunflower). Whereas, cultivation of green gram, sesame, and soybean resulted in negative net returns of Rs. 29019, Rs. 23660, and Rs. 36438 per ha respectively.

Constraints in adopting crop diversification

It was clear from Table 5 that sesame cultivated farmers opined high incidence of weeds (63.65) as a major problem if cultivated

in paddy fallows and it was followed by regeneration of paddy stubbles ranked second (51.15), followed by a high incidence of diseases (37.65), stunted growth (31.87), and lack of proper germination (28.28).
Maize cultivated farmers (n=19) opined that the most significant constraint is the regeneration of paddy stubbles (64.95), followed by a high incidence of weeds (62.5) and a high incidence of diseases such as Fall Armyworm (37.24).
Sunflower (n=14) farmers expressed a lack of sufficient seeds and high seed prices are the primary constraints (70.71). Bird damage ranks second (61.29), followed by germination problems (40.5) and high incidence of diseases (33). Weeds, although significant, rank lowest (31.5).
Groundnut farmers (n=11) face post-harvest losses due to hail storms as the most significant issue (61.75), followed by stunted growth (48.25) and a high incidence of pests (40.5).
Pulses growers (n=26) opined that germination problems in black gram and green gram as the most significant constraint (64.88), followed by a high incidence of pests and diseases (57.56) and yield losses due to cold at the flowering stage (47.52).

S.No.	Particulars	Garrett score	Rank
Sesame (n=20)			
1	Lack of proper germination	28.28	5
2	High incidence of weeds	63.65	1
3	High incidence of diseases (Macrophomina stem and root rot & Powdery mildew)	37.65	3
4	Stunted growth	31.87	4
5	Regeneration of paddy stubbles	51.15	2
Maize (n=19)			
1	High incidence of weeds	62.5	2
2	Regeneration of paddy stubbles	64.95	1
3	Heavy incidence of diseases (FAW & Ervenia)	37.24	3
4	Monkey problem	34.82	4
Sunflower (n=14)			
1	Lack of sufficient seed and high price of seed	70.71	1
2	Germination problem	40.5	3
3	High incidence of diseases (Tobacco caterpillar)	33	4
4	High incidence of weeds	31.5	5
5	Bird damage	61.29	2
Groundnut (n=11)			
1	Post harvest losses due to hail storms	61.75	1
2	Stunted growth	48.25	2
3	High incidence of pests (Helicoverpa & Spodoptera)	40.5	3
Pulses (n=26)			
1	Germination problem (Black gram & Green gram)	64.88	1
2	High incidence of pests (sucking) & diseases (Powdery mildew & Phyllody	57.56	2
3	Yield losses due to cold at flowering	47.52	3
4	Monkey problem	29.54	4

Suggestions for adopting crop diversification

Suggestions opined by sample farmers also recorded for improved level of adoption of crop diversification and the findings revealed that subsidizing inputs for alternate crops emerged as the most favored suggestion, receiving the highest Garrett score of 62.5 (Table 6). This indicates a strong inclination among farmers towards financial support to facilitate the transition to new crops. (9) supports this in his findings. Following closely behind was the suggestion to provide training on cultivation practices of alternate crops, which scored 62.0, highlighting the significance of engaging farmers in breeding processes to develop and adopt a wide range of crop varieties encouraging farmers to embrace new cultivation practices (4). Proper storage and marketing facilities for alternate crops ranked third, with a score of 55.3. This underscores the importance of infrastructure in bolstering farmers' confidence in diversifying their crops, knowing they can efficiently store and sell their produce (2). Establishing processing facilities for alternate crops secured the fourth rank, with a score of 44.6, indicating that value addition and additional income opportunities through processing facilities are perceived as beneficial. Providing training programs to promote crop diversification ranked fifth, with a score of 43.7, underscoring the need for educational efforts to raise awareness about the advantages of diversification. Lastly, providing Minimum Support Price for other crops ranked sixth, with a score of 31.7. In his findings, (5) suggested the need for an agriculture price policy to promote crop diversification.

Table 3.6: Suggestions for adopting crop diversification

S.No.	Particulars	Garrett score	Rank
1	Provide training programmes to motivate towards crop diversification	43.7	5
2	Provide training on cultivation practices of alternate crops	62.0	2
3	Provide inputs for alternate crops on subsidy basis	62.5	1
4	Provide proper storage and marketing facilities for alternate crops	55.3	3
5	Provide of MSP (Minimum Support Prices) for other crops	31.7	6
6	Establishing processing facilities for alternate crops	44.6	4

Conclusions

The study on crop diversification in the Northern Telangana Zone concludes maize in paddy fallows is nearly as profitable as paddy cultivation during the *Rabi* season, with net returns of Rs. 47,544 per ha compared to Rs. 48,641 per ha for paddy cultivation. Some crops like turmeric and maize areobserved to be highly profitable, while others like soybean and green gram show negative returns due to agronomic challenges. Higher education, more farming experience, larger landholdings, and frequent interaction with Agricultural Department officials significantly encourage crop diversification. Major problems observed are high weed incidence, inadequate seed supply, pest and disease issues, and post-harvest losses. Specific challenges include paddy stubble in maize, germination issues in pulses, and bird damage to sunflowers. To promote diversification, provide subsidized inputs, training on alternate crops, and improve storage, marketing, and processing facilities. Implement minimum support prices for alternative crops to ensure better marketability and profitability. Overall, addressing these challenges through targeted interventions can enhance agricultural sustainability and profitability in the region.

Future scope of study: Identified maize as profitable crop in paddy fallows and growing demand for maize in various industries, including food, feed, and biofuel, farmers can adopt this cropping system.

Conflict of interest : None

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