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Preface

Institutions are the framework consisting of legal structures, customary rules, property rights, implicit or explicit contracts, and governance systems in which economic actors interact and factors of production are employed. In the context of imperfect information systems, the institutions are as important as market forces in determining performances and solving emerging non-economic problems. Simple, effective and inclusive institutions are central to achieving sustainable development goals. These are critical enablers of equity, efficiency and rational decision-making behaviour by individuals and other economic actors. The role of institutions in agricultural development and poverty reduction has been well recognized. The importance of different institutional arrangements in managing natural resources and market behaviour has been equally highlighted in the literature. These arrangements can be seen for market transactions, contracts and market failures. While the theoretical aspect and generalities of institutional changes in agriculture are discussed in the literature, less has been deliberated on its empirical part. Therefore, the theme of "Institutional Changes for Inclusive and Sustainable Agricultural Development" was taken for discussion at 30th annual conference of the Association organized at the Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (SKUAST-J), Chatha Campus, J&K during 21-23 December 2022.

There has been an overwhelming response from the paper contributors to the Conference. The Chief Editor has recommended 15 papers for publication in full length and the rest in the form of abstracts. The publication in the form of an abstract in any way does not reflect quality and content of the papers.

The Association is grateful to Dr J P Sharma, Vice-Chancellor, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu for consenting to host the Conference at very short notice. The Association is also grateful to Dr S K Gupta, Director Extension, Dr Rakesh Nanda, Director Education, Dr Pradeep Wali, Director Research, and Dr Jyoti Kachroo, Director, Planning & Monitoring for guiding the organizational activities, and to Dr Sudhakar Dwivedi, Professor, Division of Agricultural Economics & ABM, for shouldering the responsibility of Organizing Secretary for the Conference.

The Association is grateful to the Indian Council of Agricultural Research (New Delhi) for providing continuous financial support for the publication of the regular issues of the journal *Agricultural Economics Research Review* and also for organization of the Annual Conference. The National Bank for Agriculture and Rural Development (Mumbai) provided financial assistance to publish papers and proceedings of the Conference in a special issue of the *Agricultural Economics Research Review*, which is acknowledged with thanks. The Association is also thankful to Dr RT Doshi Foundation (Mumbai) for annually sponsoring two prizes for the best presentations at the Conference and also two prizes for the best papers published in the *Agricultural Economics Research Review*. International Food Policy Research Institute (IFPRI) has sponsored the technical session in the Conference.

Dr P K Joshi, President, AERA has taken keen interest in various activities and programs of the conference. Special thanks are due to Dr Ashok Dalwai, CEO, National Rainfed Area Authority for delivering Distinguished Lecture, and to Dr Shahidur Rashid, Director–South

Asia, IFPRI, New Delhi for delivering Dr GK Chadha memorial lecture.All office-bearers of the Association, particularly Dr P Kumar, Chairman of the Editorial Board, and Dr P S Birthal, Chief Editor, have contributed in several ways to bring out the conference and regular issues of the journal. I take this opportunity to thank all of them for their cooperation and untiring efforts. Let me also thank eminent scholars for reviewing the articles for the journal.

We are grateful to all the invited speakers at the Conference and the paper contributors for submitting their excellent work. I sincerely thank chairpersons of different sessions and all other colleagues who have accepted various scientific responsibilities to conduct proceedings of the Conference.

Suresh Pal
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How elastic is the profit to prices of output and the variable inputs? Some insights from paddy cultivation in India

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Abstract One of the strategies that seems to be convenient to the government, farmers and policymakers is the increase output price to double the farmers' income. But how much will be the increase in the profit as a result of increase in output price depends on the profit elasticities. Profit received by the farmers is a function of output supply as well as demand of inputs used in the production process, which, in turn, depends on their respective prices. The present study estimated normalised restricted translog profit function and used duality approach to determine profit elasticities with respect to output and input prices in paddy cultivation. The study found that the profit in paddy is more elastic (-1.7108) to the decrease in input prices than the increase in output price (1.6001). On the basis of elasticities, it can be calculated that the doubling of profit from paddy requires more than 62% increase in output price and more than 58% decrease in input prices in real terms. On the demand side, the increase in profit from this crop put heavy pressure on input market which needs to be taken care to have desired effect.

Keywords Profit elasticity, restricted translog profit function, output supply elasticity, input demand elasticity, paddy

JEL codes C4, C5, O1, Q12

Indian government pledged to double farmers' income by 2022. This led many to contemplate as what is it and how to do it? The various dimensions of the income speculated were whether it is doubling of output, gross revenue or profit; doubling of nominal income or real income; or doubling of income from farm activities alone or also from non-farm activities. To be rational, there is no doubt in deciding that the government's intention seems to be to doubling income of the farmers from farming in real terms (Chand 2017). Various approaches being put forth for doubling farmers' income encompass both on-farm and off-farm strategies. The on-farm strategies include increasing of productivity and input use efficiency by adopting improved technologies in seed, fertilizer and irrigation (Saxena et al. 2017). The shifting of cropping pattern in favour of high value crops and taking advantage of vertical and horizontal integration of farm enterprises viz. cropping-poultry-fishery, processing, etc., are some of the options available to the farmers to get additional returns. Chandrasekhar and Mehrotra (2016) observed that net income from farming of animals increased by 3.21 times in 2013 over the average monthly income in 2003 and can prove to be the key driver in increasing net income of agricultural households. The off-farm strategies suggested are the development of agriculture supporting infrastructure (roads, markets, storage and processing) (Meena et al. 2017) and institutional arrangements for linking farms to the market (cooperatives, contract farming and producer companies) (Venkatesh et al. 2017). All these are age-old strategies but could not get much of the needed momentum in the past due to the presence of numerous factors desisting farmers to divert from traditional

practices. The policies targeted at prices, procurement, subsidy and consumption or distribution have favored cultivation of the selected crops especially foodgrains in the country and proved detrimental to diversification (Despande and Naika 2002; Parik and Singh 2007; Devineni et al. 2022). The cultivation of many fruits and vegetables which are generally considered as high value crops, would appear risky to a vast majority of small and marginal farmers, unless there are provisions of effective technology, price, marketing and insurance support (Haque 2006).

One of the strategies in increasing of farmers' income that is being seriously pursued by the government, the farmers and the economists alike is the increase of output price. The strong support it draws from one of the important recommendations of National Commission on Farmers (NCF) (GOI 2006) to fix minimum support prices (MSP) at least 50% more than the weighted average cost of production. The government's commitment in the recommendation is evident from the decision taken in the Union Budget, 2018 (GOI 2018) to fix MSP of kharif crops at 50% higher than the cost of variable inputs and labour. Besides the other apprehensions raised about this recommendation of NCF, how much will be the increase in profit with an increase in output price depends on profit elasticity. The amount of profit realised by a farmer in any crop is an interaction of changes in the output supply and the demand of inputs used in production of the output. In turn, the change in output supply and input demand takes place on account of changes in their prices. An econometric estimation of profit, output supply and input demand functions helps us in determining the profit elasticity with respect to output and input prices. Another related aspect which is implicit in this analysis is that, if profit doubles, what is going to happen to output supply and inputs' demand. Since, the increase in output supply does not stand in isolation; the policy makers have to think as what to do with the increased supply and the inputs' demand so that it does not result into an ultimate decline in the price of output and increase in the prices of inputs.

The present paper dwells on above mentioned aspects using dual function approach in paddy cultivation in India as the crop constitutes about 35% of area and 40% of production of food grains in the country. The profit in this case is defined as the income over cost incurred on selected inputs used in the crop. The paddy crop was selected for the study keeping in view its wide spread cultivation in the country. The study assumes that doubling of farm income is evenly distributed across all crops cultivated by the farmer and thereby, doubling of farmer's income means doubling of income per unit of each crop cultivated.

Methodology

The state wise time series data on output produced and inputs used in paddy cultivation were taken from various reports of Comprehensive Scheme for cost of cultivation of Principal crops, prepared by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. A balanced panel having time series observations for five years from 2015 to 2019 across seventeen major paddy growing states were used to estimate profit, output supply and input demand functions simultaneously by applying seemingly unrelated regression (SURE) model. Only those states were kept in the model which were having information on cost of cultivation of paddy throughout five years of duration (2015-19). The major sources of other information consulted have been cited at the same place where used.

SURE model framework

How the producer is going to respond is determined by prevailing technological relationship that exists between inputs used and the resulting output, and the choice of inputs at given market prices for both commodity and the inputs in the presence of fixed factors. Integration of these two elements in duality leads to the profit function that determines the optimum decision on output supply and input demand. The paper applied same approach to derive output supply and input demand functions using normalised restricted translog profit function of the following form:

$$\ln \pi^{*'} =$$

$$\alpha_0 + \sum_{j=1}^{5} \alpha_i \ln r_i + \frac{1}{2}\sum_{i=1}^{5}\sum_{j=1}^{5} \gamma_{ij} \ln r_i \ln r_j +$$

$$\sum_{k=1}^{3} \beta_k \ln Z_k + \frac{1}{2}\sum_{k=1}^{3}\sum_{l=1}^{3} \theta_{kl} \ln Z_k \ln Z_l +$$

$$\sum_{i=1}^{5}\sum_{k=1}^{3} \delta_{ik} \ln r_i \ln Z_k + \xi_i \qquad (1)$$

Translog functional form was chosen because of its advantage over the limitations of Cobb Douglas functional form as sited by Sidhu and Baanante (1981) and Chand (1986). The former is considered to be a flexible model with variable elasticities and at the same time giving second-order approximation of the variables. In the function, $\pi^{*'}$ is the restricted profit normalised by output price and was estimated by deducting cost of variable inputs from the gross revenue. The gross revenue was the sum of main and by-product values. The inputs included in the study were seed, fertilizer, manure, human labour and animal labour. The prices of inputs were normalised (r_i) by the output price. The normalisation reduced the function by one variable and the homogeneity constraint was automatically satisfied in this formulation. There were one fixed factor i.e. working capital (Z_1) and two state shifters i.e. proportion of gross cropped area under rice (Z_2) and irrigated area (Z_3). Since the input-output data on paddy cultivation was taken per hectare basis for each state, the inclusion of latter two variables i.e. proportion of gross cropped area under rice (Z_2) and irrigated area (Z_3), besides the prices was necessary to scale up the estimation of parameters at aggregate level or the state level. All the values were taken in natural logarithmic form except the working capital and state shifters. There ξ_i was the error term. The parameters α_0, α_i, γ_{ij}, δ_{ik}, β_k and θ_{kl} were estimated and subscripts 'i' & 'j' stands for prices of inputs (i= 1..j…5), 'z_k' stands for fixed factors and the shifters when k=1, it is the working capital and k=2 and 3 are the state shifters Z_2 and Z_3, respectively.

The partial derivatives of the log linear translog profit function, as defined earlier, with respect to log value of normalised input price yields the input share equations as given below:

$$S_i = \frac{\partial \ln \pi^*}{\partial \ln r_i} = -\frac{P_i X_i}{\pi^*} = -si = \alpha_i + \sum_{j=1}^{5} \gamma_{ij} \ln r_j + \sum_{k=1}^{3} \delta_{ik} \ln Z_k \quad (2)$$

$$S_y = \frac{P_y Y}{\pi^*} = 1 + \sum \frac{\partial \ln \pi^*}{\partial \ln r_i} = 1 - \alpha_i - \sum_{j=1}^{5} \gamma_{ij} \ln r_j - \sum_{k=1}^{3} \delta_{ik} \ln Z_k \quad (3)$$

where S_i is the negative share value of the i-th input and S_Y is the positive share value of output in the profit. Since the input and output shares form a singular system of equations (by definition Sy- ΣSi = 1), one of the share equations i.e. the output share equation, was dropped. The remaining variable input share equations and the profit function were estimated jointly using Zellner's Seemingly Unrelated Regression Equation (SURE) procedure (Zellner 1962). Since the five input share equations were derived from the same normalised translog profit function, 45 linear equality parametric restrictions were imposed along with 10 symmetry constraints. The validity of imposed fifty-five joint null hypotheses was tested using F-value statistic with asymptotic properties as suggested by Theil (1971) at 55 number of restrictions (m) and 420 (n-k) degrees of freedom where 'n' is the total number of observations and 'k' is the number of parameters estimated in unrestricted function including the intercept.

The computed $F_{(55,420)}$ value (14.3487) was found to be higher than the critical value 1.3645 at $F_{(0.05,55,420)}$ and hence, the null hypotheses was rejected. This implies that among other things, the profit was not maximised with respect to normalised prices of the variable inputs which may be specific to the Indian conditions as were found by other authors (Junankar, 1982; Kumar, 2005) and more so, paddy being a staple food in many states. Nevertheless, the further analysis was conducted using restricted profit function so that supply and demand functions meet the properties of homogeneity ($\varepsilon_{y.py} + \Sigma\, \varepsilon_{y.pxi} = 0$ and $\tau_{i.py} + \Sigma\, \tau_{i.pj} = 0$) and symmetry ($\tau_{i.pj}/\tau_{j.pi} = Sj/Si$). It was also observed that estimation of profit elasticities with respect to output and inputs' prices, which was the main objective of the study, were not sensitive to the estimated parameters of restricted or unrestricted translog profit function.

Before proceeding further with the estimation of output supply and input demand functions, the fitted functions were tested to be monotonic as the predicted output and the factor shares calculated by using the estimated parameters of demand equations at average levels of variable input prices and fixed factors were found to be positive and negative, respectively.

Following Hotelling's Lemma, the negative of the first order partial derivative of the normalised profit function with respect to normalised input prices gives a system of demand functions for variable inputs as given below:

$$-\frac{\partial \pi^{*'}}{\partial r_i} = X_i \quad (4)$$

Factor Demand Function

$$X_i = -\frac{\pi^{*'}}{s_i}\left[\alpha_i + \sum_{i=1}^{5} \gamma_{ij} \ln r_j + \sum_{k=1}^{3} \delta_{ik} \ln Z_k\right] \quad (5)$$

Output Supply Function

$$Y = \pi * ' \left[1 - \sum(\alpha_i + \sum_{j=1}^{5} \gamma_{ij} \ln r_j + \sum_{k=1}^{3} \delta_{ik} \ln Z_k) \right] \quad (6)$$

From factor demand and output supply functions, different elasticities were computed as follows:

Output supply elasticities

Output supply elasticities with respect to output price, variable input prices and the fixed factors were estimated at average value of S_i and at given level of parameters estimated from the above-mentioned demand and supply functions.

The supply elasticity with respect to output price ($\varepsilon_{y.py)}$ is given by

$$\varepsilon_{y.p_y} = -\sum s_i + \sum\sum \gamma_{ij}/(1 - \sum S_i) \quad (7)$$

The supply elasticity with respect to ith input price ($\varepsilon_{y.pxi}$) was estimated as follows

$$\varepsilon_{y.px_i} = S_i - \sum \gamma_{ij}/(1 - \sum S_i) \quad (8)$$

The supply elasticity with respect to fixed factors/ shifters was calculated as follows:

$$\varepsilon_{y.Z_k} = \frac{\partial \ln Y}{\partial \ln Zi} = \frac{\partial \ln \pi *'}{\partial \ln Zi} + \frac{\partial \ln(1 - \sum_{i=0}^{n} Si)}{\partial \ln Zi} = (\beta_k + \sum \delta_{i\,k} \ln r_i +$$

$$\sum_{l=1}^{3} \theta_{kl} \ln Z_l) - \frac{\sum \delta_{ik}}{(1 - \sum S_i)} \quad (9)$$

Input demand elasticities

From the factor demand equations estimated for seed, fertilizer, manure, human labour and animal labour, the input demand own and cross elasticities were estimated. The own price elasticity of demand for ith input ($\tau_{i.px_i}$) derived from its input share function was calculated as given below:

$$\tau_{i.p_{x_i}} = \frac{\partial \ln X_i}{\partial \ln r_i} \cdot \frac{\partial r_i}{\partial P_{x_i}} = S_i + \frac{\gamma_{ii}}{S_i} - 1 \quad (10)$$

where $S_i = -\frac{p_{x_i} x_i}{\pi^*} = -s_i$, $r_i = \frac{p_{x_i}}{p_y}$ and γ_{ii} = coefficient of i-th input share for with respect to normalised price of i-th factor.

Similarly, the cross price elasticity of demand of ith input with respect to price of jth input ($\tau_{i.px_j}$) was obtained by

$$\tau_{i.P_{x_j}} = \frac{\partial \ln X_i}{\partial \ln r_j} \cdot \frac{\partial r_j}{\partial P_{x_i}} = S_j + \frac{\gamma_{ij}}{S_i} \quad (11)$$

where γ_{ij} = coefficient of i-th input share function with respect to normalised price of j-th factor.

The elasticity of demand for i-th input with respect to output price, P_y ($\tau_{i.p_y}$) was derived from following formula:

$$\tau_{i.p_y} = \frac{\partial \ln X_i}{\partial \ln P_y} = -\sum_{i=1}^{5} S_i + 1 - \frac{\sum_{i=1}^{5} \gamma_{ij}}{S_i} \quad (12)$$

Finally, the elasticity of demand of i-th input with respect to the k-th fixed/ shift factor ($\tau_{i.k}$) was obtained from following equation.

$$\tau_{i.k} = \frac{\partial \ln X_i}{\partial \ln Z_k} = \frac{\partial \ln \pi^*}{\partial \ln Z_k} + \frac{\delta_{ik}}{S_i} = \beta_k + \sum_{i=1}^{5} \delta_{ik} \ln r_i +$$

$$\sum_{k=1}^{3} \theta_{kl} \ln Z_l + \frac{\delta_{ik}}{S_i} \quad (13)$$

where δ_{ik} coefficient of i-th input share function with respect to k-th factor

Profit elasticities

It estimates the percentage change in profit with respect to prices of output and variable inputs used in paddy production. The major concerns of the government addressed by the profit elasticities were that how the profit responded to the changes in prices of output and inputs used in its production. In this, we used profit function (π*) not normalised which can be written in the form of factor share functions as shown below:

$$\pi^* = P_y \cdot Y + \sum \frac{\partial \ln \pi^{*\prime}}{\partial \ln r_i} \cdot \pi^* \quad (14)$$

The various profit elasticity estimates can be derived from this equation. The elasticity of profit with respect to output price ($E_{\pi.py}$) is

$$E_{\pi.p_y} = \frac{\partial \pi^*}{\partial P_y} \cdot \frac{P_y}{\pi^*} = 1 - \sum\sum \frac{\gamma_{ij}}{S_y} \quad (15)$$

where 's_y' is share of value of output in profit and $\Sigma\Sigma\gamma_{ij}$ is the sum of coefficients of all factor share equations with respect to normalized prices of all variable inputs.

The elasticity of profit with respect to prices of i-th variable input is given by

$$E_{\pi.P_{x_i}} = \frac{\partial \pi^*}{\partial P_{x_i}} \cdot \frac{P_{x_i}}{\pi^*} = \varepsilon_{y.p_{x_i}} + \sum \frac{\gamma_{ij}}{s_y} \quad (16)$$

where $\varepsilon_{y.Px_i}$ is the output supply elasticity with respect to price of ith input and $\Sigma\gamma_{ij}$ is the sum of coefficients of all factor shares equations with respect to normalized price to i-th input.

Finally, the output supply elasticity of profit ($\eta_{y.\pi}$) and the inputs' demand elasticity of profit ($\eta_{xi.\pi}$) were estimated to know the proportionate change in output supply and the inputs' demand with respect to profit. The output supply elasticity of profit ($\eta_{y.\pi}$) was taken as the ratio of output supply elasticity ($\varepsilon_{y.p_y}$) and the profit elasticity ($E_{\pi.p_y}$) with respect to output price i.e. $\varepsilon_{y.p_y}/E_{\pi.p_y}$; which is elaborated below:

$$\eta_{Y.\pi} = \frac{\partial Y}{\partial \pi}.\frac{\pi}{Y} = \frac{\partial Y}{\partial P_y}.\frac{\partial P_y}{\partial \pi}.\frac{\pi}{Y}.\frac{P_y}{P_y} = \frac{\partial Y}{\partial P_y}.\frac{P_y}{Y}.\frac{\partial P_y}{\partial \pi}.\frac{\pi}{P_y} = \frac{\varepsilon_{y.p_y}}{E_{\pi.p_y}} \quad (17)$$

While the input demand elasticity of profit ($\eta_{xi.\pi}$) for the ith input was taken as the ratio of input demand elasticity ($\varepsilon_{x_i.P_{x_i}}$) for the same input and the profit elasticity ($E_{\pi.P_{x_i}}$) with respect to input prices i.e. $\varepsilon_{x_i.P_{x_i}}/E_{\pi.P_{x_i}}$ as show below:

$$\eta_{x_i.\pi} = \frac{\partial x_i}{\partial \pi}.\frac{\pi}{x_i} = \frac{\partial x_i}{\partial P_{x_i}}.\frac{\partial P_{x_i}}{\partial \pi}.\frac{\pi}{x_i}.\frac{P_{x_i}}{P_{x_i}} = \frac{\partial x_i}{\partial P_{x_i}}.\frac{P_{x_i}}{x_i}.\frac{\partial P_{x_i}}{\partial \pi}.\frac{\pi}{P_{x_i}} = \frac{\varepsilon_{x_i P_{x_i}}}{E_{\pi.P_{x_i}}} \quad (18)$$

Results and discussion

Price elasticities of input demand and paddy supply

Any policy intervention of price change does not end with it but has a rippling effect in the market in terms of effecting the supply, demand of inputs and the profit. In the process, estimates of own and cross price elasticities of paddy supply and the variable input demands for seed, fertilizer, manure, human and animal labour (Table 1) have been derived from input share function so that the sensitivity of the output supply and the input demand to the market prices may be understood. Table 1, also, shows the estimates of elasticities of paddy supply and the demand of variable inputs with respect to capital as a fixed factor and the percentages of gross cropped area under paddy and irrigation as shifter of the function.

As expected, the elasticities of paddy supply and the factors' demand were positive with respect to paddy price and negative with respect input prices except for fertilizer where own price elasticity was found to be positive but close to zero. Both paddy supply and the inputs' demand were elastic to paddy price but what is notable was that the demands of inputs were more elastic to paddy price. The results of demand and supply elasticities to paddy price convey that the increase in paddy price raise demand for inputs more than the increase in supply of its output being input intensive nature of the crop. The demand elasticity of manure to paddy price was as high as 2.845. It was followed by demand elasticity of animal labour (1.906), human labour (1.755) and seed (1.490). The demand elasticity of fertilizer with respect to paddy price was 1.206 which means 1% increase in paddy price results into 1.206%

Table 1 Price elasticity estimates for paddy supply and demand for its variable inputs, 2015-19

Crop and factor prices	Paddy	Seed	Fertilizer	Manure	HL	AL
1. Output price						
Paddy	1.110	1.490	1.206	2.845	1.755	1.906
2. Input prices						
Seed	-0.059	-0.868	-0.125	-0.087	-0.025	-0.065
Fertilizer	-0.058	-0.151	0.008	-0.118	-0.066	-0.226
Manure	-0.066	-0.051	-0.057	-1.033	-0.073	-0.068
Human labour	-0.747	-0.265	-0.586	-1.331	-1.456	-0.609
Animal labour	-0.181	-0.155	-0.446	-0.276	-0.136	-0.938
3. Fixed variable						
Capital (Rs)	1.240	0.571	1.234	1.763	0.875	0.951
4. Aggregate variables						
%GCA under paddy	0.031	-0.055	-0.441	-0.139	0.162	0.363
%GCA irrigated	-0.433	-0.236	0.231	-0.683	-0.587	-1.170

Source Authors' calculations

increase in fertilizer demand while it raises output by only 1.110%. If the government wishes to double paddy farmers' income by increasing paddy prices, this requires extensive arrangements to meet demand of the farmers for the inputs at cheaper rate keeping in view the highly elastic demand of the inputs for paddy prices.

With respect to input prices, the elasticity of paddy supply was negative, confirming, thereby, that the paddy output supply decreases with the increase of input prices. Nevertheless, paddy supply elasticities with respect to input prices were found to be inelastic which means that the output supply decreases by less than 1% with 1% increase in input prices. The increase in human and animal labour wage rates adversely affect the output supply of paddy substantially as is evident from the highest value of output supply elasticity for human labour wage rate (-0.747) followed by for animal labour wage rate (-0.181). The paddy supply was highly elastic (1.240) to fixed capital on the farm. Since percentage of gross cropped area under paddy and under irrigation were used as state shifters, the elasticity estimates of these variables indicate the effect of these variables on paddy supply and input demand in the state. In contradiction to the belief, the supply of paddy in a state reduces by 0.433% for every 1% increase in proportionate area under irrigation. On the other side, the supply elasticity of 1% increase in proportionate area under paddy was positive (0.031).

The own price elasticities for all the inputs' demand were negative except for fertilizer indicating that input prices has least effect on use of fertilizer in paddy. This may be due to the fact that the fertilizer prices do not vary much across states and over time due to subsidy. The own price elasticities of manure (-1.033) and human labour (-1.456) were found to be elastic while it was inelastic in other inputs but high enough to be close to one. This indicates that inputs' demand especially that of human labour in paddy (Mailena et al. 2013) was highly sensitive to their prices/ wage rates. The cross price elasticity of all the inputs were found to be negative revealing complementarity between the inputs as the use of one input is directly related to the use of another input. For instance, increased demand for seed require higher use of rest of the inputs namely, fertilizer, manure, human and animal labour. The cross price elasticities of all the inputs were inelastic except that of manure to the human labour wage rate (-1.331) which was even higher than the own price elasticity of manure. This may be due to the fact that collection of manure and applying them in the fields is a labour intensive work and is done only by those farms where labour is available.

The capital has significantly positive demand elasticities for all inputs which were elastic for fertilizer (1.234) and manure (1.763) but were inelastic for other inputs but high enough in case of human and animal labour. The percentage increase in demand of seed was 0.571 for 1% raise in capital availability. The proportionate area under paddy was having positive effect on the demand of human and animal labour while it was negative in rest of the inputs which may be because of the reason that paddy cultivation in the states having higher percentage of area under paddy is less input intensive to seed, fertilizer and manure. The input demand elasticities were negative to the proportionate area under irrigation for all inputs except for fertilizer because the fertilizer use increases with irrigation. The input demand elasticities of area under irrigation were inelastic for all inputs except animal labour where 1% raise in the proportionate area under irrigation reduced the demand for animal labour by 1.170%. These two estimates implicate that higher proportion of area under irrigation in a state leads to mechanisation and the demand for animal labour reduces faster in paddy cultivation. As the percentage area under irrigation increases, the demand of inputs in paddy reduced because of shifting of farmers away from paddy cultivation.

Profit elasticities with respect to output and input prices

In the present context, it is pertinent to determine how the profit from paddy cultivation changes with the change in output and input prices. In this process, this section of the paper estimates the percentage change in profit from paddy for 1% change in input and output prices including fixed factors. Table 2 indicates the estimated profit elasticities with respect to output and input price in paddy cultivation.

As expected, the increase in output price results into increase in profit while the increase in input prices lead to decrease in the profit. The value of profit elasticity to output price was estimated to be 1.6004 confirming, thereby, increase in output prices have substantial

Table 2 Estimated profit elasticities with respect to output and input prices in paddy cultivation

Crop and factor prices	Profit elasticities	Change in prices/ variables (%) to double the profit
1. Output price		
Paddy	1.6004	62.49
2. Input prices	-1.7108	-58.45
Seed	-0.1078	
Fertilizer	-0.1302	
Manure	-0.0628	
Human labour	-1.1531	
Animal labour	-0.2568	
3. Fixed variable		
Capital (Rs)	1.7765	56.29
4. Aggregate variables		
%GCA under Paddy	-0.1238	Not calculated
%GCA irrigated	-0.1592	Not calculated

Source Authors' calculations

positive effect on profit and there is nothing wrong if the policy makers are targeting raise in profit by increasing the minimum support prices. If the elasticity of profit to output price is 1.60%, 62.49% increase in paddy prices will double the profit.

On the other hand, the profit elasticity with respect to all variable input prices taken together was found to be highly elastic and reduces profit by 1.71% for 1% increase in the variable input prices. It amounts to about 58% reduction in input prices to double the profit. Thus, the reduction in input prices contributes more than the increase in output price to double the profit from paddy. Which can be further simplified to understand that if profit is to be doubled by 2022, output price should compound at the rate of 6.26% per annum and input prices should reduce at the rate of 10.28% per annum in real terms from the 2014 as base. By using scenario analysis, Balaji et al. (2017) found that letting the MSP and FHPs to increase by 10% a year will double real gross income from *arhar* (pigeon pea). Ali et al. (2012) observed that MSP for paddy (fine) experienced an annual growth rate of 6.76% over the period 1990-2009.

The availability of fixed capital has positive effect on profit. The elasticity of profit to capital was observed to be 1.77% requiring 56% increase in capital to double the profit. The role of capital in increasing the profit from crop cultivation has been advocated by various studies in the past also (Narayanamoorthy 2013). The capital available in the hands of farmers may be enhanced by various banking products like Kisan Credit Card (KCC), crop and term loans, micro-financing systems, etc. The additional capital available may be directed towards purchase in machinery, adoption of modern technology and improved skill in crop cultivation and the latter is perhaps more desired in paddy cultivation. It may be noted here that the profit elasticities of proportionate area under irrigation and rice were negative showing clearly that profitability of paddy production was lesser in states with higher proportion of area under irrigation and rice. The results demonstrate that the technological breakthroughs and other related supports are not enough to improve the productivity and profitability of the crop in these states. This can be one of the strategies towards doubling the farmers' income from paddy in those states.

State wise effect on profit from output price increase

As observed above, the doubling of profit required 62.49% increase in an average output price. Since the output price differ from state to state, the stated increase in output price is not likely to have the same effect on profit in all the states. To find out the effect on paddy profit from the increase in existing output price, state

Table 3 State wise percentage increase in profit

Change in profit (%)	States
< 50%	Haryana, Punjab, Karnataka, Gujarat and Madhya Pradesh (MP)
≥ 50% and < 80%	Andhra Pradesh (AP) , Uttar Pradesh (UP)
≥ 80% and < 100%	Maharashtra and Uttrakhand
≥ 100%	Assam, Bihar, Chattisgarh, Himachal Pradesh (HP), Kerala, odisha, Tamil Nadu (TN) and West Bengal (WB)

Source Authors' calculations

wise profit and inputs' demand equations were estimated using the estimated parameters of restricted normalised translog profit and input share functions given in Table A1 of Appendix. The changes in profit so recorded in different states at 62.49% increase in average output price are given in Table 3.

The effect of increase in output price on paddy profit was found to be the maximum in those states which were having low per hectare profit but high percentage area under rice e.g. Assam, Kerala, Chattisgarh, TN, WB, etc. The states like Punjab and Haryana, which are already getting higher profit per hectare, has less effect of output price on profit. This may be because paddy production in these states heavily depends on input use and the little gain in profit was realised by decrease in demand for inputs.

Output supply and inputs demand elasticities with respect to profit

Another question that needs to be answered is what will happen to the supply of paddy and the input demand if profit increases i.e. the elasticity of paddy supply and input demand to profit. Table 4 shows the estimated elasticity of paddy supply and major variable input demand to profit in paddy cultivation. The perusal of results clearly indicates that paddy supply is inelastic to profit i.e. if profit increase by 1%, the output supply will increase by only 0.69% and a 100% increase in profit is going to increase paddy supply by about 69.40% on an average.

However, input intensive nature of the paddy cultivation for that matter was clearly reflected by the elastic input demand to profit for most of the variable inputs except for fertilizer which was observed to be negative. The elasticity of fertilizer demand to paddy profit (-0.064%) indicated that efficiency in fertilizer use pay more in terms of greater profit rather than increase in demand for quantity of fertilizer. The elastic demand for rest of the inputs clearly indicates that the doubling of profit from paddy per hectare is likely to put higher pressure on their demand.

Table 4 Estimated elasticity of paddy supply and major variable input demand with respect to profit in paddy cultivation

Output supply and input demand	Output supply and input demand elasticity w.r.t. profit	Change in paddy supply and input demand (%) to double the profit
1. Output supply		
Paddy	0.694	69.40
2. Input demand		
Seed	8.048	804.80
Fertilizer	-0.064	-6.40
Manure	16.442	1644.29
Human Labour	1.263	126.30
Animal labour	3.654	365.40

Source Authors' calculations

The elasticities of demand for inputs other than fertilizer were 8.048, 16.442, 1.263 and 3.654 for seed, manure, human labour and animal labour, respectively. The high value of elasticity of manure demand to profit may be due to overestimation to some extent, because the quantity of manure used in paddy cultivation is abysmally low but it results into higher profit when applied by improving the soil condition. Any increase in profit from paddy is likely to cause 16 folds increase in demand of manure. A number of studies have recorded that the use of organic manure in paddy and other crops has enhanced efficiency and have reduced the requirement of chemical fertilizers (Khan et al. 2002; Singh and Gangawar 2000). The doubling of profit is likely to increase demand for seed by more than eight times, the demand for human labour by a hundred and quarter per cent (126%) and the demand of animal labour by more than three folds (365%). The results of the study succinctly indicate that raise in the profit from paddy will put greater pressure on variable input demand side rather than on output supply side.

Conclusions

Profit from paddy cultivation was found directly elastic to output price (1.6004) and inversely elastic to variable input prices (-1.7108). Representing an average situation, more than 62% increase in output price is required to double the profit while more than 58% decrease in input prices is required in real terms to attain the same level of profit. For 62% increase, the output price should compound at the rate of 6.26% per annum keeping the input prices same. An increase in profit has inelastic effect on output supply (0.694%) while it is highly elastic for the demand of major inputs. The doubling of profit is going to increase the demand for seed by more than eight times, the demand for human labour by a hundred and quarter (126%) and the demand of animal labour by more than three folds (365%) while the demand of manure is likely to increase 16 folds. Thus, the policy issues that need to be addressed is the availability of these inputs at lower rate in order to increase the profit of the farmers per hectare in case of paddy crop which account of 27% of the gross farmers' income from crop cultivation. Among non-price factors like fixed capital was the major contributor to increase in profit. The ensured use of quality seed and manure will enable the farmers to increase their profit. Since, the higher profit was attained with lesser fertilizer demand, indicating, taking advantage of efficient use of fertilizer and promoting use of organic fertilizer or manure are some of the strategies to be adopted. The higher value of elasticity of profit to human labour wage rates (-1.1531%) demands mechanization especially in those states allocating larger area to paddy which would reduce the adverse effect of human labour wages on profit.

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Influence of assets over dynasties in semi-arid India: econometric analysis using micro level panel data

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Abstract The study of the capital accumulation between generations is of critical interest for understanding the pathways out of poverty in rural India. This paper uses unique Village Dynamics in South Asia (VDSA) dataset spanning for 23 years and up to three generations covering 154 households in three rural villages of India to study this. Generalized method of moments was used to understand the influence of parents' characteristics on children. Results indicate that education and non-land assets are critical indicators of between-generation capital accumulation. In contrast, land assets, after controlling for non-land assets, appear to be associated with more stagnant capital accumulation, wealth and income effects.

Keywords Assets, household primary data, Semi-Arid Tropics, panel data

JEL codes D14, D31, Q12

Introduction

Capital accumulation is a major factor of growth as per neoclassical theory of economic development (Solow 1956; Jorgensen and Griliches 1967). The link between economic inequality and capital accumulation could also be direct. It is also possible to observe positive associations between inequality and economic development for specific context (Cosgel and Ergene 2011). Empirical studies are vital in understanding these linkages better and hone the policies accordingly. The current study based on primary data of panel nature from rural India best suits this purpose.

Capital accumulation helps reduce vulnerability and enhance resilience of rural households (Manlagnit 2004). Assets or the physical capital provide assurance for future consumption and are a source of security against income and/or food shocks. As investments, they also generate returns that generally increase aggregate lifetime consumption and improve a household's well-being over an extended time horizon (Beverly et al. 2008). Whilst income and consumption offer more direct measures of consumption possibilities they also present issues in measurement that tend to make them less preferred than asset measures for considering poverty dynamics. Most importantly, they are noisy in that income and consumption often vary substantially over time, often in order to preserve productive assets during shocks, and they tend to difficult to accurately measure using annual surveys (Deaton and Zaidi 2002). On the other hand, assets as indirect measures of welfare, directly measure the ability of a household to generate income so are tied to welfare both intuitively and conceptually (Moser and Felton 2009). In addition, assets are less subject to variation over time (other than accumulation and depreciation or dissipation) and are much easier to measure in annual surveys (Naschold 2012).

Studies on intergenerational wealth accumulation found that father's wealth and duration of wealth accumulation were positively related to son's wealth but the number of inheritors, honorary titles had no

influence on wealth accumulation (Cosgel and Ergene 2011). Evidences from empirical studies prove that assets reduce the risk of intergenerational poverty transmission (Manlagnit 2004). Consumption smoothing mechanisms are limited in low income environments where farmers are risk averse and their investment pattern depends on wealth status and weather risk (Rosenzweig and Binswanger 1992). Understanding the patterns and correlates of wealth accumulation is an essential component of developing sensible public policies toward asset accumulation for low-income households (Carney and Gale 2001).

Many economic models study the different ways in which parents and parental characteristics can influence the economic well-being of their children: education, social capital, tastes, property and financial assets, fertility and marriage, taxation, share rules, etc. Beyond the desire to bequeath, accumulation of wealth satisfies other desires: savings to finance one's old age (life cycle saving), protection against unforeseen events (precautionary saving), desire for power and the search for economic power and social prestige. (Arrondel and Grange 2006).

Torche and Spilerman 2009 explored two mechanisms of parental influence on economic child wellbeing in Mexico: an indirect effect mediated by parental investment in human capital, and the direct transfer of resources. They found that parental wealth has a substantial influence on children's educational attainment, consumption level, assets, and value of home owned. A study on intergenerational transmission of income and wealth (Behrman and Taubman 1976) summarized some evidence relating to genetics, common environment and other environment to the total variance of four indicators of individual attainment namely education, socioeconomic status of civilian occupation and earnings. They found that an economic-political system that is basically free enterprise will be one in which economic inequality will be passed on from one generation to another via genetic endowments and family environment. Another study by Degan and Thibault 2013 reveals that the main factors determining the long-run dynamics of wealth and effort are the intensity of preferences towards wealth accumulation and the predisposition towards working or the entrepreneurial attitude. From their study on African-American families, Ngina and Frank 1999 found that a young family's likelihood of owning transaction accounts and stocks is affected by whether parents held these financial assets and parents can be influential in exposing their children to financial options.

There is no dearth of literature on capital accumulation. However, asset accumulation, by nature spreads over generations and the studies of this nature are restricted due to the limited availability of datasets extending over long time periods stretching over generations. The unique Village Dynamics in South Asia (VDSA) household panel data, covering over three generations and over three decades is an ideal dataset, best suited for this purpose. The current paper uses this dataset to add to the literature the micro level evidence from rural India on knowledge on the influence of parents' wealth on children capital accumulation. This helps policy makers in developing assets accumulation strategies and policies that could reduce income inequality transmission across generations.

In this context, in the semi-arid India, where agriculture is the primary occupation, the understanding of the wealth accumulation dynamics is of importance and relevance to policy makers to guide them in developing suitable policies for poverty reduction. The main objective of this paper is to explore the association between parental wealth and education levels with current generation economic wellbeing in terms of income and assets in semi-arid survey locations of India. This paper seeks to understand if a) income today is influenced by initial capital and education of the parents or dynasty head; b) asset today is influenced by initial capital and education of the parents or dynasty head.

This paper seeks to consider the role of current income on capital accumulation of parents and children in the future and the role of assets, including human capital, held by parents on asset levels of their children. By understanding the dynamics of asset accumulation across generations, this paper provides important information on the role of population growth (asset diminishment), cultural aspects (uneven asset allocation to children) and policy (taxation and tenure) on chronic poverty amongst rural households in India.

Methodology

The empirical analysis in this study is based on the data collected as part of Village-Level Studies (VLS) program of the International Crops Research Institute

for the Semi-Arid Tropics (ICRISAT), Hyderabad, India, from 1975-76 to 1984-85, 2001-02 to 2008-09 and the Village Dynamics in South Asia (VDSA) dataset generated by ICRISAT in partnership with Indian Council of Agricultural Research (ICAR) Institutes from 2009-10 to 2013-14. A stepwise strategic approach of sampling is used in this survey. First of all, the sample covered six agro-ecological zones of the semi-arid and humid tropics of India defined by the Length of Growing Period (FAO 1996). Typical districts within the agro-ecological zones were selected based on soil and climate parameters. An additional criterion for the district selection has been that a significant share of the agricultural land is used to cultivate ICRISAT mandate crops (sorghum, pearl millet, pulses and groundnuts). A similar strategy was used to select two villages within each chosen district. In each of the 30 villages 40 households were selected based on a stratified sampling. Baseline surveys were used to classify households according to their land holding (landless, small, medium and large landholding groups). Households within each of these groups were drawn randomly (Binswanger and Jodha 1978; Rao et al. 2015 and Walker and Ryan 1990). The surveyed data contained several modules including the General Endowment Schedule (GES) which covers the data on resource endowments (family composition, land, livestock, farm implements, residential building, consumer durables, stock inventory, debt and credit) of the household. This module is collected once a year at the beginning of the crop year in July (http://vdsa.icrisat.ac.in).

The current work is based on the dynasty data constructed from VLS for the period 1975-84 (generation 1), 2001-2008 (generation 2) and VDSA dataset for the period 2009-2013. This paper uses panel data of three semi-arid villages: Aurepalle of Mahbubnagar in Telangana, Shirapur of Solapur and Kanzara of Akola district of Maharashtra in India.

However, it is challenging to collect the sensitive information on assets. The measurement of all financial instruments is very complex and susceptible to accuracy issues. All the assets including finances are the main focus of the current work. Well trained, resident field investigators who were part of the project stayed with the villagers, socialized with the village community, developed good rapport to gain the confidence of the villagers and were successful in collecting this complex data. The values of the assets as reported by the respondents in that particular year are noted as nominal values in local currency, ie INR. For the purpose of analysis, all the monetary values are converted to real values in 2009 prices by using the whole sale price index. This helps to bring them to a common scale and enables comparison over time.

VLS-VDSA panel surveys provide the suitable platform for understanding the intergenerational capital accumulation dynamics since they provide data of two-three generations of farmers. A dynasty dataset of households that were present from 1975 to 2013 either in the form of original families or their children, brothers etc. are only considered for this analysis. Dynasty household is a sequence of households considered as members of the same family. The term 'dynasty' refers to the set of households included in subsequent rounds of the survey whose members belonged to the same household in the baseline survey. A dynasty is sometimes used interchangeably with 'extended family' or 'linked households'.

This paper is developed on the theoretical concept of economic mobility. It is the ability of an individual, family or some other group to improve or lower their economic status, usually measured in income. Mobility is measured by the association between parents' and adult child's socioeconomic standing, where higher association means less mobility (Becker and Tomes 1979). Income mobility is usually approached by the father-son earnings elasticity. Intergenerational income mobility is measured by a simple linear regression model of the logarithm of the child's income Y_{child} (in adulthood) as a function of the logarithm of the parent's income Y_{parent}

$$\ln(Y_{child}) = \alpha + \beta_1 \ln(Y_{parent}) + \varepsilon$$

Life-cycle differences are usually handled by incorporating the age (Z) and squared age of both the parent and the adult child in the analysis concerned (Solon 1999).

$$\ln(Y_{child}) = \alpha + \beta_1 \ln(Y_{parent}) + \beta_2 Z_{child} + \beta_3 Z^2_{child} + \beta_4 Z_{parent} + \beta_5 Z^2_{parent} + \varepsilon$$

Literature on intergenerational wealth mobility is scarce. This is mainly due to the rare availability of relevant data on fathers-son pairs. Asadullah 2012 studied the intergenerational wealth mobility in Bangladesh. Arrondel and Grange 2006 studied the

transmission and inequality of wealth in France. Similar studies in the Indian context are not available in the literature and the current research fills this gap.

Many economic relationships are dynamic in nature and panel data allows the study of these dynamics. Several econometric challenges are faced in panel data estimation like endogeneity (causality runs in both directions resulting regressor correlation with error term); unobserved fixed effects (the time invariant characteristics correlating with explanatory variables); serial or autocorrelation (correlation of a variable with itself over successive time intervals). Dynamic panel data estimation technique, Generalized Method of Moments (GMM) is the suitable estimator to address these challenges. The current work used the dynamic panel estimators to investigate the effect of parents' capital, net assets in the form of real rupees and education years of the household head. It is found that Keane-Runkle Three Stage Least Squares (KR-3SLS) which is enhanced and more efficient version over the Arellano-Bond Difference Generalized Method of Moments (DGMM) and Arellano-Bover System Generalized Method of Moments (SGMM) (Arellano and Bond 1991; Arellano and Bover 1995), is the appropriate estimator in this case. This is implemented using xtkr tool (Keane and Runkle 1992; Neal and Keane 2015; Baltagi 2008) in STATA 14 software.

The Keane and Runkle estimator for panel-data models with serial correlation and instruments that are not strictly exogenous were developed by Michael Keane and Timothy Neal (Keane and Runkle 1992). Monte Carlo simulations show that, in certain situations, this approach offers an improvement over the popular difference generalized method of moments and system generalized method of moments estimators in terms of bias and root mean squared error. They suggest an alternative more efficient algorithm that takes into account this more general variance–covariance structure for the disturbances based on the forward filtering idea from the time-series literature. This method of estimation eliminates the general serial correlation pattern in the data, while preserving the use of predetermined instruments in obtaining consistent parameter estimates.

In literature, Keane and Runkle's three-stage least squares procedure was used to first eliminate serial correlation before final estimation using two-stage least squares. The Keane-Runkle three-stage least squares (KR-3SLS) estimation procedure has been argued to yield truly consistent and unbiased estimates for the parameters of interest in panel analyses where serial correlation is inherent and instruments are predetermined but not strictly exogenous (see Keane and Runkle 1992). Its superiority among panel data instrumental variable estimators using predetermined instruments is further emphasized by Ziliak (1997).

The present work is an attempt to understand the influence of parents' characteristics on children. In particular, the study evaluates the influence of parents' capital base in terms of net assets and education on their children's current income and net assets and non-land assets.

In the current work, a balanced panel dynasty dataset of three villages of semi-arid India (Aurepalle from Mahbubnagar of Telangana, Shirapur from Solapur, and Kanzara from Akola of Maharashtra state) for 23 years covering 70 dynasties is used.

Results

The descriptive statistics of the variables used in the models are presented in Table 1. The net assets per capita in real terms in initial survey year are around 17 lakh rupees whereas they moved up to 52 lakh rupees in latest survey year. As expected, land constitutes the major asset component of the respondents' assets. It may be noted that current household heads are more literate than in mid 70s. From the asset growth rates (Table 2), it can be discerned that the assets situation in 2000s is improving at a very faster rate compared to the mid-seventies. Consumer durables show a very fast growth as urbanization is increasing, changing the lifestyle of the people. Saving habits have improved over time.

Wooldridge test for autocorrelation in panel data show significance in all the three models ie. income, total capital and non-land asset in implying the presence of first order autocorrelation. Breusch Pagan test of heteroskedasticity show significant results notifying the presence of heteroskedastic errors. Multicollinearity among the independent variables of the three models was tested using variance inflation factor (VIF) and none of the values are high enough to conclude the presence of multicollinearity. Pairwise correlation analysis of all the variables used in regressions was done.

Table 1 Descriptive statistics of the key variables used in regressions (obs: 3542)

Variable	Mean	Std. Dev.	Minimum	Maximum
Total income per capita in real values (2009 base)	18763	25284	-85488.2	535228
Total capital per capita in real values (2009 base)	155395	316608	-23886.3	5200000
Non-land assets per capita in real values (2009 base)	33900	83890	-100585	1700000
Dependency ratio (no. of dependents/no. of working persons)	0.65	0.6	0	4
Years of education of household head	3	3.9	0	16
Years of education head in 1975	1	2.5	0	10
Assets per capita in 1975 in real values (2009 base)	53823	142655	1320.51	1700000
Borrowings per capita in real values (2009 base)	7258	14665	0	206570
Operated area per capita in ha	1.35	1.6	0	12.85
Percent irrigated area	28	39	0	100
Farm equipment value in real values (2009 base)	4158	12224	0	214477
Livestock inventory value in real values (2009 base)	4902	7982	0	93986.7
Non- agricultural capital in real values (2009 base)	5317	28794	-149014	466515
Own total area per capita in ha	1.26	1.4	0	11.35

Source Author's own calculations using VLS/VDSA data

Table 2 Compound growth rates of asset components in survey villages

	Aurepalle		Shirapur		Kanzara	
	1975-84	2001-13	1975-84	2001-13	1975-84	2001-13
Farm equipment	-5.8	4.1	-10.9	10.9	1.3	4.6
Consumer durables	19.4	22.7	1.6	18.3	-6.3	15
Owned land	3.7	17.2	2.1	14.5	-1.8	16.1
Livestock	-3.6	5.2	-4	5.7	-2.4	7.4
Buildings	0.8	14.8	-1.8	7.1	-8.2	11.2
Stocks	3.4	14.7	3	4.4	-1.9	8.8
Savings	-6	14.1	-1.6	12.7	18.4	9.7
Total assets	0.4	18.9	0.9	15.8	-2.6	16.4
Assets without land	0.8	20.2	-2.3	20.6	-5.1	19.9

Source Author's own calculations using VLS/VDSA data

The base year wealth or initial wealth and base year education years of the household head are the same for any dynasty member throughout the life period. Hence these values are same for all the members of the dynasty throughout the survey years.

Capital model: Regressing household net wealth on initial wealth, education level, i.e, values in the first year of survey or 1975 along with other socioeconomic variables.

A dynamic model of total capital (per capita net assets in real terms) was built with owned total area, farm income (sum of agriculture, livestock, farm labor incomes) as endogenous variables. Socio economic variables dependency ratio, number of years of education of household head, drought lag, road dummy variable (=1 if road is available to reach the nearest market place) as the exogenous variables and the results were presented in Table 3.

The base year education years of the household head show a significant positive effect on the current capital of the household whereas there is no evidence of any effect of base year asset value of the dynasty. Dependency ratio, previous year drought, owned total area show significant negative effect on the current

Table 3 Modelling results of factors influencing total capital per capita using Generalized method of moments (GMM)

Dependent variable: Total capital per capita (real INR)	Keane-Runkle 1992 Regression N: 2310 Panel Units: 154		
	Coefficient	Std. Err.	Significance
L1. Per capita total capital (real INR)	0.956105	0.039517	**
Own total area per capita in ha	-100895	21789.22	**
Farm income per capita (real INR)	11.52145	1.478849	**
Dependency ratio	-33731.1	11321.93	**
Years of education of household head	2728.195	1597.923	10%
Years of education of household head in 1975	7740.529	3379.917	*
Assets per capita in 1975 (real INR)	-0.01135	0.034873	
Drought lag	-38133.6	5670.004	**
A dummy of road connectivity	-111428	21250.99	**
Age of household head in years	1130.249	365.1688	**
Constant	52469.72	30427.48	10%

Source Author's calculations based on VLS/VDSA data
*, ** indicate significance at 5%, 1% levels
All endogenous variables are identified by italics

income. As the number of dependents increase in the family, their assets are expected to go down. Drought in previous year is expected to reduce per capita assets by around 38k INR. Increase in farm income is expected to increase the total assets. Higher the education years of household head, higher is the monetary capital per capita.

Non-land assets model: Regressing per capita non-land assets on initial wealth, education level i.e, values in the first year of survey or 1975 along with other socioeconomic variables.

A dynamic model of non-land assets (excluding the land value) with farm income (sum of agriculture, livestock, farm labor incomes) and operated area as endogenous variables is estimated. Socio economic variables dependency ratio, number of years of education of household head, lag of drought, dummy variable on road connectivity, age of household head are used as exogenous variables and the estimated results are in Table 4.

Dependency ratio shows a negative significant effect on non-land assets. As there are more dependents in the family the assets including non-land assets will be lower. Base year non-land assets of the household will have a positive effect on current non-land assets. Similar is the situation with previous year non-land assets. Farm income shows a negative effect on non-land assets. As the income from agriculture and other allied sectors increase, farmers prefer to invest in agricultural related assets rather than non-farm assets. Previous year drought reduces the per capita non-land asset by more than 19k INR. As the aged household heads are expected to have accumulated more assets, the per capita non-land assets are expected to be higher. Having good road connectivity leads to increase in non-land assets to the extent of 46k INR per capita. Operated area positively influences the non-land assets. A hectare increase of operated area on average is expected to increase the per capita non-land assets by 6k INR.

Income model: Regressing household income on initial wealth, education level i.e, values in the first year of survey or 1975 along with other socioeconomic variables

A dynamic model of income per capita was estimated using Keane-Runkle 3sls with operated area, percent irrigated area, farm equipment value, livestock inventory value, non-agricultural capital as endogenous variables. Socio economic variables dependency ratio, number of years of education of household head, drought dummy, per capita borrowings are the exogenous variables and the results are presented in Table 3.

Table 4 Modelling results of factors influencing non-land assets per capita using Generalized method of moments (GMM)

Dependent variable: Non-land assets (real INR)	Keane-Runkle 1992 Regression N: 2310 Panel Units: 154		
	Coefficient	Std. Err.	Significance
L1. Non-land assets	0.254	0.074	**
Own total area per capita	5952.382	1659.821	**
Farm income per capita	-0.510	0.263	*
Dependency ratio	-3700.309	1620.944	*
Years of education of hh head	-16.239	427.933	
Years of education head in 1975	61.471	586.545	
Non-land assets per capita in 1975	0.173	0.037	**
Drought lag	-19182.390	1798.141	**
Road dummy	46609.080	4452.836	**
Age of head in years	236.516	100.674	**
Constant	-10941.940	4675.424	**

Source Author's calculations based on VLS/VDSA data
*, ** indicate significance at 5%, 1% levels
All endogenous variables are identified by italics

Table 5 Modelling results of factors influencing income per capita using Generalized method of moments (GMM)

Dependent variable: Total income (real INR)	Keane-Runkle 1992 Regression N: 2310, Panel Units: 154		
	Coefficient	Std. Err.	Significance
L1. Total income	0.496	0.185	**
Operated area	-2054.615	19205.730	
Percent irrigated area	194.457	424.927	
Farm equipment value	-1.882	1.901	
Livestock inventory value	2.237	1.195	10%
Non-agricultural capital	0.242	0.490	
Dependency ratio	-505.966	5101.109	
Years of education of hh head	27.865	810.755	
Years of education head in 1975	308.796	1681.702	
Assets per capita in 1975	0.003	0.020	
Drought dummy	22.998	1574.964	
Borrowings per capita	0.833	0.688	
Constant	-37.023	29843.390	

Source Author's calculations based on VLS/VDSA data
*, ** indicate significance at 5%, 1% levels
All endogenous variables are identified by italics

Keane-Runkle three stage least squares method of moment estimation using exogenous variables and up to two lag differences of exogenous variables as instruments was conducted.

It was found that lagged value of income, livestock inventory value have significant effect on per capita income in present year. It was interesting to note that livestock value in present year is not important but two lags of livestock values were found to be significant. There is no evidence of any significant effect of the per capita dynasty income in base survey year (i.e., 1975) and education of the household head in the dynasty base year on current per capita income. Livestock inventory value has a positive effect on income.

From this analysis, it can be concluded that initial non-land capital of the dynasty influences the current non-land capital and the educated household head of the dynasty in the base year can positively influence the current capital of the household.

Discussion and conclusions

Torche and Spilerman 2009 found that parental wealth is a strong determinant of educational attainment. On the similar lines, the current study found that parental education is a strong determinant of current assets. The important findings that emerge from this study are that parental education is a strong determinant of the children assets. The non-land asset base of the parents determines the non-land assets of the children. Parents' assets or education has no influence on the income of the children. This suggests that promotion of education and employment policies help economic growth of people.

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Asymmetric price transmission: evidence from pulse markets of India

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Abstract Pulses have an important role in ensuring nutritional security and environmental sustainability. Despite the wide range of research, India's pulses sector has recorded barely any growth. The studies conducted on pulses have primarily focused on how to increase production at the farm level while the marketing and prices aspect has been given less attention. Further, the studies on market integration have researched only one dimension i.e. spatial integration and not looked into an equally important aspect, that is, whether the process of price transmission in agricultural markets is symmetric or asymmetric. The present study is conducted to test for asymmetric price behaviour of pulses in a vertically integrated market using Von cram on-taubadel model. The markets for pulses are characterized as inefficient and imperfect as reflected by few vertically integrated markets and the presence of asymmetry. The extent of integration and symmetry gives signals for efficient resource allocation, which is considered essential for ensuring greater market efficiency, price stability and food security. So, government policies should be formulated in such a way that ensures greater market efficiency through improved physical and institutional market infrastructure.

Keywords Pulses, price behaviour, asymmetric information flow, vertical integration, institutional changes

JEL codes Q11,Q13, Q18

Attaining food security for all in countries that are behind in achieving Sustainable Development Goals requires institutional and policy reforms that will help the food and agricultural system become more productive and efficient in using natural resources. Institutional reforms that improve market access, information flow and logistical infrastructure determine the income of agrpicultural households and incentivize the cultivation of diverse crops. Pulses have the potential to help address future global food and nutritional security needs along with ensuring environmental sustainability. It has been acknowledged through the UN declaration of 2016 as 'International Year of Pulses'. Pulses serve as a cost-effective and nutritionally balanced rich source of protein to the people of India who are predominantly vegetarian in dietary habits forming an important constituent of the Indian food basket.

India is the major producer, consumer as well as importer of pulses in the world. India produces around 25 per cent of global pulse production from around 35 per cent of the global area and productivity of 659 kg per ha. Chickpea, pigeonpea, blackgram, greengram and lentil are the major pulses grown and consumed in India, occupying nearly 84 per cent of the area under pulses and accounting for about 85 per cent of pulse production in the country (GoI, 2016).

Although India is the largest pulse-producing country in the world, the production of these crops in the country has shown sluggish growth over the years. Pulses production has increased from 8.41 million tonnes in 1950-51 to 17.15 million tonnes in 2014-15 whereas the area has increased merely from 19.09

million ha to 23.55 million ha over the same period. During this period, pulse production has risen only by 103 per cent as compared with a roughly 450 per cent increase in cereals production. The stagnant production and ever-increasing demand due to the rise in population have widened the demand-supply gap and about 20% of its total demand is met through imports. Import can at best be a short-term measure for augmenting the supply of pulses as suppliers in the international market are few. A cost-effective and viable option to fulfil the increasing demand for pulses, in the long run, can be effectively increasing domestic production in the country. The poor production performance of the pulse sector in the country has been an area of major concern for policymakers.

The shortfall in pulses has been attributed to several factors, the major ones being the increasing population, rising income of the people, geographical shift, abrupt climate change, complex disease–pest syndrome, socioeconomic policies and input constraints (Ali and Gupta 2012). This coupled with other economic factors like lack of assured market and non-linking of pulses to procurement policy make pulses cultivation less remunerative as compared to other crops.

Assurance of a remunerative and stable price environment for growers is very important for increasing agricultural production and productivity. A suitable price policy is likely to accelerate and sustain the growth of output by protecting the interest of the farmers on a long-term basis, particularly in respect of deficit commodities such as pulses. The success of price stabilization policies is dependent upon the efficient assessment of price volatility and price transmission. Price volatility generates uncertainties about the true price level for producers and consumers, and therefore, production and consumption decisions may lead to suboptimal outcomes compared with those attained under stabilized price conditions. Price transmission provides insights into the vertical and horizontal integration of agricultural markets. Price transmission has three aspects to it: completeness, speed and asymmetry. Completeness implies that any change at one level is fully passed on to the next level. Speed refers to the rate at which the prices at two levels adjust to any new information. The extent of integration gives signals for efficient resource allocation, which is considered essential for ensuring greater market efficiency, price stability and food security. Asymmetry in price transmission means that an increase in the prices is passed on at a faster rate than a decrease. Due to asymmetric price transmission, neither the producers benefit adequately from a price increase nor the consumers benefit from a decline in the prices. It leads to an overall welfare loss.

The studies conducted on pulses have primarily focused on how to increase the production at farm level through the dissemination of improved production technologies while the marketing and prices aspect has been given less attention. Scattered attempts have been made to investigate price volatility, price transmission and market integration in India. Further, the studies on market integration have researched only one dimension i.e. spatial integration while vertical integration has not been given adequate attention. The issue of price transmission in a vertical sector has been the subject of much research. The extant literature has not looked into an equally important aspect, that is, whether the process of price transmission in agricultural markets is symmetric or asymmetric. The Asymmetric Price Transmission (APT) process is well-researched in the case of many commodities in developed countries but such studies per se are scarce in the Indian context.

Information on the nature of price transmission is important for policymakers in developing countries like India where the agricultural markets have an overarching government presence. Against the backdrop of the above discussion, this study was conducted to investigate the issues of asymmetric price transmission in vertically integrated pulse markets of India..

Methodology

The widening gap between demand and supply has led to a secular rise in the prices of pulses. The domestic wholesale-retail price differential has also risen rapidly in the recent past. The retail prices continued to increase without responding to any changes at the wholesale level, which is a matter of great concern not only to producers and consumers but also to academicians and policymakers**.** In the present study, five pulses namely chickpea, pigeonpea, greengram, blackgram and lentil that account for nearly 80 per cent of total pulse production in India have been taken for in-depth investigation. Three major pulse-producing states for each pulse crop have been identified on the basis of

Table 1 Selection of major states and markets for chosen pulse crops

Crops	Major states	Markets selected
Chickpea	Madhya Pradesh, Maharashtra, Rajasthan	Indore, Mumbai, Jaipur
Pigeonpea	Maharashtra, Karnataka, Madhya Pradesh	Mumbai, Bangalore, Indore
Blackgram	Madhya Pradesh, Uttar Pradesh, Andhra Pradesh	Indore, Kanpur, Vijaywada
Greengram	Rajasthan, Maharashtra, Tamil Nadu	Jaipur, Mumbai, Chennai
Lentil	Madhya Pradesh, Uttar Pradesh, Bihar	Indore, Kanpur, Patna

production for TE 2014-15, and one of the major markets from each state along with Delhi as the central market has been selected to get the data at the market level. The selection of a major market from each selected state was first attempted on the basis of arrivals in the particular markets. Since retail price data were no available for the consequent markets, this criterion was discarded. Finally, the selection of major markets from each state was done based on the extensive review of the literature and various reports published by such institutions as the Indian Institute of Pulse Research, Directorate of Pulse Development, Commodities Control etc., apart from the availability of retail prices. The major states and markets thus, selected for the study are presented in Table 1.

Data on monthly wholesale and retail prices for four selected markets of each pulse crop were collected from the agmarknet portal of Govt. of India for the period from Jan 2009 to Aug 2017. The missing data for a particular month has been obtained through interpolation. Von Cramon-Taubadel model was employed to check the presence of asymmetry in wholesale-retail price transmission of pulses. They proposed a two-step estimation procedure using ordinary least squares. In the first step, Eq. (1) is estimated to get the residuals. The second step involves testing for the unit root properties of the estimated residual $\hat{a}_t$ as given by Eq. (2). If the null hypothesis $\tilde{n}$ = 0 stands rejected, then y_t and x_t are said to be cointegrated. Similarly, an error correction model (ECM) as represented by Eq. (3) is estimated where all the variables are specified in their first differences, while the error correction term, $ECT_{t-1} = \varepsilon_{t-1} = y_t - \alpha - \beta_t$ x_t is in levels.

$$y_t = \alpha + \beta x_t + \varepsilon_t \quad (1)$$

$$\Delta\varepsilon_t = \rho\varepsilon_{t-1} + \eta_t \quad (2)$$

$$\Delta y_t = \beta_0 + \sum_t^{\tau} \beta_1^{+}\Delta x_t^{+} + \sum_t^{\tau} \beta_1^{-}\Delta x_t^{-} + \beta_2^{+} ECT_{t-1}^{+} + \beta_2^{-} ECT_{t-1}^{-} + \upsilon_t \quad (3)$$

Using the F-test on the null hypothesis $\beta_2^{+} = \beta_2^{-}$, we can check for asymmetric price transmission. If the null is rejected, then $\beta_2^{+} = \beta_2^{-}$, implying that the price transmission is asymmetric. The software E-views 9.5 version was used for the analysis.

Results and discussion

Assuming that wholesale prices cause retail prices, the first regression was run between wholesale and retail prices to get residuals. These residuals were checked for unit root properties using ADF and PP tests. If the null hypothesis of the unit root has been rejected, it implies that retail prices and wholesale prices were co-integrated. The results of the unit root test for residuals got through regression are presented in Table 2. PP test was given more priority to check the unit root in the price series. It was revealed from the table that the residuals have no unit root at a five per cent level of significance implying long-run equilibrium between wholesale and retail prices of pulses.

Further, the ECM was run assuming retail prices as the dependent variable and the positive and negative component series of wholesale prices as the independent variable. The results presented in Table 3 show that retail prices behave differently to the positive and negative change in wholesale prices as depicted through different and significant coefficients of positive and negative wholesale price series. The coefficients of error correction terms were tested using the Wald test for their equality. The result showed that the coefficients were unequal, implying that the price

Table 2 Unit root test for residuals in wholesale and retail price series of pulses

Markets	ADF at level		PP at level	
	t-statistics	Prob.	t-statistics	Prob.
		Chickpea		
Delhi	-3.0721	0.0320	-4.6063	0.0003
Mumbai	-5.4957	0.0000	-5.4437	0.0000
Indore	-2.3480	0.1598	-3.1248	0.0285
Jaipur	-5.0727	0.0000	-5.0685	0.0001
		Pigeonpea		
Delhi	-0.8595	0.7971	-4.1976	0.0011
Mumbai	-3.2991	0.0176	-3.0861	0.0310
Indore	-4.6093	0.0003	-4.6964	0.0002
Bangalore	-1.0441	0.7349	-2.9992	0.0383
		Blackgram		
Delhi	-1.578	0.4899	-3.439	0.0118
Kanpur	-4.046	0.0019	-4.099	0.0016
Indore	-6.132	0.0000	-6.211	0.0000
Vijaywada	-5.361	0.0000	-5.594	0.0000
		Greengram		
Delhi	-1.4223	0.5685	-2.9066	0.0480
Mumbai	-2.9478	0.0437	-2.9524	0.0432
Jaipur	-3.5627	0.0085	-3.3525	0.0154
Chennai	-1.6503	0.4528	-2.4844	0.1226
		Lentil		
Delhi	-1.4538	0.5529	-2.3755	0.1512
Kanpur	-4.1154	0.0015	-4.1221	0.0015
Indore	-3.2396	0.0211	-3.2308	0.0216
Patna	-1.4814	0.5385	-1.0016	0.7498

transmission from wholesale to retail level was asymmetric. The error correction term's rate of adjustment indicates that the positive changes got absorbed more quickly than the negative change. The presence of asymmetry has been reported in many studies related to agricultural commodities (Bathla 2011; Rahman 2015).

Summing up, the price transmission from wholesale to retail was found asymmetric in all the vertically integrated markets of pulses. Asymmetry in price transmission implies inefficiency in markets. A larger gap in the price difference may persist due to inefficient price transmission and the consequent volatility may be passed on to the producers and the consumers causing net welfare loss.

Table 3 Parameter estimates of asymmetry test in selected markets of pulses

Markets	WP(+)	WP(-)	ECT(+)	ECT(-)	H_0: $B_2^+=B_2^-$
			Chickpea		
Delhi	0.1300	-0.0059	-0.2871	0.2561	77.6717
	(0.0223)	(0.0273)	(0.0323)	(0.03223)	{<0.0001}
Mumbai	0.0990	-0.0318	-0.3547	0.2512	51.6684
	(0.0206)	(0.0202)	(0.0468)	(0.0407)	{<0.0001}
Indore	0.0719	-0.0988	-0.3609	0.3342	57.5876
	(0.0188)	(0.0224)	(0.0469)	(0.0469)	{<0.0001}
Jaipur	0.1307	-0.0291	-0.4107	0.3870	117.3494
	(0.0195)	(0.0214)	(0.0375)	(0.0396)	{<0.0001}
			Pigeonpea		
Delhi	0.0701	-0.0284	-0.3655	0.3418	88.8096
	(0.0163)	(0.0184)	(0.0379)	(0.0393)	{0.0000}
Mumbai	0.0754	-0.0437	-0.3701	0.3285	22.3825
	(0.0237)	(0.0254)	(0.0749)	(0.0756)	{0.0000}
Indore	0.0508	-0.0366	-0.3395	0.3036	27.8461
	(0.0159)	(0.0182)	(0.0622)	(0.0619)	{0.0000}
Bangalore	0.0964	-0.0355	-0.4729	0.3779	49.3096
	(0.0173)	(0.0171)	(0.0641)	(0.0592)	{0.0000}
			Blackgram		
Delhi	0.0403	-0.0401	-0.2498	0.2768	37.6178
	(0.0219)	(0.0245)	(0.0402)	(0.0480)	{0.0000}
Kanpur	0.1099	-0.0017	-0.2504	0.2083	25.8657
	(0.0284)	(0.0332)	(0.0477)	(0.0452)	{0.0000}
Indore	0.0618	-0.0570	-0.5611	0.5825	62.3113
	(0.0179)	(0.0206)	(0.0705)	(0.0757)	{0.0000}
Vijaywada	0.0755	-0.0788	-0.6615	0.6630	51.1238
	(0.0152)	(0.0156)	(0.0919)	(0.0942)	{0.0000}
			Greengram		
Delhi	0.0260	-0.0301	-0.6398	0.6035	53.8822
	(0.01441)	(0.0172)	(0.0831)	(0.0880)	{0.0000}
Mumbai	0.0326	-0.0282	-0.6805	0.6312	14.4078
	(0.0120)	(0.0136)	(0.1733)	(0.1740)	{0.0001}
Jaipur	0.0570	-0.0272	-0.6946	0.6419	54.1977
	(0.0122)	(0.0130)	(0.0918)	(0.0917)	{0.0000}
			Lentil		
Kanpur	0.0069	-0.0654	-0.3040	0.2907	21.8181
	(0.0136)	(0.0158)	(0.6291)	(0.0665)	{0.0000}
Indore	0.0535	-0.0248	-0.5492	0.4772	77.0576
	(0.0099)	(0.0107)	(0.0603)	(0.0584)	{0.0000}

Figures in parentheses ( ) indicated standard error and { } probability of parameter

Conclusion

The results of asymmetric price transmission revealed the presence of asymmetry in almost all vertically integrated markets. It implies that retail prices adjust differently to any positive and negative change in wholesale prices. The rate of adjustment was found lower for a decline in prices means the negative shock persists for a longer period in the market. The extent of integration and symmetry gives signals for efficient resource allocation, which is considered essential for ensuring greater market efficiency, price stability and food security.

The markets for pulses were characterized as inefficient and imperfect as reflected by few vertically integrated markets and the presence of asymmetry. Imperfect markets will cause high marketing margins due to poor infrastructure and communication facilities. High marketing margins hinder the transmission of price signals. Imperfect information flow leads to asymmetry and asymmetry was found in all the vertically integrated markets of pulses. It can be concluded that the markets for pulses are imperfect in nature hindering the perfect flow of price transmission. In the context of imperfect information systems, institutions are as important as market forces in determining performances and solving emerging non-economic problems. A sustainable solution and long-term policies like the creation of a competitive, stable and unified national market are needed for the farmer to get better prices.

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Economic impact of public research investment on livestock productivity: evidence from India

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Abstract Limited literature and outdated estimates on economic impact of livestock research investment in Indian context motivated us to undertake this study. It attempts to fill the gap by utilizing a unique panel dataset of 15 states from 1991-92 to 2017-18. Using fixed effects panel regression approach, we find that investment on livestock research has significant positive impact on livestock productivity. Regionally, the impact was higher in north followed by south, east and west zones. Overall, a high marginal internal rate of return to research investment (40.9%) indicates substantial economic gains. Findings of the study reiterates that research investment is crucial determinant of productivity growth, thus recommends higher allocation of resources to livestock research.

Keywords Livestock, Productivity, Research, Impact, Economic Returns, Fixed effects

JEL codes Q1, Q10, Q12

Introduction

In India, livestock is a key contributor to agricultural sector. Its share in the gross value of agricultural output is estimated at 27%. It performs both food and non-food functions. However, in recent years, the non-food functions such as draught power, dung has declined with the advent of mechanization and chemical fertilizers. As urbanisation and economic expansion progress, the food function is likely to gain more prominence. Demand for animal origin food products is expected to rise further in the future which will put additional strain on finite land, water, and energy resources (Delgado et al. 1999). Despite being home to largest livestock population, milk productivity in India is one of the lowest in the world. Global climate change, limited natural resources and rising incidences of zoonotic diseases, threatens the sustainability of existing livestock production system which is largely driven by cattle population.

ICAR through its cooperation with various international agricultural research organisations such as International Maize and Wheat Improvement Centre (CIMMYT), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Rice Research Institute (IRRI) has been instrumental in boosting farm productivity and food security (Rosegrant and Evenson 1992; Fan et al. 1999; Joshi et al. 2005; Chand et al. 2011). Much of the success of Green Revolution was due to large scale public investment undertaken in crop genetic improvement. The research-led productivity growth in staple crops transformed many food deficits nations into food surplus nations (Rosegrant and Hazell 2000; Fan 2007). The existing evidence suggests that agricultural research investment has poverty eliminating effects with high economic rate of returns (Evenson et al. 1999; Byerlee 2000; Fan and Thorat 2000; Chand et al. 2012; Rada and Schimmelpfennig 2018). However, technological bias brought about by Green Revolution,

not only increased the social disparity but also led to massive ecological degradation (Pingali and Rosegrant 1994; Freebairn 1995). Although persistence of poverty, hunger and environmental degradation has raised sustainability concerns surrounding these innovations. Noticeably, these studies have been largely concentrated on crop research. Most of the empirical work on the adoption and diffusion of high-yielding technologies in developing countries focus on the crop sector, while very little is known regarding innovations in livestock sector (Abdulai and Huffman 2005). Globally some of the earliest studies (Peterson 1966; Widmer et al. 1987; Fox et al. 1992) estimated that economic gains of investing in poultry, beef, swine and dairy cattle research in the US and Canada are substantial. In India, studies showed that adoption of cross breeds leads to higher yield (25-40% output growth) as well as income gain (Kumar et al. 1977; Gaddi and Kunnal 1996; Kumar and Gupta 2000; Kumar et al. 2003; Bhowmik et al. 2006; Chandel et al. 2007). Most often livestock research is known to generate more puzzling outcomes than crop technologies (Haan 1995) due to biological nature and long gestation period. Numerous livestock technologies related to feed, breed, health care and housing have been developed and commercialised by ICAR Research Institutes and State Agricultural and Veterinary Universities. However, literature pertaining to their adoption and impact is almost non-existing. Most of the economic estimates regarding impact of livestock technologies (mainly crossbreed) in Indian context are outdated.

Therefore, present study is a modest attempt in this regard to provide more recent evidence and assess the economic gains from public investments in livestock research and education in India. Firstly, we build a fixed effects panel regression model to identify the major determinants of livestock productivity (TFP) and estimate their impact. Thereafter, Marginal Internal Rate of Return (MIRR) is calculated to estimate the economic returns to livestock research investment.

Data and Methodology

In order to select the sample for the study, we identify all the institutions working under the animal science division of ICAR. A total of 45 institutes were identified of which 19 were central level research institutions under direct administrative control of ICAR, 15 independent state veterinary universities and 11 veterinary colleges which are part of existing state agricultural universities (Fig 1). Based on the location of institutions, fifteen states were identified which were further incorporated into four zones (North, East, West and South) to carry out regional analysis. A unique panel data set of fifteen states namely, Andhra Pradesh, Bihar, Gujarat, Himachal Pradesh, Haryana, Karnataka, Kerala, Madhya Pradesh (MP), Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh (UP) and West Bengal, from 1991-92 to 2017-18 was developed after collecting data on several variables required in the study (Table 1). Bihar, MP and UP include the pre-incorporated states of Jharkhand, Chhattisgarh and Uttarakhand respectively. Since there was only one state i.e., MP in central zone, it was incorporated with the West zone for the analysis purpose.

Table 1 Selection of states and zones

Zone	States
North Zone	Punjab, Haryana, Uttar Pradesh and Himachal Pradesh
East Zone	Assam, Odisha, Bihar and West-Bengal
West Zone	Maharashtra, Rajasthan, Gujarat
Central Zone	Madhya Pradesh
South Zone	Andhra Pradesh, Karnataka & Tamil Nadu

Note Bihar, UP &MP are pre-bifurcation states

In order to meet the objective of the study following variables were formulated:

i. **TFP index:** This study uses non-parametric Malmquist index (DEA approach) to measure TFP. It allows estimation of multi-input and multi-output production functions without any explicit price data or any assumption regarding economic behaviour such as profit maximization or cost minimisation. The data on the overall value of livestock output is disaggregated into seven groups: milk, meat, egg, wool and hair, silk, dung, increment in animal stock, silk worm cocoon, and honey, according to National Account Statistics. Except silkworm cocoon and honey, data for all six product groups were collected in current prices and then converted into constant prices using wholesale price index with 2011-12 base prices. This aggregate measure was used as value of livestock output.

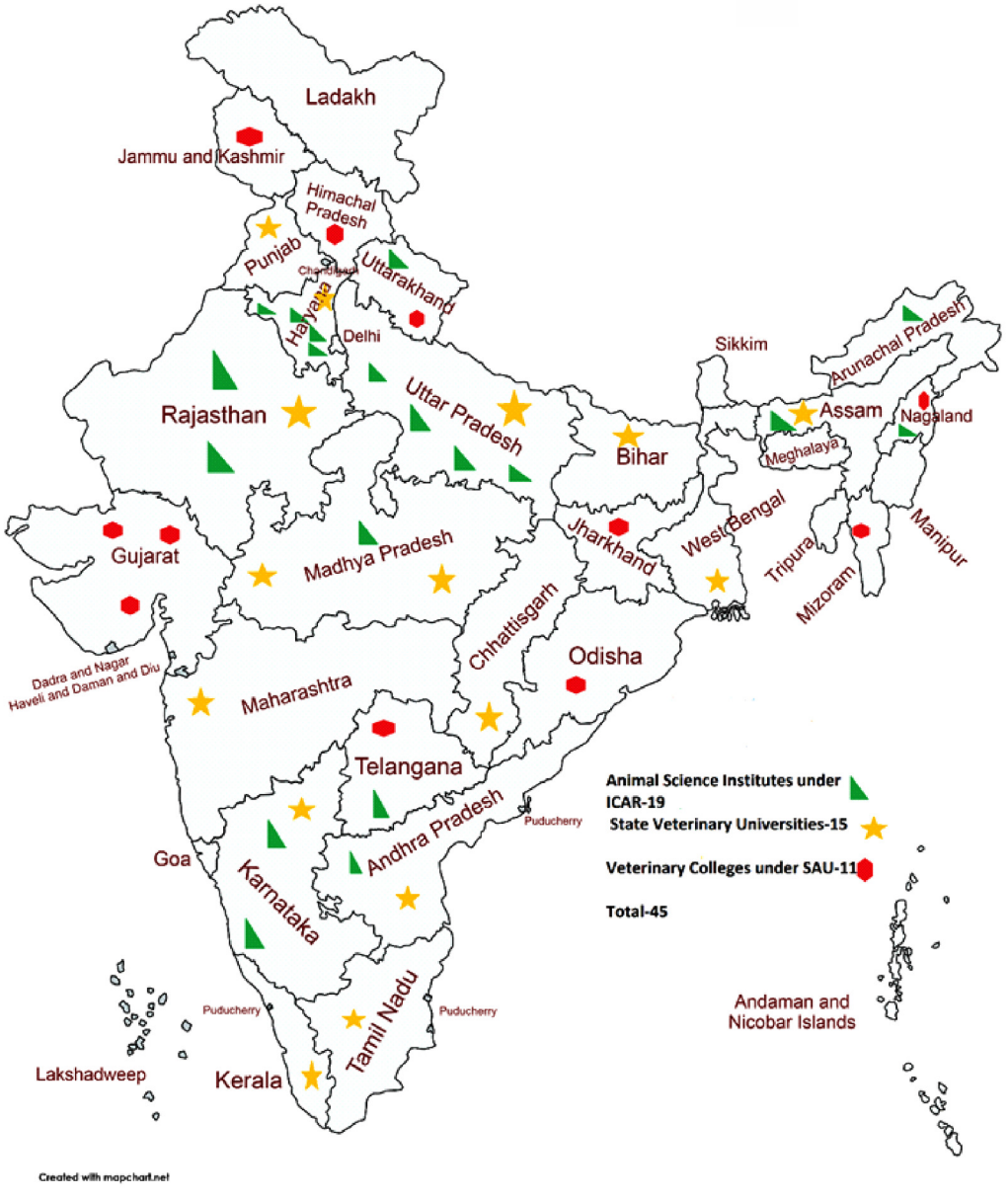

Figure 1 Distribution of Animal Science Research Institutions in India

Three major input groups used are: feed, labour and animal stock. State-wise green fodder production was estimated using the area under green fodder. Besides fodder area, the land under permanent pastures, cultivable wasteland, grazing land, land under miscellaneous uses were clubbed together to estimate fodder availability from those lands. State-wise data on the annual value of straw and stalks were collected and converted into constant 2011-12 base prices to be taken as a measure of value of dry fodder production. For detailed methodology and estimates of Malmquist TFP indices refer (Kathayat et al. 2022).

Labour: To estimate the labour population engaged in livestock production, the data on agricultural labourers and cultivators were collected from Population Census 1991, 2001 and 2011. It was assumed that one-fourth of male and three-fourth of female cultivators/agricultural labourers are engaged in livestock activities. Further, it was assumed that three women labourers are equivalent to two men labourers (Elumalai and Pandey 2004; Chand and Sirohi 2015). Interpolation was done to estimate the labour population for inter-census periods.

Animal stock: The total population of cattle, buffalos, sheep, goats, pigs and poultry was measured in terms of Standard Animal Units (SAU) using methodology by Sirohi et al. (2019). The data on livestock population were compiled from various rounds of livestock census from 1992 to 2019. Data for inter-census period were linearly interpolated.

ii. **Livestock research and education (LRE) stock:** To develop LRE stock variable, annual budget data of selected state as well as national level institutions engaged in livestock research and education was collected. Since direct research expenditure variable cannot be used for assessing its impact, creation of a research stock variable as a suitable indicator is widely prevalent in literature (Alston and Pardey 2001). Basically, LRE stock variable determines the pathway through which knowledge or technology generated as a result of persistent research activity leads to productivity growth. It takes into account the temporal aspect of the attribution problem as well. Based on the conceptual framework provided by (Alston et al. 1995(a)) knowledge stock is assumed to be a result of recurring past and current research investments by taking lagged research investments. Modelling these effects involve use of finite distributed lag structure. Polynomial distributed lag (PDL) was one the earliest lag structure to be used. Later on, some offshoots of PDL arose, such as trapezoid (Huffman and Evenson 1993) geometric and the gamma (Alston et al. 2010) have been more common. Choice of lag length and weights were mostly made arbitrarily in past studies ranging from free form to using certain criteria such as R square for selection of lag length (Fan et al. 2000). In order to account for that lag, we created LRE stock following the trapezoid lag scheme given by (Evenson 2001) by testing the alternate lag length of 8, 10,13 and 14 years (Table 1). Due to availability of data for the limited time period, we cannot exceed lag length beyond 14 years in the present study. On the basis of sign and significance level and lowest Akaike information criterion (AIC) and Bayesian information criterion (BIC) value, LRE stock using 14 years lag (equation 4) was found to be the best fit (Table 2). Lag Structure (2, 4, 2, 6) assuming 2-year lag for adoption of technology, 4 years of increasing impact, 2 years of peak impact and 6 years of declining impact was used to create research stock variable (Fig 2). After six years of declining impact, it was assumed that knowledge stock becomes obsolete and requires replacement by new technology/knowledge.

$$LRE\,stock_{it} = 0 * LRE_{1994i} + 0 * LRE_{1995i} + 0.02 * LRE_{1996i} + 0.05 * LRE_{1997i} + 0.1 * LRE_{1998i} + 0.15 * LRE_{1999i} + 0.2 * LRE_{2000i} + 0.2 * LRE_{2001i} + 0.1 * LRE_{2002i} + 0.08 * LRE_{2003i} + 0.06 * LRE_{2004i} + 0.02 * LRE_{2005i} + 0.01 * LRE_{2006i} + 0.01 * LRE_{2007i}$$

iii. **Veterinary infrastructure (VH):** Secondary data on state-wise number of veterinary hospitals, polyclinics, dispensaries and veterinary aid-centre were compiled from various issues of Basic Animal Husbandry and Fisheries statistics for the selected states. Wider coverage of veterinary infrastructure enables greater access to scientific health care reducing the incidences of various diseases such as zoonotic diseases, epizoonosis and endoparasites etc. hence minimizing losses.

Table 2 Selection of lag structure for LRE stock variable

Dependent variable	ln TFP			
Regressors (→)	Equation 1	Equation 2	Equation 3	Equation 4
LRE stock (8)	0.11			
LRE stock (10)		0.080		
LRE stock (13)			0.128**	
LRE stock (14)				0.198**
Constant	-0.565	-0.396	-0.801	-1.058**
State fixed effects	Yes	Yes	Yes	Yes
AIC	90.83	96.93	39.14	-5.811
BIC	94.37	100.39	42.33	-2.705

Note *p< 0.10,** p<0.05, ***p<0.01

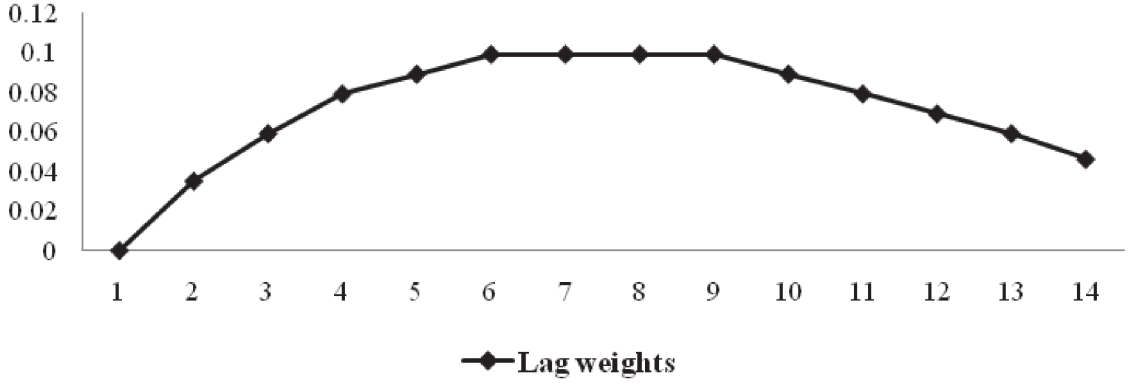

Figure 2 Trapezoidal lag scheme for developing livestock research and education (LRE) stock

iv. **Artificial insemination (AI):** Secondary data on number of artificial inseminations performed were taken from Basic Animal Husbandry and Fisheries statistics. Artificial Insemination is widely used breed improvement technique to improve milk yield of native breed by inseminating with high pedigree/exotic bull semen. Wider penetration of AI indicates higher adoption of high yielding breeds.

v. **Annual mean rainfall (Rain):** It was used as a measure of weather effect which might influence productivity positively as well as negatively indirectly through its effect on forage production and spread of diseases. State-wise annual mean rainfall data were compiled from RBI Handbook of Statistics on Indian States.

vi. **Road density (Rd):** Road density was measured as the total road length in the state normalized by state area (km per 1000 sq km area). Roads facilitates input delivery and provide access to markets for products thereby contributing to productivity. This data was collected from Basic Road Statistics of India.

vii. **Expenditure on education as ratio to aggregate expenditure (edu):** It was used as a proxy variable for literacy to depict the human resource development status of the region. Improved education helps people to move out of farming and find non-farm employment opportunities. It might also induce people to become more entrepreneurial and take up small business enterprises. The data was also compiled from RBI Handbook of Statistics on Indian States.

Analytical tools

Fixed Effects Panel regression approach was used to capture the relationship between predictor (Xs) variables and outcome variable ($lnTFP_{it}$) within an entity (state in this case). When using Fixed Effects, we assume that each state has some time-invariant individual characteristics that might influence predictor variable. Therefore, we control for those state individual fixed effects that might bias the results. Following econometric equations were established for the purpose of this study:

$$lnTFP_{it} = \beta_0 + \beta_{lre}\, lnLRE_{it} + state\ FE + error \qquad 1(a)$$

$$lnTFP_{it} = \beta_0 + \beta_{lre}\, lnLRE_{it} + \beta_{rain} Rain_{it} + \beta_{road} lnRoad_{it} + \beta_{al} lnAI_{it} + \beta_{vh} lnVH_{it} + \beta_{edu} edu_{it} + state\ FE + error \qquad 1(b)$$

$$lnTFP_{it} = \beta_0 + \beta_{lre}\, lnLRE_{it} + \beta_{r-1}\,(Zone * LRE_{it}) + state\ FE + error \qquad 2(a)$$

$$lnTFPit = \beta_0 + \beta_{lre}\, lnLRE_{it} + \beta_{rain} Rain_{it} + \beta_{road} lnRoad_{it} + \beta_{al} lnAI_{it} + \beta_{vh} lnVH_{it} + \beta_{edu} edu_{it} + \beta_{r-1}\,(region * LRE_{it})\ edu_{it} + error \qquad 2(b)$$

Equation 1(a) and 1(b) assesses the individual impact of livestock research and overall impact of different variables on TFP while controlling for state individual fixed effects respectively.

Equation 2(a) and (b) makes further distinction by accounting for zone wise separate impact by region dummy variable (Rr-1) with r indexes indicating four zones (North, East, West and South).

Marginal Internal Rate of Return (MIRR) was estimated using parameters (regression coefficients) obtained from Fixed Effects equation. MIRR is the discounted rate at which the present value of benefit stream of expected value of marginal product (EVMP) of research is equated to one. Research-induced value of production (V) could be estimated when percentage

Table 3 Model diagnostic tests

Test		Null hypothesis	Test statistics	Conclusion
Model Selection	BPG LM test	No panel effect (Variances across entities are zero)	chibar2(01) = 0.00 Prob > chibar2 =1.00	Fail to Reject Null Evidence of panel effect
	Hausman test	Preferred model is random effects	chi2(1) = 6.79 Prob>chi2 = 0.009	Reject Null Fixed effects is the preferred model
Group wise Heteroskedasticity in Fixed Effects Regression	Modified Wald test	Homoskedasticity (constant variance)	chi2 (15)=11299.82 Prob>chi2 = 0.00	Reject Null Heteroskedasticity is present
Correlation among X variables		Below 0.7 for all variables		Low

share of research in TFP is multiplied with average value of production.

Value of output per unit investment (V)–Research-induced value of production was obtained by multiplication of technical coefficient of research stock with growth rate of research stock to determine the contribution of research to TFP. This value is further multiplied with average value of production to know research induced value of production.

Expected value of marginal product of investment (EVMP) - It was derived using the following formula:

$EVMP = \beta_{lre} * (V/R)$

β_{lre}= Elasticity of research stock; V= Research induced value of production; R=Average value of research stock

Estimated elasticity of TFP with respect to research stock (β_{lre}):

$\beta_{lre} = \partial \log(TFP) / \partial \log(LREstock)$

In order to estimate the benefit stream, it was assumed that total benefits from the research investment are spread over a period of 20 years at varying rates. Initially, a minimum gestation lag of six years was assumed before investment starts generating benefits. After initial six years lag period, benefits start flowing in at an increasing rate for the initial four years followed by constant rate for the next six years and eventually starts declining at a decreasing rate for latter four years. Below equations provides the assumption regarding the structure at which returns from an investment starts to generate.

Benefits rising at an increasing rate:

$0.2 * (EVMP)_{t+6} + 0.4 * (EVMP)_{t+7} + 0.6 * (EVMP)_{t+8} + 0.8 *(EVMP)_{t+9}$

Benefits rising at a constant rate:

$1 * (EVMP)_{t+10} + 1 * (EVMP)_{t+11} + 1 * (EVMP)_{t+12} + 1 * (EVMP)_{t+13} + 1 * (EVMP)_{t+14} + 1 * (EVMP)_{t+15}$

Benefits declining at a decreasing rate:

$0.8 * (EVMP)_{t+16} + 0.6 * (EVMP)_{t+17} + 0.4 * (EVMP)_{t+18} + 0.2 * (EVMP)_{t+19}$

Overall benefit stream was obtained by summation of all the above benefits streams

$$B_k = \sum_{k=1}^{t=20} W_{t-i+k}[b_r(V_{t-i-k}/M_{t-i})] = \sum_{k=1}^{t=20} EVMP_k$$

W_{t-i+k} = weights given to investment made in time t–i–k period

B_k = Benefit stream

This stream was discounted at various discount rates (d) until the discount rate appears at which present value of the benefit stream becomes equal to one. This discount rate is considered as the marginal internal rate of return (MIRR) to investment.

$$PV_{t-i} = \frac{\sum_{k=0}^{i} B_k}{(1+d)^k}$$

Table 4 Fixed effects panel regression without region interaction term

Dependent variable	lnTFP	
Regressors	Equation 1(a)	Equation 1(b)
LRE stock(log)	0.198**	0.140
	(0.084)	(0.108)
Road density(log)		0.019
		(0.035)
AI(log)		0.040
		(0.058)
Veterinaryinfra(log)		0.129
		(0.110)
Edushare(%)		-0.029**
		(0.012)
Annual mean rainfall(log)		-0.133
		(0.073)
Constant	-1.058**	-0.867
	(0.468)	(1.544)
Rho	0.190	0.409
State fixed effects	Yes	Yes
AIC	-5.811	-5.711
BIC	-2.705	12.901
No. of groups	165	165
Observations	15	15

Note Values in parentheses are robust standard errors *p<0.10,** p<0.05, ***p<0.01

Table 5 Fixed effects panel regression with region interaction term

Dependent variable	lnTFP	
Regressors	Equation 2(a)	Equation 2(b)
North *LRE	0.645***	0.516*
	(0.149)	(0.259)
South*LRE	-0.457**	-0.312
	(0.204)	(0.350)
East*LRE	-0.535**	-0.672***
	(0.165)	(0.223)
West*LRE	-0.567**	-0.513*
	(0.156)	(0.305)
Road density(log)		0.030
		(0.072)
AI(log)		0.051
		(0.077)
Vet. Infra(log)		0.159
		(0.170)
Edushare(%)		-0.032**
		(0.014)
Annual Mean Rainfall(log)		-0.119
		(0.077)
Constant	-1.433***	-1.49
	(0.333)	(1.074)
Rho	0.969	0.973
State Fixed Effects	YES	YES
AIC	-3.096	-4.067
BIC	9.327	23.886
No. of groups	165	165
Observations	15	15

Note Values in parentheses are robust standard errors *p<0.10,** p<0.05, ***p<0.01

Results and discussion

Impact of livestock research and education on TFP

To assess the economic impact of livestock research and education on TFP, using fixed effect panel regression approach four econometric equations were formulated. In these equations, β_{lre} represents the research elasticity which indicates the research stock's influence on TFP *ceteris paribus*. Similarly, other coefficients indicate impact of the respective explanatory variable on TFP.

As stated earlier, equation 1(a) in Table 4 assessed the overall impact of livestock research stock on TFP while controlling for state individual fixed effects. Findings of equation 1(a) highlights the public research investment has significant positive impact on livestock productivity. We find that with one unit rise in LRE stock, TFP is likely to increase by 19.8 per cent *ceteris paribus* (Table 4). Equation 1(b) incorporates other explanatory variables and suggests that literacy variable (Edushare) and rainfall had significant negative impact on TFP. Equation 2(a) in Table 5 takes into account region dummy variable (R_{r-1}) with r indexes indicating four zones (North, East, West and South) to demonstrate the separate zone wise impact of livestock research on the TFP of the corresponding region. North zone acts as reference category for other region dummies. It was seen that across regions, livestock research had the largest impact on TFP in North and lowest in West zone. As per our estimates, with one unit rise in LRE stock, TFP increases by 64 per cent in North, 19 per cent in South, 10 per cent in East and about 7 per cent in West zone (Table 5). Due to widespread availability of favourable infrastructure and

proximity to national research stations, research spill-over and uptake is likely to be higher in North zone compared to other zones (Rada and Schimmelpfennig 2018).

The findings of the equation 2(b) were consistent with those of equation 1(b) with respect to estimated negative impact of share of education expenditure (indicator for literacy) and rainfall on livestock TFP. With one per cent rise in literacy variable (Edushare), TFP was observed to be declining by approximately 3 per cent. The estimated negative impact of education here may not appropriately capture the education level of farming population engaged in livestock activities and therefore leading to counter-intuitive results. Higher spending on education leads to better human resource development (HRD), which in turns opens up new opportunities resulting into transfer of better-educated labour force out of agriculture towards secondary and tertiary sectors. This could be the plausible reasoning behind the observed negative impact of education variable on TFP and similar findings have been obtained by (Rosegrant and Evenson 1992).

Although road density, artificial insemination and veterinary infrastructure showed positive association with TFP but their effect was statistically insignificant. All these variables collectively demonstrate the impact of improved infrastructure on productivity caused by reduction in productivity losses due to poor health and diseases. Our findings highlight that livestock research investment has most significant impact on productivity among the selected variables and the magnitude of impact was found to be highest for north zone followed by south, east and west zone. This study provides strong evidence of productivity enhancing effects of research activity and therefore argues in favour of greater allocation to livestock research.

Economic returns to research investment in livestock sector

The estimated coefficients of the research stock variable were used to compute expected value of marginal product (EVMP) of the research stock and marginal internal rate of return (MIRR). Overall EVMP for all zones was estimated to be Rs. 95.75, indicating the potential of higher economic gain from livestock research investment. It is evident from Table 6 that highest EVMP was obtained for North zone (Rs.313.18) followed by East zone (Rs.64.64), West (Rs.56.95) and South (Rs.52.61). These findings suggest that every additional rupee invested in livestock research is likely to generate greater benefits in all regions of the country however benefits are greatest for north zone. Based on our assumption outlined in methodology section, an additional rupee invested in research in time t leads to generation of an income stream after an initial gestation of six years, after that income starts rising at an increasing rate for the first four years from Rs. 19.51 from t+6 to Rs. 76.60 in t+9, thereafter it generates benefits at a constant rate of Rs. 95.75 from t+10 to t+15. Later on, benefits start increasing at a declining rate from t+16 onwards up to t+19.

Table 6 Zone wise expected value of marginal product and marginal internal rate of return

Region	Expected value of marginal product (in rupees‘)	Marginal internal rate of return (in %)
North	313.18	49.5
East	64.64	38.2
West	56.95	37.3
South	52.61	36.7
Overall	95.75	40.9

Zone-wise estimates reveal that the North zone had the highest MIRR (49.5%). The overall marginal internal rate of return (MIRR) was found to be 40.9 per cent. The presence of large number of animal science research institutes as well as strong state level funding, allow for higher information spill-over and technology adoption in this North region, which could be the plausible reason behind higher rate of returns. Despite being an agriculturally underdeveloped region, the East zone had the second highest MIRR (38.2%) indicating high potential for livestock sector in the region. Livestock constitute a major share of agricultural income in the East zone which has comparatively higher rates of poverty and malnutrition prevalence than the rest of the country. Focussing on location specific livestock research and its wider penetration has the potential to improve TFP growth leading to poverty eliminating effects in this region.

Livestock provides a suitable alternative for economic development of the region. The Western zone's MIRR was 37.3 percent. In this zone, Gujarat was the poster child for the success of the dairy cooperative movement–known for bringing prosperity to dairy households by improving marketing linkage. However, this was not the case for other states in the Western zone, wherein livestock research seems to be receiving low sectoral priority which is reflected in terms of its lower MIRR. Among all zones, South zone yielded lowest MIRR (36.7%) quite surprisingly. Lower adoption of livestock technologies such as cross breeds or lack of any region-specific breakthrough could be the possible reasons behind lower MIRR in South region. However, it may be concluded that, although investment in livestock research yields lower economic gains in terms of magnitude in the South zone than other zones, the returns were still significant enough to justify additional allocation.

There are many ways in which the research output from livestock maybe further augmented. There is need to strengthen the scientific staff and research capacity of most state level veterinary colleges and universities for development of location specific technologies and innovations. Also, most of the livestock innovations and technologies remain confined to the laboratory due to poor linkage between technology generator and disseminator. Hence, livestock extension mechanism might be strengthened in similar lines of crop sector. Findings of the study argue in favour of greater research allocation towards livestock research and timely impact evaluation of the ongoing research projects to assess their suitability and viability. For greater adoption of technical breakthroughs, there needs to be more collaboration amongst various stakeholders involved in the research to technology generation and dissemination process. Also, there is need to conduct more impact evaluation studies of individual livestock technologies so as to identify the factors hindering wider adoptability at farmer's level.

Conclusion

Livestock is a crucial sub-sector of agricultural economy in India with consistently rising share in agricultural GVA. Although success of crop research is well documented but empirical evidence in support of livestock research investment is almost non-existent. To fill the prevailing research gap, present study utilising a unique panel dataset of 15 major Indian states covering the period from 1991-92 to 2017-18 was undertaken. Several variables influencing livestock productivity such as research expenditure, veterinary infrastructure, artificial insemination, road density, weather and education variables were used to set up a fixed effects panel regression model and estimate economic returns. Findings suggests that investment in livestock research and education has overall significant positive impact on TFP, with per unit rise in research stock, TFP rises by almost 20 per cent. Notably the magnitude of research impact varied considerably across zones; North zone (64%) experienced highest impact on productivity, followed by South (19%), East (10%) and West (7%). Overall MIRR to livestock research investment were high (40.9%) indicating substantial economic gains of livestock research investment. With respect to return on research investment, North zone incurred greatest economic benefit with an estimated MIRR of 49.5 per cent followed by East (38.2 %), West (37.3%) and South (36.7%). Our estimates of economic returns are sufficiently high and stable thus establishing that research activity has strong influence on productivity improvement. Our findings reiterate the support for additional allocation to livestock research especially in the economically backward regions such as East zone.

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Appendix

A1. Summary statistics of the variables

Variable		Mean	Standard deviation	Observations
Total factor productivity index	Overall		0.39	N=432
	Between	1.06	0.08	n =16
	Within		0.38	T= 27
Livestock research and education (LRE) stock	Overall		161.11	N=165
	Between	301.25	152.39	n =15
	Within		64.41	T= 11
Annual mean rainfall	Overall		648.53	N=432
	Between	1172.34	632.44	n =16
	Within		211.52	T= 27
Road density	Overall		1190.98	N=432
	Between	1336.08	923.33	n =16
	Within		785.70	T= 27
Number of artificial inseminations performed	Overall		2003.16	N=432
	Between	2219	1220.58	n =16
	Within		1616.38	T= 27
Veterinary infrastructure	Overall		1505.88	N=432
	Between	3248	1385.19	n =16
	Within		681.67	T= 27
Share of education in aggregate expenditure (%)	Overall		2.73	N=288
	Between	14.82	2.14	n =16
	Within		1.76	T= 18

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Does the seed system determine the crop yield and farmers' income? an economic analysis

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Abstract The use of quality seeds is critical in determining the yield and income of the farmers. We study the major seed sources of rice and wheat in India using National Sample Survey Office (NSSO) 77th round data and examine the yield and income differences across different seed sources using a multivariate regression model. The factors determining the choice of seed source were examined using a multi-nominal logit model. The analysis indicated that economic status, social group, awareness about the variety, the experience of crop loss, etc., determine the farmers' seed choice. Besides, farmers using seeds from sources other than own-farm seeds received higher yield and income, which varied further with the seed source.

Keywords Seed system, multi-nominal logit model, multivariate regression, yield, income

JEL codes Q12, Q16, Q18

Seed is a critical input in crop production, as the response of the crop to other inputs depends on the quality of the seed. Quality seed alone contributes 15-20% to the total production directly, which can be further increased to 45% with the efficient management of other inputs (www.seednet.gov.in; Poonia 2013; Ali 2016). The use of quality seeds improves food and nutritional security, supports farmers' livelihood, contributes to sustainable resource use and makes the crop production system resilient to various abiotic and biotic stresses (Louwaars and Manicad 2022). Availability and use of good quality seeds are important factors that determine the yield and quality of the output. Hence it is crucial to develop a seed production and delivery system that continuously develops new varieties suited to the changing environment and disseminates them faster, replacing old varieties.

Seed sector interventions are important because the seed is the carrier of the technological advances made by the research system, including yield enhancement, improving nutrition including biofortification, and incorporating resilience to strive through changing climate and other biotic and abiotic stresses (McGuire and Sperling 2016). India has a well-organized public seed production and distribution system with national, state, and regional institutions involved in producing, certifying, and distributing seeds of different crops and varieties. India follows a definite seed multiplication system consisting of three generations: breeder, foundation, and certified seeds (www.seednet.gov.in).

The seed industry in India has grown significantly over the years owing to various seed legislations enacted from time to time. These policies facilitated the investments in the seed sector by the private players that shifted the predominantly public sector during the 1960s to one which is more competitive and market-driven (Chauhan et al. 2016) . Despite the progress made by the sector, only 30-35% of the total seeds distributed in the country are through the organized sector, and the rest is through the unorganized sector, comprising mainly of farm-saved seeds (GoI 2016).

The seed system is a network of seed supply channels that provides farmers with seeds from various sources based on variety, price, and availability, which can be

distinguished into formal and informal seed systems. The formal seed systems are market-based and involve the exchange of improved and certified crop varieties through research stations, governmental institutions, and commercial seed stockists. In contrast, seed exchanges between farmers using local varieties and non-certified improved varieties, as a part of cultural norms and social relations, are called informal seed systems (Schöley and Padmanabhan 2016). It is imperative to understand if the seed sector development in the country caters to the needs of all farmers in terms of access and quality irrespective of gender, caste, and socioeconomic status. Understanding the seed system dynamics helps design socially inclusive strategies to ensure quality seed access to farmers across all categories. In this context, we examine the seed system of two major staple crops in the country, rice and wheat. We explore the major seed sources of rice and wheat in India, examine the yield and income differentials across sources, and identify the source providing quality seeds that benefit the farmers in terms of higher yield and income. The study also analyses the factors determining the choice of seed source by the farmers.

Data

The study uses farm-level data from a nationally representative survey by the National Sample Survey Office (NSSO) 77th round data on situation assessment of agricultural households conducted from 1st January 2019 to 31st December 2019. The sample used in our analysis comprised 16398 households cultivating only rice and 7335 households cultivating only wheat. The households cultivating only rice and wheat were extracted separately from visits 1 and 2 of the survey.

Methodology

Multivariate regression analysis was undertaken to find if there is a significant difference in yield and income across different seed sources. The following model was estimated:

$$Y_i = \beta_0 + \sum_{i=1}^{6} \beta_i X_i + \sum_{j=2}^{5} \beta_j S_j + \sum_{k=1}^{4} \beta_k D_k + u_i \qquad (1)$$

Where, Y_i is the dependent variable. Two models were fitted, taking yield and income as dependent variables. We assume that traditional varieties sometimes may fetch higher prices or require comparatively less cost of production, which may lead to the popularity of traditional varieties. We test if this assumption holds. X_i indicates the size of the farm and expenditure incurred per hectare for crop production such as fertilizer, bio-fertilizers, plant protection chemicals, power consumption (including expenditure for diesel and electricity), and irrigation. S_j indicates a dummy for seed sources from where the sample farmers procure seeds. Ten seed sources were listed in the sample, which we grouped into 5 for analysis. Group 1 comprises farmers purchasing seeds from input dealers and local traders; group 2 comprises farmers procuring seeds from APMC Market, FPOs, Private processors, contract farming, and others; group 3 from cooperatives; group 4 from government agencies and group 5 uses own-farm seeds. Group 5 was used as the base category. D_k indicates the dummy for education, possession of Kisan Credit Card (KCC), crop insurance, and membership in any organization.

In order to evaluate the determinants of seed source choice, we adopt the multinomial logistic regression. We apply the maximum likelihood method to estimate a multinomial logit model along with robust standard errors. For this purpose, we used the four categories of seed sources as the dependent variables, and the own farm seeds group was considered the base category.

The model for seed source choice can be depicted as follows as in Greene (2003)

$$Prob(Y_i = j) = \frac{e^{\beta' j x_i}}{\sum_{k=1}^{4} e^{\beta' k X_i}} \qquad (2)$$

Where j= Groups 1,2,3 and 4 represent different sources of seeds; Group 1 consists of farmers purchasing seed from input dealers and local traders; Group 2 consists of farmers procuring seeds from APMC Market, FPOs, Private processors, contract farming, and others; Group 3 farmers purchase seeds from Co-operatives & Government agencies; and Group 4 farmers use Own-farm seeds which is taken as the base category. The estimated equations provide a set of probabilities for the $J+1$ choices of farmers, and xi_s are the explanatory variables. Only three parameter vectors are required to predict all four probabilities of seed source choices, as one is taken as the base category. The probabilities can be found using the following equation.

$$Prob(Y_i = j \mid X_i) = \frac{e^{\beta' j x_i}}{\sum_{k=1}^{j} e^{\beta' k X_i}}, \quad \text{for } j = 0, 1, \ldots, J,$$

$$\beta_0 = 0 \qquad (2)$$

Table 1 Seed source-wise number of farmers, yield and income for rice and wheat cultivating households in India

Seed sources	Rice			Wheat		
	Number of farmers (%)	Yield (kg/ha)	Income (Rs/ha)	Number of farmers (%)	Yield (kg/ha)	Income (Rs/ha)
Local market (Local traders)	65.48	3376	48372	80.72	3043	50555
Own-farm	24.02	2813	39187	12.98	2334	34945
Input dealers	2.95	3851	56095	2.68	3159	54472
Government agencies	2.4	3056	44152	0.91	1802	31400
Co-operatives	2.27	3292	51942	0.97	3490	58516
Private processors	1.13	3209	52549	0.64	3501	63615
APMC market	0.78	3168	44761	0.33	2886	54191
Farmer producer organisers	0.11	1909	25244	0.31	2012	35122
Contract farming companies	0.04	2926	42666	—	—	—
Others	0.82	3379	52514	0.45	3125	41117

The seed source choice of the farmers is influenced by the various farm and household level characteristics. The predictors included in the model are gender, age, education, social group, monthly expenditure, access to irrigation, access to information, possession of Kisan Credit Card (KCC), history of crop loss, awareness about Minimum Support Price (MSP), and farm size.

Results and discussion

Seed sources and their distribution

Sample farmers procure seeds from ten different seed sources listed in the database. As in Table 1, the major seed source for rice and wheat farmers are local market/ local traders, followed by own-farm saved seeds.

Over 65% of rice and nearly 81% of wheat farmers depend on local traders for seeds, while 24.02% and 12.98% of farmers use own-farm seeds in the case of rice and wheat, respectively. The average yield was found to be comparatively higher for seeds procuring from Input dealers, followed by local traders, cooperatives, private processors etc. At the same time, yield and income are relatively low for seeds procured from FPOs and own-farm seeds. It is clear from Table 1 that there is no advantage in terms of yield and income observed in the case of farmers using farm-saved seeds.

The farmers' access to seed sources varies across states. Figure 1 depicts the distribution of seed sources across major rice-producing states that contributes around 91% of total rice production in the country. Although

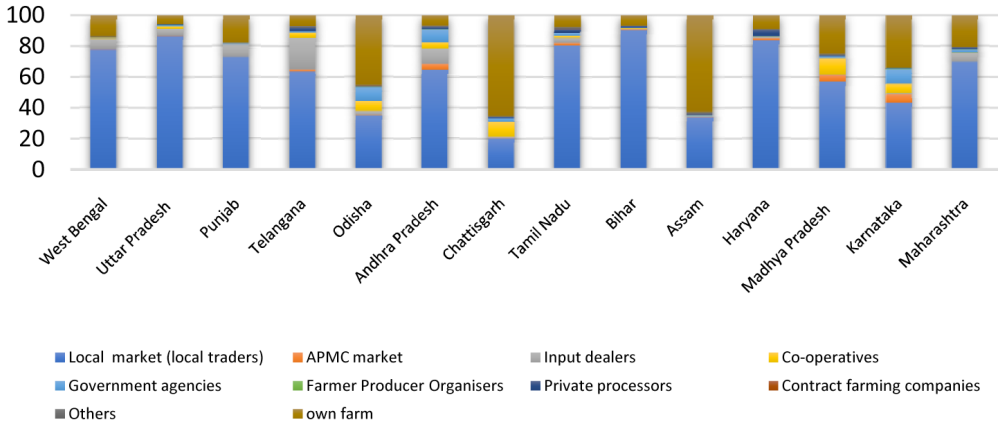

Figure 1 Distribution of seed sources in major rice-producing states

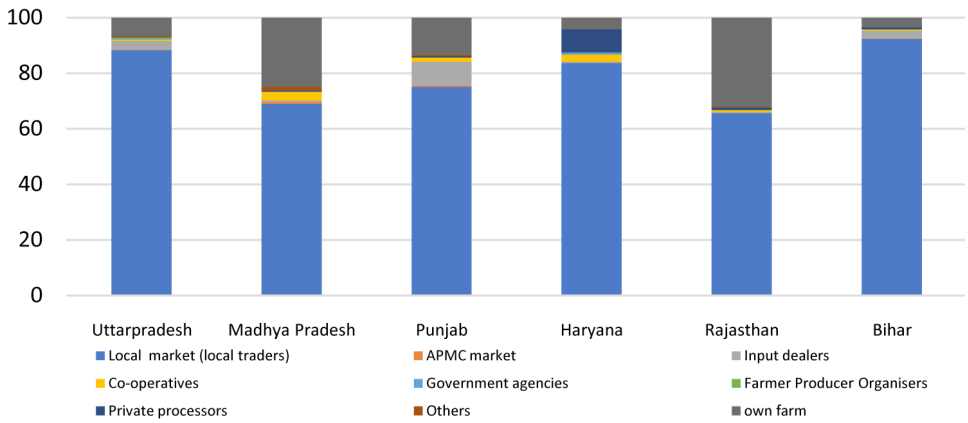

Figure 2 Distribution of seed sources in major wheat-producing states

local traders dominate the system in most of the states, the share of farmers using own-farm seeds was found to be high in states like Chattisgarh (65.5%), Assam (62.57%), and Odisha (45.58%). Inputs dealers are relatively popular in Telangana and Andhra Pradesh, and Cooperatives are highly popular in Chattisgarh, Madhyapradesh, and Odisha. APMC markets are relatively popular in Madhya Pradesh, Karnataka, and Andhrapradesh. Figure 2 depicts the seed source distribution of wheat farmers in India's major wheat-producing states. Although local traders dominate seed distribution across these states, the share of own farm seed users is significant in states like Madhya Pradesh, Rajasthan, and Punjab.

Effect of seed source choice on yield and income of the farmers

This section examines how yields and income differ across farmers using seeds from different sources. We use a multivariate regression model to examine the effect of the choice of seed source on the yield and income of farmers cultivating rice and wheat. The summary statistics of the variables used in the model pertain to rice farming households are given in Table 2, and parameter estimates are provided in Table 3.

It can be inferred from Table 3 that education, possession of a KCC, membership in any organization, and most other inputs affect the yield and income of farmers positively. Crop insured under PMFBY positively affects income with no significant effect on yield, which implies that crop insurance helps the farmer to have a stable income in the event of crop failures. Farm size is inversely related to yield, as reported in many studies (Wang et al 2015; Gaurav and Mishra 2015). The seed source choice also has a significant effect on yield and income. Compared to the base category, the farmers using own-farm seeds, all other groups realized higher yield and income. Among all sources, the yield and income of farmers using seeds from cooperatives were comparatively higher, followed by groups 1, 4, and 2. A similar analysis was undertaken for wheat farming households, and the summary statistics of variables used are given in Table 4.

From Table 5, it can be understood that almost all the input variables are positively related to yield and income. The farmers possessing KCCs could also realize better yield and income than their counterparts. Most importantly, the yield and income vary significantly across different seed sources. The farmers purchasing seeds from groups 1 and 3 realized higher yields than farmers using own-farm seeds. Compared to own-farm seeds, the farmers using seeds from all other groups could realize higher income because of the better price of the cultivated variety. So, it can be concluded that in rice and wheat farming households, the seeds from sources other than own-farm performed well by fetching better yield and income. Therefore, the farmers should be encouraged to frequently replace the seeds with good quality seeds to realize better yield and income.

Determinants of seed choice

The farmers' choice of seed source depends on various socio-economic and farming-related variables. The multi-nominal logistic model using four groups of seed

Table 2 Summary statistics of multivariate regression and multi-nominal logit model (Rice farming households)

Variables	Mean	Std. Dev.	Min	Max
Yield (Model 1)	3240.04	1730.76	0	18712
Income per hectare (Model 2)	46271	31462	-224770	589095
Education (1=literate,0-non-literate)	0.67	0.47	0	1
Kissan credit card (Yes=1, No=0)	0.17	0.37	0	1
Membership in any organisation (Yes=1, No=0)	0.04	0.19	0	1
Crop insured under PMFBY (Yes=1, No=0)	0.04	0.20	0	1
Farm Size (ha)	0.79	0.86	0	28
Fertilizer expenditure (Rs/ha)	4680.10	4518.80	0	224770
Bio-fertiliser expenditure (Rs/ha)	1627.28	3060.30	0	86450
Plant protection chemicals expenditure (Rs/ha)	1573.63	2828.09	0	80275
Power expenditure (Rs/ha)	920.69	2597.19	0	103740
Irrigation expenditure (Rs/ha)	1957.35	4182.18	0	205833
Seed source categories for multi-variate regression (Base category- Group 5)				
Group 1	0.68	0.46	0	1
Group 2	0.03	0.17	0	1
Group 3	0.02	0.15	0	1
Group 4	0.02	0.15	0	1
Group 5	0.24	0.43	0	1
Additional variables for multi-nominal regression*				
Gender (Male=1, Female=0)	0.92	0.28	0	1
Age (Years)	50.60	13.22	12	105
Access of information about improved variety (1=Yes, 0=No)	0.28	0.45	0	1
Monthly expenditure (Rs)	8507.94	4767.55	500	81700
Access to irrigation (1=Yes, 0=No)	0.67	0.47	0	1
Crop loss experienced(1=Yes, 0=No)	0.40	0.49	0	1
Awareness about MSP(1=Yes, 0=No)	0.36	0.48	0	1
Social groupsST	0.19	0.39	0	1
SC	0.16	0.36	0	1
OBC	0.40	0.49	0	1
Others	0.26	0.44	0	1
Seed source categories (Categorical Dependent Variables)				
Group 1	0.68	0.46	0	1
Group 2	0.03	0.17	0	1
Group 3	0.05	0.21	0	1
Group 4 (Base Category)	0.24	0.43	0	1
No of observations	16398			

*Some of the variables used for the multivariate regression model and multi-nominal regression model are same, hence summary statistics of both models are accommodated in the same table.

Table 3 Parameter estimates of multivariate regression model (Rice farming households)

Variables	Yield (kg/ha)		Income (Rs/ha)	
	Coefficients	Robust Std. Err.	Coefficients	Robust Std. Err.
Education (1=literate,0-non-literate)	91.31***	24.75	2590.36***	454.73
Kissan credit card (Yes=1, No=0)	114.11***	36.38	4558.67***	698.00
Membership in any organisation (Yes=1, No=0)	182.76***	55.60	4300.36***	1181.40
Crop insured under PMFBY (Yes=1, No=0)	73.03	61.58	4574.39***	1232.32
Seed sources (Base –Group 5)				
Group 1	327.86***	33.98	8639.86***	642.49
Group 2	127.80*	71.69	4816.14***	1542.70
Group 3	532.59***	78.77	14095.39***	1470.09
Group 4	245.38***	79.67	6082.20***	1470.15
Farm Size (ha)	-39.47**	17.17	588.30	360.77
Fertilizer expenditure (Rs/ha)	0.08***	0.02	0.92**	0.40
Bio-fertiliser expenditure (Rs/ha)	0.08***	0.01	0.63**	0.31
Plant protection chemicals expenditure (Rs/ha)	0.07***	0.02	1.42***	0.41
Power expenditure	0.04**	0.02	0.63	0.41
Irrigation expenditure (Rs/ha)	0.04***	0.01	0.41	0.25
State fixed effects	Yes	—	Yes	—
Constant	1224.62***	315.25	33478.74***	6229.341

*, ** and *** indicate statistical significance at the 10 %, 5% and 1% level, respectively

Table 4 Summary statistics of multivariate regression and multi-nominal logit model (Wheat farming households)

Variables	Mean	Std. Dev.	Min	Max
Yield (Model 1)	2945.14	1383.64	4.94	15808
Income per hectare (Model 2)	48503	33875	-114649.2	1851951
Education (1=literate,0-non-literate)	0.63	0.48	0	1
Kissan credit card (Yes=1, No=0)	0.23	0.42	0	1
Membership in any organisation (Yes=1, No=0)	0.02	0.15	0	1
Crop insured under PMFBY (Yes=1, No=0)	0.03	0.18	0	1
Farm Size (ha)	0.70	0.82	0	13.36
Fertilizer expenditure (Rs/ha)	4606.77	3575.45	82.33	68611
Bio-fertiliser expenditure (Rs/ha)	1614.25	3170.76	0.00	61750
Plant protection chemicals expenditure (Rs/ha)	1080.45	2360.82	0.00	135850
Power expenditure (Rs/ha)	1702.92	3169.04	0.00	45078
Irrigation expenditure (Rs/ha)	2884.40	4096.56	0.00	98800
Seed source categories for multi-variate regression (Base category- Group 5)				
Group 1	0.83	0.37	0	1
Group 2	0.02	0.13	0	1
Group 3	0.01	0.10	0	1

Contd...

Variables	Mean	Std. Dev.	Min	Max
Group 4	0.01	0.10	0	1
Group 5	0.13	0.34	0	1
Additional variables for multi-nominal regression				
Gender (Male=1, Female=0)	0.92	0.28	0	1
Age (Years)	49.30	13.57	12	104
Access of information about improved variety (1=Yes, 0=No)	0.30	0.46	0	1
Monthly expenditure (Rs)	9082.45	5294.73	800	90083
Access to irrigation (1=Yes, 0=No)	0.91	0.28	0	1
Crop loss experienced(1=Yes, 0=No)	0.33	0.47	0	1
Awareness about MSP(1=Yes, 0=No)	0.27	0.44	0	1
Social groupsST	0.09	0.29	0	1
SC	0.19	0.39	0	1
OBC	0.48	0.50	0	1
Others	0.24	0.43	0	1
Seed source categories (Categorical Dependent Variables)				
Group 1	0.83	0.37	0	1
Group 2	0.02	0.13	0	1
Group 3	0.02	0.14	0	1
Group 4 (Base category)	0.13	0.34	0	1
No of observations	7335			

Table 5 Parameter estimates of the multivariate regression model (Wheat farming households)

Particulars	Yield (kg/ha)		Income (Rs/ha)	
	Coefficients	Robust Std. Err.	Coefficients	Robust Std. Err.
Education (1=literate,0-non-literate)	40.05	30.97	1481.45*	684.46
Kissan credit card (yes=1, No=0)	163.59***	39.47	5873.29***	1859.31
Membership in any organisation (Yes=1, No=0)	-53.31	79.82	-964.75	1827.34
Crop insured under PMFBY (Yes=1, No=0)	-38.98	80.92	-1748.73	1879.65
Seed Sources (Base –Group 5)				
Group 1	260.26***	51.34	8751.41***	1017.62
Group 2	182.63	117.76	7231.54***	2467.15
Group 3	1051.23***	164.61	21715.29***	2753.93
Group 4	66.48	184.61	6502.24*	3586.18
Farm Size(ha)	-11.91	20.58	341.57	611.85
Fertilizer expenditure (Rs/ha)	0.08***	0.01	1.50***	0.22
Biofertilizer expenditure (Rs/ha)	0.02**	0.01	-0.49**	0.20
Plant protection chemicals expenditure (Rs/ha)	0.00	0.04	-0.48	0.83
Power expenditure (Rs/ha)	0.08***	0.01	1.37***	0.18
Irrigation expenditure (Rs/ha)	0.05***	0.01	0.76***	0.19
State fixed effects	Yes	—	Yes	—
Constant	1127.77***	92.46	16897***	1933

*, ** and *** indicate statistical significance at the 10 %, 5% and 1% level, respectively

Table 6 Determinants of farmers' seed choice using multi-nominal logistic regression (Rice farming households)

Particulars	Group 1		Group 2		Group 3	
	Coefficients	Std.Err.	Coefficients	Std.Err.	Coefficients	Std. Err.
Gender (Male=1, Female=0)	-0.129	0.086	0.080	0.229	-0.061	0.168
Age (years)	-0.007***	0.002	-0.001	0.005	0.001	0.003
Education (1=literate, 0=non-literate)	-0.105*	0.057	0.237*	0.135	0.123	0.105
Farm size (ha)	0.082**	0.036	0.178***	0.049	0.177***	0.044
Access of information about improved variety (Yes=1, No=0)	0.210***	0.057	0.062	0.132	0.415***	0.096
Social Group						
ST	-0.722***	0.075	-0.478***	0.189	-0.530***	0.151
SC	-0.082	0.085	0.255	0.201	0.073	0.167
OBC	-0.079	0.067	0.107	0.157	0.236*	0.124
Monthly expenditure (Rs)	0.000***	0.000	0.000***	0.000	0.000**	0.000
Kisan credit card (Yes=1, No=0)	0.304***	0.072	0.201	0.160	0.549***	0.112
Membership in any organisation (Yes=1, No=0)	-0.282**	0.123	-0.032	0.263	0.215	0.177
Access to irrigation (Yes=1, No=0)	0.283***	0.061	1.064***	0.148	0.579***	0.111
Crop loss experienced (Yes=1, No=0)	-0.170***	0.054	-0.215*	0.126	0.221**	0.095
Awareness about MSP (Yes=1, No=0)	0.319***	0.059	0.149	0.133	0.606***	0.106
State fixed effects	Yes		Yes		Yes	
Constant	0.689***	0.177	-3.781***	0.450	-2.769***	0.334

*, ** and *** indicate statistical significance at the 10 %, 5% and 1% level, respectively

sources as dependent variables was applied to determine the determinants of choice. The summary statistics for the variables used can be found in Tables 2 and 4 for rice and wheat farming households.

From Table 6, it is clear that younger farmers prefer own-farm seeds comparatively. Age is a proxy for farming experience. Hence, with experience, farmers become aware of various seed sources and use seeds from other sources than farm-saved ones. Farmers tend to prefer seeds from sources other than farm-saved seeds as farm size increases. The literate farmers use seeds from group 2 (APMC Market, FPOs, private processors, contract farming, and others) and tend not to prefer group 1 (local traders). If the farmers have access to information about improved varieties, they prefer either group 1 or group 3 (Co-operatives and Government agencies) compared to the base category. Caste-related networks in a village are crucial in determining the seed source choice (Gupta et al 2020). We found that farmers from the Scheduled Tribe group prefer farm-saved seeds to other sources. The farm households with higher spending and access to irrigation are likely to go for seeds from sources other than own-farm seeds. Farmers who have experienced crop loss tend to prefer seeds from group 3. Access to credit encourages the farmers to use seeds from groups 1 or 3.

In the case of wheat farming households, farmers at a comparatively young age prefer own-farm seeds because of the lack of experience. With a larger farm size and higher monthly expenditure, farmers prefer seeds from sources other than own-farm seeds. It implies that if the economic status of the farmers is better, they can purchase seeds beyond their own-farm seeds. If the farmer gets any information about the improved variety, they will likely go for seeds from groups 1 and 2. Also, if the farmer has awareness about policy support such as MSP, they will prefer seeds from group 3. In the case of wheat, we can see that the farmers in the ST category are likely to use own-farm seeds that seeds from other sources. It may be because of poor financial status and lack of access to information and seed sources.

Table 7 Determinants of farmers' seed choice using multi-nominal logistic regression (Wheat farming households)

Particulars	Group 1		Group 2		Group 3	
	Coefficients	Std.Err.	Coefficients	Std.Err.	Coefficients	Std. Err.
Gender (Male=1, Female=0)	-0.014	0.142	-0.203	0.368	-0.019	0.350
Age (years)	-0.008***	0.003	-0.012	0.008	-0.004	0.007
Education (1=literate, 0=non-literate)	0.003	0.016	0.027	0.038	-0.035	0.042
Farm size (ha)	0.241***	0.067	0.344***	0.114	0.289**	0.120
Access of information about improved variety (Yes=1, No=0)	0.360***	0.092	0.565***	0.211	0.253	0.209
Social Group						
ST	-0.413***	0.138	-0.275	0.391	-0.749**	0.361
SC	-0.004	0.131	0.877***	0.306	0.091	0.294
OBC	0.096	0.110	0.322	0.269	0.240	0.254
Monthly expenditure (Rs)	0.000**	0.000	0.000***	0.000	0.000**	0.000
Kisan credit card (Yes=1, No=0)	-0.057	0.096	-0.123	0.249	0.129	0.233
Membership in any organisation (Yes=1, No=0)	-0.303	0.257	-0.447	0.758	0.097	0.528
Access to irrigation (Yes=1, No=0)	0.190	0.135	-0.165	0.346	-0.169	0.307
Crop loss experienced (Yes=1, No=0)	-0.210**	0.083	0.304	0.206	-0.010	0.214
Awareness about MSP (Yes=1, No=0)	-0.246***	0.094	-0.347	0.240	1.195***	0.249
State fixed effects	Yes		Yes		Yes	
Constant	0.620**	0.318	-1.798***	0.692	-0.264	0.610

** and *** indicate statistical significance at 5% and 1% level, respectively

Conclusion

Seed is one of the critical inputs in crop production that determines the yield and income of farmers. Therefore, replacing seeds with good quality is imperative to realize the potential yield. Even after implementing various seed legislations and policies, a significant proportion of farmers still use own-farm seeds for cultivation. Using NSSO data on rice and wheat farming households, we study the reasons for farmers' preference for particular seed sources. Out of the major seed sources listed in the database, most farmers prefer seeds from local traders followed by own-farm seeds. Among all groups, the yield and income of farmers sourcing seeds from cooperatives were comparatively higher, followed by local traders in the case of both rice and wheat farmers. Both rice and wheat farmers purchasing seeds from all other sources could realize better yield and income than own-farm seeds. Hence, to improve yield and income, farmers should replace the seeds with good quality ones of improved varieties, especially in those states where the use of own-farm seeds is still widespread.

The seed source of choice of farmers is affected by various factors, which were analyzed using multi-nominal logistic regression. It was found that the farmers with better economic status tend to use seeds from sources other than own-farm seeds. If the farmer has access to information about the variety, the chance of replacing seeds using other sources is high. It indicates that creating awareness among farmers significantly affects seed replacement using quality seeds. Besides, the farmers belonging to the ST category tend to use own-farm seeds in both cases. Hence it is essential to organize awareness programs among ST category farmers and to provide necessary support in adopting improved agricultural practices to improve their income. As most farmers depend on local dealers for seeds, frequent monitoring at the seed dealers' level should be done to ensure the seeds' physical and cultivar purity.

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Regional disparity in institutional credit to agriculture sector in India: trends and performance

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Abstract Credit is as an indirect input in agricultural production. By easing liquidity constraint, it enables farmers adopt modern technology and invest in farm infrastructure. The Government of India initiated several policy measures to improve outreach of the financial institutions to farming and rural communities. As a result, the share of institutional credit, increased from 7% in 1951 to 67% in 2018. The credit to agricultural sector increased from Rs.46268 crore in 1999-2000 to Rs.1863363 crore in 2021-22 at an annual growth of 19.5%. There was an impressive increase in the credit intensity from Rs.26100 per hectare in 2011-12 to Rs.93210 per hectare in 2021-22. However, there exist significant regional disparities in it — Rs.21756 in north eastern region to Rs.259554 in southern region. Such stark disparities in agricultural credit warrant attention of the policymakers to re-orient the agricultural credit policy to the needs of the credit-starved regions.

Keywords Agriculture credit, regional disparities, inclusiveness, convergence

JEL codes Q1, Q14, Q18

Agriculture plays a crucial role in Indian economy. Although the share of agriculture in the national income has come down substantially since the beginning of planning era, from 55.4% in 1950-51 to 18.64% in 2021-22, it still remains important for the livelihood of over 45% of the population, which is directly engaged in production agriculture. A majority of the farm households are smallholders, and they lack access to finances for meeting the revenue and capital requirements of agriculture. The Government of India initiated several measures to improve their access to institutional sources of credit. The policy emphasis has been on the progressive institutionalization of credit to provide timely and adequate credit support to all the farmers, especially on small and marginal farmers and weaker sections in order to enable them to adopt modern technologies and improved agricultural practices for increasing agricultural production and productivity. The credit flow to agriculture which was just Rs.4352 crore in 1982-83 increased to Rs.1863363 crore in 2021-22.

However, despite significant increase in credit flow, disparity in credit distribution remain, across regions and farm classes. Data suggest that southern region receives almost half of the total agriculture credit disbursed. Likewise, the outreach of institutional financial agencies has remained poor to small and marginal farmers. Against this backdrop, this paper analyses growth in agricultural credit, and regional disparities therein, and suggests policy measures to reduce disparities in credit supply.

Data

The study is based on secondary data compiled from various published sources. The data on gross cropped area (GCA), agricultural gross value added (AgGVA) and gross value added (GVA) were compiled from the Handbook of Statistics on Indian States (2022), Reserve Bank of India (RBI). The data on agricultural credit were collected from the Agriculture Statistics at a Glance, published by the Ministry of Agriculture and

Farmers Welfare, Government of India (GoI), Annual Reports of the NABARD, and Economic Surveys published by the Ministry of Finance, Government of India. Data on institutional and non-institutional credit were compiled from the All-India Debt and Investment Surveys, brought out once in 10 years by the Ministry of Statistics and Programme Implementation, Government of India. The data provides useful information on different dimensions of rural finance.

Results and discussion

Evolution of institutional credit: regional dimensions

One of the main objectives of the agricultural credit policy has been to reduce the role of non-institutional credit sources, mainly moneylenders in the rural credit market. Several initiatives have been taken in this direction. Some major milestones in the rural credit are: the acceptance of Rural Credit Survey Committee Report (1954), the nationalisation of major Commercial Banks (in 1969 and 1980), the establishment of Regional Rural Banks (RRBs) in 1975 and the National Bank for Agriculture and Rural Development (NABARD) in 1982. Simultaneously, several measures like establishment of the Lead Bank Scheme, direct lending for the priority sector, banking sector's linkage with the Government-sponsored programmes targeted at the poor, Differential Rate of Interest Scheme, the Service Area Approach, the SHG-Bank Linkage Programme were also implemented to strengthen the credit flow (RBI 2004). In recent years, initiatives like Kisan Credit Card (KCC) Scheme, Special Agricultural Credit Plans, Rural Infrastructure Development Fund (RIDF) and Agriculture Infrastructure Fund, etc. have been introduced to enhance the flow of credit to the rural sector.

State-wise and region-wise shares of the institutional and non-institutional sources in the total rural credit for the last four rounds of the All India Debt and Investment Survey (AIDIS) is given in Table 1. All states witnessed a significant increase in the institutional credit after the nationalization of Commercial Banks. However, the performance and trends are not uniform across states. In states like Bihar, Chhattisgarh, Tamil Nadu and most states in the north eastern region, the share of institutional credit in the total rural credit fell dramatically. For instance, in Bihar it fell from 51.23% in 1991-92 to 23.51% in 2002-03. A similar picture emerges for all the north eastern region, where the institutional credit penetration decreased from 71.27% (1991-92) to 59.55% (2002-03), but it improved to 81.41% in 2018-19. At all India level, the share of institutional credit continuously increased from 55.65% in 1991-91 to 67.00% in 2018-19. Kumar et al. (2007) have opined that during the banking reforms period, excessive emphasis on profitability eroded the primary mandate of some formal financial institutions such as cooperatives and RRBs, facilitating the comeback of the exploitative non-institutional credit agencies. Another interesting point to note is that southern region despite its good institutional banking infrastructure continues to have a large share of borrowings from the non-institutional sources.

In order to bring the excluded agricultural households into the fold of institutional credit in a structured and sustainable manner, there is a need to build an enabling ecosystem with respect to policies, institutional innovations and digital technologies. The enabling ecosystem would include digitisation of land records, reforming of land-leasing framework, building consensus among states with regard to agriculture-related policy reforms, and initiating innovative digital solutions to bridge the information gap between the banks and farmers (RBI 2019).

Institutional credit: agency-wise ground level credit (GLC) flow to agriculture

The recent past witnessed healthy growth in the flow of agriculture credit, particularly since the introduction of the policy of 'doubling of agriculture credit' by the Government of India in 2004-05. Agriculture credit increased at an overwhelming rate of 35% per annum during 2004-05 to 2006-07. The growth in agricultural credit disbursed has been significant over the years. During 1999-2000 to 2021-22, the total agricultural credit disbursed increased from Rs.46268 crore to Rs.1863363 crore. Overall, the ground level credit (GLC) disbursed grew at a rate of 18.84% per annum, the highest growth of 21.59% was in the case of RRBs, followed by the Commercial Banks (20.63%) and Cooperative Banks (12.52%).

A prominent feature of the trends in GLC is the change in the share of different agencies. Disaggregated data indicate that the share of Cooperative Banks, which was around 40% in the GLC in 1999-2000 reduced to

Table 1 Share of institutional and non-institutional borrowings in different states of India, 1991-92 to 2018-19

(%)

State/Region	Institutional sources				Non-institutional sources			
	1991-92	2002-03	2012-13	2018-19	1991-92	2002-03	2012-13	2018-19
Haryana	52.67	61.78	63.09	73.60	47.33	38.22	36.91	26.40
Himachal Pradesh	60.30	57.16	83.72	95.20	39.70	42.84	16.28	4.80
Jammu & Kashmir	42.80	82.74	63.46	66.80	57.20	17.26	36.54	33.20
Punjab	59.26	53.82	71.70	73.90	40.74	46.18	28.30	26.10
Rajasthan	30.29	38.69	43.50	53.00	69.71	61.31	56.50	47.00
Northern region	49.06	58.84	65.09	72.50	50.94	41.16	34.91	27.50
Arunachal Pradesh	56.47	78.40	74.80	72.30	43.53	21.60	25.20	27.70
Assam	45.04	46.43	72.23	87.50	54.96	53.57	27.77	12.50
Manipur	53.19	7.76	49.65	46.90	46.81	92.24	50.35	53.10
Meghalaya	91.88	38.11	96.30	90.70	8.12	61.89	3.70	9.30
Mizoram	68.22	84.54	85.56	94.30	31.78	15.46	14.44	5.70
Nagaland	72.76	71.29	20.82	80.20	27.24	28.71	79.18	19.80
Sikkim	98.58	75.81	79.00	89.70	1.42	24.19	21.00	10.30
Tripura	84.02	74.04	69.30	89.70	15.98	25.96	30.70	10.30
North Eastern region	71.27	59.55	68.46	81.41	28.73	40.45	31.54	18.59
Bihar	51.23	23.51	28.87	49.10	48.77	76.49	71.13	50.90
Jharkhand	94.40	90.93	28.03	58.60	5.60	9.07	71.97	41.40
Odisha	70.15	69.27	37.94	61.70	29.85	30.73	62.06	38.30
West Bengal	55.52	48.63	58.10	72.60	44.48	51.37	41.90	27.40
Eastern region	67.83	58.09	38.23	60.50	32.18	41.92	61.77	39.50
Chhattisgarh	74.39	57.32	57.21	79.60	25.61	42.68	42.79	20.40
Madhya Pradesh	57.76	62.26	60.56	67.70	42.24	37.74	39.44	32.30
Uttaranchal	28.97	53.94	83.42	91.10	71.03	46.06	16.58	8.90
Uttar Pradesh	54.84	53.61	61.56	66.90	45.16	46.39	38.44	33.10
Central region	53.99	56.78	65.69	76.33	46.01	43.22	34.31	23.68
Gujarat	74.70	75.74	79.20	81.60	25.30	24.26	20.80	18.40
Maharashtra	77.06	78.12	76.50	88.20	22.94	21.88	23.50	11.80
Western region	75.88	76.93	77.85	84.90	24.12	23.07	22.15	15.10
Andhra Pradesh	25.56	37.50	43.74	35.50	74.44	62.50	56.26	64.50
Karnataka	62.78	62.51	63.00	68.40	37.22	37.49	37.00	31.60
Kerala	81.79	81.63	89.80	86.90	18.21	18.37	10.20	13.10
Tamil Nadu	61.92	46.63	63.96	67.60	38.08	53.37	36.04	32.40
Telangana	0.00	0.00	34.53	41.70	0.00	0.00	0.00	58.30
Southern region	58.01	57.07	59.01	60.02	33.59	42.93	34.87	39.98
All India	55.65	57.09	59.80	67.00	44.35	42.91	40.20	33.00

Source Data of Debt and Investment Survey NSSO, 48th, 59th, 70th and NSO 77th Rounds

13.05% in 2021-22. There was a tremendous improvement in the share of Commercial Banks, from 53.46% in 1999-2000, to 76% in 2021-22. RRBs improved their share from 6.86% in 1999-2000 to 13.03% in 2015-16. However, it has come down slightly to 10.96% in 2021-22. The higher CV of Commercial Banks (90.08%) and RRBs (94.15%) signify greater variability in the credit disbursed by these agencies in comparison to Cooperative Banks (68.43%) (Table 2).

Table 2 Agency-wise credit flow to agriculture sector in India

(Rs.crore)

Year	Cooperative Banks	Regional Rural Bank	Commercial Banks	Other Agencies	Total
1999-00	18260	3172	24733	103	46268
	(39.47)	(6.86)	(53.46)		
2000-01	20718	4220	27807	82	52827
	(29.22)	(7.99)	(52.64)		
2001-02	23524	4854	33587	80	62045
	(37.91)	(7.82)	(54.13)		
2002-03	23636	6070	39774	80	69560
	(33.98)	(8.73)	(57.18)		
2003-04	26875	7581	52441	84	86981
	(30.90)	(8.72)	(60.29)		
2004-05	31231	12404	81481	193	125309
	(24.92)	(9.90)	(65.02)		
2005-06	39403	15223	125477	382	180485
	(21.83)	(8.43)	(69.52)		
2006-07	42480	20435	166485	-	229400
	(18.52)	(8.91)	(72.57)		
2007-08	48258	25312	181088	-	254658
	(18.95)	(9.94)	(71.11)		
2008-09	45966	26765	228951	226	301908
	(15.23)	(8.87)	(75.83)		
2009-10	63497	35217	285800	-	384514
	(16.51)	(9.16)	(74.33)		
2010-11	78121	44293	345877	-	468291
	(16.68)	(9.46)	(73.86)		
2011-12	87963	54450	368616	-	511029
	(17.21)	(10.65)	(72.13)		
2012-13	111203	63681	432491	-	607375
	(18.31)	(10.48)	(71.21)		
2013-14	119964	82653	527506	-	730123
	(16.43)	(11.32)	(72.25)		
2014-15	138469	102483	604376	-	845328
	(16.38)	(12.12)	(71.50)		
2015-16	153295	119261	642954	-	915510
	(16.74)	(13.03)	(70.23)		
2016-17	142758	123216	799781		1065755
	(13.40)	(11.56)	(75.04)		
2017-18	150389	140959	877155		1168503
	(12.87)	(12.06)	(75.07)		
2018-19	152340	149667	954823		1256830
	(12.12)	(11.91)	(75.97)		
2019-20	157367	165326	1070036		1392729
	(11.30)	(11.87)	(76.83)		
2020-21	190682	190012	1194704		1575398
	(12.10)	(12.06)	(75.84)		
2021-22	243220	204180	1415964		1833363
	(13.05)	(10.96)	(75.99)		
CAGR (%)	12.52	21.59	20.63		18.84
CV (%)	68.43	94.19	90.08		87.07

Source NABARD data bank, and Ensure Portal, NABARD
Note Figures given in parentheses indicate the percentage

Overall growth and outreach of agricultural credit

In 2021-22, the institutional credit to the agriculture was to the tune of Rs.18.63 lakh crore against the target of Rs.16.50 lakh crore. This includes Rs.10.99 lakh crore short-term credit and Rs.7.64 lakh crore long-term credit (Table 3). It may also be observed from the table that the share of Cooperative Banks, RRBs and Commercial Banks in crop loans was 57.36%, 5.85% and 36.80%, respectively in 1995-96. However, the share of Commercial Banks has increased to 64.00% in 2021-22 and that for RRBs had improved significantly (15.17%) in 2021-22, whereas the share of Cooperative Banks declined significantly to 20.83%. The share of short-term credit decreased from 65.93% in 1995-96 to 59.02% in 2021-22. During the same period, the highest growth was witnessed in the case of RRBs (23.83%), followed by Commercial Banks (22.47%) and Cooperative Banks (13.75%).

It is well recognized that long-term credit has been the major driver of private capital formation in agriculture (PSCFA). With the concerted efforts of the Rural Financial Institutions, operationalization of Small Finance Banks, Non-banking Financial Companies-Micro Finance Institutions (NBFC-MFIs), refinance support from NABARD under Long Term Rural Credit Fund (LTRCF) to RRBs and Rural Cooperative Banks, and Area Development Scheme of NABARD, the investment credit/long term credit to agriculture has been exceeding the target for the past four consecutive years. The share of long-term credit in the total institutional credit to agriculture has been rising steadily, and exceeded 40% mark in 2018-19. The share of long-term credit increased from 22.48% in 2011-12 to 40.98% in 2021-22.

During 1995-96 to 2021-22, the long-term credit, which aids capital formation in agriculture, increased at a rate similar to that in the total agricultural credit (over 19%) (Table 3). This can also be seen in the increase in the share of private sector in the Gross Capital Formation in agriculture to 85.69% in 2020-21 from 56% in 1980-81.

Disparities in credit dispensation

Regional disparities

Despite the rapid growth in the credit disbursal, it is pertinent to note that this growth has not been uniform across regions. In fact, amongst striking features of the agricultural credit schemes in India, is the persistence of regional disparities in agricultural credit by the rural financial institutions (Kumar 2021). In 2021-22, southern region had the largest share (47.13%), followed by the northern region (16.27%), central region (12.84%), western region (12.18%), eastern region (10.83%) and north eastern region (0.76%).

Incidentally, the share of southern region in the total agriculture credit has been increasing since 2016-17, whereas the share of other regions, except eastern and north eastern regions, has been declining since 2013-14 (Table 4).This indicates a persistent and deeper regional imbalance of the credit flow across regions.

Higher share of southern region is often attributed to its higher credit absorption capacity on account of better infrastructure facilities and outreach. In terms of credit disbursement per hectare also there exist large disparities across regions, with southern region having the highest amount of Rs.259554, much more than the national average of Rs.93210 (Table 5). Similarly, region-wise amount of loan disbursed per account is the highest in southern region and the lowest in north eastern region.

Region-wise and agency-wise average share in agriculture credit

Disparities also exist in the disbursement across agencies in the regions, with the Commercial Banks sharing 47.67% of the total credit in the southern region, followed by the northern region (18.83%) during 2017-18 to 2021-22. Region-wise disparities in credit disbursement are greater for crop loans by Commercial Banks where 50.55% of the total short-term loans disbursed are in the southern region. The disbursement patterns by RRBs are also similarly skewed in favor of southern region. However, it is pertinent to note that in terms of regional credit disbursement spread, Cooperative Banks are found most equitable, especially when it comes to the crop loan disbursement (Table 6).

Regional disparities: credit vis-a-vis real indicators in agriculture

Empirical evidence indicates that there is a disconnect between the real sector parameters and distribution of agriculture credit across regions. For example, the

Table 3 Flow of institutional credit to agriculture in India

(Rs.crore)

Year	Short-term (ST) Credit				Medium-term/Long-term (MT/LT) Credit				Total (ST+MT/LT) Credit			
	Coop. banks	RRBs	Comm. Banks	Total	Coop. banks	RRBs	Comm. Banks	Total	Coop. banks	RRBs	Comm. Banks	Total
1995-96	8331	849	5345	14525	2148	532	4827	7507	10479	1381	10172	22032
1996-97	9328	1121	6549	16998	2616	563	6234	9413	11944	1684	12783	26411
1997-98	10895	1396	8349	20640	3190	644	7482	11316	14085	2040	15831	31956
1998-99	12544	1710	9622	23876	3413	750	8821	12984	15957	2460	18443	36860
1999-00	14845	2423	11697	28965	3518	749	13036	17303	18363	3172	24733	46268
2000-01	16583	3245	13486	33314	4218	974	14321	19513	20801	4219	27807	52827
2001-02	18829	3777	17904	40510	4777	1077	15683	21536	23605	4854	33587	62046
2002-03	19707	4775	21104	45585	4010	1295	18670	23975	23716	6070	39774	69560
2003-04	22697	6088	26192	54976	4262	1493	26249	32005	26959	7581	52441	86981
2004-05	27261	10010	38791	76062	4163	2394	42690	49247	31424	12404	81481	125309
2005-06	34997	12712	57640	105350	4788	2511	67836	75135	39786	15223	125476	180485
2006-07	38622	16631	92846	148099	3858	3804	73639	81301	42480	20435	166485	229399
2007-08	43294	21133	116966	181393	4964	4179	64121	73264	48258	25312	181087	254657
2008-09	40230	22413	147818	210461	5961	4352	81133	91446	46191	26765	228951	301907
2009-10	56946	29802	189908	276656	6551	5415	95892	107858	63497	35218	285800	384514
2010-11	69038	38121	228391	335550	9083	6172	117486	132741	78121	44293	345877	468291
2011-12	81829	47401	266928	396158	6134	7049	101688	114871	87963	54450	368616	511029
2012-13	102592	55957	314950	473500	8611	7724	117540	133875	111203	63681	432490	607375
2013-14	113574	70697	364164	548435	6390	11956	163342	181687	119964	82653	527506	730123
2014-15	130350	89326	415736	635412	8119	13157	188640	209916	138469	102483	604376	845328
2015-16	143803	101579	419931	665313	9492	17681	223024	250197	153295	119261	642954	915510
2016-17	131880	105001	452576	689457	10878	18215	347205	376298	142758	123216	799781	1065756
2017-18	136102	119790	497322	753214	14219	21426	347205	382850	150321	141216	844527	1136064
2018-19	142750	125654	483805	752209	9591	24013	471017	504620	152340	149667	954823	1256830
2019-20	148287	138069	538795	825151	9080	27257	531241	567579	157367	165326	1070036	1392729
2020-21	179267	156369	558121	893757	11415	33643	636583	681641	190682	190012	1194704	1575398
2021-22	229093	166782	703804	1099679	14127	37398	712160	763685	243220	204180	1415964	1863363
CAGR (%)	13.75	23.83	22.47	19.56	6.35	19.13	20.86	19.24	12.82	22.75	21.83	19.53

Source Department of Agriculture, Cooperation & Farmers Welfare, GoI

Note ST= Short Term, MT= Medium Term and LT= Long Term

Table 4 Region-wise credit flow to agricultural sector in India

(Rs.crore)

Region	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	CAGR (%)
Northern region	167813 (22.98)	202479 (23.95)	216919 (23.69)	232847 (21.85)	256991 (22.10)	270197 (21.50)	283945 (20.39)	269899 (17.13)	303191 (16.27)	6.27
North Eastern region	4345 (0.60)	4453 (0.53)	5833 (0.64)	8773 (0.82)	10273 (0.88)	11172 (0.89)	11809 (0.85)	16502 (1.05)	14085 (0.76)	18.37
Eastern region	56217 (7.70)	80013 (9.47)	103673 (11.32)	86860 (8.15)	96751 (8.32)	113792 (9.05)	131668 (9.45)	151007 (9.59)	201727 (10.83)	13.12
Central region	110929 (15.19)	133118 (15.75)	153289 (16.74)	156476 (14.68)	167096 (14.37)	171261 (13.63)	197015 (14.15)	223109 (14.16)	239168 (12.84)	8.70
Western region	95420 (13.07)	106981 (12.66)	107934 (11.79)	136787 (12.83)	136374 (11.73)	151115 (12.02)	156206 (11.21)	185151 (11.75)	227017 (12.18)	9.92
Southern region	295398 (40.46)	318284 (37.65)	327862 (35.81)	444013 (41.66)	495132 (42.59)	539292 (42.91)	612087 (43.95)	729731 (46.75)	878175 (47.13)	14.01
All India	730123 (100)	845328 (100)	915510 (100	1065756 (100)	1162617 (100)	1256830 (100)	1392729 (100)	1575398 (100)	1863363 (100)	11.03

Source NABARD Data Bank (various issues) and Ensure Portal, NABARD
Note Figures in parentheses indicate the percentage share in Total GLC

Table 5 Region-wise average loan disbursement per account during 2021-22

(Amount Rs.)

Region	Average loan amount of all farmers	Average loan amount of small/marginal farmers	Agriculture credit disbursement per ha
Northern region	152025	105692	72991
North Eastern region	70250	58980	21756
Eastern region	78668	55267	84035
Central region	101921	73309	40829
Western region	164714	94283	63983
Southern region	129580	108592	259554
All India	122099	90836	93210

Source Authors calculated based on NABARD Data Bank (various issues) and Ensure Portal, NABARD

Table 6 Region-wise and agency-wise average share in agriculture credit disbursement between 2017-18 to 2021-22

(%)

Region	Cooperative Banks			Regional Rural Banks			Commercial Banks			Total Agri. Credit		
	ST	LT	TL	ST	LT	TL	ST	LT	TL	ST	LT	TL
Northern	22.55	13.97	21.96	21.70	5.78	19.00	21.92	15.63	18.83	22.01	15.10	19.23
North Eastern	0.07	2.09	0.21	0.30	3.88	0.91	0.32	1.69	1.00	0.27	1.81	0.89
Eastern	16.37	12.15	16.08	9.50	35.61	13.92	3.24	12.50	7.80	6.78	13.66	9.54
Central	15.03	4.01	14.26	24.54	3.33	20.95	14.30	11.07	12.71	16.13	10.53	13.88
Western	16.73	28.55	17.55	5.71	1.44	4.99	9.67	14.41	12.00	10.36	14.06	11.84
Southern	29.24	39.23	29.94	38.25	49.95	40.23	50.55	44.69	47.67	44.46	44.84	44.61
Total	100	100	100	100	100	100	100	100	100	100	100	100

Source Authors calculated based on Data on Ensure Portal, NABARD
Note ST=Crop Loan, LT= Long Terms and TL=Total Loan

central region accounts for 28.77% of the gross sown area (GSA), 34.75 % of the gross irrigated area (GIA), 33.24% of foodgrains, 27.92% of oilseeds, 29.14% of vegetables and 21.73% of fruits and has a cropping intensity of 149%, but it hardly accounts for 13.88% of the agriculture credit. The northern region has the highest cropping intensity (178%) and with 20.96% share in the GSA and 25.35% in the GIA accounts for hardly 19.23% of agriculture credit disbursed. The share of the eastern region is quite low, compared to its share in the GSA and GIA. The southern region accounts for around 16.96% of the GSA and 14.56% GIA but accounts for the highest share (44.61%) of agricultural credit disbursed. The ratio of agricultural credit to agricultural gross valued added (AgGVA) varies from 21.22% in north eastern region to 140.44% in southern region as against 43.65% at the all India level. The higher share of the southern region could be due to better infrastructure facilities, better outreach, and credit delivery outlets (Kumar 2021). The situation is improving in the eastern and north eastern regions due to special initiatives taken by the NABARD.

Disparities by landholding size

Disparities in credit disbursement occur not just across regions but also across farm classes. Data reveals, that although small and marginal farmers (SMF) have a share of 77.0% in the loan accounts with Commercial Banks, their share in loan disbursed by these is 53.4% in 2021-2022 (Table 8). This is mainly on account of lower loan amount sanctioned for the SMF. Cooperative Banks and RRBs have relatively higher share of 63.8% and 72.4%, respectively, in their total lendings to small and marginal farmers. The average loan disbursement per account for SMF was Rs.90836, varying from Rs.69728 by Cooperative Banks to Rs.121439 by RRBs.

Trends in agricultural credit performance indicators

Agricultural credit as a proportion of agricultural gross value added (AgGVA) has been increasing continuously, from 34.02% in 2011-12 to 47.03% in 2021-22 (Table 9). The agricultural credit as proportion of total GVA, which increased from 6.30% in 2011-12 to 8.72% in 2021-22. The agricultural credit per hectare of gross cropped area has shown an increasing trend. It increased from Rs.26100 in 2011-12 to Rs.93210 in 2021-22. More than three-fold increase has been

Table 7 Regional distribution of agriculture credit and real sector indicators

(%)

Region	Credit disbursement@	Gross sown area#	Gross irrigated area#	Cropping intensity#	Food-grains*	Oilseeds*	Vegetables*	Fruits*	Gross Value added*	Ratio of agri credit to agri GVA (2020-21)	Share in rural/ semi urban branches (As on 31-3-2022)
Northern	19.23	20.96	25.35	177.53	25.45	24.7	9.06	6.95	9.14	85.75	16.77
North Eastern	0.89	3.22	0.97	140.98	2.9	1.24	3.46	4.84	2.23	21.22	3.97
Eastern	9.54	12.08	13.37	143.99	16.69	4.97	30.09	12.19	9.51	44.00	19.42
Central	13.88	28.77	34.75	148.94	33.24	27.92	29.14	21.73	16.12	34.98	21.71
Western	11.84	17.97	10.99	125.19	6.97	30.57	13.45	20.46	9.37	52.31	11.83
Southern	44.61	16.96	14.56	131.35	14.74	10.6	14.52	33.7	13.01	140.44	26.28
All India	100	100	100	143.16	100	100	100	100		43.65	100

Source Authors compilation using data from the Handbook of Statistics on Indian Economy, RBI 2021 and 2022 and Ensure Portal of NABARD

Note # Indicates average of five years (2013-14 to 2017-18), * Indicates average of five years (2015-16 to 2019-20 and @ Indicates average of five years (2017-18 to 2021-22)

Table 8 Ground level credit flow to agriculture-share of small and marginal farmers

Year	Agency	No. of accounts (lakh)			Loan disbursed (Rs.crore)			Average loan amt of SF/MF (Rs.)
		Total	SF/MF	Share of SF/MF (%)	Total	SF/MF	Share of SF/MF (%)	
2013-14	Comm. Banks	385.2	232.5	60.4	527506	201296	38.2	86579
	Coop. Banks	321.4	206.5	64.1	119964	69352	57.8	33585
	RRBs	99.3	66.6	67.1	82653	51359	62.1	77116
	Total	805.9	505.6	62.7	730123	322007	44.1	63739
2014-15	Comm. Banks	426.2	195.4	45.9	604376	197540	32.7	101095
	Coop. Banks	306.9	202.8	66.1	138471	78736	56.9	38824
	RRBs	120.5	87.8	72.9	102483	70390	68.7	80171
	Total	853.6	486.0	56.9	845328	346666	41.1	71286
2015-16	Comm. Banks	441.6	210.2	47.6	642954	200346	31.2	95312
	Coop. Banks	324.2	232.9	71.8	153295	97999	63.9	42078
	RRBs	133.2	97.3	72.8	119261	81653	68.5	84178
	Total	899.6	540.4	60.7	915510	379998	41.5	70318
2016-17	Comm. Banks	664.2	482.5	72.6	799781	362675	45.4	75166
	Coop. Banks	269.5	190.1	70.5	142758	89178	62.5	46911
	RRBs	137	99.0	72.3	123216	82496	67	83329
	Total	1071	771.6	72.6	1065755	534351	50.1	69252
2017-18	Comm. Banks	732.7	556.9	76.0	871080	389866	44.8	70009
	Coop. Banks	254.6	183.7	72.2	150321	98109	65.3	53401
	RRBs	144.6	104.9	72.5	141216	92482	65.5	88191
	Total	1132	845.5	74.7	1162617	580457	49.9	68655
2018-19	Comm. Banks	850.1	631.8	74.3	954823	428063	44.8	67753
	Coop. Banks	255.5	192.9	75.5	152340	106849	70.1	55405
	RRBs	149.8	106.7	71.3	149667	98749	66.0	92539
	Total	1255	931.4	74.2	1256830	633661	50.4	68036
2019-20	Comm. Banks	942.7	711.8	75.5	1070036	505849	47.3	71069
	Coop. Banks	260.3	196.0	75.3	157367	109754	69.7	55991
	RRBs	156.0	111.1	71.2	165326	108125	65.4	97357
	Total	1359.0	1018.9	75.0	1392729	723728	52.0	71034
2020-21	Comm. Banks	1073.7	764.0	71.2	1194704	610505	51.1	79912
	Coop. Banks	294.6	224.8	76.3	190682	136465	71.6	60695
	RRBs	163.5	114.6	70.1	190012	124171	65.3	108311
	Total	1531.8	1103.4	72.0	1575398	871140	55.3	78947
2021-22	Comm. Banks	1068.5	822.5	77.0	1415964	756821	53.4	92018
	Coop. Banks	290.1	222.7	76.8	243220	155254	63.8	69728
	RRBs	167.5	121.8	72.7	204180	147900	72.4	121439
	Total	1526.1	1166.9	76.5	1863363	1059976	56.9	90836

Source NABARD Data Bank (various issues) and Ensure Portal, NABARD

Note Comm. Banks = Commercial Banks, Coop. Banks = Cooperative Banks and RRBs = Regional Rural Banks

Table 9 Ratio of direct agricultural credit (disbursements) to agricultural gross value added (AgGVA)

Year	Agricultural credit/Total GVA (%)	Agricultural credit/AgGVA (%)	Agricultural credit per ha (Rs.)
2011-12	6.30	34.02	26100
2012-13	6.60	36.26	31273
2013-14	7.05	37.90	36333
2014-15	7.35	40.38	42612
2015-16	7.28	41.10	46460
2016-17	7.63	42.31	53234
2017-18	7.54	41.29	58451
2018-19	7.32	41.48	62870
2019-20	7.59	41.47	69668
2020-21	8.72	43.65	78805
2021-22	8.72	47.03	93210

Source Authors calculations based on GLC data from NABARD, Agricultural Statistics at a Glance (2021) and RBI (2022)

registered in nominal terms during the same period.

Conclusion and policy suggestions

The share of institutional agencies in total cash debt of cultivator households increased from 7.3% in 1951 to 66.3% in 1991 and subsequently decreased to 58.4% in 2012 but increased to 67.1% in 2018-19. The total institutional credit to agriculture sector has increased more than 5.5 times during 2008-09 to 2021-22. In the total credit, the ratio of crop loans in the total loans remains high despite a decline from 69.71% in 2008-09 to 59.73% in 2021-22. It was found that the households with larger landholdings carry higher debt burden as compared to the households with smaller landholdings. The credit disbursed per hectare of GCA was Rs.93210 at all India level. The per hectare credit flow indicates an impressive increase from Rs.26100 in 2011-12 to Rs.93210 in 2021-22.

There exists inter-regional disparities in credit supply, with southern region accounting for the bulk of it, and followed by northern, western, and central regions. The disparities are well highlighted in terms of credit per hectare which is Rs.21756 per hectare in north eastern region and Rs.259554 per hectare in southern region. Less availability of credit is a disincentive to the adoption of modern farming techniques and private capital investment, which in turn hamper realization of the full potential of agricultural sector, and also pushes farmers to borrow from non-institutional sources. Consequently, the demand for agricultural credit for short and long-term purposes is dampened.

These findings have some important implications for agricultural credit system

Enhance outreach of rural financial institutions

- Due emphasis should be given on improving the health of the rural financial institutions in the regions with low credit disbursement. Recent initiatives like recapitalization of RRBs and introduction of scheme for PACS computerisation will go a long way in strengthening the rural financial institutions in the laggard regions.
- To ensure better convergence of efforts towards enhancing ground level credit flow, it is imperative that institutions and forums like State Level Bankers' Committee (SLBC), District Level Review Committee (DLRC) and Block Level Bankers' Committee (BLBC) are effectively and efficiently utilized. The review and monitoring mechanism should be strengthened particularly in districts where the Credit-Deposit (C-D) ratio is low.
- There are approximately 7.1 crore active Kisan Credit Cards (KCCs) as on 31 March 2022 against a total of 14.5 crore operational holdings in India. There is a need to sensitise all ground level bank

officials to saturate all eligible & willing farmers with KCCs.

Address demand-side challenges

- A renewed push towards enhancing the financial literacy amongst farmers is needed. Financial literacy campaigns in rural areas especially in backward areas will generate awareness and access to credit products.
- There is a need to channelize more term-loan to allied activities (dairy, poultry and fisheries) that contribute 40% to agricultural output but receive only 6 to 7% of the total agriculture credit.
- From 2021-22 onward, a separate specific target is being allocated for GLC to the allied sector (animal husbandry and fisheries). The target is proposed to be further increased to Rs.1.26 lakh crore in 2022-23 (up from Rs.0.61 lakh crore in 2021-22). This along with measures like special schemes such Kisan Credit Card for allied activities will help enhance credit demand in allied sector.
- Due emphasis should be given to strengthening ground level community institutions like Self Help Groups (SHGs), Joint Liability Groups (JLGs) and Farmer Producers Organisations (FPOs). These institutions play a critical role in group model financing and infusion of credit culture through greater community participation. The present initiatives of promoting SHGs under National Rural Livelihood Mission and creation of 10,000 FPOs (Central Sector Scheme) will go a long way in promoting credit penetration through the group mode financing.

Address structural issues

- Lack of land records is one of the reasons for low penetration of credit flow in agriculture. Therefore, the state governments should complete digitisation process and updating of land records in a time bound manner.
- In order to simplify the documentation process, state governments should give access to banks to digitised land records for verification of land titles. Banks should not insist on submission of land title documents in such cases.
- Greater credit demand in the states may be created through promotion of crop diversification schemes for high-value crops.

Tap into the digital revolution

- It is important that the existing network of Business Correspondent/Business Facilitators (BC/BFs) is channelised along with tailor-made easily accessible credit products. To fully utilize the digital penetration, App/UPI-based lending products need to be explored.
- With more than 500 million Indians connected to the internet, primarily through smartphones, the impact of digital governance could be beneficial. The budget announcement of setting up of 75 digital banking units, once operationalized, would go a long way in furthering the interest of excluded regions and excluded sections of the society.
- The operations of so-called 'digital banks'/ 'neo banks' formulation should be covered under Reserve Bank's regulations. 'Digital-only' Non-Banking Financial Companies can be encouraged and bank-FinTech partnerships may be streamlined (Union Budget 2021-22).

Address infrastructural bottlenecks

- To enhance credit absorption capacity of potential borrowers, investment in rural infrastructure is a sine qua non. Therefore, corpus of Rural Infrastructure Development Fund (RIDF) should be increased and the state governments, especially in regions with low credit disbursement, should be sensitised to allocate a larger portion of their borrowing from RIDF for rural infrastructure development.
- Due focus should be given on developing the requisite micro-infrastructure (like watersheds, irrigation channels, springsheds, etc.) which serve as critical linkages between major infrastructure projects and farmers.

Address anomalies in crop loaning system in southern region

- During last 8 years, agriculture credit disbursement has been growing at annual average rate of 5% and 8% in northern and central regions,

respectively, yet their share in agriculture credit has been decreasing. This is because of the rapid growth in crop loans disbursed in southern region, predominantly due to high agricultural gold loans, wherein the quantum of loan is delinked from the Scale of Finance. As per the RBI's Internal Working Group on Agriculture Credit (2019), the incidence of crop loans outside KCC is very high (71%) in southern states. In Tamil Nadu, the extent of crop loans disbursed outside of KCC is around 88%. Thus, the crop loan sanctioned is much higher than the actual credit requirement. This ultimately leads to diversion of funds and consequently high incidence of indebtedness. Therefore, in order to curb the mis-utilisation of interest subsidy, banks should provide crop loans, eligible for interest subvention, only through KCC mode.

- There is a need to address the issue of sanctioning of agricultural loans against gold as collateral. Presently, such loans are not separately flagged in the core banking solution (CBS) platform of banks. Hence, banks should develop a management information system (MIS) to flag agricultural loans sanctioned against gold as collateral in CBS in order to segregate such loans for effective monitoring of end use of funds.

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Agricultural credit in Punjab: trends and future potential

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Abstract This study examines various aspects of agricultural credit in Punjab using primary and secondary data. Under state-directed lending policies, the institutional agricultural credit has witnessed massive expansion since 2004-05. However, the credit disbursement far outpaced the actual demand for agricultural credit. It caused a significant amount of credit diversion towards house construction, immigration of family members, purchase of vehicles, expenditure on social ceremonies, etc. Changing consumption habits and rising incomes enhance the demand for processed products and increase the potential for credit expansion for agro-processing. The crop diversification efforts will also require a substantial allocation of institutional agricultural credit. Skill development, agri start-ups, FPOs, agro-machinery service centers, etc., are other important sources for expanding institutional agricultural credit in Punjab.

Keywords Institutional agricultural credit, credit diversion, credit expansion in agriculture, absorption capacity, Punjab agriculture

JEL codes Q1, Q14, Q10, Q18

Institutional agricultural credit has witnessed tremendous growth in India, from Rs 4352 crore in 1982-83 to Rs 1.17 lakh crore in 2017-18. Its share in agricultural GDP also went up from 18.55% in 2004-05 to 40.86% in 2017-18 (at 2011-12 prices) (Mohan 2006; Golait 2007; Kanz 2016; Kumar et al. 2017; Nair 2017). As a result, the proportion of farmers borrowing from non-institutional sources declined significantly from 90% in 1951 to about 28% in 2015 (AIDIS 2013; Mohan and Ray 2017; NABARD 2017). The sharp expansion in credit resulted from the Union government's policy to expand institutional agricultural credit and the provision of interest rate subvention (Narayanan 2016; Rajeev and Vani 2019).

The institutional agricultural credit played a vital role in transforming Punjab agriculture by enhancing the productivity and profitability of farming (Sidhu et al. 2001; Sidhu et al. 2008; Sidhu and Vatta 2012). However, since the 1990s, there has been a significant rise in input costs, investments in borewell deepening/replacement due to falling groundwater table, and a decline in profitability (Kalra 1996; Kaur 2010; Simpy et al. 2012; Kaur et al. 2014; Namboodiri 2005; Radhakrishna et al. 2007; Hoda and Terway 2015). The crisis of rising costs, fixed investments, and falling incomes combined with the ever-rising credit disbursement has led to farmers' large-scale indebtedness (NSSO 2005; Sidhu and Rampal 2016; Singh et al. 2017). Many studies have linked indebtedness with the rising number of farmers' suicides in India (Shergill 1998; Sidhu 2002; Singh et al. 2014; Singh 2018).

The extent of farmers' debt in Punjab has risen from Rs 51029 in 1997 to Rs 218092 in 2013 per farm household (Shergill 1998; Singh et al. 2014). Such a situation has led to the demands for farm loan waivers and other financial packages (Mukherjee et al. 2018; Khanna 2020). The present situation calls for a critical examination of the growth in institutional agricultural credit, gaps between demand and supply, credit

diversion, and options for optimal utilization and expansion of institutional agricultural credit. The present study has examined these aspects in Punjab in a paradoxical situation of massive expansion in agricultural credit, large-scale indebtedness, and stagnation in agricultural growth.

Data sources

The study is based on both primary as well as secondary data. The secondary data on various aspects of institutional agricultural credit, gross state domestic product (GSDP), and gross value of output (GVO) were obtained from the reports on Currency and Finance published by the Reserve Bank of India (RBI), State Focus Papers of NABARD, Annual Credit Plans and reports of State Level Bankers Committee (SLBC) for the period of 1980-81 to 2017-18. In addition, multiple primary surveys were conducted during 2019-20 to collect data on credit availed, end-use, and other related parameters. The details of these surveys are given as under:

- The first survey covered 321 rural households from 15 districts (a total of 22 districts) of Punjab (one village in each district). There were 21% landless households, 30% small farmers (below 2 hectares), 32% medium farmers (2-6 hectares), and 17% large farmers (6 hectares and above).
- The second survey covered 21 commercial dairy farmers who were active members of the Progressive Dairy Farmers Association (PDFA), Punjab. The PDFA has a total membership of about 8000 dairy farmers.
- The third survey covered 24 poultry farmers who were active members of the Independent Poultry Association (IPA). The IPA has a total of 35 members in Punjab.
- The fourth survey covered 23 Progressive Piggery Farmers Association (PPFA) members. There are a total of 150 members of PPFA.
- The fifth survey covered 20 goat-rearing farmers, members of the Progressive Goat Farmers Association (PGFA). The PGFA has a total membership of 32.
- The sixth survey covered 20 member farmers of the Innovative Fish Farmers Association (IFFA), with a total membership of 55.
- The seventh survey covered 23 members of the Bee Keepers Association of Punjab.
- The eighth survey covered ten mushroom farmers trained by Punjab Agricultural University, Ludhiana.
- The ninth survey covered 20 flour mills, 12 rice shellers, seven oil expellers, eight honey processing units, 12 cattle feed mills, 18 jaggery making units, and 15 food processing units, totalling 92 agro-processing units.

Current scenario of agricultural credit in Punjab

The institutional agricultural credit disbursement and outstanding have increased continuously in Punjab since the 1980s, but it gained pace after 2004-05. The institutional agricultural credit disbursed (at 2011-12 prices) rose almost 35 times from Rs 1936 crores in 1980-81 to Rs 66711 crores in 2017-18 (Table 1). Such an increase is much higher when compared to the rise in the agricultural GDP of the state. It helped in reducing the overdependence and over-exploitation of farmers by non-institutional sources. However, expansion of institutional credit led to an increase in credit outstanding from Rs 3237 crores to Rs 65597 crores in 2014-15; an increase of 20 times during this period.

Compared to 1980-81 to 2003-04, the growth rate of credit disbursement almost doubled from 2004-05 to 2014-15 (7.4% to 13.8%). However, the growth in credit outstanding more than doubled, from 5.4% to 13% during the later period. It could be attributed to the government's policy of significant expansion in institutional lending in 2004-05. It led to a spike in credit disbursement and created enormous credit outstanding.

To a great extent, the period or nature of credit, short or long term, defines the utilization of loans – productive or non-productive. Short-term credit is observed to be diverted more – not used for the proposed purpose – and is often put to non-productive use compared to term loans due to more frequent disbursal. Literature reveals that the diversion of credit leads to the farmers' indebtedness (Namboodiri 2005). While the amount of short-term credit advanced rose by about 42 times during the period 1980-81 to 2017-

Table 1 Total institutional agricultural loans disbursed and outstanding in Punjab

(Rs crore)

Year	Credit disbursement		Credit outstanding	
	At currentPrices	At constant prices	At current prices	At constantprices
1980-81	235	1936	392	3237
1990-91	662	2759	1960	8169
2000-01	3719	7884	6207	13159
2004-05	11323	19956	12321	18896
2010-11	33486	35249	38000	40000
2014-15	81924	70334	76407	65597
2017-18	86790	66711	NA	NA
Compound growth rate (% per annum)				
1980-81 to 2003-04	15.0	7.4	12.9	5.4
2004-05 to 2014-15	21.4	13.8	19.8	13.0

Note Constant prices are calculated at 2011-12 prices
Source Report on Currency and Finance, RBI; SLBC 2020

18, the long-term credit increased by only about 18 times (Table 2). It highlights a structural change in the pattern of lending and the resultant inevitability of the indebtedness of the farmers. The growth rate of the amount of credit advanced, both short and long term, exhibits an increase over time though it is higher for short-term credit.

Credit disbursed as a percentage of gross value added (GVA) of agriculture reveals a significant increase (Table 3). Also, credit as a percentage of gross state

Table 2 Short-term and long-term credit advanced in Punjab

(Rs crore)

Year	Short-term		Long-term		Total	
	Current prices	Constant prices	Current prices	Constant prices	Current prices	Constant prices
1980-81	154.4	1273.9 (65.8)	80.3	662.5 (34.2)	234.7	1936.5
1990-91	411.9	1716.8 (62.2)	250.1	1042.3 (37.8)	662.0	2759.1
2000-01	2949.2	6252.6 (79.3)	769.4	1631.2 (20.7)	3718.6	7883.8
2004-05	9174.0	16168.1 (81.0)	2149.4	3788.1 (19.0)	11323.4	19956.3
2010-11	27390.1	28831.8 (81.8)	6096.1	6416.9 (18.2)	33486.2	35248.7
2017-18	70966.8	54548.1 (81.8)	15823.6	12162.7 (18.2)	86790.4	66710.8
Compound growth rate (% per annum)						
1980-81 to 2003-04	15.9	8.2	12.5	5.0	15.0	7.4
2004-05 to 2014-15	16.9	10.7	20.0	13.6	18.0	11.7

Note: Figures in parentheses are% to total. Constant prices are calculated at 2011-12 prices
Source: Report on Currency and Finance, RBI; SLBC 2020

Table 3 Credit advanced vis-a-vis GSDP and GVO of Punjab

Year	% of GSDP Agri-allied	% of GVO Agriculture
1980-81	9.5	NA
1990-91	8.0	8.8
2000-01	13.9	22.9
2003-04	27.7	41.9
2004-05	35.8	-
2010-11	52.1	85.6
2017-18	67.1	NA

Source: Report on Currency and Finance, RBI and SLBC 2020

domestic product (GSDP) of allied activities exhibited a similar trend. However, after 2004-05, the credit advanced as a percentage of GVA and GSDP increased rapidly. In other words, with time, the share of agriculture in state development is primarily driven by capital infusion through credit to farmers.

When compared to GSDP, it was found that agricultural credit advanced as a percentage of GSDP from agri-allied activities increased from 9.5% in 1980-81 to 27.7% in 2003-04. But under the doubling of the farm credit proposal initiated by the Union government in 2004- 05, it had increased from 35.8% in 2004-05 to 67% in 2017-18. Similarly, agricultural credit advanced as a percentage of Gross Value of Output (GVO) in agriculture was 8.8% in 1990-91, but it showed a tremendous increase to 85.6% in 2010-11.

We have examined the credit intensity of agricultural loans, which increased tremendously on per ha of net area sown (NSA) and gross cropped area (GCA) basis. On net sown area basis, short-term credit at constant prices was Rs 3039 per hectare in 1980-81, which increased to Rs 132403 per hectare in 2014-15 (Table 4). On the other hand, long-term credit was Rs 1581 per hectare of net sown area and has increased to Rs 38352 per hectare during the same period. As a result, total agricultural credit advanced has increased from Rs 4620 per hectare of NSA in 1980-81 to Rs 170755 per hectare in 2014-15 at constant prices. In terms of GCA, it was Rs 2863 per hectare in 1980-81 and jumped to Rs 89517 per hectare in 2014-15. Both these proportions indicate a massive pumping in agricultural credit, especially since 2004-05.

Credit availed, absorption capacity, and diversion

Institutional sources dominate the credit disbursement to the agriculture sector in Punjab. They accounts for more than 78% of the credit to small farmers and reaches 96% for large farmers (Table 5).

The study shows that per farm credit availed from institutional sources was 79% (Table 6). On the other hand, landless households availed of 36% credit from non-institutional sources, more than the landholding categories due to the requirement of no collateral security. On the other hand, medium and large farmers availed almost 77% and 85% of per farm household loan from institutional sources.

Table 4 Agricultural loans advanced in Punjab

(Rs crore)

Year	Short-term credit		Long-term credit		Total agricultural credit			
	Rs/ha of NSA				Rs/ha of NSA		Rs/ha of GCA	
	Current prices	Constant prices#	Current prices	Constant prices#	Current prices	Constant prices#	Current prices	Constant prices#
1980-81	368	3039	192	1581	560	4620	347	2863
1990-91	977	4071	593	2472	1570	6543	883	3678
2000-01	6939	14712	1810	3838	8749	18550	4683	9928
2004-05	21843	38496	5118	9019	26960	47515	14277	25162
2010-11	65873	69340	14661	15433	80534	84773	42361	44590
2014-15	154222	132403	44672	38352	198894	170755	104269	89517

Source Report on Currency and Finance, RBI and SLBC 2020

Calculated at 2011-12 prices

Table 5 Farm-size-wise availing of institutional and non-institutional credit in Punjab

(% farmers)

Farm-size category	No Loan	Institutional credit	Non-Institutional credit
Landless	8.8	39.7	61.7
Small	1.0	78.1	58.3
Medium	0.00	90.2	54.9
Large	0.00	96.4	49.1
Overall	2.2	76.9	56.4

Source: Primary Survey (2019-20)

Source-wise credit availed per borrower presented the same picture, with more credit availed through institutional sources. On average, small, medium, and large farmers had taken Rs 30, 35, and 55 lakh loans, of which Rs 19, 23, and 42 lakh came from institutional sources. We have analyzed the credit absorption capacity of farmers based on short-term production needs, consumption needs, and investment needs. However, we have estimated the absorption capacity mainly on the first type. An attempt to find the relation between absorption capacity and credit disbursed revealed that a tremendous amount of credit was disbursed from the year 2005-06 and onwards. A considerable amount of credit was disbursed above the requirement, leading to credit outstanding of Rs 33 thousand crores in 2010-11 to Rs 76 thousand crores in 2015-16.

The absorption capacity of borrowers vis-a-vis loans disbursed was analyzed by developing three scenarios considering the demand for agricultural credit. In the first scenario, small farmers needed their entire capital requirement, medium farmers needed 75% of their capital requirement, and large farmers needed half of that through credit. The second scenario assumed that the small and medium farmers required 100% and the large farmers needed 75%. The third scenario took 100% capital requirement for all the farm size categories through credit. A comparison of demand and supply of credit based on these three scenarios is presented in Table 7. It reveals a shift in the pattern of credit disbursement in Punjab. Till 2001-02, credit disbursement and its demand were better synchronized. However, it started far exceeding the demand after 2000-01 and reached almost two and half times the actual credit requirement during 2015-16. It is probably the most significant cause of a sharp rise in outstanding credit in Punjab agriculture after 2000-01.

About 52% of farmers received credit above their absorption capacity, with small farmers being 62.5%,

Table 6 Per farm and per borrower institutional v/s non-institutional credit availed by sample households

(Rupees)

	Landless	Small	Medium	Large	Overall
		Institutional			
Average per farm household	91794	313300	612304	1342364	535526
	(64.3)	(73.8)	(77.1)	(84.8)	(79.0)
		Non-Institutional			
Average per farm household	50897	110979	181324	239909	142695
	(35.6)	(26.1)	(22.8)	(15.1)	(21.0)
		Institutional			
	Landless	Small	Medium	Large	Overall
Average per borrower	1484424	1987826	2329951	4178008	2711129
	(80.0)	(65.5)	(66.0)	(75.0)	(74.4)
		Non-institutional			
Average per borrower	370788	1048056	1202765	1386975	935510
	(20.0)	(34.5)	(34.0)	(24.9)	(25.6)

Note Figures in parentheses represent the% of total credit
Source Primary Survey (2019-20)

Table 7 Absorption capacity vis-a-vis loans advanced

(Rs Crore)

Year	Scenario-1	Scenario -2	Scenario-3	Credit disbursement	Credit outstanding
1981-82	795	1049	2015	154	392
1985-86	1026	1351	2545	492	960
1990-91	1441	1884	3756	668	1817
1995-96	2324	3082	6180	956	2609
2000-01	3178	4221	8940	2861	5378
2005-06	4070	5390	11470	9174	11321
2010-11	6028	7957	16907	18920	33000
2015-16	8806	11567	24361	63524	76407

Source Authors' estimates from the secondary data available and data on absorption capacity

Table 8 Absorption capacity and credit diversion by the farmers in Punjab

Category	Loan as% of absorption capacity	% of farmers who diverted loan		Credit diverted as% of credit borrowed	
		Short-term	Long-term	Short-term	Long-term
Small	378.0	56.2	33.3	52.2	19.1
Medium	184.2	56.4	40.0	51.4	23.6
Large	117.0	64.1	37.5	51.7	33.5
Overall	168.6	58.0	37.0	51.6	27.4

Source Primary Survey (2019-20)

medium farmers being 49.0%, and large farmers being 41.8%. A farmer's average amount of institutional credit was almost 1.68 times his absorption capacity (Table 8). The situation is worse for small farmers, where the ratio is 3.7, and is 1.8 for medium farmers. The institutional credit of large farmers exceeded their absorption capacity by only about 17%.

The diversion of credit is happening with almost all the farmers and for short and long-term credit. About 58% of farmers diverted their short-term credit and long-term credit diversion occured with 37% of farmers (Table 8). Out of an average short-term loan of Rs 6.7 lakh, diversion amounted to Rs 3.4 lakh with a share of 52%. About 27.4% of the long-term loan was diverted to non-agricultural purposes. Maximum diversion of long-term loans was found with large farmers, whereas nearly one-third of the borrowed amount was for non-agricultural purposes.

The perusal of table 9 highlights that, on average, farmers diverted Rs 3.4 lakh of the borrowed short-term credit mainly for construction/renovation of the dwelling house (23.4%), wedding ceremonies(19.4%), and purchase of the land (17.5%), etc.

The diversion of long-term credit is also presented in Table 9, and it reflects significant diversion towards the purchase of luxury vehicles (36.2%), immigration of family members (28%), and investment in other business avenues (10.0%), etc.

Allied enterprises, food processing, and institutional credit

Over time, agriculture has expanded horizontally and vertically with many commercial activities in the allied sectors. Large-scale adoption of allied activities can raise the stagnating farm incomes and diversify agriculture. We analyzed the credit situation for various allied activities through primary surveys and focused group discussions with multiple stakeholders in such supply chains. The access to credit and its sources, level of investment, and potential demand for institutional credit are examined for dairy, poultry, piggery, goat farming, fish farming, bee-keeping, and mushroom cultivation activities.

Table 9 Purpose-wise diversion of short-term and long-term credit in Punjab

(Rs/household)

Purpose	Short-term	Long-term
Wedding ceremonies	67273	-
	(19.4)	
Sending family members abroad	51877	4743
	(14.9)	(28.1)
Construction/ renovation of dwelling house	81166	791
	(23.4)	(4.6)
Consumption Expenditure	20302	1186
	(5.8)	(7.0)
Purchase of land	60968	-
	(17.5)	
Leasing in of land	5968	-
	(1.7)	
Investment in business ventures	28439	1680
	(8.2)	(10.0)
Purchase agricultural machinery	11858	845
	(3.4)	(5.0)
Paying off old debts	5138	-
	(1.4)	
Purchase of vehicles	5494	6126
	(1.5)	(36.2)
Installation of the solar system	3557	-
	(1.0)	
Litigation	2372	-
	(0.7)	
Medical Expenses	-	1520
		(9.0)
Miscellaneous	2134	-
	(0.6)	
Total	346547	16897
	(100.0)	(100.0)

Note Figures in parentheses indicate the percentage to total
Source Primary Survey (2019-20)

The data on credit availed by the farmers (pursuing allied activities) from various institutional and non-institutional sources is given in Table 10. On average, the credit availed by a dairy unit was Rs 9.13 lakh, by a poultry unit was Rs 83.03 lakh, by a bee-keeping unit was Rs 4.50 lakh, by piggery unit was Rs 3.56 lakh, goat rearing unit was Rs 1.44 lakh, by the mushroom unit was Rs 10.18 lakh and by a fishery unit was Rs 4.23 lakh.

The share of credit in the total investment is presented in Table 11, and it varied between 11-81% for various activities. The average investment for allied enterprises varied from Rs 7.20 lakh for goat farming to Rs 2.67 crore for poultry farming. The share of credit in the total investment for dairy farming, poultry farming, goat farming, bee-keeping, mushroom farming, fish farming, and pig farming was 56%, 31%, 20%, 11%, 81%, 19%, and 31%, respectively. We have used such

Table 10 Credit availed for allied activities by the farmers in Punjab

(Rs lakh/unit)

Source of Credit	Poultry	Bee Keeping	Dairy	Piggery	Goatry	Mushroom	Fishery
Commercial Banks	82.26	4.08	8.23	3.11	0.75	10.00	3.54
	(99.1)	(95.2)	(91.6)	(89.4)	(57.2)	(98.2)	(97.4)
Cooperative Banks	0.77	0.20	0.75	0.06	0.15	0.18	0.09
	(0.9)	(4.7)	(8.4)	(1.8)	(11.4)	(1.7)	(2.5)
RRB's andMicrofinance Banks	-	-	-	0.30	0.41	-	-
				(8.7)	(31.3)		
Institutional Credit	83.03	4.29	8.99	3.48	1.31	10.18	3.63
	(100.0)	(95.2)	(98.4)	(97.5)	(90.6)	(100.0)	(85.8)
Non-Institutional Credit	-	0.21	0.14	0.08	0.13	-	0.60
		(4.8)	(1.5)	(2.4)	(9.3)		(14.2)
Total Credit	83.03	4.50	9.13	3.56	1.44	10.18	4.23
	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Note Figures in parentheses are %age to total credit
Source Primary Surveys (2019-20)

Table 11 Average investment and the share of credit for allied activities

Activity	Investment (Rs lakh)	Credit (Rs lakh)	% share of credit in investment
Dairy Farming	16.30	9.13	56
Poultry Farming	267.84	83.03	31
Goat Farming	7.20	1.44	20
Bee-Keeping	40.91	4.50	11
Mushroom Cultivation	12.57	10.18	81
Fish Farming	22.26	4.23	19
Pig Farming	11.48	3.56	31

Source Primary Surveys (2019-20)

proportions in the following section to derive the credit potential for such enterprises in the entire state.

Agro-processing units

Currently, Punjab state is focusing heavily on the agro-processing industry to boost growth in the agriculture sector. Different agro-processing units (APUs) are being installed with the state's active technical and financial support. We examined the response of entrepreneurs involved in multiple agro-processing activities for their future expansion and overall expansion of the activity in the state. The agri-entrepreneurs were keen to establish/ expand cattle feed mills, flour mills, rice shellers, and the processed food industry among different processing units. Out of these, cattle feed manufacturing and processed food products have shown high response, while it was moderate for flour and rice mills. However, the requirement for credit was expressed by 45% of respondents. Despite the considerable potential for expansion, some critical constraints should be adequately addressed to realize the full potential of agro-processing in Punjab. Despite high response for processed products, the area under spices and oilseeds was less in the state, and the supply of these was not regular. In addition, 72% of entrepreneurs reported difficulty in branding, including procedural problems in brand creation, permission from various agencies, etc. Competition from existing units

in terms of prices, quality, advertisement, etc., was also a constraint cited by 45% of units. Marketing difficulties due to limited demand, transportation, packaging, etc., were cited by 56% of units.

Opportunities for credit expansion

In light of excessive funding in agriculture, it appears that the potential for further expansion of institutional agricultural credit is relatively limited. However, many sub-sectors within the farm sector have poor access to institutional agricultural credit and are more expensive. Hence there is potential to develop new lending instruments aiming at delivering credit to those sectors. The following section highlights important avenues of effective credit expansion in agriculture.

Fruit and vegetable farmers

The Government of Punjab is showing a keen interest in diversifying its cropping pattern in the immediate future. The state is currently focusing on diverting 12 lakh hectares from paddy to other crops such as maize, cotton, sugarcane, oilseeds, pulses, vegetables, and fruits. The average scale of finance for paddy and wheat is Rs 62500 per ha, and for fruits and vegetables is Rs 112500 per ha. Expanding the area under fruits and vegetables in Punjab will lead to enhanced opportunities for institutional lending. Based on our discussions with various stakeholders, the current area and targeted area under different vegetable and fruit crops, along with the demand for credit as per the scale of finance, is given in Table 12. The state intends to expand the area under fruits and vegetables by 206.4 thousand ha. The annual demand for credit for fruits and vegetables is Rs 3123 crore, which will grow to Rs 5445 crore per annum due to such diversification. Such diversification efforts will cause an increase in demand for credit by Rs 2322 crore annually.

The financial institutions (FIs) should focus heavily on fruit and vegetable growers. The Department of Horticulture in Punjab promotes horticultural crops in Punjab through extension services, subsidies, and other related facilities. The FIs should forge collaboration with the Department of Horticulture. As horticultural farmers have better repayment capacity than the other farmers, the problem of defaults and NPAs is likely to be significantly less.

Table 12 Current and targeted area under vegetables and fruits for crop diversification plan in Punjab

Crop	Current area (thousand ha)	Current demand for credit (Rs crore)	Target area (thousand ha)	Future demand for credit (Rs crore)	Projected expansion in demand (Rs crore)
A. Vegetables					
Pea	38.8	436.50	100.0	1125.00	688.50
Potato	100.0	1125.00	130.0	1462.50	337.50
Onion	10.2	114.75	20.0	225.00	110.25
Garlic	7.6	85.50	15.0	168.75	83.25
Chilli	9.5	106.88	18.0	202.50	95.62
Cauliflower	16.7	187.87	24.0	270.00	82.13
Tomato	10.0	112.50	20.0	225.00	112.50
Carrot	11.0	123.75	20.0	225.00	101.25
Muskmelon	5.6	63.00	10.0	112.50	49.50
B. Fruits					
Kinnow	53.0	596.25	100.0	1125.00	528.75
Guava	9.1	102.37	15.0	168.75	66.38
Pear	3.2	36.00	6.0	67.50	31.50
Litchi	2.9	32.63	6.0	67.50	34.87
Total	277.6	3123.00	484.0	5445.00	2322.00

Source: Authors' Estimates

Table 13 Lending opportunities for allied enterprises in Punjab

Enterprise	Unit cost (Rs lakh)	Physical units (No.)	%age of credit in total unit cost	Credit potential (Rs Lakh)	Total credit potential (Rs Crore)
Dairy (10 animals)	8.40	113317	56	3.69	4188.19
Poultry (5000 broilers)	15.90	4384	31	10.97	480.97
Poultry (5000 layers)	20.25	5843	31	13.97	816.41
Goat Farming (40+2)	2.42	6600	20	1.94	127.78
Bee-keeping (50 beehive colony)	3.58	8695	11	3.19	277.04
Mushroom cultivation (100 bags)	8.40	9142	81	1.59	145.91
Fisheries	6.34	6931	19	5.14	355.93
Piggery (10+2)	5.00	3223	31	3.45	111.19

Note %age of credit is estimated from the enterprise surveys conducted in this study
Source Potential Linked Plans, 2021

Allied enterprises

Potential Linked Credit Plan (PLPs) provides district-level potentials for rural economic activities in physical and financial terms. NABARD, in 1988-89, took the initiative of preparing PLPs for agriculture and rural development. The broad strategy by NABARD for formulating PLPs envisages the estimation of long-term potential (in terms of physical units) in each sector of agriculture and rural development (Potential Linked Plans 2021). The potential has been assessed for allied enterprises such as dairy, poultry, goat farming, bee-keeping, mushroom cultivation, and fisheries for the year 2020-21 in Punjab based on these district-wise PLP reports. The financial outlay estimates for major allied activities were computed for Punjab. These estimates are provided in Table 13.

In the case of dairy, there is a potential of financing to the tune of Rs 4188.19 crore annually, for poultry (broilers) Rs 480.97 crore, poultry (layers) Rs 816.41 crore, piggery Rs 111.19 crore, goat farming Rs 1278.78 crore, fishery Rs 355.93 crore, bee-keeping Rs 277.04 crore and for mushroom farming Rs 145.91 crore in Punjab. It is to be noted that almost entire credit is expected to come from institutional sources as the non-institutional sources usually do not finance such investments or do so at a very high interest rate. Owing to the stagnation in the traditional crop sector, allied enterprises offer considerable potential for future growth in agriculture and effective expansion of agricultural credit.

Agro-machinery service centres

Since 2008, the state government promoted agro-machinery service centres (AMSCs) in Punjab through primary agricultural cooperative societies (PACSs) and started custom hiring services for agricultural machinery. Some studies highlighted the economical viability of such centres and their positive effect in reducing the fixed costs of farmers, and decline in farmers' debt burden in the long run (Sidhu and Vatta 2012; Singh 2018). The relevance of such AMSCs becomes even more critical in recent times when there is a need for costly machinery and is not required by an individual farmer for a longer duration during a year. At least 4000 AMSCs can be easily promoted in more than 12000 villages of Punjab. Currently, there are approximately 1200 such centres and are mainly working under PACSs. The new AMSCs can be promoted under the private sector, emphasising employing the rural youth. It will create a large number of self-employment opportunities. As these centres also require supporting workers, there will be additional employment opportunities in the rural areas. On average, if each centre requires an investment of Rs 25 lakh, setting up of additional 2800 AMSCs in the private sector will require Rs 700 crore. The FIs have a massive opportunity in this segment as a successful model will lead to faster expansion in future and hence the credit expansion.

Farmer producer organizations

FPOs are likely to emerge as potential and viable aggregators in future. For this, they require a significant

amount of financial resources both for infrastructure development and working expenses. Financial institutions should develop specialized lending instruments/ credit packages to finance FPOs. NABARD has planned to set up 10 thousand FPOs in India. There are around 12500 villages in Punjab. While the financial requirements for each FPO will vary as per their activities and their scale, this segment provides a huge opportunity for credit expansion by the FIs.

Agro-processing units

As discussed earlier, the state government extensively promotes various agro-processing units in Punjab, such as flour mills, oil extractors, cattle feed mills, jaggery units, honey processing, and other processed products such as pickles, chutneys, and jams. There is very high interest in starting these activities or expanding them in the future, hence a significant scope for credit expansion in this segment. Currently, there are 313 agro-processing centres (APCs) in Punjab, with a potential of around 2000 APCs in the future as each APC can cover 2-3 villages. The average investment in different types of APCs is about Rs 15 lakh. At the current investment rate, the financial requirements to set up APCs in Punjab would be Rs 300 crore, and it provides an attractive window for credit expansion to the FIs

Startups and new enterprises

As mentioned earlier, i) Skill Development Centre, ii) Punjab Agri-Business Incubator, and iii) Food Industry Agri Incubation Centre have promoted entrepreneurship and new startups in the agriculture sector. These startups need a strong handholding in technical knowledge, government support in subsidies, and institutional credit. The Union Government has also shown immense interest in promoting the startups. The FIs should develop a special credit plan for startups in Punjab agriculture in collaboration with the above facilitators/incubators.

Conclusions

The institutional credit has witnessed a massive expansion in Punjab agriculture especially after 2004-05. The share of agricultural credit in GSDP in agriculture and credit intensity also increased over time reflecting the increased attention to agricultural credit. However, more than half of the farmers availed credit in excess of their actual demand. It has also led to a sharp rise in outstanding credit in Punjab agriculture. There has been a significant diversion of credit towards house construction, immigration of a family member, purchase of vehicles and expenditure on social ceremonies.

Due to rise in incomes and changing consumption habits, there is a vast potential to expand allied enterprises and agro-processing in Punjab. Hence, focusing on newer areas of credit expansion will help in optimal utilization of institutional agricultural credit. The newer avenues are allied activities, agro-processing, crop diversification towards fruits and vegetables, FPOs, agro-machinery service centres, etc. Such reorientation of institutional agricultural credit will spur future agricultural growth, will limit credit diversion and will check indebtedness.

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Product standards, farmers' practices and global trade: a critical analysis with respect to pesticide residue levels in Indian small cardamom

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Abstract We analyse the potential export markets of Indian small cardamom and the global and importing country-specific product standards (pesticide residue level). Indian exports of small cardamom are negatively and seriously impacted by chemical pesticide residue levels fixed by major importers like Saudi Arabia. The global and country level specifications substantially vary and Indian standards are not in harmony with them. The pesticide usage, handling and trade practices in producing areas are unscientific, leading to accumulation of pesticide residues. The export potential can be fully tapped only through harmonisation of global specifications coupled with responsible interventions in research, legal, extension systems, and stringent monitoring of the production system.

Keywords SPS measures, cardamom, Pesticide residues, MRL, Codex standards, TBT

JEL codes F13, F53, Q17

Introduction

The Agreement on Sanitary and Phyto Sanitary (SPS) measures came into force with the global Agreement on WTO in 1995. This Agreement sets out basic guidelines and rules for food safety and human, plant and animal health. Each country can set standards based on scientific evidence, local situations and risk factors. However, they are encouraged to follow international standards by major global organisations like FAO/ WHO *Codex Alimentarius Commission* for food safety. Increasing incomes and growing health consciousness in developed and developing economies have considerably increased the demand for quality food, causing stringent SPS measures in the world food trade. Technical Barriers to Trade (TBT) Agreement covers all technical regulations, voluntary standards and procedures. It is the type of measure which decides whether it is under the TBT agreement, while the purpose of the measure determines whether it is subject to the SPS agreement. Thus, the regulation which addresses microbial contamination and allowable chemical pesticide residue falls under the SPS agreement. However, these standards can potentially impact the global trade in food products as catalysts or barriers.

Consequently, Non-Tariff Measures (NTMs) like SPS measures are gaining greater significance in the international trade of agricultural commodities and

form a powerful protectionist tool (Shepherd and Wilson 2013; Ferro, Otsuki, and Wilson 2015). The EU standards inhibit the export from developing economies, though the type and degree of impact are sector-specific (Shepherd and Wilson 2013). The food safety standards imposed by the developed countries could impede processed food export from developing countries (Jongwanich 2009). There are reports of trade restrictions between developed economies also. The EU US trade in fresh fruits and vegetables is constrained by the Maximum Residue Levels (MRL) of pesticides fixed by the EU (Hejazi et al. 2022).

The Basmati rice exports from India to European Union (EU) were down by 35 per cent to 2.5 Lakh Tonnes in 21-22 compared to the previous year, due to pesticide residues above the MRLs specified by the EU. There are reports that the exports to countries such as Qatar and Jordan are also under threat, as these countries follow EU standards. These issues have been there since 2012. As an immediate measure to manage the threat to agricultural export, the Government of Punjab has banned ten chemical formulations of pesticides during the crop season of 2022.

Food and health authorities continuously monitor pesticide residues in agricultural commodities by setting the MRL of pesticides in foods. The MRL of pesticides is the maximum concentration of pesticide residue expressed as mg/kg of food/ animal feeding stuff legally permitted in the food, indicating that the food is safe to eat. The adaptability of producers in developing countries to these measures is seriously constrained by their technical and financial capabilities (Shepherd and Wilson 2013; Jongwanich 2009), as well as local socio-economic and market conditions. Though these measures have the potential to act as a catalyst for safer production (Maertens and Swinnen 2009; Josling 2008), the farm-level practices in developing countries often substantially deviate from scientific prescriptions (Khanal and Singh 2016; Rahman et al. 2018; Devi 2009; Devi et al. 2017), especially in the case of chemical pesticide use leading to higher pesticide residue levels in agricultural commodities.

The globally accepted concepts of sustainable food production and consumption philosophies, as well as food safety concerns, necessitate strategic changes in the food production pattern in developing economies to continue in the global market. This paper analyses the status of global trade in Small Cardamom, the potential markets, major trade restricting aspects (pesticide residue) and the farm-level practices in major producing state, based on which policy suggestions are made.

Methodology

The paper is based on primary and secondary data. Secondary data on exports of cardamom from India and NTMs faced by Indian cardamom were collected from World Integrated Trade Solution (wits.worldbank.org). The export potential, ease of trade, market access and import requirements for Indian cardamom were derived from the International Trade Centre (ITC) Market potential and Market access maps.

The export potential of Indian cardamom was visualized using the Market Analysis Tool developed by the International Trade Centre (ITC) to estimate export potential. This methodology identifies the potential export value for an individual exporting country for a given product and target markets based on an economic model that combines the exporter's supply with the target market's demand, market access conditions and the bilateral links between the two countries (International Trade Centre, 2020). It is based on the decomposition of a country's potential exports of a product to a given target market into three factors: supply, demand and easiness to trade (Decreux and Spies, 2016). The potential export value means the potential value at which a country can export small cardamom to a specific target market given its current supply capacities and the target market's demand and market access conditions. The untapped potential is the gap between actual and potential exports, if any. The reasons for unrealized potential include lack of information about or difficulties in meeting consumer preferences in the target market andmarket regulations, lack of business contacts or knowledge about distribution channels, and mismatch of supplied and demanded varieties (International Trade Centre, 2020).

Primary data was collected from the cardamom farmers in the Idukki district of Kerala, India's leading district and state in small cardamom cultivation. The data on cultivation practices and inputs were collected from a sample of 180 practising farmers drawn through proportionate sampling from different Block

Panchayaths in Idukki District based on the share of area under cardamom. The data was collected through the personal interview method using a structured interview schedule, informal discussions and direct observation. We have also discussed with chemical pesticide retailers, dealers, manufacturing company representatives, and applicators. The data collection was conducted during 2021.

We have compiled the monthly analysis reports on pesticide residue levels detected in cardamom from the Pesticide Residue Research and Analytical Laboratory located at the College of Agriculture, Vellayani, Kerala Agricultural University, corresponding to the period from 2017 to 2021. The laboratory has NABL accreditation (ISO-17025:2017) and with a facility for estimating 98 chemical pesticide residues in water, fresh fruits, vegetables, cereals, pulses, spices, meat and milk.

Results

Global trade in small cardamom and India's share and performance

Global cardamom production shows an increase of almost six times from Triennium Ending (TE) 1970 to TE 2018. India, formerly the leader, is presently the second-largest producer of cardamom after Guatemala, with an annual production of 22,520 tonnes in 2020-21(Spices Board, 2021). The share of India in the world trade of cardamom has decreased from 60 per cent in TE 1972-73 to 18 per cent in TE 2017-18 (IPC, 2020). Among the Indian states, Kerala is the largest producer, with 56 per cent of the area and 89 per cent of the production in the country and more than 90 per cent of the output value (IPC, 2020), followed by Karnataka and Tamil Nadu. Idukki district, with 31,106 ha area and 11,243 tonnes of production, accounted for more than 90 per cent of the area and production of cardamom in the state (GoK, 2021).

More than 90 per cent of the world trade in cardamom is accounted by whole cardamom or cardamom neither crushed nor ground. India is the second largest exporter, with an average annual export of 1850 tonnes in 2019-20. India is also one of the significant consumer of cardamom. The share of Indian cardamom exports in total world exports decreased from 28 per cent in 1988 to 9 per cent in 2020 in quantity and 42.5 to 9 per cent in value. The share of Indian cardamom imports in world imports also has shown a slightly declining trend over the years.

Cardamom has been one of India's most exported spices, and traditionally the prime market for Indian cardamom was the Middle East countries. The majority of small cardamom exports from India in terms of quantity and value during TE 1979-80 were to Kuwait and Saudi Arabia. UAE emerged as an export market after 2000. Nearly 61 per cent of India's small cardamom export was to Saudi Arabia, which was reduced to 30 per cent during the decade ending TE 2019-20. The Indian share in the imports to Saudi Arabia decreased to a low 1.28 per cent in quantity and 0.82 per cent in value terms in 2019, mainly due to the rejection of the consignments consequent to the detection of pesticide residue. In 2019, after the efforts by the Government of India, the export share had slightly improved to around 5 per cent.

Export potential is the value of the export of cardamom, which India can export to a specific target market or importing country, given its supply capacities and market conditions. In Figure 1, the number given for the countries indicates the export potential rank, the circle's diameter indicates the demand potential for cardamom exports, and the lines' thickness indicates the ease of trade for India with these countries. It could be observed that the countries with the highest export potential ranks were UAE, Saudi Arabia, Bangladesh, China, UK, Egypt, Germany, Kuwait and Iraq. The markets with the highest demand potential were Saudi Arabia, UAE, China, Egypt, Bangladesh, Netherlands, United Kingdom, Kuwait, Iraq and Jordan. The countries with which India had the greater ease of trade were Bangladesh, UAE, Oman, Pakistan, Qatar, Bahrain and Kuwait. The markets with the most significant untapped potential for India's cardamom exports are Saudi Arabia, Bangladesh and the United Arab Emirates. Saudi Arabia shows the highest absolute difference between potential and actual exports in value terms, leaving room to realize additional exports worth 20.8 million US$, followed by Bangladesh and UAE with 20.4 and 19.6 US$ million, respectively (Table 1). The untapped potential in the Saudi Arabian market was 51.7 per cent of the actual potential, while it was 45.4 per cent and 87.3 per cent in UAE and Bangladesh, respectively. In order to tap this potential export market in Saudi Arabia and other emerging global markets, the primary challenge is to manage the pesticide residue level.

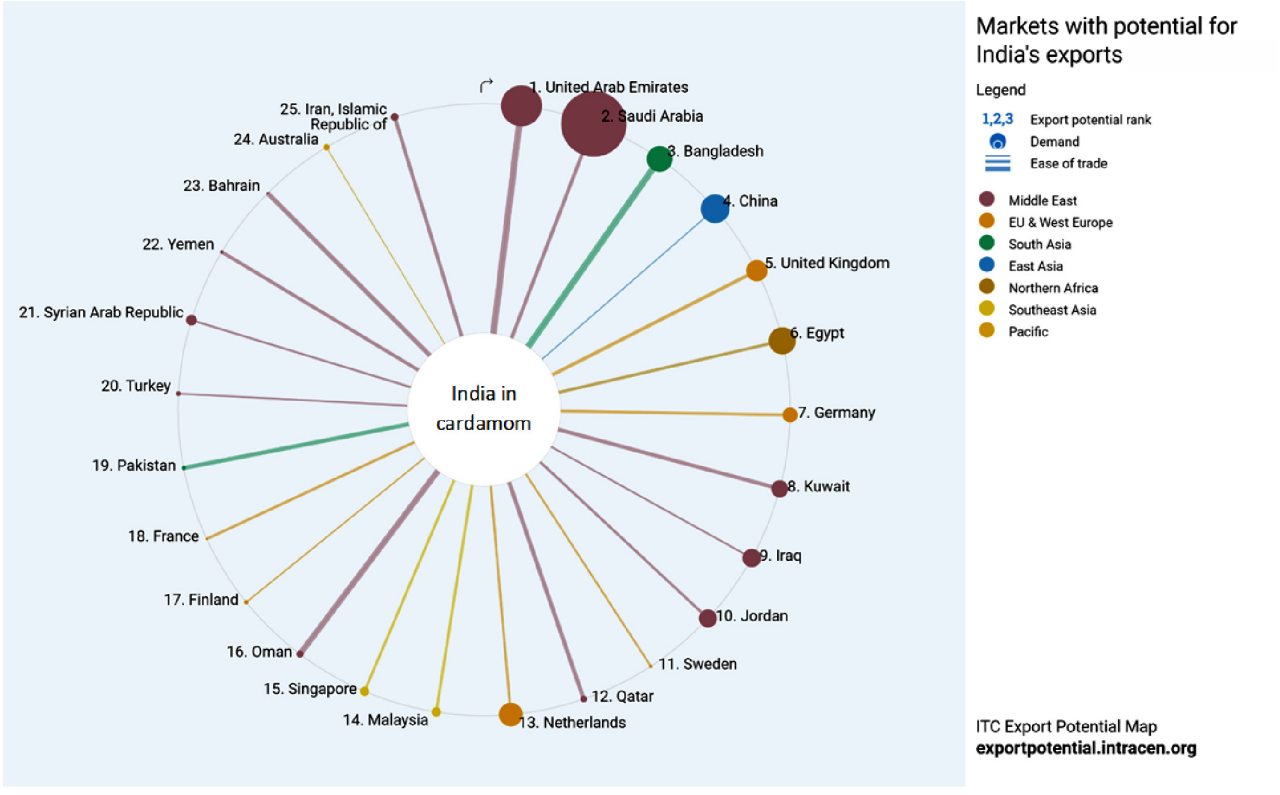

Figure 1 Export potential and ease of trade for Indian cardamom
Source Estimated using ITC export potential map

Table 1 Potential for Indian cardamom in major export markets (in US$ million)

Sl No.	Countries	Export potential	Actual exports	Untapped potential
1	UAE	43.1	23.5	19.6 (45.5)
2	Saudi Arabia	40.3	19.5	20.8 (51.6)
3	Bangladesh	23.2	2.9	20.4 (87.9)
4	China	9.2	0.1	9.1 (98.9)
5	Kuwait	7.1	7.4	- -
6	Egypt	8.1	0.3	7.8 (96.3)

Source Derived from ITC Export Potential Map
Note 1. Figures in parentheses indicate untapped potential as a percentage of total export potential
2. Potential export value of cardamom supplied by India to any country in dollars, is calculated as supply × demand (corrected for market access) × bilateral ease of trade. Supply and demand are projected into the future based on GDP and population forecasts, demand elasticities and forward-looking tariffs

NTMs - the case of pesticide residue

The MRL fixed for chemical pesticide residue in food while ensuring the health of the consuming population act as a vital barrier in global trade. The SPS and TBTs cover more products and trade value than price and quantity-control measures. Furthermore, SPS measures are more prevalent than TBT in agri-food products (WTO, 2012). The number of notifications raised by the European Union in the Rapid Alert System for Food and Feed (RASFF) portal is presented in Table 2. Of the total 11098 notifications during two years, 20.18 per cent is for exports from India. The border rejections in proportion to the notification and destruction to border rejections of the consignment were also the

Table 2 Number of notifications raised by the European Union in RASFF portal (April 1, 2005- May 31, 2017)

Country	Notifications	Border rejections	Border rejections in proportion to notifications (%)	Destruction of consignment
Brazil	1139	717	62.9	None
China	3374	1730	51.3	391 (22.60)
India	2240	1490	66.5	583 (39.12)
Turkey	3296	2018	61.2	431 (21.36)
Vietnam	1049	372	35.5	136 (36.56)
Total	11098	6327	NA	1541

Note 1. Figures in parentheses indicate the proportion of destructed consignments to that of border rejections

highest from India compared to Brazil, China, Turkey and Vietnam. The proportion of border rejections to notifications (66.5 per cent) and the proportion of destruction of consignments to rejections were found to be the highest for exports from India. Number of import detentions for major horticultural products from India to US was also very high. Among the exports of food commodities to the US, spices faced the maximum rejections from April 2010 to March 2011 (Fig 2). This involves a very high resource burden on the economy due to investments in time, efforts and financial resources. The situation also leads to price responses as lagged behaviour, thus affecting farmer welfare as well.

Indian Cardamom is favoured in global markets for its unique quality attributes. However, SPS measures form the major NTMs in cardamom exports by all the major importing countries (Saudi Arabia, UAE, USA, Kuwait and Canada). SPS, TBT and others formed 100 specifications for imports in UAE, 87 in Saudi Arabia and 81 in Kuwait (Table 3). Even though UAE imposed the highest number of NTMs, India exported the highest quantity of Cardamom to UAE in 2020. Nevertheless, the exports to the conventional importer Saudi Arabia were the least mainly due to unacceptable levels of pesticide residue (Fig 3). The Saudi Food and Drug Authority (SFDA) detained four import consignments from India during April-May 2018 due to the detection of pesticide residues above MRLs. Consequently, the exporters stopped exporting Cardamom to Saudi Arabia, fearing detention. A delegation from SFDAvisited Spices Board's Quality Evaluation Laboratory in Kochi, spices export processing units and cardamom plantations. The Spices Board was advised to draw up a work plan to address the issue of pesticide residues in Cardamom to resume the exportsto Saudi Arabia.

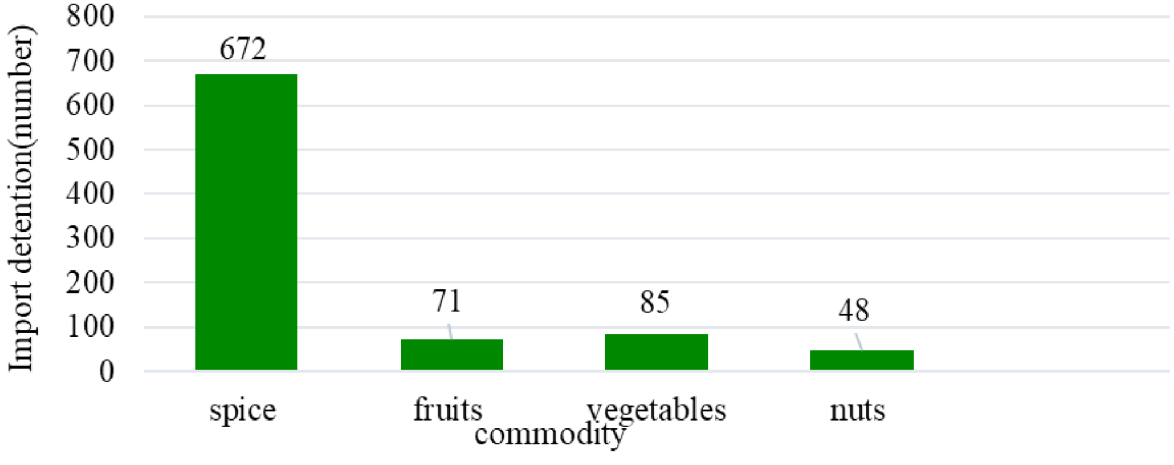

Figure 2 Number of USFDA import detentions for various horticultural products from India during 2010-2011

Table 3 NTMs affecting Indian cardamom trade by types and countries (2020)

Countries	SPS	TBT	Others	Total
Saudi Arabia	78 (89.65)	3 (3.45)	6 (6.90)	87 (100.00)
UAE	97 (97.00)	1 (1.00)	2 (2.00)	100 (100.00)
USA	33 (73.33)	11 (24.44)	1 (2.23)	45 (100.00)
Kuwait	77 (95.06)	2 (2.47)	2 (2.47)	81 (100.00)
Canada	34 (97.14)	1 (2.86)	0 (0.00)	35 (100.00)

Note Figures in the parentheses indicate percent to row total

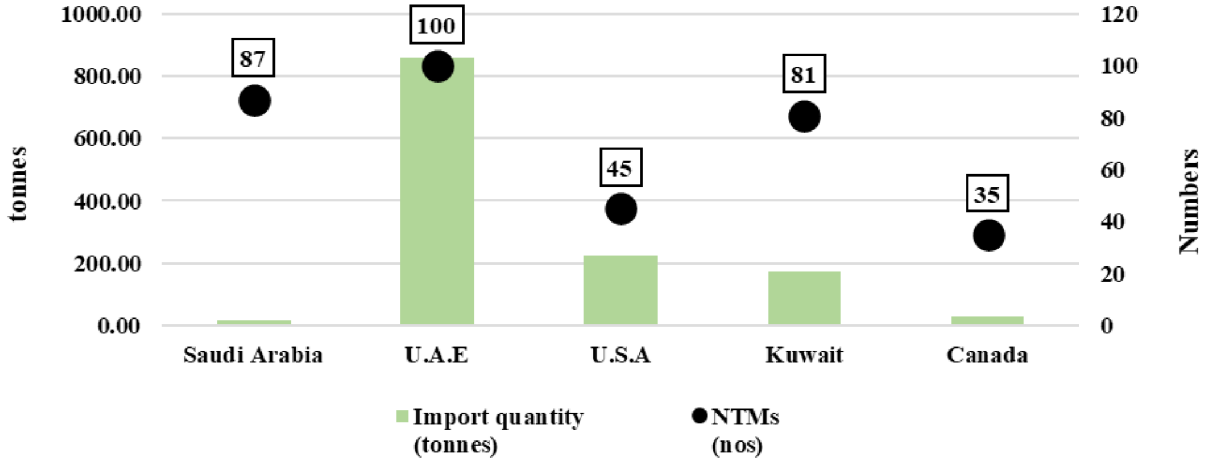

Figure 3 Imports and import requirements of Indian cardamom in major importing countries (2020)
Source Estimated using data from ITC Market Access Map

Farm level practices and pesticide residue level in cardamom

More than 95% of the total area under cardamom cultivation in Kerala is the high-yielding variety "Green Gold", which is highly susceptible to multiple biotic and abiotic stresses. This variety requires higher levels of nutrient uptake and therefore, external application of fertilizers and manures is unavoidable to maintain higher yields, especially under the acid soil conditions. The resultant luxurious growth favour pest multiplication and disease incidence. Further, the changing weather pattern (erratic rainfall coupled with warming) across all seasons favour pests multiplication, mainly the shoot and capsule borers, thrips, root grubs and whiteflies. Decreased precipitation levels in July–September have increased the population levels of significant pests, particularly thrips and capsule borers, beyond the critical levels inflicting severe damage to the developing capsules. An early start and long summer, along with increased break periods during monsoon months, provide a favourable environment for whiteflies. Continuous use of synthetic pyrethroids and combination products had led to population build-up of sucking (whiteflies) and lacerating type (thrips) pests, leading to insect resistance to pesticides, thereby tempting the farmers for more frequent application. Summer rainfall, higher mean minimum temperatures and higher relative humidity favour continuous flowering and yield and the farmers adopt regular plant protection to ensure better harvest and visual quality of the capsule. The attack of thrips on the capsules

results in a scabby appearance, and the attack of borer causes the development of boreholes. Such defective product has a low market preference and is either rejected or fetch lower prices. Bold and parrot green cardamom has more market acceptance and hence farmers resort to regular plant protection measures. Continuous and sustained unscientific application of potentially lethal pesticides has substantially damaged the population of natural enemies of pests triggering the chances of rapid pest multiplication in this ecosystem. Consequently, with a desperate bid to protect the crop, farmers resort to several rounds of chemical pesticide spray. Since capsule borers are cryptic, their chances of escaping pesticide exposure are high, making repeated pesticide application inevitable. Chemical control of thrips resulted in better cardamom quality which fetched a higher price in the market (Murugan et al. 2017). Cardamom capsule has a life of 120 days and is often exposed to a minimum of six to seven chemical sprays, each spray containing a combination of two to three pesticides. More than 15 rounds of pesticide application per crop season are reported in cardamom. Table 4 furnishes the details of major chemical pesticides applied in small cardamom. Our field-level study found 38 different chemical formulations used for pest control, of which 28 are insecticides, 8 are fungicides and one is an acaricide and the other, a plant growth promoter. Most of these chemicals are sprayed as combination sprays, and the scientific prescriptions concerning concentration, method of application and precautions are seldom followed. The national level scientific prescriptions for pest management in cardamom are furnished in Appendix 1.

The majority chemicals that were sprayed in the crop (16 numbers) belong to the yellow category (Highly Toxic), 12 were BLUE (moderately toxic), eight were GREEN (slightly Toxic), and two were RED category chemicals (Extremely Toxic) as per the World Health Organization (WHO) categorization of chemical pesticides based on toxicity levels. Among these chemicals, only three chemicals (Lamda Cyhalothrin (YELLOW), Quinalphos (YELLOW) and Diafenthiuron (BLUE) have the label claim for use in cardamom. Label claim, issued based on scientific evidence, prescribes the chemical for specific crops and pests. This ensures legal protection for using the chemical in the specified crop against specified pests, as per technical prescriptions.

The poor monitoring and regulatory system in the trade sector add to the unscientific behaviour of the users as the retailers form the primary source of technical information regarding the choice of chemicals and related aspects. Farmers opt for plant protection based on technical advice, personal experience, advice from other farmers, and advice from company representatives or pesticide dealers. Farmers were more inclined to suggestions and recommendations from pesticide companies or input dealers. The field-level representatives of major manufacturing firms are actively present in the cardamom growing areas. There are several reports on the unscientific practices of trade, use and handling of chemical pesticides in India (Devi 2010; Shetty, Murugan, and Sreeja 2008) and cardamom plantations of Kerala in particular and related ecological health issues (Usha 2007; Murugan et al. 2017; Sreedharan et al. 2014). It is reported that 50 per cent of the total pesticide consumption in the state is used in cardamom. On average, farmers apply pesticides every l5-18 days, resulting in 18-25 sprays per year as against the need-based recommendation by KAU. Insecticides form the primary group of pest control chemicals, possessing high levels of insect and mammalian toxicity. The unscientific use of dangerously high levels of pesticides in cardamom plantations is hazardous to the environment's biotic and abiotic components.

The unregulated market conditions, weather factors and conventional farmer behaviour result in unscientific use and handling practices and lead to high levels of the residue of chemical pesticides in the products offered for sale, apart from the ecological and health damages. The micro-level crop health management practices are to be redesigned to ensure clean production practices and safe produce.

Pesticide residue levels and barriers to trade

Kerala Agricultural University and the Kerala State Department of Agriculture conduct periodic analyses of farm products produced and traded in the state. The presence of pesticide residue in cardamom as per these reports (from January 2017 to December 2021) is furnished in Table 4. Out of the 38 chemicals sprayed in cardamom, residues of 15 chemicals were found of which only one belongs to the GREEN category. The residue is above MRL for two of the three chemicals with label claim, i.e. Lamda Cyhalothrin and

Table 4 Common insecticides used in small cardamom production in Idukki district, Kerala state

Sl. No	Classification	Chemical name	Residue status	MRL Level
1	Green	Azoxystrobin		2
2		Carbendazim	Reported	2
3		Chlorantranilprole		2
4		Cyanthraniliprole		2
5		Flubendiamide		2
6		Novaluron		2
7		Spinetoram		2
8		Sulphur		2
9	Yellow	Acetamiprid		2
10		Alpha Cypermethrin	Reported	2
11		Bifenthrin	Reported	2
12		Cartap Hydrochloride		2
13		Chlorpyriphos	Reported	2
14		Cypermethrin		2
15		Ethion	Reported	2
16		Fenpyroximate		2
17		Fipronil		2
18		Imidacloprid	Reported	2
19		Indoxacarb	Reported	2
20		Lamdacyhalothrin * (4.9 CS)	Reported	
21		Phenthoate		2
22		Profenophos	Reported	2
23		Quinalphos * (25% EC)	Reported	1
24		Thiodicarb		2
25	Blue	Acephate	Reported	2
26		Diafenthiuron* (50% WP)		Below MRL
27		Difenconazole	Reported	2
28		Emamectin Benzoate		2
29		Fluopyrum		2
30		Fluensulfone		2
31		Metalaxyl	Reported	2
32		Propiconazole		2
33		Spinosad		2
34		Spiromesifen		2
35		Tebuconazole		2
36		Thiamethoxam	Reported	2
37	Red	Carbosulfan		2
38		Methomyl	Reported	2

Note * denotes having label claim

**1 if it is above MRL and 2 if MRL is not fixed

Quinalphos. Most of the pesticides used by cardamom farmers have no label claim for the crop; hence, the MRL is not fixed. Food Safety and Standards Authority of India (FSSAI) is the agency to fix the MRL for major pesticides and regulations to ensure domestic food safety. The agency fixes the MRL for only those pesticides with label claims for the crop.

Table 5 furnishes the details of the MRLs fixed by the four major agencies (WHO/FAO Codex Alimentarius, European Union (EU), FSSAI and SFDA for major chemicals used for pest management in small cardamom. These four agencies have fixed the MRLs for only 14 chemicals, while the chemicals differ across agencies. Codex standards are there for nine chemicals, EU for eight, SFDA for six and FSAAI for four chemicals. The chemicals and levels of MRL are specified at a uniform level by the Codex, EU and SFDA for five major chemicals, *viz*. Triazophos, Dithiocarbamate, Cypermethrin, Profenophos and Lambda cyhalothrin. Though chemical compounds are the same for Codex and EU in the case of nine chemicals, one differs in MRL level specification. In the case of Bifenthrin, Codex standard of MRL is lower (0.03 mg per kg) than 0.1 mg per kg of EU.

SFDA standards for six chemicals are almost on par with Codex levels, though Acetamiprid does not find a place in the Codex list. Interestingly, none of the chemicals for which FSSAI fixes MRL, finds a place in the Codex, EU and SFDA specifications.

Analyzing the results of the pesticide residue levels reported from 2017 to 2021 (Table 6), it could be seen that the residue levels of all the chemicals vary across the period and was higher than the MRL in the case of chemicals that global agencies specify. For instance, the MRL for Ehion is fixed at 5mg per kg by Codex and EU and the residue level was as high as 7.79 in at least one year and was very close to the value in two years. The residue level of Lambda-cyhalothrin was higher than the MRL of 2 mg per kg fixed by Codex, EU and SFDA in all the years. Profenphos, for which the MRL is 3mg per kg (Codex, EU and SFDA), the residue was reported at more than that level (3.01) as well as very close to 3 (2.95). The residue level was five times the specified level in the case of Chlorpyriphos at least in one year though it was within limits on many occasions. Bifenthrin, for which there are different standards for Codex (0.03) and EU (0.01), the residue level was as high as 4.13 and was always higher than the specifications. Acetamiprid, for which MRL is specified only by SFDA, at 0.1 mg per kg, was detected at a residue level of more than 1 mg per kg. Dithiocarbamate and Triazophos, included in the SFDA, are not reported to be used by the farmers. Cypermethrin residue is not detected in any samples analyzed during the period. It is a matter of concern that the small cardamom grown in the high ranges of the state follows unscientific pest management practices that lead to undesirable levels of chemical

Table 5 Comparison of MRLs of chemical pesticides in small cardamom (mg/Kg) specified by different agencies

Sl. No.	Name of the chemical	Codex Alimetarius	EU	SFDA	FSSAI
1	Dithiocarbamates	0.1	0.1	0.1	-
2	Cypermethrin	3	3	3	-
3	Profenophos	3	3	3	-
4	LamdaCyhalothrin	2	2	2	-
5	Triazophos	4	4	4	-
6	Ethion	5	5	-	-
7	Chlorpyrifos	1	1	-	-
8	Bifenthrin	0.03	0.1	-	-
9	Cyhalothrin L	2	2	-	-
10	Monocrotophos	-	-	-	0.50
11	Quinalphos	-	-	-	0.01
12	Diafenthiuron	-	-	-	0.50
13	Fosetyl Al	-	-	-	0.2
14	Acetamiprid	-	-	0.1	-

Table 6 Year-wise changes in the pesticide residue status in small cardamom (2017-2021)

Sl. No.	Category	Chemical name	2017	2018	2019	2020	2021
1	Green	Azoxystrobin	ND	ND	ND	ND	0.06-0.25
2		Carbendazim	0.11-0.61	0.04-1.7	0.05-3.04	0.05-0.43	0.07-0.21
3		Chlorantranilprole	ND	ND	ND	ND	ND
4		Cyanthraniliprole	ND	ND	ND	ND	ND
5		Flubendiamide	ND	ND	ND	ND	ND
6		Novaluron	ND	ND	ND	ND	ND
7		Spinetoram	ND	ND	ND	ND	ND
8		Sulphur	ND	ND	ND	ND	ND
9	Yellow	Acetamiprid	ND	ND	ND	ND	ND
10		Alpha Cypermethrin	ND	ND	2.05-2.61	0.065-1.44	0.07-1.68
11		Bifenthrin	0.11-0.87	0.05-0.7	0.05-4.13	0.05-0.68	0.05-1.27
12		Cartap Hydrochloride	ND	ND	ND	ND	ND
13		Chlorpyriphos	0.06-0.54	0.06-0.82	0.05-5.22	0.10-0.586	0.06-0.71
14		Cypermethrin	ND	ND	ND	ND	ND
15		Ethion	0.06-1.00	0.10-7.79	0.06-2.58	0.06-5.3	0.07-4.54
16		Fenpyroximate	ND	ND	ND	ND	ND
17		Fipronil	ND	ND	ND	ND	ND
18		Imidacloprid	0.08-0.43	0.05-0.48	0.05-1.01	0.05-1.04	0.07-0.38
19		Indoxacarb	ND	ND	0.13	0.15-0.239	0.05
20		Lamdacyhalothrin * (4.9 CS)	0.11-2.90	0.23-2.05	0.10-5.42	0.08-2.55	0.09-2.02
21		Phenthoate	ND	ND	ND	ND	ND
22		Profenophos	0.74-3.01	0.06-1.44	0.07-1.39	0.1522-1.04	0.06-2.95
23		Quinalphos * (25% EC)	0.23-9.49	0.2-2.22	0.10-9.45	0.21-13.38	0.07-3.19
24		Thiodicarb	ND	ND	ND	ND	0.18-0.34
25	Blue	Acephate	ND	0.46	0.05-0.052	0.118-0.736	0.08
26		Diafenthiuron* (50% WP)	ND	ND	ND	ND	ND
27		Difenconazole	0.13	0.05-0.12	ND	0.05-1.95	0.06-0.57
28		Emamectin Benzoate	ND	ND	ND	ND	ND
29		Fluopyrum	ND	ND	ND	ND	ND
30		Fluensulfone	ND	ND	ND	ND	ND
31		Metalaxyl	ND	0.14-0.47	0.09-0.45	0.05-0.37	0.07-3.61
32		Propiconazole	ND	ND	ND	0.237-1.43	0.06-0.38
33		Spinosad	ND	ND	ND	ND	ND
34		Spiromesifen	ND	ND	ND	ND	ND
35		Tebuconazole	ND	ND	ND	0.05-0.33	0.07-0.91
36		Thiamethoxam	ND	0.05-0.68	0.07-1.19	0.05-0.68	0.06-0.09
37	Red	Carbosulfan	ND	ND	ND	ND	ND
38		Methomyl	0.07-0.56	0.05-0.36	0.11	0.062-0.169	0.07-2.62

Note 1. Unit- mg /Kg
2. ND denotes Not Detected

pesticide residue that hamper the prospects of export markets.

The prospects of exploiting the potential markets can be ensured through the harmonisation of FSSAI and Codex standards and .scientific pest control practices.

Conclusion

India is among the countries with significant potential to export small cardamom. However, it has realized less than fifty per cent of its export potential, leaving an untapped potential worth 134.6 million US$. The primary destinations are United Arab Emirates, Saudi Arabia and Bangladesh. Saudi Arabia is the market with the highest export potential for Indian Cardamom. Despite this favourable condition, the share of imports of Saudi Arabia of Indian small cardamom shows a declining trend, mainly owing to food quality concerns (pesticide residue). This situation is mainly attributed to the farm-level undesirable production practices, which are influenced by the poorly monitored pesticide trade system, legal and technical aspects, and market responses. Unscientific practices of pesticide use have a bearing on the financial, ecological and social dimensions of the local, regional and global economy, both in the short term and long term. The situation necessitates policy interventions that include research for technology development, farmer education, supply regulations, monitoring and residue analysis, and global consensus on standards.

The use of plant protection chemicals in cardamom should achieve sustainability in the system through Integrated Pest Management (IPM), application and promotion of bio-control agents, and judicious and supervised application of chemical plant protection formulations. The chemical pesticides under the IPM protocol need to be specified by the scientific community. It is desired if such chemicals are those for which global specifications of pesticide residue standards are already fixed. The legal compliance for using these chemicals must be ensured by assigning label claims. Consequently, FSSAI may fix the MRL for such chemicals to comply with global standards.

A traceability system in the trade sector needs to be established by applying modern technologies like blockchain. Correspondingly, educating the stakeholders of the value chain (with a focus on consumers as well) on the quality aspects and appearance, as well as scientific grading practices, can signal the farmers for the adoption of greener technologies. Knowledge and skill development on safe and scientific use of chemicals in farming is the collective responsibility of the public sector and the manufacturers of chemicals.

In the short run, we need to comply with the specifications of importing nations. Hence, the use of pest control chemicals in cardamom must be restricted to only those permitted by importing countries like Saudi Arabia, coupled with a compliance mechanism to ensure field-level adoption. As a long-term strategy, efforts at the policy level may be taken to adopt uniform standards by importing countries. Internationally harmonized EU standards facilitate the global trade of developing countries as they favour better cost management, especially fixed costs.

It is also to be mentioned that the concept of sustainable food production principles, which the EU establishes, includes broader aspects like social, ecological, climatic and economic dimensions of crop production. Apart from the food quality and ecological safety aspects, it includes a reduction in greenhouse gas emissions during agri-food production and supply, which corresponds to the main goal of the EU Green Deal 57, aimed at decarbonization and achieving climate neutrality. Thus, the food trade may take into consideration the aspects like food quality (nutritive value), climate change influence (greenhouse gas emissions), ecological impacts (use of chemical pesticides, prevention of land degradation, biodiversity loss) and social angle (employees' rights, use and rights of women and child labour). Developing countries must design a mix of policy, technology and governance interventions to transform the production systems to meet the future global market specifications.

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Appendix

A1 Insecticides having label claim for cardamom under Central Insecticide Board and Registration Committee (CIB &RC)

Crop	Name of pests	Dosage / ha			Waiting period (days)	MRL levels
		a.i (gm)	Formulation (gm/ml)	Dilution in water (Litre)		
Diafenthiuron 50% WP	Thrips, Capsule borer	400	800	1000	7	0.5
Monocrotophos 36% SL	Thrips	375	937	500-1000		0.5
Quinalphos 25% EC	Thrips	0.03%	600-1200	500-1000	30	0.01

Source Major uses of Pesticides, (UPTO - 31/01/2020) Directorate of Plant Protection, Quarantine & Storage Central Insecticide Board & Registration Committee N.H.-IV, Faridabad-121 001 (Haryana)

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Intellectual property rights for inclusive and sustainable agricultural development : issues and challenges in India

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Abstract Two Intellectual Property Rights (IPR) systems are highly relevant to crop sector in India. They are Geographical Indications and Protection of Plant Varieties and Farmer's Rights. In this paper, an attempt is made to examine the potential effect of these on inclusive and sustainable agricultural development. Creation of producer groups, review of product standard from time to time, value chain development under GI system, characterisation of farmers varieties to promote their use in plant breeding are the key measures for realising the full potential of the IPR systems for inclusive and sustainable agricultural development.

Keywords Geographical indications, farmers' rights, plant variety protection, IPR, seed, competition, sustainability, inclusiveness

JEL codes O34, O38, Q01, Q18, R58

Introduction

Under the World Trade organization (WTO) agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) it is mandatory for member countries to provide IPR to plant varieties and biological materials. In this backdrop, India is providing IPR to plant varieties and seeds under multiple IPR mechanisms. Mainly two Intellectual Property Rights (IPR) systems are highly relevant to crop sector in India. They are Geographical Indications (GI) under the Geographical Indications of Goods (Registration and Protection) Act of 1999 and Plant Variety (PV) rights under the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act of 2001. Both are "*sui generis"* type IPR Acts enacted as compliance mechanism under TRIPS agreement. In this paper, an attempt is made to examine the progress and potential effect of these two IPR systems on inclusive and sustainable agricultural development and identify future interventions/ corrective measures needed.

A geographical indication is a sign used on products that have a specific geographical origin and possess qualities or a reputation that are due to that origin. Geographical indications (GIs) are indications that identify a good as originating in the territory of a country, or from a region or locality within that territory, where a given quality, reputation, or other characteristic of the good is essentially attributable to its geographic origin. Indian GI act specifies that in case the good is a manufactured good, one of the activities of either production or of processing or the preparation of goods concerned takes place in the territory or region or locality as the case may be, for GI registration. Further, under Indian GI Act, any name which is not the name of a country, region or locality of the country shall also be considered as GI, if it relates to specific geographic area and is used upon in relation to particular goods originating from the country, region or locality as the case may be. For instance, "basmati" is not name of a place, but it is GI assigned to specific rice type which meet specific quality standards and cultivated in specific areas of Indo-Gangetic plains of India.

GI by signalling distinctness and intrinsic quality of a product helps in building reputation for the product

and mitigate the problem of "asymmetry of information" between producers and consumers. Hence, GI products are expected to command premium price in markets. Promotion of diversity in goods, protection of producers against unfair competition and misappropriation and protection of consumers against counterfeit goods are some of the benefits associated with GIs.

Plant variety right is a limited period exclusive right granted to a breeder for producing and marketing seeds of the variety developed by the breeder, so as to encourage development of new varieties of plants. In India under the PPV&FR Act of 2001, not only breeders' rights but also farmers' rights (both as breeders and users of seeds) are protected.

Methodology

The current study is mainly based on secondary data on GIs and plant varieties registered under GI Act, 1999 and PPV&FR Act 2001 respectively. The data were collected from respective authorities' websites. Simple tabular analysis was used for analysing the secondary data. Besides this, examination of key provisions in the two IPR Acts that aid in sustainable and inclusive development in agriculture was carried out. A review of literature was also carried out to draw some insights regarding needed interventions for strengthening role of these two IPRs in inclusive and sustainable development.

Results and discussion

GI status in India

In India, Registration of GIs began in 2004-05 after the GI Act came into effect from 15th September 2003. Under Indian GI Act, broadly five categories of goods are registered. They are (i) agricultural (ii) food stuff (iii) manufactured (iv) handicraft and (v) natural. Protection period under GI act is 10 years from the date of filing but can be renewed from time to time. Till march 2022, 420 registrations were effected under GI Act, of which 55% were GIs for handicraft goods. Agricultural GIs constituted 30%. In contrast, at the global level GIs relating to wines and spirits accounted for 56.1% of total GIs in force in 2020, followed by agricultural products and foodstuffs (38.6%) (WIPO 2021). Handicrafts accounted for only 3.6 % of total GIs in force at global level in 2020. Number of GIs registered in India increased from 3 in the year 2004-05 to 50 in the year 2021-22 (Figure 1). On average 23 GIs were registered per year in India during 2004-05 to 2021-22, with 7 GIs from agricultural sector, and 13 GIs from handicraft sector and the rest 3 GIs from other sectors.

In 2020, China had the highest number of GIs (7417) for agricultural products in force, followed by Germany (2014) and Portugal (1898) (WIPO 2021). In India, cumulative total of GIs for agricultural products was 112 in 2020-2021 and it increased to 128 in 2021-2022.

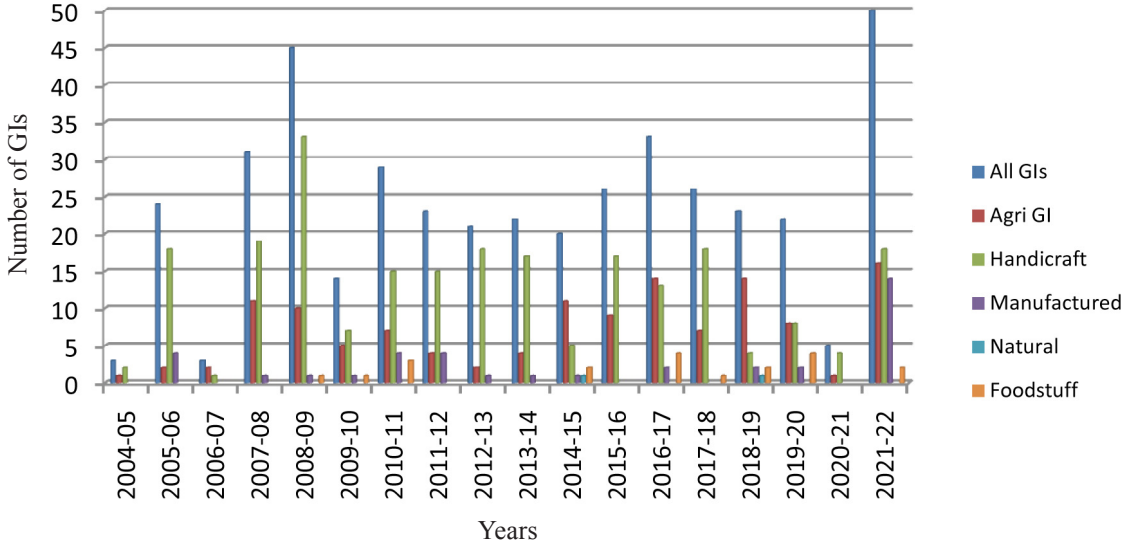

Figure 1 Progress of GI registration in India

These agricultural GIs covering 48 crops/goods is spread over 28 states (Table 1). Maharashtra, Karnataka and Kerala are the top three states with 25,22, and 19 agricultural GIs respectively. Rice followed by mango and chilli are the top 3 crops constituting 32 percent of Agricultural GIs registered under the GI act of India. Some GIs with respect to crops viz., betel leaf, cardamom, chilli, coffee, pepper and rice are shared between two or more states due to spread of geographic area of production of these GI goods across these states. This spread of agricultural GIs across crops and states in India indicates, the potential of GIs in regional development and crop diversity maintenance.

As per GI Act of India "any association of persons or producers or any organization or authority established by or under any law for the time being in force representing the interest of producers of the concerned goods, who are desirous of registering of a geographical indication in relation to such goods" have to apply for GI registration. Accordingly, diverse actors like, coffee board, tea board, spices board, State Agricultural Universities, Directors of Horticulture of different states, producer groups of different commodities and in some cases processors associations/co-operatives, marketing associations, state agro-industries development corporations, North Eastern Regional Agricultural Marketing Corporation Limited (NERAMAC) in case of GI of commodities in North Eastern states were the applicants for the 128 agricultural GIs. Subsequent to the registration of these GIs, these diverse actors are the registered owners of these GIs. In the case of Basmati rice, The Agricultural and Processed Food Products Export Development Authority (APEDA) is the applicant for GI and owner of the GI. Thus, the situation in India is in contrast to situation in some countries like Japan, Cambodia and Laos wherein the producer's association is the only body authorized to apply for GI (Marie-Viven 2020).

As second part of GI registration, any person claiming to be the producer of the goods in respect of which a GI has been registered, has to apply for registration as authorised user. In case of agricultural goods definition of producer is persons dealing with production, processing, trading or dealing. Based on available data regarding authorised users registered (https://www.ipindia.gov.in/IPIndiaAdmin/writereaddata/Portal/Images/pdf/Details_of_GI_Authorised_User_Applications_Registered_as_on_July_15__2022.pdf) out of 128 agricultural GIs in India, only with respect to 75 agricultural GIs, authorised users are registered. Number and nature of authorised users varied with commodity and also with extent of area delineated for each GI. Besides individual farmers/ producers, Tribal Cooperative Marketing Development Federation of India Limited (TRIFED), Agricultural Producers Co-operative Marketing Society Limited in different states and some private companies are some of the registered authorised users of various agricultural GIs. In case of 3 agricultural GIs, i.e., Jalgaon Banana, Alphonso Mango and Solapur Pomegranate (all from Maharashtra) the number of authorized users ranged between 1082 to 1766. In case of another 12 agricultural GIs, number of registered authorized users ranged between 100 to 733. Out of these 12 agricultural GIs, 8 were from Maharashtra. In case of 9 agricultural GIs, Tribal Cooperative Marketing Development Federation of India Limited (TRIFED) is the registered authorized user (Table 2). This indicates potential for development of tribal communities through these 9 agricultural GIs.

Impacts of GIs

GIs can play a role in agricultural sustainability and economic development through several ways (Blakeney 2021). Production of specific types of crops registered as GIs cannot be " delocalised" and also must be produced following specific practices so as to ensure quality control. Quality control is essential for commanding premium price in market. The premium price is expected to reinforce adoption of sustainable agricultural practices and conserve the resources like soil quality, and biodiversity. It is also anticipated that as GIs are collective IPR linked to a particular good, particular territory/location and authorized users, enables all the authorised producers to have their share in premium commodity market. GIs are viewed as club goods because of excludability and non-rivalry properties (Rangnekar 2004). GI being a mechanism of reputation building through collective action of producers of particular goods in a given "terroir", aids in sharing cost of quality maintenance, monitoring and reputation building (Lence et al. 2007; Moschini et al. 2008). Further, GIs in agriculture are expected to have some spinoff effects like creation of rural employment, agri-tourism, preserve traditional knowledge and cultural expression. In the backdrop of these expected

Table 1 Distribution of Agricultural GIs registered in India till 2021-22

S. No.	Goods/Crop	Number of GIs	Share (%)	States	No. of states
1	Banana	7	5	Goa(1), Karnataka(2), Kerala (1), Maharashtra(1), Tamil Nadu (2)	5
2	Beetel leaf	4	3	Bihar(1), Karnataka(1), Kerala(1), Uttar Pradesh (1) Madhya Pradesh(1)	5
3	Beetel nut	1	1	Karnataka (1)	1
4	Black cumin	1	1	Himachal Pradesh(1)	1
5	Brinjal	2	2	Karnataka (1), Maharashtra(1)	2
6	Cardamom	3	2	Karnataka(1), Kerala(1), Sikkim(1), Tamil Nadu(1)	4
7	Cashewnut	1	1	Maharashtra (1)	1
8	Chikoo	1	1	Maharashtra (1)	1
9	Chilli	10	8	Andhra Pradesh (1), Goa (2), Karnataka (1), Kerala(1), Maharashtra(1), Manipur(1), Mizoram (1), Nagaland (1), Sikkim (1) West Bengal(1)	10
10	Citrus	1	1	Karnataka(1)	1
11	Clove	1	1	Tamil Nadu (1)	1
12	Coconut	1	1	Tamil Nadu (1)	1
13	Coffee	7	5	Andhra Pradesh (1), Odisha (1), Karnataka (5), Kerala(3) Tamil Nadu(1)	5
14	Cucumber	1	1	Nagaland(1)	1
15	Custard Apple	1	1	Maharashtra (1)	1
16	Fig	1	1	Maharashtra (1)	1
17	Garlic	1	1	Tamil Nadu(1)	1
18	Ginger	2	2	Assam(1), Mizoram (1)	2
19	Grapes	2	2	Maharashtra (1), Karnataka(1)	2
20	Guava	1	1	Uttar Pradesh (1)	1
21	Indian Bay leaf	1	1	Uttarakhand(1)	1
22	Indian butter tree	1	1	Uttarakhand(1)	1
23	Jaggery	3	2	Maharashtra (1), Kerala(2)	2
24	Jasmine	4	3	Karnataka (3), Tamil Nadu (1)	2
25	Jowar	1	1	Maharashtra(1)	1
26	Kewda flower	1	1	Odisha (1)	1
27	Kidney bean	1	1	Maharashtra (1)	1
28	Lemon	2	2	Assam(1), Manipur (1)	2
29	Litchi	2	2	Assam (1), Bihar (1)	2
30	Mango	12	9	Andhra Pradesh (1), Bihar(1), Gujarat(1), Karnataka(1), Kerala(1), Maharashtra (2), Uttar Pradesh (2), West Bengal(3)	8
31	Mangosteen	1	1	Maharashtra(1)	1
32	Mehandi	1	1	Rajasthan (1)	1
33	Onion	2	2	Karnataka(1), Maharashtra(1)	2
34	Orange	7	5	Arunachal Pradesh(1), Karnataka (1), Maharashtra (2), Manipur (1), Meghalaya(2)	5
35	Pepper	1	1	Kerala (1) Karnataka(1), Tamil Nadu(1)	3
36	Pineapple	2	2	Kerala (1), Tripura (1)	2
37	Pomegranate	1	1	Maharashtra(1)	1

Contd...

S. No.	Goods/Crop	Number of GIs	Share (%)	States	No. of states
38	Raisin	1	1	Maharashtra(1)	1
39	Razma	1	1	Uttarakhand(1)	1
40	Redgram	2	2	Karnataka(1), Maharashtra(1)	2
41	Rice	19	15	Assam(3), Bihar (1), Chhattisgarh (1), Kerala(6), Madhya Pradesh (1), Maharashtra(2), Manipur (1), Uttar Pradesh (2), West Bengal (2), Punjab(1), Haryana(1), Delhi(1), Himachal Pradesh(1), Uttarakhand(1), Jammu and Kashmir(1)	15
42	Saffron	1	1	Jammu and Kashmir(1)	1
43	Strawberry	1	1	Maharashtra(1)	1
44	Tea	4	3	Assam(1), Himachal Pradesh(1), Tamil Nadu (1), West Bengal (1)	4
45	Teak	1	1	Kerala(1)	1
46	Tomato	1	1	Nagaland(1)	1
47	Turmeric	4	3	Maharashtra (2), Odisha (1), Tamil Nadu (1)	3
48	Wheat	1	1	Gujarat (1)	1
	Total	128	100		

Source https://www.ipindia.gov.in/writereaddata/Portal/Images/pdf/GI_Application_Register_List_14-07-2022.pdf
Note Figures in parenthesis indicate number of agricultural GIs

Table 2 Details of agricultural GIs where TRIFED is the authorised user

S. No.	Application No.	Year of registration	GI	State	crop	Registered authorised user
1	241	2017-18	Banaganapalli Mango	Andhra Pradesh	Mango	TRIFED (Ministry of Tribal Affairs, Govt. of India), Regional Office, Hyderabad
2	610	2019-20	Kandhamal turmeric	Odisha	Turmeric	TRIFED, Ministry of Tribal affairs, RO, Bubhaneswar
3	466	2014-15	Kachai Lemon	Manipur	Lemon	TRIFED, Ministry of Tribal affairs, RO Guwahati
4	439	2016-17	Joha Rice of Assam	Assam	Rice	TRIFED, Ministry of Tribal affairs, RO Guwahati
5	558	2018-19	Boka Chaul rice	Assam	Rice	TRIFED, Ministry of Tribal affairs, RO Guwahati
6	602	2019-20	Chak-Hao (Black rice)	Manipur	Rice	TRIFED, Ministry of Tribal affairs, RO Guwahati
7	115&118	2008-09	Assam (orthodox) Logo-tea	Assam	Tea	TRIFED, Ministry of Tribal affairs, RO Guwahati
8	1&2	2004-05	Darjeeling Tea	West Bengal	Tea	TRIFED, Ministry of Tribal affairs, RO Kolkata
9	611	2018-19	Jeera phool	Chhattisgarh	Rice	TRIFED, Regional Office, Raipur, Ministry of Tribal Affairs

multiple effects, several studies examined impact of GIs on different dimensions of development across different countries.

Larson (2007) while analysing GIs impact on biodiversity observed that, economic viability of a specific livelihood tied to a genetic resource, contributed to conservation of biodiversity in developed countries. That is the link between genetic resource and quality, thereby differentiation of product for competing in market by way of GI and value chain development in developed countries contributed positively in biodiversity conservation. But in developing countries, negligible effects and negative effects were more frequent due to weaker or underdeveloped institutional context. To avoid successful GI implementation becoming as mechanism to exclude poor farmers and consumers, Larson (2007) argued for clear policies of regulation and product development, value chains that address local, regional, national and export markets.

Torok et al. (2020) reviewed empirical studies on the economic impact of GIs. More specifically they focused on three aspects viz., market size, price premium and impact on rural development. They found it is impossible to draw any general conclusions about the economic impact of GIs. This in turn is due to (i) considerable heterogeneity between different GI products and between the outcome for similar GI products in different regions (ii) higher costs associated with producing GI products and indirect costs associated with complying with the GI regulation and (iii) uncertainty regarding flow of price premium to primary producers in value chain.

Based on review of studies analysing environmental effects of GIs, Milano and Cazella (2021) observed that GIs in European countries generated more positive environmental results. In contrast in developing countries with greater social inequality and also high biodiversity, GIs had some kind of negative environmental effects. Milano and Cazella (2021) identified six different factors underlying these diverse results. They are (i) Social governance i.e social organization to achieve collective participation and action in the construction and management of the GI (ii) the existence of policies to encourage the desired productive practices (iii) the existence and communication of a clear connection between the product and its terroir (iv) insertion of clear and applicable environmental objectives in the technical specification of the GIs (v) profitability of the GI and its capacity to leverage other activities like tourism and (vi) existence of technical assistance appropriate to the reality of GI. Andrea et al. (2020) analysing justification for approved amendments to product specification of registered GIs in European Union, observed that market changes, available new technology and strengthening product quality were the most important justification. By in-depth analysis, they observed that environmental justifications were indirectly used as a means to achieve better market competitiveness.

Pick and Viven (2021) compared effectiveness of state driven GI system in Vietnam and producer driven GI system in France, in ensuring representativeness of relevant stakeholders. They observed that under producer driven GI system, prolonged negotiations and (production practice) standards that can continue to be challenged post GI registration were the results. On the other hand, in state driven GI system, little understanding and low use of GIs by stakeholders were the results. Further Pick and Viven (2021) argued that rules for the representation of all GI users in the decision making processes do not necessarily lead to fairness. They suggested a in-between solution where in the first stage state organizes a consultation of a wide range of stakeholders of the value chain and second with those outside the value chain such as local representatives, traders and consumers. They also suggested re-examination of representativity throughout the long life of a GI.

Impact and performance of GIs in India

In Indian context as stated earlier there is diversity in GI ownership and authorized users. Hence, GI is being viewed as a hybrid between a public quality standard and a (collective) IPR (Bienabe and Viven 2017). Further in case of some goods like basmati rice, Darjeeling tea, GI registration was effected after they already got worldwide reputation. In the case of basmati rice GI registration was effected only during the year 2015-16. By this time India faced legal battle in several countries and paid huge cost for competition. This could have been avoided if India registered its basmati GI early (Mulik and Crespi 2011).

In India, still many agricultural GIs are not yet widely used to harness potential, thus considered as sleeping GIs (Marie-Viven 2020). The diversity in proprietors and authorized users of GI in India, and their varied capacities in promoting the products by creating brands, and regulating production standards, indicates that the effectiveness and impact of GIs in India will be case and context specific (Das 2010). Marie-Viven (2020) suggested a provision in law, making it mandatory to create a collective organization of producers/processors within a short period after the GI is registered in cases where there are no collective bodies and to bring together value chain stakeholders for effective use of GIs. Casbianca and Viven(2022) suggested that in GI conception, exclusion at production stage (by way of limiting area of production of GI good) to preserve distinctive quality of good is necessary exclusion. Inclusiveness in Governance of GI is necessary to increase solidarity and cohesiveness,

In India, rice is the crop with maximum number of GIs registered (Table.1). Premium price in case of GI protected rice types (basmati as well as non-basmati) in India as well at international level are well documented (Yadav et al.2019; Khan 2020; Roy 2019; Ravindra et al. 2018). This premium price reinforces the incentive to produce GI tagged rice and helps in biodiversity management in rice crop. But India's policy on export of non-basmati rice will also have its implication in creating market for the 'non-basmati" type GI tagged scented rice varieties. Besides this, higher the share of benefits to farmers from GI tagged rice value chain, higher will be the incentive effect. In the case of "Pokkali" rice in Kerala, intermediaries' higher share in profits was reported to act as disincentive and discourage farmers (Anson and Pavithran 2014). Subsequently under Rashtriya Krishi Vikas Yojana (RKVY) a scheme was implemented to motivate farmers to cultivate Pokkali rice with a incentive of Rs 10000 per ha (DOA 2013). Radhika and Raju (2021), Radhika et al. (2021), and Napasintuwong et al. (2022) observed issues of unawareness among cultivators of GI rice about GI, post GI registration implementation issues like accessing markets, and quality control in the case of many GI rices from Kerala. They recommended revival of producer societies in order to take collective decisions on defining production area limits, agreeing on code of conduct, identifying indicators of quality and addressing marketing issues. In case of Tulaipanji rice of West Bengal also marketing problems was reported (Mondal and Dutta 2014; Dipak 2019).

Kishore (2018) reported in the case of Malabar Pepper and Vazhakulam Pineapple (2 agricultural GIs) producers were not being benefitted directly as these producers are dependent on powerful intermediaries. Lalitha et al.(2021) observed that though cost of cultivation of Bhalia Wheat (GI) in Gujarat was lower than irrigated wheat, yield of Bhalia wheat was lower. Despite of premium price commanded by Bhalia wheat, changes in the consumer's preference in favour of readymade flour to make bread, demands from urbanization, changing climate, availability of canal water were leading to reduction in area under Bhalia wheat, which is cultivated under Conserved Soil Moisture Condition. Lalitha and Soumya (2022) analysed eight agricultural GIs spread over three states, using SWOT (Strength, Weakness, Opportunity and Threat) framework. In case of Bhalia wheat and pokkali rice, they observed strong geo link and production in sustainable manner. Absence of clearly defined value chains, absence of functioning farmers collectives and lower use of GIs were identified by them as weakness. In the case of 7 GIs out of 8 selected GIs, they observed declined in area under cultivation.

GI Overlap with PV Rights

Primarily agricultural GIs offer legal protection to specific crop outputs along with protection to authorized producers with respect to each specified output. However, in a specific crop GI output can arise from several varieties of the crop. For example basmati rice is protected under GI act, but in basmati rice category, till date 43 varieties were notified under Seeds Act of 1966 (AIREA-All India Rice Exporters' Association). Further some of these basmati rice varieties are registered under PPV&FR Act, thereby protecting rights to produce and market seeds. Moreover, in the case of open pollinated varieties seeds and grains are interchangeable. Besides Basmati registration under both GI act and PPVFR Act, some more attempt for registering some other GI tagged rice varieties with PPVFR Authority are noticed recently like in case of Kalanamak (Yadav et al. 2019), Jeeragasala and Ghandakasala rice from Kerala. This is due to development of varieties of different GI rices with higher yield, resistance and tolerance to various

biotic and a-biotic stresses. Similar may be the case in the case of other agricultural GIs also.

In the case of Navara rice some controversy is documented in the literature (Blakeney et al. 2020). This is because under GI, Navara rice is registered for collective right but under PPVFRA an individual farmer applied for registration. Thus there is overlap between PPVFR and Agricultural GI Act in the case of "subject matter" but with different "scopes". As long as there is no conflict between right holders under PPV&FR Act and authorized users under GI act, simultaneous protection under both the acts are possible

Status of plant varieties registered under PPV&FR Act

For implementing PPV&FR Act, the PPV&FR Authority was created under Ministry of Agriculture and Farmer's Welfare. Under PPV&FR Act plant varieties are registered for protection by farmers, private seed companies and public sector research institutions. Protection period under PPV&FR act is 15 years for field crops and 18 years for perennials and vines. Plant varieties with DUS (Distinct, Uniform and Stable) characteristics are eligible for protection under this act. Plant varieties under this act are registered under four categories viz,. Extant-notified, Extant-Varieties of Common Knowledge (VCK), new varieties and Essentially Derived Varieties (EDVs). Farmer's varieties are a sub category under extant varieties. Protection for extant varieties is a unique feature of Indian PVR act and is limited period opportunity available. Hence application for registration of extant varieties under different crop species have to be submitted before a specified date fixed by PPV&FR authority. Protection to farmers varieties is yet another unique feature of Indian PPV&FR act. Registration under PPV&FR act confers exclusive right on the breeder or his successor, authorised person, agent or licensee to produce, sell, market, distribute, import or export the variety seeds.

Plant breeding is a cumulative and sequential innovation process, that is a new variety development requires access to existing varieties or biological material. Hence, to facilitate follow on innovations, certain provisions are there in PPV&FR Act. One such provision is researcher's exemption provision. That is a researcher can use varieties protected under PPV&FR act for their research purpose, but the researcher needs to seek authorization from the registered breeder if he has to use the registered variety repeatedly in the production of a newly developed variety. Another provision for facilitating follow-on innovation, while preserving incentives for both initial variety developer and follow on developer is Essentially Derived Variety (EDV) concept. According to UPOV 1991 convention, a variety shall be deemed to be EDV when three conditions are cumulatively fulfilled. The conditions are (i) EDV is predominantly derived from the Initial Variety (IV) (ii) EDV is clearly distinguishable from the initial variety and (iii) except for the difference which results from the act of derivation, the EDV conforms to the initial variety in the expression of the essential characteristics that result from the genotype or combinations of genotypes of the initial variety (UPOV, 2017).

The trend in registration of plant varieties for plant variety right is captured in Figure 2. The status of plant varieties registration under PPV&FR act as at 31-12-2021 is given in the table 3. In total 4847 varieties were registered with PPV&FR authority till 31-12-2021. In total varieties registered, farmers are leading with 39 percent followed by public sector with 32 percent. As is evident from Table 4, farmers varieties registered under PPV&FR Act are spread over 34 crops and different states indicating their contribution in varietal diversity creation and management. Besides exercising rights as breeders, farmers can also claim benefit sharing when their varieties are used as parents in new varieties developed. In this way, PPV&FR system is attempting for inclusive growth. However to enable the farmers to have their share in benefits, their varieties need to be characterised and special characteristics like biotic or abiotic stress tolerance, nutritional richness need to be documented for accelerating their use in future breeding programs.

In order to avoid extending/manipulating the protection period of a hybrid by way of sequential application for protection to individual parents and hybrids, a provision of mandatory composite registration is implemented under the PPV&FR Act. Hence a hybrid along with its parents have to be registered at the same time for protection. If one or more of the parents is previously registered then the validity period of the hybrid will be that of the period of protection of the earliest

Table 3 Distribution of plant varieties registered under PPVF&R Act as on 31-12-2021

Category of breeders	Extant	New	EDV	Total	Share of different category breeders
Farmers	1894	-	-	1894	39
Private	687	723	14	1424	29
Public	1364	165	-	1529	32
Total	3945	888	14	4847	100
Share of different types of varieties	81	18	0	100	

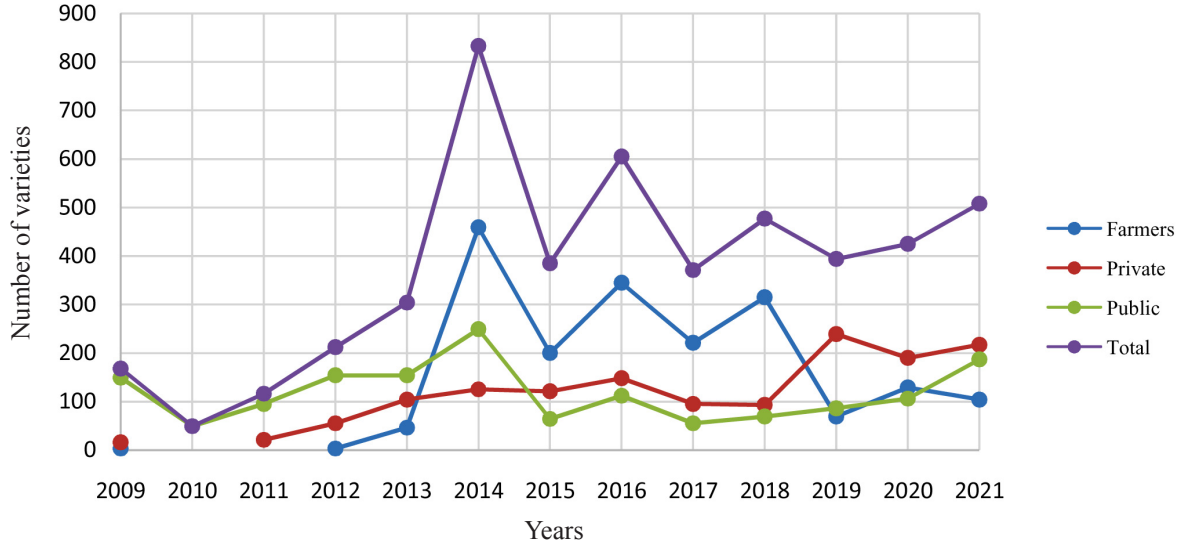

Figure 2 Trend of varieties registered under PPV&FR Act

registered parent among its parents. Further, as per the current Act, it is not feasible to register the three-way crossed or double-crossed or multi-parent chain-crossed hybrids.

Under PPV&FR Act, at any time, after the expiry of three years from the date of issue of a certificate of registration of a variety, any person interested may make an application to the authority showing that the reasonable requirements of the public for seed or other propagating material of the variety have not been met or that the seed or other propagating material of the variety is not available to the public at a reasonable price and request for the grant of a compulsory licence. This provision acts as a check on abuse of IPR right by way of limited production of seeds of a protected variety which is in high demand, or selling of seeds at exorbitant price. Thus some provisions are there in PPV&FR act to check abuse of IP rights and control price, so as to ensure affordability of seeds and in-turn ensure inclusiveness.

Emerging challenges

Disputes regarding area delimitation under GIs like basmati rice is one emerging challenge in both national (Mishra and Fatesaria,2022) and international arena. Climate change is emerging as another challenge to GI framework as climate change affects quality of products and also changes suitability of area (Henry,2022).

Conclusions and way forward

Specific provisions are there in both the IPR systems in India i.e GI system and PPV&FR system, which

Table 4 Farmers varieties distribution across crops and states

S. No.	Crop	Number of varieties	State	No.of states
1	Apple	2	Himachal Pradesh (2)	1
2	Apricot	30	Jammu and Kashmir (30)	1
3	Barley	5	Jharkhand(2), Madhya Pradesh(3)	2
4	Black pepper	5	Kharnataka(2), Kerala(3)	2
5	Blackgram	2	Rjasthan(1), Uttar Pradesh (1)	2
6	Bread wheat	7	Jharkhand(1), Punjab(1), Uttar Pradeh (5)	3
7	Brinjal	6	Bihar (1), Madhya Pradesh (1), Tripura(1), West Bengal (3)	4
8	Cauliflower	1	Bihar (1)	1
9	Chickpea	8	Bihar(3), Jharkhand(2), Madhya Pradesh (1), Rajasthan(1), Mahrashtra(1)	5
10	Chilli	1	West Bengal (1)	1
11	Custard apple	1	Maharashtra(1)	1
12	Fenugreek	1	Jharkhand (1)	1
13	Field pea	3	Jharkhand(3)	1
14	Grapes	5	Mharashtra(5)	1
15	Greengram	6	Jharkhand(3), Telangana(1), Uttar Pradesh (2)	3
16	Groundnut	1	Bihar (1)	1
17	Guava	1	Uttar Pradesh (1)	1
18	Indian mustard	11	Bihar (1), Chattisgarh (3), Haryana(1), Jharkhan(4), Rajasthan(1), Uttar Pradesh(1)	6
19	Kidney bean	1	Jammu and Kashmir (1)	1
20	Lentil	7	Bihar (2), Jammu and Kashmir (1), Jharkhand (4)	3
21	Maize	7	Himachal Pradesh (3), Jharkhand (1), Rajasthan(2), Uttarakhand(1)	7
22	Neem	1	Maharashtra(1)	1
23	Okra	1	Maharashtra(1)	1
24	Orchid	4	Meghalaya(4)	1
25	Pigeon pea	10	Assam(1), Jharkhand(2),Madhya Pradesh (1), Maharashtra(1), Rajasthan(1), Telangana(1), Uttar Pradesh (3)	7
26	Rapeseed	9	Assam(3), Jharkhand (2), Tripura(1), West Bengal(3)	4
27	Rice	1700	Andaman and Nicobar (5), Assam(16), Bihar (5), Chhattisgarh (360), Gujarat(1), Haryana(1),Himachal Pradesh (1), Jammu&Kashmir(1), Jharkhand(116), Kerala(21), Madhya Pradesh (48), Maharashtra(3), Manipur(12), Odisha(767), Punjab(1), Sikkim(1),Tamil Nadu (6), Tripura(6), Uttar Pradesh (6), Uttarakhand(5), West Bengal (318)	21
28	Sesamum	1	Uttar Pradesh (1)	1
29	Small cardamom	6	Kerala(6)	1
30	Sorghum	18	Karnataka(2), Madhya Pradesh (5), Maharashtra (6), Telangana(2), Tripura(2), Uttarakhand (1)	6
31	Soyabean	5	Madhya Pradesh (5)	1
32	Tetraploid cotton	1	West Bengal (1)	1
33	Tomato	3	Bihar(2), Chattisgarh(1)	2
34	Wheat	24	Bihar(1), Jharkhand (7), Madhya Pradesh(5), Rajasthan (2), Uttar Pradesh (6), Uttarakhand(2), West Bengal (1)	7
	All crops	1894		

Note Figures in parentheses indicate number of plant varieties

have potential to aid in inclusive as well as sustainable agricultural development. However, there is need for ground level intervention with respect to each individual agricultural GI in terms of creation of producer group, value chain creation, establishment of quality standards and review of standards from time to time. Similarly, in the case of rights under PPV&FR Act, to enable the farmers to have their share in benefits, their varieties need to be characterised and special characteristics like biotic or abiotic stress tolerance, nutritional richness need to be documented for their use in future breeding programs. Competition and pricing behavior of private sector in seed industry more specifically with respect to protected varieties under PPV&FR Act need to be monitored continuously. These actions will accelerate the realization of inclusive and sustainable agricultural development under the current IPR regime in India. Registration under Indian GI act is only the first step towards realizing economic potential of agricultural GIs. Registering these GIs in other countries need to be taken up for realizing market potential through trade. India has to decide on the route to do this.

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Patent landscape for Internet of Things (IoT) in agriculture in India

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Abstract Innovative digital technologies have huge potential to provide solutions for the many complex problems in agriculture. IoT based technological applications are now been accepted even by small hold farmers for judicious use of resources with precision and better predictability. With improved digital infrastructure across the country, the agritech startups offer innovative IoT based smart solutions addressing the problems of farmers. Many such agritech startups have made their mark in the market with their own patented technologies. In this paper patent analytics is used to measure the current status, emerging trends in technology development in IoT landscape for agriculture applications and growth prospects of agritech startups. States of Karnataka, Maharashtra, Tamil Nadu and Telangana with favorable startup policies see greater concentration of these agristartups.

Keywords Internet of Things, patents, agritech, startups

JEL codes O 34, O 31, O 13, M 13, Q 16

Introduction

The concept of IoT or 4th Industrial Revolution interconnects physical things offering Human to Machine (H2M) communication over the existing model of Machine to Machine (M2M) communication. A study by (Mackinsey 2015) has estimated the potential economic impact of IoT to be $ 4.0 trillion to $ 11 trillion by 2025 with large number of applications in health care, manufacturing, power, urban security, vehicles and agriculture. In the market, Google has spent $5.5 billion in acquiring IoT based companies like Nest, Boston Dynamics, Waze and Dropcam indicating the importance of IoT based technologies (LexInnova 2014). In such a dynamic and lucrative, competitive market, protection of intellectual property (IP) by the creators and owners becomes vital and often an important business strategy to enter the markets (Kock Michael 2013). Any assessment of the IP landscape becomes an important exercise for the players specially the startups before entering this market (Teixeira and Ferrerira 2019).

In recent years increased acceptance of digital technologies by the stakeholders in agriculture including farmers is attracting attention of policymakers, industry and even startups (Coble et al. 2018; DiPrinzio et al. 2018; Waltz 2017). Leveraging the use of platform based IoT for solutions across each point of agri-value chains has been found to be more remunerative and also sets in the judicious use of resources with precision and better predictability (Khanna and Kaur 2019; Verma et al. 2019; Ojha, Misra and Raghuwanshi 2015). Of late, smart agriculture practices are being adopted by many farmers even in third world countries including India (Kangogo, Dentoni and Bijman 2021). This system of automated and directed information technology applied with the IoT is essentially a combined approach with internet and wireless communications, Remote Monitoring System (RMS) etc. with applications for better and precise use of inputs at targets and predict better outputs leading to advisories on price and profitable decisions at market levels (Ayaz et al. 2019).

Thus, these technologies have potential to boost the efforts in improving the supply chain, marketing and productivity ultimately leading to Doubling Farmers Income and improved economic stimulus to agriculture under Atma Nirbhar Bharat. The Government of India (GoI) is encouraging private investments in agriculture. With the government support and improved digital infrastructure, the agritech startups bring innovation with the combination of new-age technologies such as the Internet of Things (IoT), data analytics, artificial intelligence (AI) and remote sensing and offer solutions addressing the pain points of farmers (Anupam Anand, and Saravanan 2019: Ernst & Young 2020; Murray 2020). Many of these agri startups are making their mark with their own patented technologies (Inc42's Startup Watchlist 2020).

Patent informatics is now a well-known tool for analysis of patents for making assessments about emerging technology (Jaffe and Trajtenberg 2002). It can be regarded as an important indicator of the broader path of innovation in an emerging field as patents reveal information about inventors as well as type of inventions and their applications (Gupta et al. 2020, Kalpana, Shrivastava and Rao 2013). Patent analysis has often been used to measure current status, emerging trends in technology development and for future strategic planning for the growth of organizations (Aristodemou and Tietze 2018; Hullmann and Meyer 2003).

The present study was undertaken to (i) depict the trajectory of IP landscape of the IoT based patents in agriculture in the Indian context, and (ii) upcoming Agritech startups holding IoT based patents and their growth prospects.

Methodology

Patents related to internet of things applications in agriculture are collected from Patentscope, the World Intellectual Property Organization (WIPO) database (wipo.int/patentscope/en/). A set of subject specific keywords and standardized search strings are identified; standardized search strings made with truncation, appropriate Boolean operators and identified keywords to perform search of patents (patent title, abstract, claims). The WIPO guide which identifies, explains large number of perceptions on patent analysis and methodology on how to track the different types of analysis on patent data was studied (Trippe 2015).

Retrieved relevant records[1] were then subjected to full text search of patents (patent title, abstract, claims and description) and scrutiny through International Patent Classification (IPC). IPC is a hierarchical classification system used primarily to classify and search patent documents according to the technical fields they pertain. It is a very powerful tool for searching patent related databases enabling the user to locate the appropriate technology in the search. All the search results are combined and duplicates are removed, and temporary work sheet is exported is CSV format. A set of patent documents are retrieved belonging to 128 patent families for India. Only one priority member per FAMPAT family is analyzed i.e. each patent represents one priority document of the respective patent family. FAMPAT is the worldwide collection of patents grouped by invention based families containing bibliographic information, full text and legal status. The patent search data is up to 13th November, 2020. The data on investment raised by startups having patents in different IoT applications were collected from various sources.

Results and discussion

Leading countries with IoT patents in agriculture

It was observed that about 2835 patent publications with the keywords ("Internet of Things" OR "IoT") AND ("Agricultur*" OR "Farm*") are spearheading the IoT technologies in agriculture worldwide.

The patenting activity seems to be more concentrated with China, and United States of America. Figure 1 depicts the leading countries with China at the top with 62% patents followed by US with 20% patents. India is contributing to about 4.8% patents. About 8.7% patents are the PCT filings indicating the interest of the R&D players growing in various geographical markets. Kshetri (2017) and Friedman (2014) report the leading position of China in IoT technologies.

Patent time line analysis

Globally the patenting activity in the IoT based applications in agriculture started in 2011 but more actively from 2014 onwards (LexInnova 2014). In

[1]Include all filed patent documents.

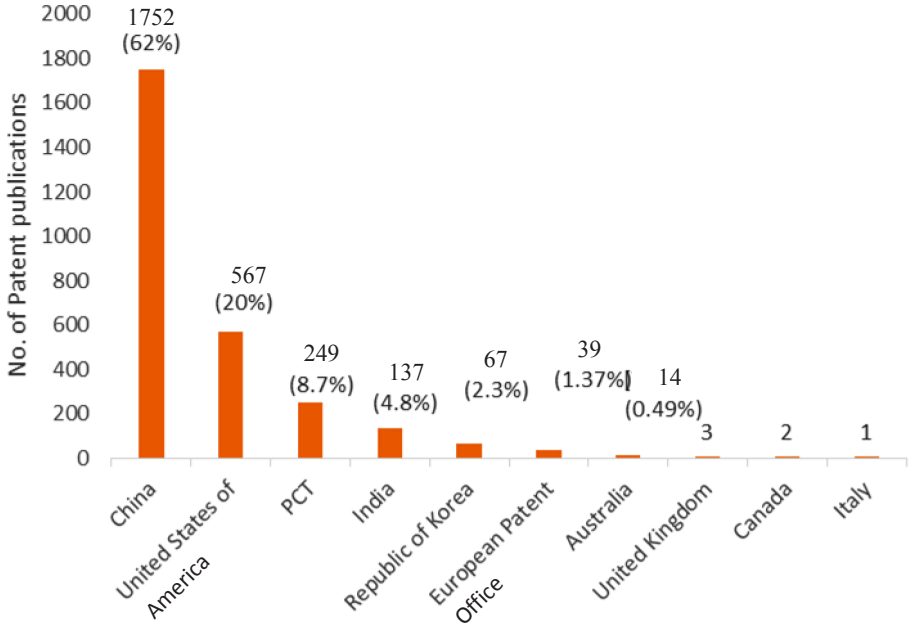

Figure 1 Distribution of agriculture/farm related IoT based patents in earliest priority country (n=2835)

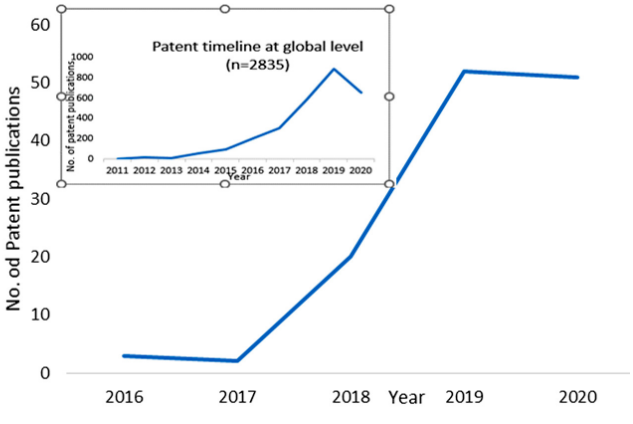

Figure 2 Yearly filing of patent (n= 128, one priority document per family) in India, inset shows yearly filing trend at global level

India, patents with IoT applications in agriculture sector started in 2016 and is rising in accordance with the global trend as shown in Figure 2. About 137 patents were found through WIPO database Patentscope, which was screened and of this, 128 relevant patents were analysed.

Taxonomy of patents

Seamless incorporation of IoT and the wireless sensors in smart agriculture has raised agriculture to newer levels. It was found maximum patents in Resource Management followed by Crop Monitoring and Pest Management (Figure 3).

About 42% of the patent applications represent in the area of resource management including soil sampling and mapping. The distance and depth for sowing the seed efficiently can be decided using IoT based sensors and vision -based technologies. Many traditional farming issues, like yield optimization, drought response, land suitability, irrigation, and pest control can be improved with the IoT based solutions and practicing smart agriculture techniques.

About 13% patents represent crop monitoring and 7% in pest management. The usage of pesticides by growers are slashed significantly by using these IoT based intelligent devices e.g. wireless sensors, robots and drones, with precise spotting of crop enemies. In comparison to traditional farming practices modern IoT-based pest management provides real-time monitoring, modeling, disease forecasting thus proving to be more effective. Patent applications in the area of Veterinary/Dairy, Prediction & Green houses are between 5-3% each. An IoT-based greenhouse remotely monitor the inside parameters viz humidity, temperature, light, and pressure etc.

Top Assignees

Figure 4 shows the distribution of top 10 assignees in the IoT based patents in agriculture sector. Applicants

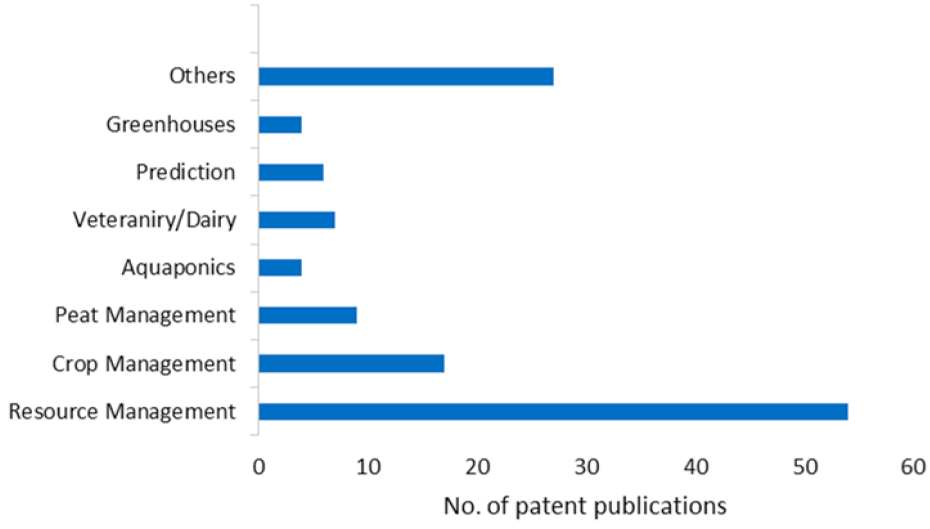

Figure 3 Categorization of IoT based patents in agriculture (n=128)

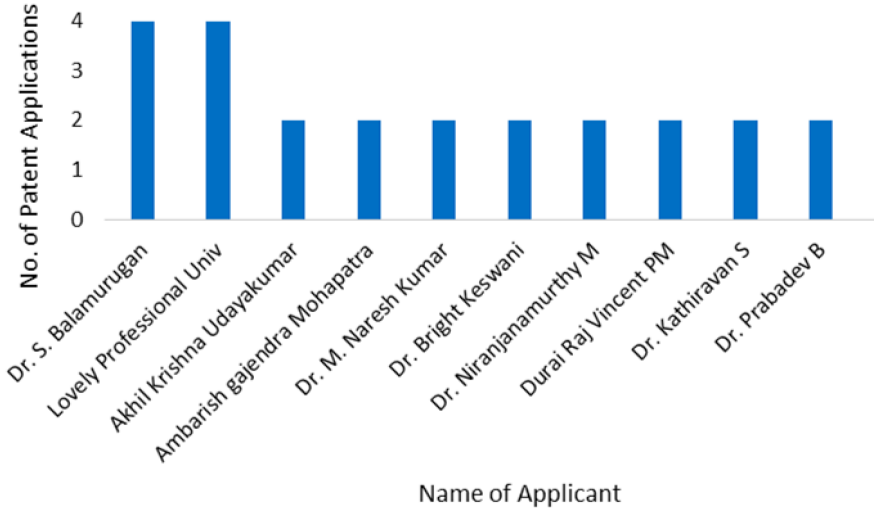

Figure 4 Top 10 Assignees in IoT application in agriculture (n=102)

Dr. Balamurugan and Lovely Professional University are at the top with 04 patents each followed by many applicants with individual patents. Dr. Balamurugan's patent No. IN283299301 is for "IoT based security system and method for smart agriculture", IN296579954 is "IoT based intelligent pesticide man machine system for agricultural purposes", IN297816610 is "IoT and cloud based agricultural data management system and method for effective planting and breeding", IN300871671 is about "system and method of smart drones for smart farming". The patents filed by Lovely Professional University, Punjab is mainly IN283300055, IN283164479 for "Smart surveillance system for water distribution in agriculture field". IN283165823 is about "farm assist: an intelligent farmer assistant for selling crop" and IN283176894 is" an IoT enabled system for plant health monitoring system and image processing".

Distribution of IPC codes

The distribution of the patents is mainly in the IPC A01G, G06Q, H04L & G01N indicating the patents applied in the technology areas of horticulture, floriculture, data processing systems, forecasting etc. (Table 1).

Table1 Distribution of the Patents in the IPC Codes

S.No.	IPC	No. of patents	Technology description
1.	A01G	41	Horticulture, cultivation of vegetables, flowers, rice, fruit, vines, seaweed, forestry, watering
2.	G06Q	22	Data processing systems or methods, adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes
3.	H04L	17	Transmission of digital information
4.	G01N	10	Investigating or analysing materials by determining their chemical or physical properties
5.	A01B	9	Soil working in agriculture or forestry, parts, details or accessories of agricultural machine or implements
6.	G05B	8	Control or regulating systems in general, functional elements of such system, monitoring or testing arrangement of such systems or elements
7.	A01C	7	Planting, Sowing, Fertilizing
8.	A01K	5	Animal Husbandry, agriculture, apiculture, pisciculture, fishing, rearing or breeding animals
9.	H04W	5	Wireless communication networks
10.	A01M	4	Catching, trapping or scarring of animals, apparatus for destruction of noxious animals or noxious plants

IoT based startups in agritech

The patent landscape of IoT patents in agriculture in India shows that the number of patents filed in India are majority from individual inventors. This has resulted in many startups emerging in this sector with innovative ideas (Lim, Kwon and Lee 2018). The entrepreneurial landscape of India has grown and is presently the 3rd leading startup ecosystem especially due to the support of the Startup India Scheme, Ministry of Commerce and Industry, GoI and NITI Aayog's Atal Innovation Mission. As per the (NASSCOM July 2019) report there are about >450 agri-startups in India, every 9th agritech startup in the world is from India. Agritech in India is continuously attracting interest from startups and investors. The key target segments of majority of Agritech startups are Big Data analytics, Farming as a service, Market linkage models and IoT. As the Agritech ecosystem is maturing in India, significant growth in terms of investments is observed. Some of the prominent investors in the Agritech sectors are Omnivore, CIIE.CO, Accel, Ankur Capital, Kalari Capital, Aavishkaar Capital, Menterra etc. (Ernst & Young 2020, NASSCOM Report 2018).

Indian Agritech startups have received the investment of $ 1.7 billion in 2014-19 compared to $0.2 billion in previous five years (Ernst & Young 2020). International investors are investing about 80% of the capital, which attracted Indian investors who are now ready to invest in such startup innovations for better profitability. The funnel concept of investment usually starts with wide pool of potential investors and narrow down to that worth reaching out to. But, the investment pattern in agritech startups is "Bloated-in-the-Middle" investment funnel rather than broader at the mouth of the funnel indicating the absence of investment prospects in initial stages, absence of innovative business models or the emerging Agtech ecosystem is struggling to create a quality pipeline. Due to this gap funding, the startups are taking lengthier time to reach the metrics that investors expect for deploying large amount of capital, as business models take longer period to show traction. Growing trends in four key subsectors i.e., DownstreamAgTech (solutions to optimize the output supply chain and creating linkages with the end consumer), UpstreamAgTech (improving input access for the farmers through digitalization of the input supply chain) , PrecisionAgTech (use of digital data to target smart farming) and AgFinTech (novel solutions to enable easy financing and insurance) is highlighted in the report of Think Ag 2020.

Precision AgTech includes companies either exclusively software-led or coupled with IoT devices to collect data. These startups offer solutions in farm management, remote sensing, traceability, digital grading, and "Uberization" of farm services. Funding deal in 2017/2018 primarily focused on IoT and market

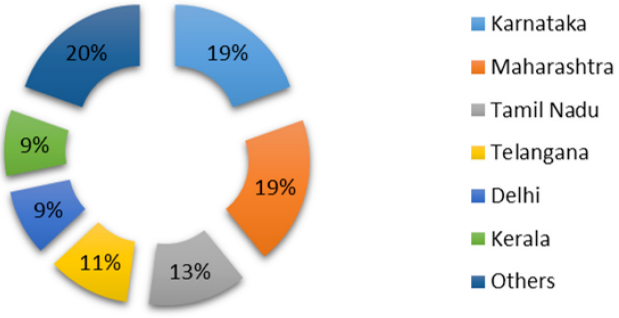

Figure 5 State-wise representation of IoT startups in agritech sector (*Source* Startup India website Accessed on 20th Feb.2020)

linkage platforms. Recently NITI Aayog has initiated a pilot project on precision agriculture using Artificial Intelligence in 10 districts from seven states. Similarly, Agri open data portals have been launched by states of Telangana, Tamil Nadu, and Maharashtra. Karnataka has collaborated with IBM for forecasting pricing of agricultural commodities using AI and ML technologies.

There are about > 1500 IoT based startups in India and out of this only 5% are in the agritech sector. The state wise data indicates that Karnataka and Maharashtra are the most prominent hubs of supporting startup ecosystem having 19% of startups in each, followed by Tamilnadu and Telangana with 13 & 11% of IoT based agri startups.(Figure 5) The aggregation of the agri startups in the southern part of India may also be partially due to the favorable policies and conducive ecosystem of the Agribusiness incubators such as aIDEA, ICAR-NAARM, Villgro, ICRISAT, C-CAMP etc. nurturing the early–stage enterprises having high growth potential.

Recently, many agritech startups holding patents have attracted investments from venture companies. Table 2 shows few such innovative startups.

Table 2 Promising IoT based Indian Agristartups holding patents

S.No.	Startup	Area	Patent No.	Investment
1.	AgNext Chandigarh	Precision farming, hyperspectral imaging	IN201931006934 IN201731027171	$21mn
2.	Stellapps Pune/Benguluru	Dairy supply chain digitization via IoT	3018/CHE/2013 3020/CHE/2013 3026/CHE/2013	$14mn
3.	Cropin Benguluru	Precision agriculture	-	$8mn
4.	Intello labs Benguluru/Gurgaon	Supply chain with AI & IoT platforms	IN201947032826	$5.9mn
5.	Fasal Gurgaon	Climate Smart Precision Agriculture	-	$1.6mn
6.	Krishitantra Udipi	IoT based device for soil testing	IN201941032268 IN201841041790	$1mn
7.	Hydrogreens Benguluru	Micro climate –controlled fodder grow house	IN201941051982	Prize grant (undisclosed)
8.	Poultrymon Hyderabad	IoT based platform for poultry	IN201841012716	$0.135
9.	SNRAS Systems Pune	Blue box- Re-circulatory aquaculture system	IN201921026336	Boot Strapped
10.	Bariflo Labs Benguluru/ Bhuvanewswar	AI & IoT Aeration device for aquaculture	IN201831031000 IN320950-001 IN320950-003	Boot Strapped

Source Indian Patent Office and others

AgNext is a precision agriculture startup working on the juncture of hardware, software, and analytics for quality estimation in food and agriculture. Accelerated by aIDEA, ICAR-NAARM and incubated at IIT Kharagpur, AgNext has raised funding from impact venture Omnivore and recently has received $21 million Series A funding from Alpha Wave Incubation. Stellapps, an IoT based dairy farm solution firm, has raised $14mn from Bill & Melinda Gates foundation and IndusAgePartners. Gurugram based startup Intello Labs provides image analysis-based solutions for agri product grading, recently raised Series A funding from Saama Capital. The agristartup Fasal uses its AI-powered IoT-SaaS platform to help the farmers. The platform captures real-time data of the crop from on-farm sensors and delivers farm-specific, crop-specific actionable advisories to farmers via mobile in vernacular languages. Fasal, got seed funding led by Omnivore Ventures and Wavemaker Partners in 2019. Krishitantra for soil testing received seed funding of Rs. 4.00 Cr. from NAB Ventures and Omnivore.

Conclusions

In last few years, Agri Startups have got a boost from the Government of India and the recent reforms announced in the agriculture are expected to revolutionize the sector. Penetration of the digital technologies such as IoT & AI, blockchain etc. has enabled many startups to venture into agriculture and receive support from investors for scaling and helping the farmers. This study provides insights about the distribution of IoT based patents in agriculture sector in India. It shows the emergence of innovative agristartups holding the IoT based patents with applications in precision agriculture, dairy, fisheries etc. From a geographical perspective, it is interesting to highlight the concentration of these startups in the states of Karnataka, Maharashtra, Tamil Nadu and Telangana having favorable startup policies.

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Analysing the effectiveness of crop insurance scheme as an adaptive strategy against climate change in Himachal Pradesh

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Abstract Using the data from different altitudes of Himachal Pradesh, present study analyses the effectiveness of crop insurance scheme, which is not only restricted to simple comparison of costs and returns, but also incorporates the application of standard treatment effect model to analyse the selection bias, if any, prevalent in the model. The findings revealed that crop insurance couldn't bring much difference in the income of farmers. Only, little difference of 2.5% has been observed in tomato, mainly due to the credit that has helped them to invest more in quality inputs and thus, bringing higher returns. The study suggests for an effective improvement in the system to safeguard the interests of the farmers.

Keywords Crop insurance, insured, non-insured, treatment

JEL codes Q12, Q18, Q58

Climate change is speeding up, and this, together with rising income levels and population, poses a challenge to global food security. India has reasons to be concerned about climate change (Garg et al. 2009) because a large portion of its population relies on different climate-sensitive sectors. Indian agriculture is one of the most vulnerable and exposed to climate change (Birthal and Hazrana 2019; Datta, Behera, and Rahut 2022), owing to a lack of adaptive capacity to deal with the consequences of the climate change (Birthal et al. 2014). Climate change impact combined with other risk factors has created a crisis situation in Indian agriculture (Kanwal, Sirohi, and Chand 2022; Nadkarni 2022); as a result farmers' suicides are being reported in most of the states. This necessitates the need for a broad spectrum of policy responses and strategies at different levels.

Crop insurance is one among the anticipatory adaptation measures proven worldwide as an effective institutional mechanism to overcome the adverse impacts of climate variability. It helps in stabilization of farm production and income through promoting technology, encouraging investment, and increasing credit flow in the agriculture sector of the farming community (Jain and Dharmaraja 2018). Although, crop insurance, in general, has not been so successful in India (Gulati, Terway, and Hussain 2018) and is mostly prevalent in the southern states of the country. However, the northern regions of the country have a very low enrolment ratio under the scheme. North Himalayan ecosystems are among the most vulnerable to climate change around the world. They have rugged topography along with the limited livelihood choices, financial constraints, limited land for cultivation and are highly susceptible to the natural disasters (Negi et al. 2017; Tewari, Verma, and Gadow 2017). This calls for an effective institutional mechanism that can safeguard the interests of the farmers in these regions.

Various crop insurance studies conducted in India have brought inconsistent outcomes, for instance, positive impact has been witnessed in the state of Andhra Pradesh (Kumar and Babu 2021), Tamil Nadu (Varadan and Kumar 2012); while it has failed to meet the expectations in Gujarat (Bahinipati 2022). However,

no such attempt has been made too far to assess the efficiency of crop insurance in one of the most susceptible states of Himachal Pradesh. The outcomes of a simple comparison between insured and non-insured farmers may be biased due to the influence of several unobservable factors (Kishore 2019). Keeping this into consideration, the present study analyses the effectiveness of crop insurance scheme across different altitudes of the Western Himalayan ecosystem by keeping into consideration the selection bias.

Data and descriptive statistics

Study area

The present study has been conducted in Himachal Pradesh state of India. Being a part of Himalayan mountain ecosystem, the state is especially vulnerable to climate change, and all its attendant adverse effects (Bisht et al. 2018). The state is located at the foothills of the western Himalayas, with over 89% of the population living in rural areas (Statistical Abstract of Himachal Pradesh 2019-20) where people have comparatively lower rates of technology adoption and modernization. Agriculture, which employs roughly 70% of the working population and accounts for nearly 22% of the total state domestic product, is the primary source of income for communities residing in the state (State Performance Report 2020-21). Small and marginal farmers own 88.86% of the total land holdings, while rainfed agriculture accounts for nearly 80% of the total cultivated area in the state (Himachal Pradesh Economic Survey, 2020-21). Extreme weather conditions along with inability of the people to cope up with the situation renders the state as one of most vulnerable ecosystems.

Being primarily an agrarian state, which is highly prone to natural disasters; Himachal Pradesh needs a robust crop insurance system. However, the number of farmers covered under crop insurance is comparatively very low in the state. According to the report of Comptroller and Auditor General of India (CAG), 2017, less than 2% of farmers in Himachal Pradesh were covered under the crop insurance scheme during the period from 2014 to 2017. Moreover, farmers benefited under PMFBY scheme ranged between 1.64 and 15.92% in *Kharif* season and between 0.80 and 36.40% in *Rabi* season of the total farmers in different districts. Thus, in order to address the various issues which are hindering the adoption and successful implementation of the schemes in the state, it is imperative to analyse the effectiveness of crop insurance scheme in Himachal Pradesh.

Sampling

Multistage stratified random sampling has been done to select the farmers for the collection of primary data. Presently, two crop insurance schemes viz., Pradhan Mantri Fasal Bima Yojana (PMFBY) and Restructured Weather Based Crop Insurance Scheme (RWBCIS) are operative in the state. Both the schemes cover different kind of crops in the state. PMFBY covers the major foodgrain crops while; RWBCIS covers the major fruit and vegetable crops. Since, the present study is concerned with one agricultural year; therefore, only vegetable crops, covered under RWBCIS, have been taken into account. The present research aims to study the usefulness of crop insurance scheme as an adaptive measure against the ill-effects of climate change. As, altitude of a place governs the climate of a region, therefore, firstly the districts where all the three altitude ranges (low hills (upto 1000 m amsl), mid hills (1001-1500 m amsl) and high hills (1500 - 2500 m amsl)) exist are selected. Among them, those districts which are having maximum number of farmers covered under the crop insurance are selected.

Overall, a total of four districts i.e. two districts under each crop insurance scheme have been selected. Kangra and Mandi districts have been selected to represent Pradhan Mantri Fasal Bima Yojana (PMFBY), as these districts together shared more than 80% of the insured farmers, among the districts possessing all the three altitudes. Similarly, under Restructured Weather Based Crop Insurance Scheme (RWBCIS), Solan and Sirmour districts have been selected as both of them were collectively covering more than 80% of the total insured farmers under the scheme and possess wide elevation range across the districts.

Selection of farm households

All the blocks of selected districts have been classified into three strata based on major portion under the above mentioned three altitudes. Thereafter, one block has been selected randomly from each stratum of each selected district, making up a total of 12 blocks from 4 districts. From each block, 3 villages have been selected randomly. Out of each village, 5 insured and 5 non-insured farmers have been selected randomly, thus, a

Table 1 Crop-wise coverage of farmers under different crop insurance schemes in Himachal Pradesh (2018-19)

Pradhan Mantri Fasal Bima Yojana (PMFBY)			Restructured Weather Based Crop Insurance Scheme (RWBCIS)		
Crops	Number of farmers enrolled	Percentage to total	Crops	Number of farmers enrolled	Percentage to total
Wheat	86823	49.86	Tomato	9540	79.40
Maize	70710	40.60			
Total	174149	100	Total	12015	100

Source Department of Agriculture, Shimla, Himachal Pradesh (2020-21)

total of 30 farmers have been selected from each of the 12 blocks selected from 4 districts. The total sample comprises of 360 farmers (180 insured and 180 non-insured farmers).

Selection of crops

In order to assess the effectiveness of crop insurance scheme, major insured crops of the study area under each scheme have been selected. On the basis of number of farmers covered under the scheme; tomato crop has been selected under RWBCIS while, wheat and maize have been selected under PMFBY (Table 1).

Table 1 Crop-wise coverage of farmers under different crop insurance schemes in Himachal Pradesh (2018-19)

Descriptive statistics

In order to assess the effectiveness of crop insurance scheme, the cost of and returns from the major insured crops have been compared with the non-insured crops using cost concepts given by Commission for Agricultural Cost and Prices (CACP) as Cost A_1, Cost A_2, Cost B_1, Cost B_2, Cost C_1, Cost C_2, Cost C_2^* and Cost C_3.

- Cost A_1 : It includes :

1. Value of hired human labour
2. Value of hired and owned bullock labour
3. Value of hired and owned machine power
4. Value of seed
5. Value of manures and fertilizers
6. Value of mulch
7. Irrigation charges
8. Expenses on plant protection chemicals
9. Depreciation
10. Land revenue
11. Interest on working capital
12. Insurance premium
13. Miscellaneous expenses

- Cost A_2 : Cost A_1 + rent paid for leased-in land, if any.
- Cost B_1 : Cost A_1 + imputed value of interest on owned fixed capital (excluding land).
- Cost B_2 : Cost B_1 + rental value of owned land (net of land revenue) + rent paid for leased-in land.
- Cost C_1 : Cost B_1 + imputed value of family labour.
- Cost C_2 : Cost B_2 + imputed value of family labour.
- Cost C_2^* : estimated by taking into account value of labour at statutory minimum wage rate or actual wage rate, whichever is higher.
- Cost C_3 : Cost C_2^* + 10% of cost C_2^* as management cost.

The net returns computed at Cost C3 and yield of selected crops grown on insured farms are compared with that of non-insured farms and the difference between the two is examined statistically using t-test.

Empirical strategy

Differences in the net income between the insured and non-insured farmers cannot be attributed wholly to the adoption of crop insurance scheme. It may be due to a variety of unobservable factors (such as better farming

experience, management skills etc.) that could contribute to a difference in the profit margins as well. Hence, a simple comparison of the net income may be biased and therefore, a standard treatment effects model has been used to correct this bias. In a regression framework, the treatment effects model is given by:

$$R_i = a + bC_i + cX_i + \mu_i \quad (1)$$

Where, R_i is the net revenue of i^{th} farmer for respective crop, C_i is dummy variable taking the value 1 if one adopts crop insurance and 0 otherwise, X_i is vector of the variables believed to affect the net income and μ_i is zero mean random variable. An OLS estimate of equation (1) is likely to be biased because of the effects of unobservable factors. Hence, two-stage Heckman procedure is used to correct for the bias from the endogeneity of right hand side variables. In the first stage, following adoption equation is considered:

$$C_i = \gamma_1 + \gamma_2 Z_i + \mu_i \quad (2)$$

Where, C_i is a binary variable (1 for adopters of crop insurance and 0 for non-adopters) and Z_i is a vector of explanatory variables influencing the adoption. Variables in Z_i will overlap with variables in X_i. Identification requires that there should be at least one variable in Z_i that is not in X_i. If this condition is met, the predicted value from equation (2) can be used as instrument for C_i in the second stage of the model i.e. regression equation (1). Thus, from equation (2), inverse Mills ratio (IMR) is estimated and has been used as an instrument in equation (1) which would yield a consistent estimate of b.

Results and discussion

Comparison of costs and returns from selected crops

The input-use pattern and returns realized from selected crops have been worked out separately for insured and non-insured farmers (Table 2). The above results conclude that not much difference has been witnessed between the proportional spending of insured and non-insured farmers. However, insured farmers spend more on farm inputs while non-insured farmers spend more on labour costs. Thus, they are found to realize comparatively more returns than the non-insured farmers. Overall comparison for all the three crops have revealed that comparatively more returns have been realized for the insured farmers in all the three cases. The difference in the yield of insured and non-insured farmers is found to be significant in case of maize and tomato crops, whereas, it is insignificant for the wheat crop. However, difference in the net returns (at cost C3) of the insured and non-insured farmers is insignificant for maize and wheat crop, while it is observed to be significant for the tomato growers. Further, it has been observed during the survey that majority of the insured farms were of large size as compared to the non-insured farms, while most of the insured farmers were loanee farmers, i.e. those who have taken crop loans. This may conclude that by one or the other way; insurance has benefitted the farmers. Overall, insured farmers invest comparatively more on high valued inputs to increase production, while non-insured farmers rely more on labour.

Treatment effect model for correcting the bias

A simple comparison of average returns between the insured and non-insured farmers could be biased due to the presence of variety of other unobservable factors (such as better farming experience and management skills, etc.). Thus, to consider this bias, standard treatment effects model have been used.

Factors influencing the adoption of crop insurance scheme

First stage of the model corresponding to the equation 2, involving the estimation of probit model to identify the factors that influenced the farmer's decision to participate in crop insurance scheme for all the selected crops is given in Table 3. The results indicate that probability of adoption of crop insurance scheme is higher for those who are KCC holders and have availed crop loan. This is due to the fact that till *Kharif*, 2020; it was mandatory for the loanee farmers to get compulsory insurance.

Besides this, size of the land holding and farming experience of the respondent also have a positive influence on the adoption of crop insurance scheme. The second stage of this approach involves a standard treatment effects model using predicted probabilities from the probit model as an instrumental variable, with net revenue per hectare from crop cultivation as the dependent variable.

After having accounted for the selection bias, effect of crop insurance on net income of the farmers has been

Table 2 Comparative analysis of costs and returns from selected insured and non-insured crops (2019-20)

Particulars	Wheat				Maize				Tomato			
	Insured		Non-insured		Insured		Non-insured		Insured		Non-insured	
	Cost	% of total	Cost	% of total	Cost	% of total	Cost	% of total	Cost	% of total	Cost	% of total
Variable cost												
Human labour (Hired)	1313	5.58	1361	5.75	707	3.89	1100	5.98	5273	8.54	5332	8.71
Human labour (Owned)	3063	13.03	3175	13.41	2357	12.97	2568	13.96	19319	31.29	19508	31.85
Machine labour	6795	28.91	6878	29.05	5705	31.40	5589	30.39	7817	12.66	7923	12.94
Seed	2228	9.48	2181	9.21	2491	13.71	2184	11.87	11884	19.25	11272	18.41
Manures and fertilizers	6470	27.53	6386	26.97	4605	25.35	4583	24.91	8023	13.00	7838	12.80
Plant Protection Chemicals	2311	9.83	2364	9.98	1201	6.61	1265	6.88	4974	8.06	4970	8.12
Miscellaneous	859	3.65	868	3.66	739	4.07	744	4.05	3479	5.63	3447	5.63
Interest on Working Capital	466	1.98	468	1.97	360	1.98	361	1.96	967	1.57	952	1.55
Sub-total	23504	100	23682	100	18166	100.00	18394	100.00	61736	100.00	61242	100.00
Fixed cost												
Insurance premium	450	3.76	0	0.00	600	5.02	0	0.00	5000	34.64	0	0.00
Land revenue	31	0.26	31	0.28	31	0.26	31	0.28	31	0.22	31	0.35
Rental value of owned land	7477	62.55	7422	67.49	7471	62.53	7458	67.36	5324	36.88	5145	58.41
Depreciation	2196	18.37	1936	17.61	2240	18.75	2124	19.18	2479	17.18	2159	24.51
Interest on fixed capital	1799	15.05	1608	14.62	1605	13.44	1459	13.17	1600	11.08	1474	16.73
Sub-total	11954	100	10997	100	11948	100	11072	100	14434	100	8808	100
Total cost at Cost C3	35781		34994		30383		29729		76900		70719	
Yield of main product (qt/ha)	31.34		30.90		28.88		27.71		298.75		294.01	
Yield of by-product (qt/ha)	43.24		42.64		49.09		47.77		0		0	
Price of main-product (Rs/qt)	1975		1975		2000		2000		1162.85		1157.77	
Price of by-product (Rs/qt)	500		500		100		100		0		0	
Gross returns (Rs/ha)	83520		82344		62671		60204		347401		340401	
Cost of production at cost C3(Rs/qt)	846		839		970		988		255		238	
Net Returns (Rs./ha) over Cost C3	47739		47350		32288		30475		270501		269682	

Note The difference between the yield of insured and non-insured farmers is statistically significant at 5% for maize and tomato crops, while difference between the net returns at Cost C3 is significant only for tomato crop)

Table 3 Probit estimates for determinants of adoption of crop insurance for selected crops

Dependent variable: Adoption of crop insurance scheme (Yes=1; No=0)

Crops	Wheat		Maize		Tomato	
Independent variables	Coefficient	Marginal effect	Coefficient	Marginal effect	Coefficient	Marginal effect
Age of the respondent (years)	-0.008	-0.002	-0.020***	-0.004	-0.005	-0.001
	(0.013)	(0.003)	(0.014)	(0.003)	(0.022)	(0.004)
Total owned land holding (hectares)	0.135***	0.028***	0.147*	0.030*	0.262*	0.045*
	(0.025)	(0.004)	(0.026)	(0.005)	(0.056)	(0.008)
Years of education	0.172**	0.035***	0.164*	0.034*	0.157	0.027
	(0.023)	(0.003)	(0.023)	(0.004)	(0.032)	(0.004)
Farming experience (years)	0.106***	0.022**	0.105*	0.022*	0.115**	0.020*
	(0.015)	(0.002)	(0.016)	(0.003)	(0.025)	(0.004)
Other income source dummy (yes=1; no=0)	-0.222	-0.045	-0.278	-0.058	-0.292	-0.050
	(0.226)	(0.046)	(0.229)	(0.047)	(0.311)	(0.053)
KCC holder dummy (yes=1; no=0)	0.767***	0.157***	0.688**	0.143**	0.224*	0.038***
	(0.291)	(0.058)	(0.293)	(0.060)	(0.420)	(0.072)
Constant	-5.103		-4.304		-4.946*	
	(0.683)		(0.638)		(0.927)	
Number of observations	307	295	195			
LR chi^2	200.5	188.85	149.98			
Prob>chi^2	0.0008	0.000	0.0000			

Note Figures in parentheses are standard errors; *, ** and *** indicate significance at the 1% , 5% and 10 %, significantly.

Table 4 Results of the outcome equation for the selected crops

Dependent variable: Net returns from wheat cultivation (Rs/hectare)

Crops (→)	Wheat	Maize	Tomato
Independent variables	Coefficient	Coefficient	Coefficient
Total owned land holding (hectares)	0.0003*	0.0037***	0.0014***
	(0.0013)	(0.0011)	(0.0024)
Farming experience (years)	0.0010**	0.0008*	0.0009*
	(0.0007)	(0.0005)	(0.0010)
Family size (Number of family members	0.0025	-0.0017**	-0.0102*
	(0.0038)	(0.0031)	(0.0061)
Major occupation dummy (agriculture=1, otherwise=0)	-0.0281	0.0048	-0.0161
	(0.0114)	(0.0093)	(0.0168)
Insurance dummy (adopters = 1, non-adopters = 0)	0.0044	0.0199	0.0255***
	(0.0126)	(0.0099)	(0.0193)
Inverse Mills ratio (IMR)	0.0033	-0.0031	0.0113**
	(0.0101)	(0.0082)	(0.0137)
Constant	4.616***	4.524***	5.386*
	(0.0378)	(0.0296)	(0.0543)
Number of observations	307	295	195
Prob>F	0.0076	0.0005	0.0003
R-squared	0.199	0.245	0.2341

Note Figures in parentheses are standard errors; *, ** and *** indicate significance at the 1%, 5% and 10 %, significantly.

estimated for all the selected crops (Table 4). The results of the outcome model suggest that Inverse Mills Ratio (IMR) is statistically significant only in the case of tomato crop, thus, implying that selection bias was prevalent in the model and has been corrected. Further, adoption of crop insurance positively influences the net returns from tomato cultivation i.e. it increases the net returns of tomato growers by 2.5%. However, size of the land holding and farming experience with the farmer are positively related with the net returns of all the selected crops, irrespective of their enrolment under crop insurance scheme.

Conclusions

Himachal Pradesh, being highly prone to natural disasters, needs an effective crop insurance system. However, besides having a low enrolment ratio in the state, the benefits availed from crop insurance are also below the mark. Findings of the study have shown that being a KCC holder has been identified as the most important variable influencing the adoption of crop insurance scheme, mainly due to the earlier provision of compulsory registration of the loanee farmers. Moreover, crop insurance led to a marginal increase of 2.5% in the net returns of tomato crop, while an insignificant impact has been witnessed in case of wheat and maize crops. Overall, the results indicate towards the inefficiency of crop insurance scheme in the state, thus, necessitating the need of government intervention in order to improve its effectiveness, particularly in north Himalayan states, which are under the ultimate risk of climatic vulnerability.

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Effectiveness of contract farming: evidence from cultivators of onion in Maharashtra

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Abstract The present paper attempts to quantify the benefits of contract farming on farmers' income and examines the determinants of participation in contract farming. The study is based on a survey of 180 farmers engaged in cultivation of onion. The study reveals that contract farming, by connecting smallholders to high-end international markets, ensures them with higher returns to the tune of Rs. 12.5 per kilogram. Access to institutional credit, extension services, farm-size, own transport, and migration significantly affected farmers' participation in contract farming.

Keywords Contract farming, onion, income,

JEL codes M11, M12, I38

Contract farming (CF) has played important role in promoting modernization and commercialization of agriculture, globally. It has long been well established in the developed countries; and has been receiving considerable attention in developing countries. Contract farming has come up as a key component in the process of agricultural transformation that facilitates direct firm-farm linkages. Contract farming may help farmers in overcoming the high transaction costs in marketing of their produce. It provides farmers with opportunity for non-spot transactions, which are useful when the transaction costs are high or markets fail. Markets fail due to factors like imperfections in credit market, economies of scale in transportation and marketing, asymmetric information about market prices, and lack of capacity for smallholders to absorb risk. Further, spot markets, mainly due to problems of asymmetric information, have lower ability to deliver efficient solution to quality and food safety issues than CF. A number of studies show that CF can increase agricultural productivity, profitability, farmers' income, and reduce food insecurity (Kumar et al. 2016). Even though potential benefits of CF are considered significant for both contractors and contracted, particularly when quality and safety are critical issues, its role and possible impacts in the developing countries are still controversial. A contentious issue in CF is the threat of exclusion of smallholders, particularly when the higher transaction cost, along with stringent demand for quality and safety, may prevent participation of small and marginal farmers in CF. India has gone through significant rural transformations and institutional changes that have shaped today's agricultural sector and agricultural policies. According to Chand (2005), CF's benefits to smallholders, who represent about 80% the rural population, include access to credit, inputs, and extension services; another benefit is the linkage between input markets and providers and the international markets by organizing the production of high-value food crops (HVF).

The evidence of CF's impact in the context of India has been mixed. For instance, Dev and Rao (2005), Nagaraj et al. (2008), Kumar and Kumar (2008), Birthal, and Joshi (2006), Singh, and Singh (2005), Birthal, (2005), Kalamkar (2012) and Kumar (2006) all found that contract producers earned more profits than independent producers, due to higher yields and

assured output prices. On the other hand, Singh (2002) found negative impact of CF on the environment, welfare of farmers, and the power structure between contractors and farmers. This study is aimed at identifying the factors that motivate farmers' participation in contract farming and also assesses its impact on farmers' economic welfare.

Methodology

The study is based on the data from a survey of 180 farmers cultivating onion. The survey was conducted in Maharashtra during 2018. The list of contract farmers in Nashik and Jalgaon districts was obtained from a contracting firm (henceforth the sample firm). Farmers from Jalgaon had formal contracts for the production and supply of white onions with Jain Farm Fresh Foods Limited. Contract onion farmers were from Vadali, Pasardi, Nashirabad Wakadi and Shirsoli villages. Independent farmers were selected from Nashik district, adjacent to the Jalgaon district. Nashik is the largest onion-producing district, contributing more than 25% of the state onion production. Jalgaon and Nashik are located in the same agro climatic zone i.e. Western Maharashtra Scarcity Zone. Data were collected from 90 contract onion growers and 90 independent onion growers. For selection of independent farmers, we randomly identified three blocks from Nashik district, namely Lasalgaon, Niphad and Sinnar, and a sample of 30 farmers was drawn from each block. Then we selected five villages from each block. Finally, we chose sample households in proportion to the village population for detailed investigation.

The econometric analysis conducted to identify the factors which motivate farmers' participation in contract farming and to assess impacts of contract farming on the farm profitability. We estimated OLS and 2SLS regressions. We employed a 2-Stage Least Squares (2SLS) model with instrumental variables: (i) to examine the impact of factors associated with a farmer's willingness to opt for contract farming (in the first stage of regression); and (ii) assessed the impact of participation in contract farming on farmers' profitability (in the second stage of regression). The equation for the 2SLS regression is $\pi i = \alpha + \delta di + \gamma Xi + \varepsilon i$ (1) where, πi is the net profit per kg for a farm household involved in cultivation of onion, di is a dummy variable that equals 1 if a farmer is under contract and 0 if not under contract, Xi is a vector of farmer characteristics and εi is the error-term.

Results and discussion

Characteristics of contract and independent sample onion growers

Table 1 presents average values of key household characteristics of onion farmers.

The average age of farmers 47 years and 97 % of the households are male-headed. Contract farmers are more educated. Farming is the main occupation for almost all households. There is little difference in farming experience of contract and independent farmers. The average size of family farmers is around 6. The average farm size is 1.8 ha. About half of onion farmers have access to institutional credit. One third of sample farmers are members of a cooperatives.

Close to 71 % of onion growers have their own means of personal transport. Some characteristics exhibit significant differences between contract and independent farmers. For example, contract and noncontract farmers of onion differed in terms of education, operational holding size, access to institutional credit, membership of cooperatives, crop insurance, number of annual visits by private extension official and own means of personal transport;

Table 2 presents data on yield, production cost, output prices, and profits of both contract and independent onion farming households.

The average onion yield is higher for contract growers (243.2 qtl/ha) than noncontract producers (192.6 qtl/ha) and it differs significantly at 1 per cent level. Additionally, the average price realized by onion contract farmers (Rs. 815.5/qtl) is significantly higher vis-à-vis noncontract farmers (Rs. 690/qtl). The cost of onion cultivation is significantly lower for contract farmers (Rs. 595/qtl) than non-contract farmers (Rs 766/qtl). The higher yields, better prices and lower cost of production for contract farmers made onion cultivation more profitable. Further, the prices for onions had crashed in open market due to increased production in 2018. Therefore, the independent onion growers incurred a loss of Rs 75/qtl. The contract farmers got cushion against price fluctuation due to price fixed in contract and earned a profit of Rs 220/qtl.

Table 1 Household characteristics of farmers

Household characteristics	All	Contract	Independent	difference	t-statistic
Age household head (years)	47.5	45.5	48.3	-2.8	0.6146
Gender -head (%) (male=1, otherwise=0)	99.8	100.0	99.8	0.2	0.4214
Education -head (years)	9.4	11.2	9. 2	2.0***	5.2335
% farmers with farming as main occupation (%)	99.5	100.0	99.4	0.6	0.7778
Experience in farming (years)	20.0	21.9	20.9	1.0	0.7738
Household size	5.8	6	5.7	0.3	0.4947
Dependency ratio	0.62	0.56	0.64	0.08	0.7410
Operational land (ha)	1.8	3.1	1.4	1.9***	7.0284
Access to institutional credit (%)	49.6	69.4	46.1	23.3***	4.1185
Membership of cooperative or other organization (%)	30.2	51.2	24.7	27.1***	5.4185
Crop insurance (%)	5.6	21.8	1.5	20.3***	7.8921
No of visits per annum by Private companies	1.8	5.9	0.9	5.0***	10.2567
Own means of personal transport (%)	69.9	65.4	74.5	9.1**	2.6334

Source Field survey
Notes ***, ** and * represent significance at 1%, 5% and 10% levels, respectively.

Table 2 Economics of cultivation of onion for contract and independent farmers in Maharashtra

Economics of cultivation	All	Contract	Independent	Difference
Yield (q/ha)	199.8	243.2	192.6	50.6***
	(75.6)	(75.7)	(74.02)	
Price (Rs/q)	752.7	815.5	690.0	125.5***
	(190.3)	(392.5)	(888.6)	
Cost of production (Rs/q)	680.5	595.2	765.8	170.6***
	(220.3)	(185.2)	(244.3)	
Profit (Rs/q)	72.25	220.3	-75.8	296.1***
	(272.5)	(289.6)	(246.7)	

Source Field survey (2016)
Notes ***, ** and * represent significance at 1%, 5% and 10% levels, respectively. Figures in bracket represent standard deviation.

Determinants for farmers' participation in CF

Table 3 presents the results of the first stage of 2SLS regression that shows the determinants of farmers' participation in contract farming for onion cultivation. Farm size, access to institutional credit, number of visits by government extension official, number of visits by private extension official, and own personal transport, have significant positive influence on participation in contract farming. On the other hand, migration of household members has negative impact on participation in contract farming.

Impact of contract farming on farmers' profit

Table 4 shows results of the impact of contract farming on profits of onion cultivators. It gives outcomes of the second stage of 2SLS regression along with OLS regression. Unlike OLS regression, the 2SLS regression takes care of the unobserved factors in regression and gives true impact of CF on farmers' profit. The results in Table 4 show that contract farming has a significant positive impact on the profits. The participation in contract enhances farmers' profit by Rs 12.5/kg. Migration has negative impact on the profits.

Table 3 Determinants for onion farmers' participation in Contract farming

Dependent variable: Participation in contract farming (yes=1/no=0)

Variable	Coefficient	S.E.
Socio-Demographic variables ln(Age of the household head) (Years)	-0.151	(0.895)
Square of ln(Age of the household head)	0.0231	(0.129)
Gender of household head (Male=1, 0 otherwise)	0.0820	(0.0890)
ln(Years of education of the household head)	-0.0384	(0.0673)
Square of ln(Years of education of the household head)	0.0173	(0.0218)
ln(Number of economically active family members)	0.00612	(0.0175)
Migration (Yes=1, 0 otherwise)	-0.119***	(0.0501)
Ln(Operational land) (Ha)	0.0364**	(0.0168)
Own personal transport (Yes=1, 0 otherwise)	0.0847**	(0.0428)
Economic variables		
Main occupation (Farming=1, Other=0)	-0.00185	(0.135)
Access to institutional credit (Yes=1, 0 otherwise)	0.0752***	(0.0229)
Ln (No. of visits by government extension officer)	0.0670**	(0.0314)
Ln (No. of visits by private extension officer	0.0348**	(0.0160)

Table 4. Impact of contract farming on profits for onion cultivators in Maharashtra

Dependent variable: Unit profit in production of onion

Variable	OLS		2SLS	
	Coefficient	S.E.	Coefficient	S.E.
Contract Farming (Yes = 1, 0 otherwise)	1.728***	(0.330)	13.51**	(4.950)
Socio-Demographic variables				
Ln(Age of the household head) (Years)	-41.43	(32.43)	-42.33	25.70)
Square of ln(Age of the household head)	5.512	(4.148)	6.554	(3.550)
Gender of household head (Male=1, 0 otherwise	-2.612	(3.237)	-3.662	(4.550)
Ln(Years of education of the household head)	-0.411	(1.335)	0.155	(1.554)
Square of ln(Years of education of the household head)	0.8599	(0.847)	0.688	(0.812)
Ln(No. of economically active family members)	0.781	(1.301)	0.655	(1.169)
Migration (Yes=1, 0 otherwise)	-7.789*	(3.180)	-6.548*	(2.325)
Ln(Operational land) (Ha)	0.188	(0.494)	-0.292	(0.778)
Own personal transport (Yes=1, 0 otherwise)	-2.853*	(1.347)	-5.010	(1.899)
Economic variables				
Main occupation (Farming=1, Other=0)	5.988	(3.195	6.125	3.145)
Access to institutional credit (Yes=1, 0 otherwise)	0.145	(0.521)	-0.621	(0.695)
Ln (No. of visits by government extension officer)	0.818	(1.231)	-0.195	(0.621)
Ln (No. of visits by private extension officer)	1.743	(0.910)	1.254	(0.741)
No. of observations				
R-squared	0.224		0.178	
Root MSE	13.987		13.828	

Source Authors' analysis based on field survey (2016)

Notes Standard errors in parentheses; ***, ** and * represent significance at 1%, 5% and 10% levels, respectively.

Conclusions

This paper has assessed determinants of participation in contract farming and estimates its impact on profits. Access to institutional credit, extension facility, ownership of transport, and farm size has positive effect on farmers' participation in contract farming. The contract farmers earn significantly higher profits. The higher profit comes mainly from higher yield and lower cost of production along with assured price. These findings have several important policy implications. The benefits of contract farming are product and contract specific, and therefore policymakers should design appropriate strategies and mechanisms to promote Contract farming in several agricultural commodities, especially in high value crops. A need is suggested for better institutional mechanism to make contract farming more inclusive and sustainable.

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Annexure

Table A.1 The economics of cultivation of onion by sample contract and independent farmers

(Rs per ha)

Particulars of cost of cultivation	Contract	Independent	Difference
Labour	24,865	20,770	4,095***
Inputs			
Seed	11,890	21,150	-9,260***
Fertilizers	14,755	13,120	1,635*
Irrigation	30,952	28,630	2,322
FYM	6,250	9,244	-2,994***
Pesticides	10,450	12,921	-2,471***
Other costs	0	22	-22
Rent for bullock pair / machinery	7,510	10,880	- 3,370***
Marketing costs	9,544	9,741	- 197
Total cost of cultivation	116,216	126,478	- 10,262**

Source Field survey (2018)

Notes ***, ** and * represent significance at 1%, 5% and 10% levels, respectively.

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Beyond production: how can diversification enhance farm income in the North-Eastern region of India?

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Abstract Raising the production and productivity in agriculture and improving the level of living of smallholders is a major challenge for the planners and policy makers in Tripura. Due to dominance of ultra-small landholdings the traditional farming may not be sufficient for raising income. The present study captures the nature and extent of crop diversification through Simpson index using data obtained from 400 farm households. Further, it identifies the determinants of crop diversification and its role in augmenting farmers' income. The results show diversification as pivotal in augmenting farm income.

Keywords Diversification, farm income, Simpson index, cropping pattern, Tobit model

JEL codes Q12, Q15, Q18, Q19

Introduction

Doubling farmers' income by 2022 is the main thrust of the Government of India since the Prime Minister of India set the target in 2016. Odisha is the only state where the income has doubled during the last decade. In other states, farmers' income has increased but not doubled (Chandrasekhar and Mehrotra 2016).

Crop diversification is one of the approaches to enhance agricultural productivity and increasing farmers' income (Lama 2019). Several researchers have articulated the need for crop diversification to improve farm productivity and boost smallholders' income (Bigsten and Tengstam 2011; Birthal et al. 2008; Jha 2001; Vyas 1996). Some studies (Sharma 2007; Mondal and Bezbaruah 2013; Lama 2019) have identified a positive impact of crop diversification on farmers' income. The north-eastern region of India consists of eight states, which account for about 8% of the country's geographical area. The north-eastern region has a limited cultivable area because of hilly topography. In such circumstances, crop diversification toward high-value crops is a means of enhancing farmers' income. Tripura is the third smallest state in the country, having the highest population density. About 75% of the state's rural population is engaged in agriculture. Crop farming is the main activity, accounting for about half of the household' income (Ranganathan 2013).

Crop diversification towards high-value crops may be a strategy in Tripura also. The magnitude of crop diversification at the macro-level is moderate. The productivity of different crops is low, but the share of high-value crops like fruits and vegetables in gross cropped area is increasing. Further, there is not much improvement in the cropping intensity, indicating that crop diversification is basically shifting from one crop to another instead of bringing additional land under cultivation.

The forces for crop diversification can be numerous including reduction in production and market-related risks, arresting depletion of natural resources, enhancing farm income, increasing cropping intensity, minimizing migration, engaging female farmers in income generating activities, and managing insect, pest and weed problems (Acharya et al. 2011). The present study is an attempt to answer the following questions:

Is crop diversification taking place in Tripura? Who is diversifying? Is crop diversification towards high-value crops or food grains? Is crop diversification improving farm household income? What are the factors responsible for crop diversification?

Methodology

We have followed mixed method of data collection covering the entire Tripura state. Secondary information was collected from all the districts, while primary information was collected from respondents following multistage sampling. The sampling plan has been designed to select a representative sample of district, subdivision, block, village and households covering all the areas in the state and in probability proportionate to different size groups. At the first stage we have selected all four districts (before 2012) purposively. At each subsequent stage, we randomly selected one subdivision followed by one block and two villages. Thus a total of eight sample villages were selected, and final respondents were selected in probability proportionate to different size categories within a village. It is to be noted here that there was not a single large farmer in the selected villages.

Primary data were collected from 400 farm households through personal interview during 2016-17 (Table 1). Primary data includes both quantitative and qualitative information based on long-term experiences of the households as crop diversification analysis requires both qualitative and quantitative information of the households over time. The data were collected from the sample households on various aspects related to farming and farm households.

To capture the extent of crop diversification, we used Simpson diversification index (SI) the most suitable measure of diversity (Joshi et al. 2004). In fact SI is derived from the Herfindahl Index (HI):

SI =1- HI

$$H.I. = \sum_{i=1}^{N} P_i^2$$

Where, N is the total number of crops grown by a particular farmer and P_i represents the proportion of area under i^{th} crop in the gross cropped area. Its value is bounded by zero and one. With the increase in diversification, the Herfindahl index would decrease. The index value is one when there is a complete specialization and approaches zero as N gets large, i.e., if diversification is perfect.

In order to identify determinants of crop diversification, a Tobit model has been used. The available literature provides the possible determinants to crop diversification. These include agro-climatic conditions, capabilities of the farmers, resource endowments of the farmers, compulsions, risks, profitability and infrastructural facilities available with the farm farmers as well as within the locality. Initially, we have tried the regression model with many explanatory variables. However, due to the problem of multi-collinearity required to drop several variables like age of the farmer, distance from agricultural market, amount of crop loan availed, land-man ratio, membership to social bodies, etc. We have also tried with the share of non-farm income (NFARM) instead of per-capita non-farm income (PCNF), and amount of credit (LOAN) instead of access to credit (CREDIT). But PCNF gave better test statistics than NFARM, and similarly CREDIT than LOAN. We have tried the model with different combinations of these variables but chose the

Table 1 Sampling frame

Sampling stage	Numbersof units	Sampling technique	Selected units			
Districts	4	Purposive	North	Dhalai	West	South
Sub-Divisions	One from each district	Random	Panisagar	Long Tarai valley	Kishangarh	Udaipur
Blocks	One from each sub-division	Random	Jubarajnagar	Manu		Kishangarh Malabari
Villages	Two from each block	Random	Jubarajnaga, Zhang	Panama, Taichung	Nabinagar, Jaipuijala	Portia, Jowalikhamar
Households	400 (50/ village)	PPS	50	50	50	50

combination which gave the best fit to our model.

Since the dependent variable (SI) is bounded between 0 and 1, an ordinary regression model is not suitable as the predicted value from a linear model will not necessarily be contained within the interval of 0 and 1 (Roy et al. 2018a). Even a logit transformation may not be appropriate, under such context, because in a cluster of observations the dependent variable takes the value of 0 (mono-cropping). Therefore, a Tobit model is used to avoid any information loss (see Kumar et al. 2012; Mondal and Bezbaruah 2013). The model is formulated with the help of a latent variable Y_j^*, which can take any possible value but is not always observable. The observed dependent variable Y_j (i.e., SI) is linked to the latent variable. The Tobit model used is:

$Y_j^* = \beta_i X_i + \mu_i \qquad \mu_i \ 4 \ N(0, \sigma^2)$ i=1, 2, 3,....., n

$Y_j = Y_j^* \quad$ if $Y_j^* > 0$

$Y_j = 0 \quad$ otherwise

where Y_j^* is the unobserved latent variable (linked with Y_j), Y_j is the observed censored dependent variable (representing SI), β_i represents the vector of parameters and X_i represents a vector of exogenous explanatory variables. The random disturbances μ_i are assumed to be independently and normally distributed with zero mean. The model was estimated by Maximum Likelihood Estimation (MLE).

The coefficients of Tobit model (β_i) need to be interpreted in a slightly different way than OLS estimates, as it tells us the linear effect of an explanatory variable on the uncensored latent variable (Y_j^*), rather on the observed outcome (Y_j). The β coefficients are not the effect of X_i on Y_i rather a combination of the change in Y_i of those above the limit, weighted by the probability of being above the limit, and the change in the probability of being above the limit, weighted by the expected value of Y_i.

Further, we have examined how crop diversification helps raise farm and total household income. Accordingly, we estimated two models: Model-I and Model-II. In Model-I the dependent variable is family income, and in Model-II the dependent variable is farm income. In both models, the set of explanatory variables kept unchanged. The impact of crop diversification on household total income and farm income has been explored through a linear multiple regression model.

$I = \tau_0 + \tau_i Z_i + \mu_i$

where I is the dependent variable. τ_i represents a vector of parameters associated with Z_i a vector of explanatory variables. The explanatory variables include SI, amount of loan, percent area under irrigation, education of the head of the family, percent area under high value crops, family size, distance from market, farm size and farm category dummies. The model has been estimated by ordinary least square (OLS) technique.

Results and discussion

Descriptive statistics

Table 2 shows a wide variation across the farm categories in land-man ratio, cropping intensity and area under irrigation. The net irrigated area is 27.80% varying from 11.18% on medium farms to 33.86% on marginal farms. The table also shows a very unfavorable land-man ratio (0.13) for marginal farmers and less than 100% per cent cropping intensity for medium farmers. It indicates that a large portion of land owned by the medium farmers remains uncultivated.

Table 2 Basic characteristics of sample households in Tripura

Category	Average family size	Average operated area (in ha)	Landman ratio	Cropping intensity	Net irrigated area (%)	Education of head of family (years)	Market distance (in km)
Marginal	4.86	0.62	0.13	151.59	33.86	5.87	4.79
Small	5.14	1.47	0.28	113.38	21.36	5.12	6.34
Medium	4.43	2.85	0.64	77.79	11.18	5.60	10.56
Total	4.39	1.10	0.22	132.64	27.80	5.61	5.83

Source Author's own calculation

Table 3 Size category-wise income of sample farmers in Tripura

Farm category	Districts				Tripura (Overall)
	North Tripura	South Tripura	West Tripura	Dhalai	
Total household income (Rs./household)					
Marginal	76540.00	55696.66	62476.56	73690.47	66708.01
Small	157924.32	165984.37	187810.00	128167.31	160970.80
Medium	140553.85	101062.50	65416.66	172272.72	129557.89
Overall	114974.00	94618.00	100253.00	98698.50	102135.87
Total farm income (Rs./household)					
Marginal	49806.00	40531.66	42278.12	50471.43	45602.11
Small	108348.64	110250.00	117083.33	85501.92	106179.60
Medium	84992.30	64875.00	43750.00	129090.91	87010.52
Overall	76041.00	64789.00	64808.00	68227.50	68466.37
Share of farm income (as % of total income)					
Marginal	65.07	72.77	67.67	68.49	68.36
Small	68.60	66.42	62.34	66.71	65.96
Medium	60.46	64.19	66.88	74.93	67.16
Overall	66.14	68.47	64.64	69.13	67.03

Source Author's own calculation

The average annual income of sample household is low; Rs. 102136. A perusal of the Table 3 reveals that the share of farm income in the total family income is more or less uniform across districts. On average, two-thirds of the total household income is derived from farm enterprises. Average household income is highest in North Tripura and lowest in South Tripura. So is the case with average farm income. However, one distinctive feature is that, barring in Dhalai district, average farm income, as well as family income, is the highest for small farmers and the lowest for marginal farmers.

Nature and extent of diversification

We captured the nature and extent of crop diversification through three measures viz: average number of crops grown per farmer, cropping pattern and changes therein and use of crop diversification indices. Farmers grows many crops. In all the districts and among all categories of farmers, the average number of crops grown has increased substantially during the last 10 years. This shows a very encouraging trend towards crop diversification (Table 4). Further, it is evident that almost all the groups of farmers have

Table 4 Average numbers of crops grown in Tripura

Farmer groups	Average numbers of crops grown									
	North		South		West		Dhalai		Total	
	Past	Present	Past	Present	Past	Present	Past	Present	Past	Present
Marginal	3.70	6.34	2.72	4.63	2.53	4.95	2.38	4.58	2.83	5.19
Small	3.24	6.55	2.81	6.47	2.67	6.73	3.12	5.92	2.96	6.29
Medium	2.76	6.07	2.62	5.25	2.50	5.16	4.94	5.64	3.20	5.52
Overall	3.41	6.50	2.74	5.27	2.59	5.50	3.48	5.07	3.05	5.63

Source Author's own calculation

Note Past means 10 years earlier

Table 5 Cropping pattern across different farm size groups in Tripura

Crops	Share in total cropped area (%)			
	Marginal farmers	Small farms	Medium farms	Overall
Jhum	1.49	6.15	6.17	4.24
Paddy	57.41	42.87	30.37	46.75
Oilseeds & pulses	3.66	1.87	0.47	2.37
Vegetable	18.25	12.98	6.04	13.98
Fruits	3.35	10.66	12.74	8.00
Nuts & Plantation	15.83	25.48	44.21	24.63
Total	100.00	100.00	100.00	100.00

Source Author's own calculation

increased the numbers but with varying rates. However, small farmers are the main agents in this process.

The cropping pattern is highly diversified. Though the share under paddy is the highest (Table 5). What is encouraging is that the share of high-value crops like fruits, vegetables and nuts is quite high and has been increasing. Small farms are the most diversified towards high- value crops.

Crop diversification is presented in Table 6. Crop diversification should not be measured only in terms of a number of crops or cropping patterns but on the degree of reliance on multiple crops. It is pertinent to mention here that, the value of the Simpson Index changes with the change in level of measurement. For example, in a situation where individual farmers are practising mono-cropping (but different crops), their level of diversification at household level will be zero, but at an aggregate level (village/district/state), it may represent a diversified cropping system. Therefore, while drawing conclusions based on the Simpson Index's value, the measurement level is very important.

The average value of Simpson Index is more than 0.5. The household-level crop diversification varies across districts and size categories of farmers. It varies from 0.59 in North Tripura to 0.43 in Dhalai. The crop diversification index for South Tripura and West Tripura is 0.48 and 0.57, respectively. The reason for a lower level of crop diversification in South Tripura and Dhalai is that many farmers in these districts are practicing mono-cropping with either paddy or plantation crops.

Across farm categories, the value of Simpson Index is the highest on small farms and in all the districts.

Determinants of crop diversification

Results of the censored regression (Tobit) model are presented in Table 7. The model produced a reasonably good fit as indicated by Log Likelihood, McFadden

Table 6 Crop diversification index at household level in Tripura

Farmer groups	Simpson Index									
	North		South		West		Dhalai		Total	
	Past	Present	Past	Present	Past	Present	Past	Present	Past	Present
Marginal	0.31	0.59	0.34	0.41	0.41	0.52	0.28	0.40	0.33	0.48
Small	0.27	0.61	0.31	0.60	0.40	0.68	0.27	0.53	0.34	0.61
Medium	0.39	0.56	0.42	0.48	0.43	0.54	0.39	0.34	0.40	0.48
Overall	0.33	0.59	0.34	0.48	0.41	0.57	0.28	0.43	0.34	0.52

Source Author's own calculation

Note Past means 10 years earlier

Table 7 Determinants of crop diversification in Tripura

Explanatory variables/ particulars	Dependent variable: SI (Simpson Index of crop diversification)	
	Estimated co-efficient value	Standard error
Farm size (in ha)	0.0332	0.0226
Irrigation facilities (% area irrigated)	0.0027**	0.0003
Family size (Numbers)	0.0258**	0.0062
Access to Credit (Institutional=1; Otherwise=0)	0.1821**	0.0215
Tenancy (Owned cultivation=1; Otherwise=0)	0.0929**	0.0223
Caste (ST=1, Otherwise=0)	-0.0141	0.0192
Education of head of family (No. of years of schooling)	-0.0039	0.0030
Per capita non-farm income (thousand rupees/annum)	0.0091**	0.0013
Small Farm Dummy (Small farm=1,Otherwise=0)	0.1110**	0.0431
Marginal Farm Dummy (Marginal farm=1, Otherwise=0)	0.0609	0.0558
Dummy for North Tripura (North=1, Otherwise=0)	0.1068**	0.0255
Dummy for South Tripura (South=1, Otherwise=0)	0.0171	0.0233
Dummy for Dhalai (Dhalai=1, Otherwise=0)	-0.0295	0.0242
Constant	-0.0024	0.0790
Number of observations	400	
Log Likelihood	89.397	
McFadden Pseudo R^2	1.925	
F (13, 400) or LR χ^2 (13)	372.16	

** 1% level of significance, * 5% level of significance

Pseudo R^2, and Likelihood Ratio of χ^2. Further, all the estimated coefficients, except of caste and education, have expected signs, and most of them are statistically significant.

Irrigation turns out to be a significant determinant influencing farmer's decision toward crop diversification. Assured irrigation reduces production risk. High-value crops are riskier than traditional crops; thus, unavailability of irrigation may expose the farmers to higher risks. Further, in irrigated land, farmers can go for multiple crops. This is one of the critical reasons for the increase in area under vegetables. Provision of assured irrigation helps farmers in the cultivation of winter as well as summer vegetables.

Family size has a positive and significant impact on crop diversification. In hilly areas and in traditional societies, farming operations are done mostly manually. High-value crops are labour intensive.

Access to institutional credit induces farmers to cultivate more crops. Most of the farmers are resource-poor and are unable to borrow from non-institutional sources at a high rate of interest. A diversified cropping pattern requires more capital, quality inputs, and improved technologies. Such a cropping pattern, therefore, requires typically a large number of purchased inputs. Access to credit helps the resource poor farmers to arrange for such inputs. In line with our expectation, ownership cultivation leads to higher crop diversification than any other tenurial arrangements. Share cropping is basically concerned with subsistence crops rather than high value crops (Mondal and Bezbaruah 2013).

Non-farm income is found to have a significant and positive impact on crop diversification. Non-farm income helps farmers to invest more on farm machinery, HYV seeds, fertilizers and pesticides.

To know whether farm size influences crop diversification we have included dummies for different size categories. The coefficient on small farms is positive and statistically significant, but not in the case of marginal farms. The regression results also show

that caste has no relationship with crop diversification. Surprisingly, the coefficient on education is negative though it is statistically non-significant.

District dummies were incorporated to capture the influence of location-specific characteristics on crop diversification. Dummy for North Tripura is found to be positive and statistically significant, indicating a higher degree of diversification.

Crop diversification and household income

The relationship between crop diversification and household income is judged by comparing the average household income of mono-croppers (farmers with no crop diversification) with that of farmers with low level of crop diversification, moderate level of crop diversification, and high level of crop diversification (Table 8). Farmers are categorized into four groups i.e., complete specialization (SI=0), low diversification (SI=0.1 to 0.25), moderate diversification (SI=0.26 to 0.50), and high diversification (SI=.>0.50).

A close perusal of the table indicates a clear trend that, across all the districts, the farm income is invariably very low for farmers practicing mono-cropping. And, as the level of crop diversification increases, there is a commensurate increase in farm income.

Table 8 Level of crop diversification and farm income in Tripura

(in Rupees/household/annum)

Category	Level of crop diversification			
	Complete specialization (SI=0)	Low diversification (SI= 0.1 to 0.25)	Moderate diversification (SI=0.26 to 0.50)	High diversification (SI =>0.50)
North Tripura				
Marginal	11250.00	29600.00	38446.15	57011.76
Small	NA	NA	59150.00	117693.33
Medium	NA	36000.00	87766.66	78400.00
Overall	11250.00	32800.00	50818.18	85108.11
South Tripura				
Marginal	21690.00	39500.00	41894.73	46980.76
Small	NA	NA	81062.50	119979.16
Medium	45000.00	NA	NA	71500.00
Overall	25575.00	39500.00	53500.00	80892.86
West Tripura				
Marginal	36187.50	32500.00	43166.66	43390.69
Small	NA	NA	55925.00	126492.30
Medium	NA	60000.00	34200.00	42075.00
Overall	36187.50	41667.00	45641.17	72916.43
Dhalai				
Marginal	18438.09	35000.00	40881.25	84136.00
Small	10925.00	NA	60166.66	123266.66
Medium	105000.00	64000.00	136400.00	100000.00
Overall	24762.00	44667.00	62366.66	96989.74
Tripura				
Marginal	22343.90	34150.00	41131.66	55696.09
Small	10925.00	NA	64970.00	121521.51
Medium	75000.00	49000.00	108833.33	71566.00
Overall	26339.36	39100.00	54510.10	82369.83

Source Author's own calculation; NA=Not Applicable (No farmers)

It is important to examine the scope for enhancing farm or non-farm wage income through crop diversification and other interventions. This has been explored through a linear multiple regression model discussed in detail in the methodology section.

The results of regression analysis of determinants of rural household income in Tripura is presented in Table 9. The coefficient of Simpson Index is positive and statistically significant in the case of household as well as farm income. This suggests that apart from being a risk mitigation strategy, crop diversification can also be an essential strategy to augment income. This is because of diversification towards high-value crops like fruits, vegetables, spices, condiments, nuts, flowers, and medicinal plants.

Institutional credit has a positive and statistically significant impact. This implies that the availability of institutional credit can induce farmers to practice crop diversification towards high- value crops. Moreover, most of the farmers are resource-poor. Hence, credit availability from institutional sources may enable them to carry on farming operations better by providing them financial assistance to purchase the necessary inputs at a relatively lower interest rate. This eases their liquidity constraints to purchase modern farm inputs necessary for a diverse cropping pattern. The coefficient of irrigated area is positive and statistically significant only in Model-II. Access to irrigation is found to impact per hectare farm income positively. This is because access to irrigation facilitates farming in the rabi season and the use of high yielding varieties of seeds and chemical fertilizers, which in turn contributes towards an increase in the productivity of crops. Therefore, a positive relationship between irrigation and per hectare farm income is quite obvious.

Table 9 Determinants of rural household income in Tripura

Explanatory variables/particulars	Dependent Variables	
	Model-I Family income	Model-II Farm income
Simpson Index	94070.301** (17523.611)	45648.420** (11217.651)
Institutional Credit (in '000 rupees)	1.390** (0.374)	0.475* (0.239)
Irrigation facilities (% area irrigated)	148.824 (131.128)	94.156* (44.941)
Education of head of family (No. of years of schooling)	3188.235 (1123.334)*	733.373 (719.097)
Share of high value crops (% of GCA)	286.794* (116.450)	148.012* (74.545)
Family size (No of family members)	746.269 (2260.760)	1039.775 (1447.215)
Market distance (Distance of the nearest market in Km)	-173.374* (86.113)	-31.310 (279.816)
Small Farm Dummy (Small farm=1,Otherwise=0)	17879.100 (11509.901)	14906.930* (7368.007)
Marginal Farm Dummy (Marginal farm=1, Otherwise=0)	-62250.100** (11260.420)	-39231.600** (7208.301)
Constant	39677.890* (19531.340)	38705.390** (12503.021)
Number of observations	400	400
Adjusted R^2	0.444	0.396
F (9,399)	36.406	30.114

** 1% level of significance, * 5% level of significance, Figures in the parenthesis are standard errors

It is not surprising to see that education strongly affects household income but not farm productivity. In a traditional agricultural system, formal education may not have much role in the package of practices to be adopted, but lack of it definitely puts an entry barrier for many non-farm job avenues. The coefficient of education is positive and statistically significant at 5% level of significance. This may due to the fact that more educated individuals often seek opportunities in non-farm activities rather than getting engaged in low-paid wage activities. The coefficient of share of high value crops having positive and significant effect on family income as well as farm income. Rural infrastructure, particularly marketing infrastructure (proximity to town), is found to be significant determinants for enhancing per capita household income. Proximity (reverse of distance) to market or town gives rural farmers an opportunity for better livelihood outcomes in terms of earning higher incomes from the nearby cities or towns.

The negative and statistically significant coefficient for marginal farm dummy suggest that ceteris paribus, per hectare farm income as well as per capita household income is lower if a farmer belongs to marginal farm size category. This means that if land holding can be increased beyond one hectare there will be an increase in both farm productivity and household income. This will increase farm income and provide an opportunity for off-farm and non-farm employment through self-employment. One of the main problems in rural Tripura is over dependence on land based agricultural activities with very small size of holding. Due to population growth, sub-division and fragmentation of land holding is on the rise and average land holding is continuously declining. Therefore, consolidation of holding may be an important intervention to make farm units economically viable. The coefficient of constant is statistically significant, thereby implying that there are few other factors that determine the farm income as well as household income. The results are inconsistent with the findings of several studies (Birthal et al. 2005; Birthal et al. 2007; Joshi et al. 2003; Joshi et al. 2007; Mahmud et al. 1994; Minot and Roy 2007; Ryan and Spencer 2001; Hazra 1997; Pingali et al. 2005; Barghouti et al. 2005; World Bank 1990; Abro 2012; Abro and Sadaqat 2010; Ahmad and Isvilonanda 2003; Alam 2005; Pingali 2004; Vyas 1996).

Conclusion

Agriculture is the main source of income in rural Tripura, and it has been diversifying gradually towards high-value crops. This has led to higher farm income as well as household income, implying crop diversification is an important means to enhance income of small and marginal farmers. Other than crop diversification, availability of institutional credit, development of irrigation facilities, consolidation of land holdings, education and development of rural markets can augment farm and family income.

The future agenda for sustainable development of agriculture should focus on expanding irrigation, encouraging use of modern farm inputs; increasing cropping intensity; ensuring regular flow of institutional credit, and promoting crop diversification towards high-value crops.

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Impact of Custom Hiring Centres on farm profitability – some evidences from Tamil Nadu

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Abstract Custom Hiring Centres (CHC) are the trending institutional developments to boost the net income of the farmers. The study compares cost of cultivation, profitability and efficiency for farmers who availed machinery services from Government CHC and private individual farmers. The results indicated cost saving and higher yield for those availing machinery services from Government CHCs.

Keywords Custom hiring centres, profitability, farm mechanisation, technical efficiency

JEL codes O32, O43

Indian agriculture is upfronting scarcity of labour due to which there is a gradual shift from human labour and animal power to machine labour. The migration, which has significantly decreased the labour supply for agriculture, is the main cause of the labour shortage. Compared to human labour, machine power has become more cost-effective. Mechanization is crucial for achieving the goals of timeliness and effective use of natural resources. Farm mechanisation is essential for boosting rural income and agricultural output. The use of farm machinery not only boosts agricultural growth but also raises farmers' standards of living. According to World Bank estimates, half of the Indian population would be urban by the year 2050, and also percentage of agricultural workers in total workforce would reduce to 25.7% by 2050 from 58.2% in 2001. Thus, there is a need to improve the level of farm mechanisation in the country. Large landholdings require mechanical power more frequently than small and marginal land holdings. Their inability to acquire farm equipment is primarily a result of their financial situation.

Custom Hiring Centres (CHC) were established by the government to promote farm mechanisation through subsidies and to assist small and marginal farmers who are unable to afford to buy and maintain high-tech and expensive farm machineries in order to help them meet the availability of specific machinery for various operations. The Custom Hiring Centres are essentially a collection of farm machinery, implements, and equipment that farmers can rent on a hired basis. The Custom Hiring Centres were built as another institutional intervention to sustainably adapt to climate resilient technology. The primary goal of Custom Hiring Centres is to provide farm equipment to small, marginal, and low-income farmers on a rental basis at discounted rates, as well as to enhance the quality, boost crop production, and accelerate the timeliness and efficiency of agricultural operations. This makes it possible for small and marginal farmers to start their farming operations on time. In order to promote mechanisation, Government of Tamil Nadu has established 3536 CHCs during 2014-2022 for the benefit of small and marginal farmers.

Custom Hiring Centres: an overview

Early in the 19th century, custom hiring of farm equipment was first used in Indian agriculture, when a steam thresher with a 30-inch (diameter) was employed for special hire. The devices were transported to around 10 different locations, where they operated for two to three days a piece. Midway through the 1960s, when Agro-Industries Corporation (AIC) was established in the states, organised custom hiring was made to encourage the usage of agricultural machinery across several farms. From the 1970s to the 1990s, AICs largely focused on issues of land development and tillage operation and had not yet expanded to other significant field operations. When the Indian government introduced a plan to establish agro-services centres across the nation in 1971, the custom hire of farm equipment received an additional boost. Custom recruiting services were launched in the 1990s as part of national programmes known as NATP and NAIP. The manpower usage and technical competence of KVKs are harnessed in 2010 under NICRA, by bringing in 100 KVKs spread around drought/flood/ hill area and other challenging situations of agriculture, to popularise bespoke hiring services. The number of working days has decreased in modern times due to climate change and its effects, which include frequent droughts, heavy rainfall, and extreme weather events. Numerous new crop production systems and related equipment have gained popularity. Under the National Innovations in Climate Resilient Agriculture (NICRA) initiative, an ICAR Flagship Platform, CRIDA has taken the lead and developed more than 151 Custom Hiring Centres of farm equipment throughout all ecological areas in India. These Custom Hiring Centres were developed and are being run by numerous State Government Agencies, NGOs, and other entrepreneurs throughout the nation.

Sowmya *et al*. (2018) in her study on economic impact of CHC in maize cultivation in Karnataka revealed that the maize farmers have an additional profit and saved the cost of cultivation by availing services from CHC when compared to private individual farmers. The findings showed that CHC's performance in terms of net returns was determined to be negative, which was caused by the centres' dead investment. Custom hiring centres formed at block level and village level assisted in bringing the additional area of about 400 to 600 ha under cultivation in their operations and also found that the average income generated was varying from Rs.0.5 million to Rs.1.5 million. Murugesan (2019). Hiremath *et al.* (2015) assessed the performance of CHC established by PACS and it revealed that the private owners charge higher hiring charges compared to CHC and also helped the small and marginal farmers to increase the productivity and income to the extent of 10 to 15%. Subhash *et al*. (2020) in their assessment on custom hiring centres in Khandva district of Madhya Pradesh revealed that the CHC is 100% beneficial to farmers and 70% of the farmers were satisfied with the machinery of CHCs. The study analysed the distribution of land holdings, primary and secondary occupation, education level and problems faced by CHC owners. Ranjith *et al*. (2018) estimated breakeven analysis of Custom hiring centres in Karnataka. They revealed that all the machineries owned by farmers are capable of generating high incomes which are having greater demand from the users whereas some of the machineries owned by government sponsored CHC were unable to meet even fixed and variable cost.

The present study attempts to assess the economic impact of Government sponsored custom hiring centres in maize cultivation with the specific objectives (i) to estimate the economics and profitability of maize cultivation with respect to Government-led CHCs and private individual farmers, (ii) to study the economic performance of custom hiring centres, and (iii) to assess technical efficiency of maize cultivation by availing machinery services from different sources.

Data and method

Namakkal district was purposively selected for the study as it has maximum number of CHCs in Tamil Nadu. As maize is largely cultivated in the study area, it was purposively selected. Puduchatram and Namagiripet Block of Namakkal district were selected based on the highest number of CHCs in Namakkal district. 120 maize-growing farmers were chosen from Puduchatram and Namagiripet Blocks @ 60 per block. The respondents who had used CHC and private individual farmer services were chosen using the purposive random selection method. Regarding operations required for maize production, the degree of mechanisation was established. Farms that use machinery for land preparation, sowing, applying a base dose of fertiliser, harvesting, and threshing were classified as HMF (Highly mechanised farms). MMF

(Moderately mechanised farms) farms are those that use machinery for Land preparation, applying a base dose of fertiliser, harvesting, and threshing. LMF (Less Mechanised farms) refers to farms where only threshing and land preparation are automated. Farms were divided into two categories: those that used CHC services and privately owned farms. Primary information on the operation-wise labour and input utilisation in maize production was gathered through personal interviews for the agricultural year 2021-2022. The sources of mechanisation with hiring charges of mechanised operations were obtained from farmers. The custom hiring centre's economic performance was evaluated for the period of 2021-2022. The secondary data relating to investment made on purchasing equipment and tools, operational and fixed costs incurred for maintaining the centre, and profits produced from renting out equipment.

Profit function was estimated using profit realized per unit area as dependent variable and expenditure on human labour, machine labour, intercept dummy variables representing degrees of mechanization and sources of mechanization as independent variables in order to capture the influence of various degrees and sources of mechanization in maize cultivation.

$$Y = a + b_1X_1 + b_2X_2 + b_3D_1 + b_4D_2 + b_5D_3$$

Where, Y is the profit per hectare (Rs), X_1 is the expenditure on machine labour (Rs) and X_2 is the expenditure on human labour (Rs). D_1 is a dummy for HMF taking the value "1" and "0" for MMF and LMF

D_2 – Dummy variable represent MMF which takes the value "1" and "0" for HMF and LMF

D – Dummy variable represent sources of mechanization which takes the value "1" for CHC and "0" for private individual farmers.

b_1, b_2, b_3, b_4, b_5 are the regression coefficients and a – intercept.

Data envelopment analysis

It is a non-parametric approach to measure efficiency. The effectiveness of mechanized maize farms was evaluated in this model using variable returns to scale that were cost-effective input orientated method. Mechanized maize farms were regarded as a unit of decision-making. For each DMU, the cost-DEA efficiency score took into account the amount of maize produced per quintal (output), labour hours, man days, and machine hours, as well as the related unit costs (input). The DMU operating at 100% technical efficiency has an efficiency score of 1, while the DMU operating at a lower technical efficiency has a score below 1. The ability of the farm to produce the maximum amount of product with a specific set of inputs is referred to as its technical efficiency. The cost efficiency is the product of the technical and allocative efficiencies and is stated as a percentage. The allocative efficiency is related to the cost of inputs in relation to output.

Results and discussion

Profile of sample farmers

The ease of family labour availability for agricultural operations are determined by family size. Among the sample respondents, 46.6% of the farm households belonged to medium size family with four to five persons per family, 24.16% belonged to small size family with less than four persons per family and 29.16% were large families with more than five persons per family. It was observed that majority of the farmers were in the age group of 41 to 60 years, these farmers could venture into new innovations and in the adoption of technologies and cultivation practices. Educational status of the farmer determines their decision behaviour on the adoption of new technology, to a great extent. It was found that, 34.16% of the farmers having higher secondary level of education. Experience of the farming influences the decision behaviour on each and every activity involved in farming. Among the sample respondents, 36.6% of the farmers were having experience of more than 30 years in farming.

Cropping pattern

The cropping pattern of sample maize farms is shown in Table 1. Most farmers grew maize during the kharif season, making up 51.33% of the total cultivated area followed by Jowar (17.66%), and tapioca (accounts for 8.47% of the region's total cultivated land. In the study area, cropping intensity was 109.60%. According to research of the cropping practices of maize farmers, the majority of farmers produce maize.

Extent of mechanisation

The majority of farmers in the study area grow maize

Table 1 Cropping pattern of mechanised maize farms

Season	Crop	Area (acre)	% of GCA
Kharif	Sorghum	61.5	17.66
	Maize	178.75	51.33
	Groundnut	26	7.47
	Tapioca	29.5	8.47
	Onion	19.5	5.60
	Brinjal	8	2.30
	Fodder sorghum	7.25	2.08
	Cotton	9.75	2.80
	Black gram	3	0.86
	Greengram	4	1.15
Perennial	Mulberry	1	0.29
	Gross cropped area	348.25	100.00
	Net cropped area	317.75	
	Cropping intensity	109.60	

Source Primary Survey, 2021-2022

because it is used as poultry feed. It necessitates extensive cultivation, which includes operations like threshing, harvesting, inter-cultivation, and land preparation. For the aforementioned operations, the maize farmers use machineries. Based on the levels of mechanisation, the sample farms were divided into three categories: highly mechanised farms, moderately mechanised farms, and less mechanised farms.

Regarding operations required for maize production, the degree of mechanisation was established. Farms that use machinery for land preparation, sowing, applying a base dose of fertiliser, harvesting, and threshing were classified as Highly mechanized farms (HMF). Medium mechanised (MMF) farms are those that use machinery for Land preparation, applying a base dose of fertiliser, harvesting, and threshing. Low mechanised (LMF) farms where only threshing and land preparation are automated. Sample Farms were divided into two categories: those that used CHC services and privately owned farms.

The degree of mechanisation differed across maize growers. 52.5% of the sample farmers have used machineries for land preparation and threshing operations falling under LMF cateogory whereas compared to 32.5% of the farms are classified under MMF and 15% of farmers are under HMF category. This shows that very few percent of sample farmers have knowledge regarding mechanical devices for sowing and harvesting. In between these two extreme situations, there exist moderately mechanised farms wherein mechanical devices are being used for tillage, fertiliser application and threshing operations. Out of 120 farmers, 52.5% of the farmers were availed machineries from Government led CHC and remaining 47.5% of the farmers were availed machineries from Private individual farmers. This also clearly shows that majority of farmers were unaware of the Government led CHCs (Table 2).

Table 2 Extent and source of mechanisation in sample maize farms

Extent of mechanisation	Mechanised operations	No. of sample farmers	Source of mechanisation	Number of sample farmers
HMF	Land preparation Sowing Basal dose of fertiliser application Harvesting Threshing	18 (15)	Government led CHC	57 (47.5)
MMF	Land preparation Basal dose of fertiliser application Harvesting/Threshing	39 (32.5)		
LMF	Land preparation, Threshing	63 (52.5)	Private individual farmers	63 (52.5)
		120		120

Note Figures in the parentheses indicate percentage to total. HMF-Highly Mechanised Farm, MMF- Moderately Mechanised Farm, LMF – Less Mechanised Farm

Economics of maize cultivation

The economics of maize cultivation across sources of mechanisation i.e. farmers hired machinery and equipment services for maize cultivation through government-led custom hiring centres and private individual farmers (not availed machineries from government CHC) were compared and is shown in Table 3.

As shown in the table, farmers who availed equipment and machinery services from government CHCs incurred a total cost of Rs. 57860/ha whereas the farmers who availed these services from private individual farmers was Rs. 60984.50/ha. It is evident that using machinery and equipment services from the government-led CHC resulted in lower costs for growing maize compared to farmers availing machinery services from private individual farmers.

Table 3 Economics of Maize cultivation by sources of mechanisation

(Rs/ha)

Sources of mechanisation	Farmers availing machinery services from government CHC		Farmers availing machinery services from Private individual farmers	
	Qty	Value in Rs.	Qty	Value in Rs.
I. Machine labour (hrs)				
Land preparation	3.59	2872.00	3.64	4368.00
Sowing	1.46	1168.00	0.70	840.00
Harvesting	1.68	13440.00	1.01	9090.00
Threshing	1.21	1089.00	1.35	2025.00
Sub total	7.94	18569.00	6.70	16323.00
II. Human labour (man days)				
Sowing	15.90	7950.00	18.80	9400.00
Fertilizer application	1.60	480.00	1.84	552.00
Weeding	14.22	7110.00	17.43	8715.00
Weedicide application	1.30	390.00	1.92	576.00
PP Chemical application	1.02	306.00	1.10	330.00
Harvesting	13.24	6620.00	18.02	9010.00
Sub total	47.28	22856.00	59.11	28583.00
III. Inputs				
Seeds (kg)	18.82	6587	18.57	6499.5
Urea (bag)	2.53	759	2.61	783
DAP (bag)	1.01	1212	1.44	1728
Potash (bag)	0.69	759	0.91	1001
Complex (bag)	1.48	1998	1.02	1377
Weedicide (L)		1120		1090
PP Chemicals (L)		4000		3600
Sub total		16435.00		16078.50
Total cost (Rs/ha)		57860.00		60984.50
Yield (qtl/ha)		47.12		45.10
Price (qtl)		1500.00		1500.00
Returns from main product		70680.00		67650.00
Returns from by product		5000.00		4000.00
Gross returns		75680.00		71650.00
Net returns		17820.00		10665.50

Due to the use of seed cum fertiliser drills that could maintain an optimal plant population, farmers using government CHC services were able to produce an additional yield of 2.02 quintal. It is also evident that net profits per hectare might be increased to the tune of Rs. 7154.5/ha. Therefore, farmers might increase their profits by 67% and cut the cost of growing maize by 5.12% by using machinery and equipment from CHSCs.

Estimated profit function

From the profit function analysis, the model's goodness of fit was 0.54, indicating that included independent variables could explain 54 per cent of the total variation in the dependent variable (profit per hectare).

The coefficient of expenditure on machine labour (X1) was found to be statistically significant at one per cent level of significance. The intercept dummy variables D1 and D2 capturing the influence of degrees of mechanisation in maize cultivation were found to be statistically significant at ten per cent and one per cent level of significance. The coefficient of human labour (X2) was statistically non-significant. The results indicate that every rupee spent on machine labour results in additional profit of Rs. 1.03. The contribution of human labour towards profit per hectare decreased the profit of Rs. 0.92. This indicates unequivocally that mechanisation increases maize farming's profitability. The magnitude of increased profits due to different degrees and sources of mechanisation is reflected in the coefficients D1, D2 and D. The increased profit per hectare on HMF availing mechanical services from CHSCs was Rs. 52196.46 per hectare, HMF availing services from private individual farmers was Rs. 40524.69 per hectare, MMF availing services from CHSCs was Rs. 17829.87 per hectare and MMF availing services from private individual farmers was Rs. 16405.74. The differences in the magnitude of profits are apparent across sources of mechanisation. The estimated profits realised by HMF and MMF availing services from CHSCs were on par with each other. The expected profit per hectare on farms with various levels and sources of mechanisation was calculated and shown in Table 4 at the mean level of independent variables. This result clearly demonstrates the economic advantage of mechanisation in maize cultivation.

$Y= 13949.13 + 1.04\,X_1 - 0.93\,X_2 + 1337.89\,D_1 + 3813.61\,D_2 + 7418.36\,D$

Profit function of HMF availing mechanical services from CHCs

$Y= 13949.13 + 1.04\,X_1 - 0.93\,X_2 + 1337.89\,D_1 + 7418.36\,D$

$Y= 22705.38 + 1.04\,X_1 - 0.93\,X_2$

Profit function of HMF availing mechanical services from Private individual farmers

$Y= 13949.13 + 1.04\,X_1 - 0.93\,X_2 + 1337.89\,D_1$

$Y= 15287.02 + 1.04\,X_1 - 0.93\,X_2$

Profit function of MMF availing mechanical services from CHCs

$Y= 13949.13 + 1.04\,X_1 - 0.93\,X_2 + 3813.61\,D_2 + 7418.36\,D$

$Y= 25181.1 + 1.04\,X_1 - 0.93\,X_2$

Profit function of MMF availing mechanical services from Private individual farmers

$Y= 13949.13 + 1.04\,X_1 - 0.93\,X_2 + 3813.61\,D_2$, $Y= 17762.74 + 1.04\,X_1 - 0.93\,X_2$

Table 4 Estimated profit across different degrees and sources of mechanisation

Particulars	Mean expenditure on			Estimated profit per hectare
	Machine labour	Human labour	Profit function	
HMF, CHC	34155	6484	Y=22705.38+1.04X1-0.93X2	52196.46
MMF, CHC	13939	23503	Y=25181.10+1.04X1-0.93X2	17829.87
LMF, CHC	17455	16673	Y=13949.13+1.04X1-0.93X2	16596.44
HMF, PRIVATE	27691	3829	Y=15287.02+1.04X1-0.93X2	40524.69
MMF, PRIVATE	17170	20660	Y=17762.74+1.04X1-0.93X2	16405.74
LMF, PRIVATE	18775	22442	Y=13949.13+1.04X1-0.93X2	12604.07

Profit function of LMF availing mechanical services from CHCs;

$Y = 13949.13 + 1.04 X_1 - 0.93 X_2$

Profit function of LMF availing mechanical services from Private individual farmers

$Y = 13949.13 + 1.04 X_1 - 0.93 X_2$

Cost efficiency in maize cultivation

Cost efficiency, which takes into account both allocative and technological efficiency, was used to assess the total economic effectiveness of decision-making units. The average technical, allocative, and cost efficiency ratings for the 120 farmers in the sample were determined to be 0.97, 0.81, and 0.79, respectively. The average cost efficiency score suggested a 79% economic efficiency. Rather than technical inefficiency, the cost inefficiency was mostly caused by allocative inefficiency. Due to the inefficient allocation of scarce capital to human labour and material inputs, which are generally more expensive than machine labour, allocation inefficiency exists.

Table 5 displays the frequency distribution of cost effectiveness in maize farming across levels and sources of mechanisation. The perusal of table indicates that 100% of the HMF who used CHSCs for mechanical services were determined to be economically efficient, with a cost efficiency score of greater than 0.6. For the majority of MMF using mechanical services from CHSCs, the cost efficiency score varied from 0.4 to 0.8. Majority of the farmers availing mechanical services from private individual farmers were found to be less efficient in terms of overall economic efficiency with cost efficiency score of 0.2-0.6. This finding reiterates the existence of economic efficiency on farms hiring mechanical services from CHSCs.

The Mean value of Technical, allocative and economic efficiency of the farmers availing machineries from CHC and private individual farmers were given in table 6.

Investment, utilisation and returns generated by CHSC

CHCs maintain stocks of various types of machinery and equipments. They are broadly categorised into (1) tillage machinery, (2) planting and sowing machinery, (3) plant protection equipments, (4) intercultural equipments, (5) harvesting equipments, (6) post harvesting equipments and (7) other accessories presented in Table 7.

Investment made on the machineries and equipments jointly by government. Out of the total investment, investment made on harvesting and post harvesting operations accounted for 27.38 per cent and 32.97 per cent. The farmers used post harvesting implements such as chaff cutter, round baler and shredder which is used for cutting the fodder as it is mainly used for the cattle feed. Most of the farmers used harvester for harvesting maize. Investment on tillage machinery alone accounted for 24.44 per cent. The tillage equipments and machineries included tractors, tillers, disc ploughs,

Table 5 Cost efficiency in maize cultivation for CHC and private farmers

Cost efficiency	Farmers availing machinery services from government CHC			Farmers availing machinery services from Private individual farmers		
	HMF (n=15)	MMF (n=39)	LMF (n=3)	HMF (n=3)	MMF (n=25)	LMF (n=35)
0.2-0.4						14 (40)
0.4-0.6		10 (25.64)			9 (36)	15 (42.86)
0.6-0.8	8 (53.33)	12 (30.77)			9 (36)	3 (8.57)
0.8-1.0	7 (46.67)	17 (43.59)	3 (100)	3 (100)	7 (28)	3 (8.57)

Table 6 Technical, allocative and economic efficiency for CHC and private individual farmers

Source of mechanisation	Extent of mechanisation	Technical efficiency	Allocative efficiency	Economic efficiency
Farmers availing mechanical services from CHC	HMF	0.962	0.841	0.812
	MMF	0.982	0.770	0.757
	LMF	1.000	0.984	0.984
Farmers not availing mechanical services from CHC (Private)	HMF	1.000	0.890	0.870
	MMF	0.969	0.724	0.702
	LMF	0.922	0.637	0.586
Mean		0.973	0.808	0.785

Table 7 Investment, Utilisation and Returns Generated by CHSC

Machineries/Euipments	Investment	Hours used	Returns generated
Tillage machinery	672175	5429.09	2524527
	(24.44)		(58.07)
Planting and sowing machinery	303300	431.66	200721.9
	(11.03)		(4.62)
Intercultural equipments	100500	721.5	335497.5
	(3.65)		(7.72)
Plant protection equipments	14700	125	40750
	(0.53)		(0.94)
Harvesting equipments	753000	1467.14	682220.1
	(27.38)		(15.69)
Post harvesting equipments	906400	941.88	563719.2
	(32.97)		(12.96)
Total	2750075	9116.27	4347436

rotovators, cultivators, levellers, harrows, cage wheels etc., which are highly expensive and beyond the means of ordinary farmers. The maximum number of hours spent using tillage machinery and equipment was discovered to be 5429.09 hours, which produced an annual income of Rs. 25,24,527, or 58.07% of the total income. The following in line was harvesting machinery and equipment, which was used for 1467.14 hours and generated a profit of Rs. 6,82,220.1. The aforementioned table show that farmers need tillage and harvesting equipment since these two operations must be finished promptly in order to realise the potential crop output. Chaff cutters, shredders, and balers are included in the post-harvesting group and require an investment of Rs. 5,63,719.2 Frequent repairs encountered by the centre emerged as the other reason for its limited use.

Economics of Custom Hiring Centre

Economics of working 30 CHSC was estimated and presented in Table 8.

The centre's annual maintenance costs were calculated to be a total of Rs. 57,344. The operational expenses worked out to Rs. 44,530.8 formed the major share in the total expenses (77.65 per cent). The cost of fuel for operating machinery and equipment was the largest operational expense, coming in at Rs. 34124.11 (59.51%), followed by salary at Rs. 5660.167 (9.87 per cent). 19.5% of the total costs were made up by interest on fixed investments and depreciation on machinery. The centre could, nevertheless, make a profit of Rs. 4317436. The centre's poor maintenance is reflected in the increased operating and fixed costs. The government should develop a plan to increase the

Table 8 Economics of Custom Hiring Centres

Particulars (n=30)	Value (Rs./yr)
Operational cost	
Fuel	34124.11
	(59.51)
Lubricants	2265.694
	(3.95)
Salary & wages	5660.167
	(9.87)
Annual repair & maintenance	1378.056
	(2.40)
Insurance	729.8611
	(1.27)
Miscellaneous	372.9167
	(0.65)
Sub total	44530.8
	(77.65)
Fixed cost	
Depreciation	11440.93
	(19.95)
Interest on fixed capital 12%	1372.911
	(2.40)
Sub total	12813.84
	(22.35)
Total expenses	57344.64
	(100)
Total returns	4317436

employability of agricultural engineering graduates in order to boost the region's economic performance. Since it guarantees technical graduates work on the one hand and increases the centre's sustainability on the other, it is a win-win situation for the government.

Conclusion

Comparing these farms to those that used services from private individual farmers, the economic impact was to the tune of 4.56%, 4.47%, and 61% in terms of cost savings, greater yield, and increased net returns. The profit analysis indicated that HMF availing mechanical services from CHCs was Rs. 52196.46 per hectare. The efficiency analysis indicated that cent per cent of HMF availing services from CHCs have cost efficiency score of more than 0.6. Keeping this in view, government should increase the number of CHSCs and narrow down its operational area to village level. Government should hire and appoint technical graduates with degrees in agricultural engineering as managers of these centres in order to boost the economic performance of the centre. Nodal workshops with technical graduates should be created at taluk/district headquarters to minimise the cost associated with regular maintenance. To ensure their viability, centres should purchase equipment based on the cropping pattern that is more useful to the farming community

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Choice of millets cultivation in India: an evidence from farm household survey data

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Abstract The present study aims at investigating the determinants of millets production at the farm-household level in India. We have used farm household survey data collected by the National Sample Survey for the year 2018-19. Using Heckman sample selection model, the study has estimated the functional relationship between area adoption under millets and various farm household-related characteristics to avoid the sample selection problem associated with the survey data. The results reveal that the price of millets is the key factor affecting the choice of millets production and area expansion. Ensuring a higher price for millets may encourage the expansion of area under millets. As millets are considered less input intensive crops and rich in nutrients, more area adoption under millets may help achieve the sustainable development goals of food security and efficient use of resources.

Keywords Nutrient security, millets, probability, sample selection, adoption

JEL codes Q12, Q13, Q15, Q16

Introduction

Millets contain high nutritive values such as proteins, minerals, vitamins, antioxidants, non-glutinous and non-acid forming diets, as compared to other cereals. They are called as 'nutritious millets' or 'nutricereals' and they, therefore, are considered more for human consumption. Bajra (pearl millet) and ragi (finger millet), among other millets, possess protein content of 11.8 and 7.4 g per 100 gram grain, respectively and low fat of around 1.3 g per 100 g grain (Sakamoto 1982; Muthamilarasan et al. 2016). Moreover, millets have higher levels of low Glycemic Index (GI) non-starch polysaccharides and dietary fibres protecting against diabetes. Most of the millet crops are cultivated in the semi-arid regions as they are resilient to climate change; require low labour, water, inorganic fertilizers and other market inputs; resistance to pests and diseases; require a short duration (60-90 days); and survive under low rainfall, high temperatures, and poor nutrient levels in the soil (Lata et al. 2013; Bergamini et al. 2013). Further, the cultivation of millets can contribute to carbon sequestration and reduction in greenhouse gas emissions. However, the area under millet crops and their production shows a significantly declined trend over the decades.

The decline in the millet production could be attributed to a less demand and over-dependency on rice and wheat accounting for about 50% of the average Indian household calorie intake and significant changes in the dietary pattern of households from cereals to high-value food commodities such as livestock products, fruits, vegetables and beverages (Bansil 1999; Radhakrishna 2005; Chatterjee et al. 2006; Chandrakanth and Akarsha 2011; Kumar et al. 2011). Besides, an increase in per capita income, growing urbanisation, availability of expected fresh and processed food products in the market, improvements in transportation, storage facilities and a rise in supermarkets and changing tastes

and preferences are some of the other factors responsible for a decline in the production and consumption of millets (Chand 2007; Chengappa et al. 2007; Kumar et al. 2011; Vasileska and Rechkoska 2012). Also, a less attention paid by researchers with respect to the significance of underutilized millets (Padulosi and Hoeschle-Zeledon 2004), resulted in neglected nutrition and health opportunities (Frison et al. 2006; Hawtin 2007; Smith and Longvah 2009). On the other side, limited marketing opportunities available to these so-called inferior millets are also responsible for their low-price levels, and affecting the producers (Nagarajan et al. 2005).

Although a couple of studies have dealt with the importance of millets in terms of demand and performance by the public (Anbukkani et al. 2017; Umanath et al. 2018), a detailed information on the nature of production choice and area expansion at the farm level is unavailable. Such information is needed for producers, market actors to take market-oriented production decisions in order to benefit from growing markets (Lapar et al. 2010) and policy makers to initiate millets production promotion strategies as these crops consume a low amount of water and chemicals besides being climate resilient in nature. Given their importance in respect of farm production decisions, it is crucial for policy makers and other stakeholders involved in the production, marketing and processing of millets to understand the factors determining the production choice of millets and adoption at the farm household level.

A number of previous studies have estimated the adoption of area under various crops using, Nerlovian expectation model based on time-series data (Nerlove 1958; Abidoye and Mabaya 2014). Nerlovian expectation model has been applied to estimating the price expectation behaviour of farmers in relation to the previous year performance and analysing both the speed and level of adjustment of actual acreage towards a desired acreage (Nerlove 1958; Mythili 2012). However, price expectation theory is not appropriate when it comes to estimating the effect of household level characteristics at the farm level based on cross-sectional data. Many studies have tried to estimate the effect of household level characteristics on technology adoption and crop choice, notably using the choice theory or binary variable models such as logit, probit, and their updated versions like multinomial logit models (Chandio and Yuansheng 2018; Okuthe et al. 2000; Sheikh et al. 2003; Nagarajan et al. 2007; Idrisa et al. 2012; Udimal et al. 2017; Chianu et al. 2007; Issoufou et al. 2017; Uduji and Okolo-Obasi 2018; Ali 2021), but there are no studies available that focussed on the farm level characteristics affecting the area adoption of various crops in general and millets in particular in the Indian context. Therefore, this paper focus on filling this gap by analysing their relationship, which is crucial to policy formulation. This study is a modest attempt at drawing attention to the determinants of choice and area under millets in the Indian context.

Indian millets scenario

Millets are largely grown in Asia and Africa's semi-arid regions, with a total area of 39.21 M.ha (million hectares) and a production of 24.25 Mt (million tonnes) as of 2019-20 (FAO 2021) of which, India accounts for the largest area of 15.29 M.ha (26.6% of the world and 83% of Asia millets area) with a production of 10.24 M.t (36.08% of the world's production). Nevertheless, the area under millets shows a decline from 19 M.ha, on an average, in the 1960s to 9.71 Mha in 2020 (FAO 2021) - a decline of almost 49%. The major millets grown and consumed in India include jowar (sorghum), ragi (finger millet), bajra (pearl millet), kangni (foxtail millet), cheena (proso millet), kodo millet, barnyard millet, and small millets (NAAS 2013). Particularly, bajra, jowar, and ragi are the major millets produced and consumed in the country. Bajra is considered the fourth important crop grown predominantly in the states of Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat and Haryana. Bajra accounts for an area of 6.93 Mha with a mean production of 8.61 Mt and productivity of 1243 kg per ha in India for 2018-19. Ragi is produced at 1.17 M.t under 1.79 Mha and with 90% of it being produced in the states of Karnataka, Uttrakhand, Maharashtra, Tamil Nadu, Odisha and Andhra Pradesh. Bajra is cultivated under 4.9 Mha in India with a production of 4.8 Mt. According to Commission for Agricultural Costs and Prices (CACP) report (2020-21), jowar, bajra and ragi in India are produced at a cost of Rs.10829, Rs.10070.21 and Rs.16668.22 per acre, respectively as of 2017-18.

The changes in the existing production and consumption of millets are associated with the policies implemented in the country. Millet crops remain mostly

ignored in this regard, with policies favouring rice and wheat production since the era of Green Revolution. Recently, with a view to achieving nutritional security in the country, the government initiated some millet development schemes such as through Intensive Millets Production (INSIMP) under National Agriculture Development Programme (NADP), Rainfed Area Development Programme in 2011-12, Integrated Cereals Development Programmes in Coarse Cereals based Cropping Systems Areas (ICDP-CC) in 1994, National Agricultural Insurance Scheme-1999-2000, Weather Based Crop Insurance Scheme, Minimum Support Price, Pradhan Mantri Fasal Bima Yojana. All these are expected to favour an increased production of millets. Moreover, the National Food Security Act of 2013 included millets for the first time in the food security system as an important component, along with rice and wheat. Several states are also distributing millets such as bajra, jowar and ragi through the public distribution system along with rice and wheat. Efforts are also on to include minor millets in the mid-day meal scheme in government schools, especially in Karnataka and Telangana.

Data

The household level data on agricultural situation assessment collected by the National Statistical Office (NSO), Government of India through large scale National Sample Survey (NSS) has been used in this study to capture the spatial variations in the farm-household characteristics. This comprehensive national sample survey is conducted once in five years in all the states on a quinquennial basis. For our analysis purpose, we have used the latest survey data (77th round) pertaining to the year 2018-19 with the main aim of this survey being to collect information about cropping pattern and the production of various crops, input expenditure, output levels, sales, markets, value of output and demographic and farm level characteristics. The 77th round survey covered a sample size of over 58,040 households. The survey offers information on crop-wise cultivated area, expenses on farm inputs, value of commodities in Kharif season, and several farm household characteristics such as asset position, social and demographic details, and income sources. In addition, data on some institutional aspects related to agriculture such as credit, insurance, and extension contact, etc., have also been collected by the survey. As the cropping pattern in India remains more or less the same in recent times, 77th round survey data may resemble the current scenario with respect to the cropping pattern.

For analysis, we selected sample farms from the major millets growing states and ignored other states, where millets are not cultivated predominantly. Thus, the final sample size comprised 43,824 samples, of which only 40% of farmers have involved in millet production, and rest of the farmers did not cultivate any of millets.

Heckman sample selection model

A common problem we face in the observational farm household survey data on the cropping pattern and inputs usage relates to the possibility of a group of respondents reporting non-cultivation of millets and consequent output and resource use. In the case of such censored data, using ordinary least square (OLS) regression for estimating the influence of household characteristics on the area expansion under millets may produce biased, inconsistent, and inefficient coefficients. Also, the selection of sub-samples of millets growers and non-millets growers is subject to the problem of sample selection due to the absence of randomisation in the sub-samples selection from such a larger survey data. Using such sub-samples without controlling for the effect of non-randomisation on regression analysis may also result in a biased estimation. In this situation, Heckman developed a sample selection model to address this problem and the same we have employed to estimate the area adoption under millets using the notations of Yen and Rosinski (2008):

$$\log y = x'\beta + v \quad if \quad z'\alpha + u > 0 \,, \qquad (1)$$

$$y = 0 \qquad if \quad z'\alpha + u \le 0 \,,$$

where,

y is the dependent variable;

x and z are vectors of independent variables;

β and α stand for the conformable vectors of parameters; and

u and v are the error terms, which are distributed as bivariate normal with zero means and a finite covariance matrix:

$$\begin{bmatrix} u \\ v \end{bmatrix} \sim N\left\{\begin{matrix} 0 \\ 0 \end{matrix}\right\}, \begin{bmatrix} 1 & \sigma\rho \\ \sigma\rho & \sigma^2 \end{bmatrix} \qquad (2)$$

where,

σ represents standard deviation of v, and

ρ is the correlation between u and v.

Since the standard deviation of u is not known, it is considered as 1, and the binary selection outcomes take the value of 1 or 0.

The sample likelihood function is

$$L=\prod_{y=0}[1-\Phi(z'\alpha)]\prod_{y>0}\Phi\left[\frac{z'\alpha+\rho(\log y-x'\beta/\sigma}{(1-\rho^2)^{1/2}}\right]y^{-1}\frac{1}{\sigma}\phi\left(\frac{\log -x'\beta}{\sigma}\right) \quad (3)$$

where

y^{-1} is the Jacobian transformation from $\log y$ to y,

$\phi(.)$ is the standard normal probability density function (pdf), and

$\Phi(.)$ is the cumulative distribution function (cdf).

If the errors are independent ($\rho = 0$), equation 3 reduces to the same of a two-part model. The log likelihood function is separable into parameters α and [β, σ], and the assessment would be broken down to a probit model (to assess α) deploying the entire sample and a linear regression of $\log y$ on x (to assess β and σ) by only the non-limit sample.

We have estimated the marginal effects of the sample selection model by adopting the procedure of Yen and Rosinski (2008), where the conditional mean of the dependent variable y is

$$E(y|y>0)=\exp(x'\beta+\sigma^2/2)\,\Phi(z'\alpha+\sigma\rho)/\Phi(z'\alpha) \quad (4)$$

Since the marginal probability of a positive observation is

$$\Pr(y>0)=\Phi(z'\alpha) \quad (5)$$

the unconditional mean of y is

$$E(y)=\exp(x'\beta+\sigma^2/2)\,\Phi(z'\alpha+\sigma\rho) \quad (6)$$

Differentiating Equations (4), (5) and (6), we find the marginal effects on probability, conditional mean, and unconditional mean of a common element of x and z (say $x_j = Z_j$):

$$\partial\Pr(y>0)/\partial x_j=\phi(z'\alpha)\alpha_j \quad (7)$$

$$\partial E(y|y>0)/\partial x_j=[\Phi(z'\alpha)]^{-2}\exp(x'\beta+\sigma^2/2)\{[\Phi(z'\alpha)\phi(z'\alpha+\sigma\rho)-\phi(z'\alpha)\Phi(z'\alpha+\sigma\rho)]\alpha_j+\Phi(z'\alpha+\sigma\rho)\beta_j\} \quad (8)$$

$$\partial E(y)/\partial x_j=\exp(x'\beta+\sigma^2/2)[\phi(z'\alpha+\sigma\rho)\alpha_j+\Phi(z'\alpha+\sigma\rho)\beta_j \quad (9)$$

These marginal effects can be evaluated at the data points of interest, such as the sample means of the explanatory variables.

Selection of variables

The dependent variable in the Heckman sample selection (maximum likelihood) model is the area under millets in acre. The dependent variable in equation 1 is the natural logarithm of the total area on millets in a year. The following are the explanatory variables used in the model:

I. Household characteristics

1. Age of head of farm household (in years);
2. Educational level of head of farm household (dummy variables: 0 for illiterate; 1 for primary; 2 for high-school; 3 for higher secondary; 4 for diploma; 5 for collegiate level; and 6 for post graduate education)
3. Household size (in numbers);
4. Gender of household head (dummy variables: 0 for female-headed households and 1 for male-headed households);
5. Presence of regular salary earners (RSE) in household (dummy variables: 0 for absence of RSE; 1 for presence of RSE)
6. Non-farm income (dummy variables: 1 for having non-farm income generation activities and 0 for none).

II. Farm level characteristics

1. Farm size (in hectare);
2. Tenurial status (in acre);
3. Livestock activity (in numbers)
4. Irrigation sources (dummy variables: 0 for no irrigation; 1 for canal; 2 for surface; 3 for groundwater; 4 mixed; and 5 for others)

5. Family labour contribution (dummy variables: 0 for none; and 1 for contribution)
6. Choice of competitive crops (dummy variables: 0 for none; and 1 for respective crops).

III. Institutional characteristics

1. Training attended
2. Extension contact (in number)
3. Credit availed of agricultural purpose (dummy variables: 1 for credit availed, and 0 for credit not-availed);
4. Insurance policy available (dummy variables: 0 for none; and 1 for policy available;
5. Member in farmers organisation (dummy variables: 0 for no; and 1 for yes); and
6. Awareness regarding minimum support price (MSP) (dummy variables: 0 for no; and 1 for yes).

IV. Economic variables

1. Price of millets (in Rs. per kg);
2. Expenditure on fertilizers/acre (in Rs.);
3. Expenditure on labour/acre (in Rs.);
4. Expenditure on machine power/acre (in Rs.); and
5. Net farm income/acre (in Rs.).

While estimating the Heckman regression model, choosing independent variables is an issue and hence, we have used exclusion conditions for identifying the model parameters. Although there are no *a*-priori exclusion conditions for the current samples, we have used farm size in the area expansion equation, while three types of farm category (small, medium and large farmers) are included in the crop choice or selection equation. Also, the variables such as choice of other crops is included only in the choice equation, as it is expected to affect the millets choice more than area expansion. On the other hand, net farm income variable is included in the area expansion equation, as it is expected to affect the size of area than the choice of millets. Employing different set of variables in the two equations ensures that the model is identified. We have used *heckman* command in Stata (version 14.1) for estimating the log likelihood function of the Heckman sample selection model and its marginal effects at different levels.

Descriptive statistics

Cropping pattern

Examining the existing cropping pattern followed by the sample farmers helps understand the millet choice, area expansion, production and its determinants at the farm level. The cropping pattern followed by all the sample farmers as well as millet growing farmers is presented in Table 1 and 2. From Table 1, it is observed that, on an average, total cropped area accounts to 1.181 acre under unirrigated condition of which, millets occupy an average area of 0.28 acre. Also, it is noted that about 10% of the sample farmers are engaged in unirrigated-millets cultivation. Cereals, after millets, account for about 21% of the total cropped area grown by about 21% of the total farmers, followed by oilseeds, pulses and fibres. Under irrigated area, cereals grown constitute 48% of the total cropped area, followed by fodder crops, millets, oilseeds, sugar crops, pulses and vegetables (Table 1). We have tried to understand how diverse is the cropping pattern, when millets are considered as part of farm crops. It is interesting to note that bajra, grown solely accounts for about 39% of the total cropped area followed by jowar, pulses, fibres, fodder, oilseeds, ragi and maize. Paddy, maize and small-millet crops are grown on a small scale under unirrigated condition. Under irrigated condition, bajra grown accounts for more than 43% of the total cropped area, followed by paddy, jowar, oilseeds, fibre and fodder crops (Table 2). It is revealed that the cropping pattern varies across irrigated and millet growing areas with a higher proportion brought under bajra production under both irrigated and unirrigated conditions.

Farm household characteristics

Descriptive statistics related to farm household characteristics are presented in Table 3. About 40% of the sample farmers cultivate millets, including jowar, bajra, ragi, and other small-millets. Overall, agriculture and allied sectors is the primary source of income for 72% of the sample farmers, but only 54% for millet growing farmers rely the agricultural sector for their primary income, as compared to non-millet growing farmers (about 86%). Around 93% of the farmers are male, who live in households with more than five family members. Almost 90% of the farms are involved in their own faming activities. About 50% of the

Table 1 Cropping pattern followed by all sample farmers

Crops	Unirrigated condition						Irrigated condition					
	Area in acre	% to total cropped area	% of farmers	SD	Minimum	Maximum	Area in acre	% to total cropped area	% of farmers	SD	Minimum	Maximum
Cereals	0.254	21.49	21.25	0.804	0	20	0.675	48.03	46.75	1.793	0	68
Millets	0.280	23.69	10.43	1.213	0	28	0.145	10.32	8.49	0.653	0	29.5
Pulses	0.181	15.37	8.87	0.852	0	18.05	0.086	6.12	4.72	0.812	0	68
Sugar crops	0.001	0.07	0.69	0.048	0	5.75	0.075	5.34	5.22	0.538	0	17.41
Spices & Condiments	0.001	0.06	0.26	0.027	0	7	0.005	0.38	0.55	0.094	0	3.5
Fruits	0.006	0.47	0.69	0.144	0	14	0.008	0.54	0.67	0.224	0	18
Tubers	0.002	0.13	0.55	0.042	0	3.4	0.003	0.24	1.00	0.070	0	5.06
Vegetables	0.006	0.50	2.15	0.087	0	6	0.019	1.34	3.09	0.208	0	12
Oil seeds	0.231	19.58	7.22	1.255	0	66.62	0.185	13.20	6.68	1.385	0	61.8
Fibres	0.175	14.86	6.55	1.050	0	70	0.134	9.56	5.91	0.777	0	28.83
Dyes	0.000	0.00	0.00	0.000	0	0	0.000	0.00	0.01	0.004	0	3.13
Drugs	0.000	0.00	0.00	0.000	0	0	0.000	0.00	0.01	0.007	0	2.72
Fodder	0.044	3.71	2.09	0.451	0	17.06	0.060	4.29	8.56	0.476	0	20.03
Plantation	0.000	0.01	0.03	0.010	0	2	0.000	0.02	0.02	0.029	0	4
Flowers	0.000	0.00	0.01	0.001	0	0.52	0.001	0.06	0.13	0.027	0	3.5
Medicinal crops	0.000	0.00	0.01	0.002	0	0.4	0.001	0.07	0.03	0.070	0	8
Other food crops	0.001	0.06	0.32	0.036	0	9.05	0.000	0.01	0.38	0.015	0	2.72
Other non-food crops	0.000	0.01	0.01	0.009	0	0.92	0.007	0.48	0.01	0.175	0	16
Total cropped area	1.181						1.405					

Table 2 Cropping pattern followed by millet growing farmers

Crops	Unirrigated farmers						Irrigated farmers					
	Area in acre	% to total cropped area	% of farmers	SD	Minimum	Maximum	Area in acre	% to total cropped area	% of farmers	SD	Minimum	Maximum
Paddy	0.031	1.34	4.81	0.217	0	6.5	0.133	10.40	8.41	0.942	0	30
Maize	0.074	3.20	5.34	0.442	0	9	0.048	3.72	3.82	0.376	0	20
Wheat	0.000	0.02	0.12	0.028	0	2	0.001	0.10	0.16	0.058	0	3
Jowar	0.336	14.55	15.27	1.300	0	25	0.117	9.14	9.12	0.563	0	20
Bajra	0.900	38.98	37.65	1.963	0	28	0.555	43.32	34.08	1.140	0	20
Ragi	0.076	3.30	9.28	0.409	0	10	0.010	0.81	1.09	0.135	0	3
Small millets	0.009	0.38	1.92	0.123	0	4	0.002	0.18	0.22	0.084	0	7.42
Pulses	0.385	16.70	17.69	1.201	0	18.05	0.068	5.28	4.03	0.460	0	7
Sugar crops	0.000	0.01	0.03	0.010	0	0.5	0.029	2.25	1.27	0.467	0	16
Spices & Condiments	0.001	0.02	0.09	0.046	0	7	0.002	0.15	0.43	0.042	0	2
Fruits	0.006	0.26	0.34	0.243	0	14	0.006	0.43	0.56	0.111	0	3
Tubers	0.001	0.05	0.53	0.021	0	1	0.000	0.04	0.28	0.013	0	4
Vegetables	0.007	0.31	2.95	0.123	0	6	0.018	1.39	1.89	0.237	0	12
Oil seeds	0.082	3.55	5.46	0.578	0	25	0.091	7.13	5.00	0.569	0	13.2
Fibres	0.252	10.93	8.88	1.057	0	17.06	0.095	7.40	4.93	0.644	0	15
Dyes	0.000	0.00	0.00	0.000	0	0	0.000	0.00	0.03	0.008	0	3.13
Drugs	0.000	0.00	0.00	0.000	0	0	0.000	0.00	0.00	0.000	0	0
Fodder	0.136	5.88	5.40	0.784	0	17.06	0.092	7.15	7.23	0.788	0	20.03
Plantation	0.000	0.01	0.09	0.021	0	2	0.001	0.07	0.06	0.054	0	3.1
Flowers	0.000	0.00	0.00	0.000	0	0	0.000	0.01	0.09	0.008	0	1.5
Medicinal crops	0.000	0.00	0.00	0.000	0	0	0.000	0.02	0.06	0.020	0	1.99
Other food crops	0.001	0.02	0.09	0.062	0	9.05	0.000	0.00	0.40	0.000	0	0
Other non-food crops	0.000	0.00	0.00	0.000	0	0	0.012	0.90	0.00	0.279	0	10
Total cropped area	2.308						1.281					

Table 3 Descriptive statistics related to categorical variables

	Non-millets growing farmer (Number of farmers)	Millets growing farmer (Number of farmers)	All farmers (Number of farmers)
Household characters			
Primary source of income			
Agriculture			
Non-agriculture			
Household head age			
Youngster	14.03	22.84	17.59
Middle age	49.76	46.54	48.46
Elders	36.20	30.62	33.95
Household head Education			
Illiterate	35.31	41.91	37.97
Primary	37.84	36.87	37.45
High-school	12.74	10.44	11.82
Higher secondary	7.07	5.65	6.50
Diploma	0.98	0.87	0.94
Collegiate	4.83	3.14	4.15
Post-graduate	1.22	1.11	1.18
Gender			
Male	92.05	85.74	89.51
Female	7.95	14.26	10.49
Household size (average number)	4.96	4.69	4.87
Presence of regular salary earners			
No	99.90	99.62	99.79
Yes	0.10	0.38	0.21
Non-farm income generating activities			
No	92.62	96.56	94.21
Yes	7.38	3.44	5.79
Farm groups			
Small farmers	88.85	89.03	88.90
Medium farmers	8.77	8.20	8.61
Large farmers	2.38	2.77	2.49
Farm level characters			
Farm size (average acre)	2.213	1.863	2.092
Leased-in land (average acre)	0.321	0.180	0.273
Livestock (average numbers)	3.890	4.225	3.996
Irrigation sources			
No irrigation source	32.12	82.58	52.45
Canal	12.40	2.54	8.43
Surface	3.01	0.77	2.11
Groundwater	49.70	13.30	35.03
Mixed	0.99	0.21	0.67
Others	1.78	0.61	1.31

Contd...

	Non-millets growing farmer (Number of farmers)	Millets growing farmer (Number of farmers)	All farmers (Number of farmers)
Family labour contribution			
No	13.07	2.82	8.93
Yes	86.93	97.18	91.07
Institutional character			
Training attended			
No	98.34	99.15	98.66
Yes	1.66	0.85	1.34
Extension contact (average no. of media)	8.826	4.338	7.276
Credit availing for farming			
No	45.04	74.55	56.95
Yes	54.96	25.45	43.05
Credit outstanding (average Rs.)	78160.20	47728.94	76729.12
Insurance policy taken			
No	91.56	96.74	93.65
Yes	8.44	3.26	6.35
Member in farmer's organisation			
No	95.78	96.52	95.96
Yes	4.22	3.48	4.04
Awareness on minimum Support price			
No	76.04	97.04	84.52
Yes	23.96	2.96	15.48
Economic variables			
Price of millets (average Rs.)	17.71	18.17	17.87
Expenditure on fertilizers (average Rs.)	1870.17	831.03	1696.88
Expenditure on labour (average Rs.)	2158.29	928.39	1953.32
Expenditure on machine power (average Rs.)	1489.62	979.26	1404.51
Net farm income (average Rs.)	16497.65	5685.42	12761.18

farmers are of middle age group, followed by old age (34%) and youngsters (14%). About 38% of the farmers are illiterate, while 37% have only primary level of education. About 12 and 6.5% of the farmers have completed high- and higher-secondary schooling, respectively, while only 5% of the farmers have completed collegiate level education. A meagre 0.21 of the farmers are regular salary earners, while 6% are engaged in non-farming business activities such as wholesale and retail marketing, food and beverages production, construction, textiles, education, computer related works etc.

Among the sample farmers, almost 89% of the farmers are small farmers (<5 acres), 8.6% are medium farmers (5> & <10 acres) and only 2.5% are large farmers (>10 acres). On an average, farmers possess 2.09 acres of own land and 2.27 acres of operational holdings with 0.27 acres of leased-in land and 0.09 acres of leased out land. It is interesting to note that the total holding and operational size of land are 75% more in the case of millet growing farmers, as compared to other farmers. Also, about 50% of the total operational holdings is under irrigated condition. Farmers use different sources of irrigation for crop cultivation such as canal water, surface water, groundwater and other minor irrigation sources. Among the sample farmers, more than 35% of the farmers rely on groundwater sources, 8% on canal water and 2% on surface water. In particular, more than 80% of the millet growing farmers operate under unirrigated condition, while only

32% of the non-millet growing farmers operate under unirrigated condition.

With respect to institutional characteristics, only 4% of the farmers have membership with farmers' organisation and 1.34% have attended government training programmes. Also, more than 80% of the farmers are not aware of the minimum support price (MSP) policy. It is observed that sample farmers get farm-related technical advice from different sources, including mass media, social media, extension officers, scientist, agro-clinic, call-centres, NGOs etc. Overall, on an average, farmers obtain farm-related information from nine different sources. In the case of financial services, about 43% of the farmers have obtained loans-from both institutional and non-institutional agencies for the purpose of agricultural operations and household management with an outstanding amount of over one lakh rupees. In particular, 25% of the total millet-growing farmers have availed of loans with the outstanding amount of Rs.47729, while more than 54% of the non-millet growing farmers have availed of loans with the outstanding amount of Rs.78160. It is also noted that only 6% of the farmers have an insurance policy.

Eventually, economic and technical parameters can determine significantly area adoption and the size of area under any crop. The average price of millets is observed at Rs.18 per kg. Overall, farmers have spent Rs.1,697 on fertilizers, Rs.1,953 on labour and Rs.1,404 on machine power per acre. It is also noted that per acre cost of these inputs incurred by non-millet growing farms amounts to 44, 43 and 62%, respectively, higher than millets growing farms, indicating that farms with millet crops are less input intensive. Moreover, economic viability of a farm in terms of generating income from various crops and livestock activities is expected to affect the amount of millets production. It is observed that the net farm income amounts to Rs.5,685 in millet growing farms, while it is three times higher for non-millet growing farms at Rs.16,497 per farm.

Millet choice and area expansion across major household characteristics

Area adoption under millet crops across major household characteristics is presented in Table 4. Larger farmers, as expected, have adopted more area under millets than medium and small farmers. On an average, large famers cultivated crops over 6.43 acre followed by medium farmers (3.38 acre) and small farmers (1.32 acre). It is also noted that small farmers cultivate millets over 65% of their total cropped area. It is more than the medium (53%) and large farmers (46%). Elder farmers grow millets over an average of 2.05 acre followed by middle age and young farmers – but youngster are observed to have prioritised millets over other crops as 65% of their total cropped area is under millet crops as compared to middle age (59%) and elders (54%). It is interesting to note that graduate farmers favour millets production over other crops. For instance, graduate and postgraduate farmers have not only adopted more area under millets, but also they have allocated 65% of their total cropped area to millets. Across gender, female farmers preference for millet crops is more than male farmers. Farmers with no irrigation facilities have allocated more area (2.05 acre) to millets. Moreover, more than 50% of the total cropped area is allocated to the millet crops by farmers, using all the available irrigation sources, excepting canal irrigation. Farmers using canal irrigation have allocated only 39 per cent of the total cropped area to millets, indicating that the possibility of millets production under canal irrigation system is less. Farmers with access to credit facility adopting millet crops accounts to 26% lesser than their counterparts, but they have allocated a higher proportion of the cropped area to millets, as compared to non-credit holders, indicating that credit facility helps more area allocation to millets.

Results and discussion

Determinants of area adoption under millets

We estimated the functional relationship between the area expansion under millets by farm households and its key determinants-farm household level characteristics (Table 5). As the present data obtained from the household survey is subject to the problem of sample selection for choosing sub-samples of millet farmers and non-millet famers without any randomisation procedure followed, the estimate of parameters using OLS regression is expected to be biased. To avoid such biased results due to sample selection problems, Heckman sample selection model has been used for estimating the parameters of

Table 4 Acreage under millet crops by household characters

Variables	Irrigated Jowar	Unirrigated Jowar	Irrigated Bajra	Unirrigated Bajra	Irrigated Ragi	Unirrigated Ragi	Irrigated Small millets	Unirrigated Small millets	Total area under millets	% share to total cropped area
Age: Youngster	0.109	0.349	0.459	0.683	0.009	0.079	0.001	0.002	1.692	64.94
Middle age	0.107	0.328	0.462	0.704	0.007	0.101	0.000	0.014	1.724	59.08
Old age	0.133	0.4	0.492	0.88	0.026	0.111	0.004	0.007	2.053	54.18
Education: Illiterate	0.107	0.343	0.403	0.964	0.014	0.135	0.000	0.009	1.976	56.19
Primary	0.113	0.312	0.457	0.709	0.013	0.087	0.004	0.013	1.708	58.92
High-school	0.158	0.258	0.566	0.345	0.026	0.111	0.000	0.006	1.47	54.09
Higher secondary	0.075	0.634	0.545	0.521	0.002	0.052	0.000	0.004	1.834	58.88
Diploma	0.293	0.67	0.452	0.387	0.000	0.087	0.000	0.002	1.893	54.48
Collegiate	0.131	0.729	0.806	0.676	0.018	0.013	0.000	0.003	2.377	65.94
Post-graduate	0.177	0.22	0.735	1.914	0.000	0.001	0.000	0.001	3.048	69.85
Sex: male	0.115	0.365	0.472	0.787	0.013	0.097	0.002	0.01	1.861	57.00
Female	0.134	0.257	0.472	0.501	0.031	0.144	0.001	0.004	1.544	69.99
Farm category: small farmers	0.096	0.234	0.42	0.433	0.016	0.11	0.002	0.01	1.32	65.18
Medium farmers	0.245	0.77	0.792	1.472	0.007	0.084	0.002	0.01	3.381	52.75
Large farmers	0.169	1.361	0.622	4.267	0.002	0.01	0.000	0.006	6.437	46.26
Irrigation sources: No irrigation source	0.011	0.579	0.013	1.265	0.004	0.175	0.000	0.016	2.064	59.46
Canal	0.299	0.141	0.51	0.356	0.041	0.057	0.000	0.007	1.411	39.32
Surface	1.048	0.469	0.139	0.132	0	0.024	0.000	0.004	1.816	53.22
Groundwater	0.208	0.089	1.022	0.195	0.021	0.013	0.003	0.002	1.554	55.86
Mixed	0.122	0.018	1.297	0.017	0.119	0.231	0.000	0.000	1.804	58.18
Others	0.046	0.072	1.782	0.001	0.099	0.022	0.000	0.000	2.022	82.62
Non-farming income	0.042	0.725	0.383	0.611	0.01	0.053	0.000	0.003	1.827	58.00
No non-farming	0.121	0.331	0.478	0.773	0.014	0.105	0.002	0.01	1.834	57.75
No credit availed	0.143	0.437	0.480	0.898	0.012	0.094	0.002	0.007	2.074	55.57
Credit availed	0.084	0.258	0.462	0.597	0.016	0.110	0.001	0.012	1.542	61.75
No MFO	0.242	0.462	0.423	0.731	0.02	0.047	0.002	0.003	1.93	55.89
MFO	0.112	0.352	0.474	0.764	0.014	0.103	0.001	0.01	1.83	57.84

Table 5 Sample selection model for millets area adoption (Maximum likelihood function)

Variables	Crop selection equation		Area expansion equation	
	Coefficients	Standard errors	Coefficients	Standard errors
Household head age				
(Reference : Youngster)				
Middle age	-0.006	0.075	0.028	0.066
Elders	0.121	0.080	-0.009	0.071
Household head Education				
(Reference : Illiterate)				
Primary	0.061	0.060	-0.102**	0.049
High-school	0.316***	0.089	-0.121	0.078
Higher secondary	0.312***	0.100	-0.214**	0.090
Diploma	0.587	0.362	-0.123	0.482
Collegiate	0.255*	0.147	-0.173	0.153
Post-graduate	0.333*	0.185	-0.146	0.124
Gender	-0.055	0.090	-0.192**	0.081
Household size (average number)	0.017*	0.010	0.022***	0.008
Presence of regular salary earners	-0.097	0.365	0.269*	0.146
Non-farm income generating activities	0.112	0.100	-0.253**	0.099
Farm level characteristics				
Farm size (average acre)	-	-	0.117***	0.008
Farm category (reference: small farmers)				
Medium farmers	0.612***	0.078	-	-
Large farmers	0.546***	0.152	-	-
Leased-in land (average acre)	0.089***	0.021	0.083	0.022
Livestock (average numbers)	0.021**	0.009	-0.007**	0.003
Irrigation sources				
(Reference : no irrigation source)				
Canal	-0.940***	0.126	-0.059	0.175
Surface	-0.349**	0.173	0.163	0.122
Groundwater	-0.304***	0.058	0.060	0.052
Mixed	-1.138***	0.322	0.147	0.266
Others	-0.373**	0.163	0.372**	0.189
Family labour contribution	0.195**	0.082	-0.068	0.082
Choice of cereals	-1.710***	0.063	-	-
Choice of vegetables	-0.257**	0.125	-	-
Choice of pulses	-0.428***	0.064	-	-
Choice of oilseeds	-1.415***	0.093	-	-
Choice of fodder	-0.178**	0.075	-	-
Institutional characteristics				
Extension contact (average no. of media)	-0.128	0.083	0.059	0.067
Credit availing for farming	0.054	0.053	0.152***	0.047
Insurance policy taken	0.198**	0.091	-0.025	0.061
Member in farmers' organisation	0.076	0.146	-0.040	0.165
Awareness regarding Minimum Support Price	-0.476***	0.065	0.125	0.067

Contd...

Variables	Crop selection equation		Area expansion equation	
	Coefficients	Standard errors	Coefficients	Standard errors
Economic variables				
Price of millets (average Rs.)	0.081***	0.013	0.000	0.008
Net farm income (average Rs.)	-	-	-0.001	0.001
Expenditure on fertilizers (average Rs.)	-0.054*	0.030	-0.046**	0.019
Expenditure on labour (average Rs.)	-0.029**	0.013	-0.028	0.020
Expenditure on machine power (average Rs.)	-0.023	0.020	-0.018	0.019
Constant	0.281	0.801	-0.314*	0.638
Rho	-0.679***	0.043		
Sigma	0.823***	0.024		
Lambda	-0.559***	0.047		
Likelihood ratio chi2(1) = 108.74***				

Notes *** - significance at 1% level; ** - significance at 5%; * - significance at 10%

determinants of area under adoption under millets (Yen and Rosinski (2008). The results of the estimated equations of millets adoption and its area expansion are presented in Table 5. From the table, it is found that the estimated error correlation coefficient (-0.56) between the equations of millets adoption decision and area expansion, and its corresponding covariance term (0.82), is significant (P<0.01); and the independence of the error terms of the adoption and area expansion equations is rejected. This emphasizes the importance of selectivity correction in this analysis. Moreover, most of the estimated coefficients in both the equations are found to be statistically significant.

With a separate equation to accommodate the sample selection and level, and with logarithmic transformation in the dependent variables, the effects of explanatory variables on the probability of crop choice and area expansion are non-trivial. In order to explore the impact of farm household characteristics on the choice of millets, and on the extent of area under millet crops, we worked out the marginal effects on probability, conditional level (current farmers), and unconditional level (average farmers) (Equations 7–9). The effects on conditional level or conditional marginal effects, measure how a specific independent variable changes the extent of area cultivated under millets across existing millets growing farms. The effects on probability or the marginal effects of probability, explain the binary decision of adopting millets or not i.e., these explain how independent variables influence farmers, who have not adopted millets, into adopting. The effects on the unconditional level assess, overall, what contributes to area expansion by increasing (or decreasing) the probability or conditional level.

Impact of changes in economic factors

Table 6 shows the marginal effects of independent variables on millets choice and level of area expansion. As expected, the market price of millets has a positive and significant effect on the choice of millets production i.e., farmers would be 1.73% more likely to choose millets production, if the price of millets increased by Rs.10/- per kg. Also, the effect of millet price on extent the level of area expansion under millets shows a positive and significant relationship both at the conditional and unconditional levels. If the price of millets increased by Rs.10/- per kg, millet acreage would be increased by 0.03 acre at the conditional level and 0.005 acre at the unconditional level. These results indicate that increased price of millets encourages farmers to adopt more area under millets, as a higher price provides more remuneration to the farmers.

Farm expenditure on fertilizer and labour shows a negative and significant effect on millet adoption and its area expansion. For instance, a Rs.1000 increase in the farm expenditure on fertilizer and labour would cause a decline in the probability of millets adoption by famers by 1.15% and 0.62%, respectively. In addition, a Rs.1000 increase in the farm expenditure

Table 6 Estimated marginal effect of independent variables

Variables	Marginal effects probability (%)		Marginal effect at the conditional level		Marginal effect at the unconditional level	
	Coefficients	Standard errors	Coefficients	Standard errors	Coefficients	Standard errors
Middle age groups	-0.12	0.016	0.025	0.059	0.007	0.016
Old age groups	2.60	0.017	0.040	0.063	0.005	0.018
Primary	1.27	0.012	-0.076	0.046	-0.023*	0.012
High-school	6.92***	0.020	0.007	0.075	-0.014	0.024
Higher secondary	6.82***	0.023	-0.088	0.082	-0.045	0.027
Diploma	13.48	0.091	0.107	0.455	0.003	0.183
Collegiate	5.50*	0.033	-0.069	0.125	-0.034	0.044
Post-graduate	7.31*	0.043	-0.011	0.119	-0.021	0.038
Gender of farmers	-1.16	0.019	-0.215***	0.078	-0.055***	0.021
Household size	0.36*	0.002	0.029***	0.008	0.007***	0.002
RSE	-2.02	0.074	0.229	0.148	0.064	0.040
Non-farm income	2.43	0.022	-0.208**	0.094	-0.069**	0.029
Farm size	-	-	0.117***	0.008	0.033***	0.002
Tenure	1.90***	0.005	0.120***	0.021	0.029***	0.006
Livestock rearing	0.44**	0.002	0.001	0.004	-0.001	0.001
Canal	-18.60***	0.021	-0.461***	0.149	-0.053**	0.026
Surface	-7.90**	0.037	0.022	0.125	0.022	0.032
Groundwater	-6.96***	0.014	-0.062	0.046	-0.002	0.014
Mixed	-21.40***	0.044	-0.346*	0.192	-0.031	0.027
Others	-8.42**	0.034	0.220	0.159	0.072*	0.039
Family labour contribution	4.00**	0.016	0.013	0.073	-0.005	0.018
Extension contacts	-2.72	0.018	0.007	0.060	0.008	0.017
Credit availing	1.16	0.011	0.174***	0.042	0.046***	0.012
Insurance	4.36**	0.021	0.055	0.059	0.005	0.018
Member in FO	1.64	0.032	-0.010	0.146	-0.007	0.045
MSP awareness	-9.54***	0.012	-0.075	0.062	-0.001	0.014
Price of millets	1.73***	0.003	0.033***	0.006	0.005***	0.002
Net farm income	-	-	-0.001	0.001	0.000	0.000
Expenditure on fertilizers	-1.15*	0.006	-0.068***	0.020	-0.016***	0.005
Expenditure on labour	-0.62**	0.003	-0.040**	0.019	-0.010*	0.005
Expenditure on machine power	-0.49	0.004	-0.027	0.019	-0.006	0.005
Medium farmers	14.52***	0.021	0.238***	0.034	0.045***	0.009
Large farmers	12.84***	0.039	0.215***	0.055	0.039***	0.013
Choice of other cereals	-46.75***	0.016	-0.694***	0.050	-0.120***	0.015
Choice of vegetables	-5.18**	0.024	-0.107**	0.055	-0.015**	0.007
Choice of pulses	-8.33***	0.011	-0.179***	0.029	-0.026***	0.004
Choice of oilseeds	-24.38***	0.011	-0.623***	0.052	-0.084***	0.006
Choice of fodder	-3.65**	0.015	-0.074**	0.031	-0.011**	0.004

Notes *** - significance at 1% level; ** - significance at 5%; * - significance at 10%

on these inputs would reduce the size of area under millets by 0.068 and 0.04 acre, respectively, at the conditional level and 0.016 and 0.01 acre, respectively, at unconditional level. It is understood that farm input intensification leads to a reduction in the area under millets. Conversely, a study points out that the absence of input intensification in millet farming can limit crop production (Muthamilarasan and Prasad 2021).

Impact of changes in the demographic variables

Gender of farmers has no significant role in the choice of millets, but has a negative effect on area increase under millets. If a farmer is female, the size of area under millets decreases by 0.215 acre at the conditional level and 0.055 acre at the unconditional level. Similarly, age level has no significant effect on the choice of millets and area expansion. However, it is observed that education has a significant positive relationship with the choice of millets, i.e., farmers with high school, higher secondary and collegiate level education prefer to grow millets. Surprisingly, education does not have a significant effect on level of area adoption under millets.

Household size has a positive and significant effect on the choice of millets and its area expansion. For instance, an increase in the household size by one member increases the probability of millet adoption by 0.36%, while the size of area under millets increases by 0.029 acre at conditional level and 0.007 acre at the unconditional level. In line with this finding, family labour contribution to the farm also has a positive relationship with millets cultivation i.e., those farms contributing family labour are 4% more likely to adopt millets cultivation on the farm. Thus, it is revealed that a larger family size facilitates more area adoption under millets. Porgo et al., (2018) found family labour as a significant determinant of area under millets. It might be noted that significant farming activities like sowing, weeding and harvesting are carried out by family members only, specifically in the case of small farmers (Rouamba et al. 2021). Sdrali (2006) noted that households with a large family size were engaged more in pearl millet production than households with a small family size. Non-farm income generating activities affect negatively the area expansion under millets i.e., if there is any non-farm income generating activity in the farm households, there would be a decline by 0.208 acre at the conditional level and 0.069 acre at the unconditional level. In general, the effect of non-farming activities on agricultural production is ambiguous. On the one hand, it is assumed that non-farm activities act as alternative sources of income and employment for farmers and help buy more of inputs used in crop production. Also, non-farm activities mainly help commercial farming (Braun et al. 1991). On the other hand, non-farming activities have a negative effect on subsistence farming by withdrawing a portion of family labour force from farming and subsequently decrease production (Wang et al. 2011). Our study results also conform to the latter that non-farming activities are not favourable to the cultivation of millets. This could be due to the less remunerative nature and lack of commercialisation of millets production in rural areas.

Impact of changes in the farm level characteristics

Regarding farm characteristics, farm size, other crop competitiveness, livestock rearing, irrigation sources and family labour contribution are found to have a significant impact on adoption of millets production. When compared to small farmers, medium and large farmers are 14.52% and 13%, respectively, more likely to adopt millets production on the farm. At the conditional level, medium and large farmers are expected to grow millets over 0.238 acre and 0.215 acre more, respectively, vis-a-vis small farmers. Similarly, it is 0.045 acre and 0.039 acre, respectively, at the unconditional level. It is also noted that 1 acre increase in the size of farm land leads to an increase in the area under millets by 0.117 acre at the conditional level and 0.033 acre at the unconditional level. All these imply that farmers with a relatively larger size of land may have more cultivatable space to experiment with a variety of crops, including millets. Rearing of livestock has a positive effect on millets cultivation i.e., if a farmer rears livestock in the farm household, millets have a 0.44% chance of being adopted. It is attributed that leaves and straws of millets can be used as important feed materials in the crop–livestock systems. In the developing countries, most of the millet crops are used for dual purposes - grain provides food for humans and by-products are used as feed for livestock (Herrero et al. 2010). Harinarayana et al., (2005) observe that jowar is a gifted millet, as it provides food, feed, stover to millions of poor farm families and their livestock. Unexpectedly, tenurial

status of a farm increase the probability of increased adoption of millets i.e., 1 acre increase in the leased-in land increases the probability of millets production by 1.9%. Also, increased area of leased-in land by one acre increases the area under millets by 0.12 acre at the conditional level and 0.029 acre at the unconditional level. The positive effect on millets area expansion may be attributed to cheap availability of cultivable land in rain-fed regions.

Farmers reliant on irrigation sources for crop production are found less likely to adopt millets cultivation. For instance, a farm dependent on canal water for irrigation is 18.6% less likely to cultivate millet crops. Similarly, farmers with surface and groundwater irrigation are 7.9% and 7%, respectively, less likely to adopt millets production. It is noted that a farm accessing water from various sources is 21.4% less likely to adopt millets production. When compared to rain-fed farms, farms having canal irrigation facility are expected to reduce area expansion under millets by 0.461 acre at the conditional level and 0.053 acre at the unconditional level. All of these findings suggest that millets production is predominantly rainfed. It is also found that production of other crops such as cereals, vegetables, pulses, oilseeds and fodder crops restrict the production of millets. For instances, the probability of millets production is 47% less, in the case of a farm cultivating cereals. Similarly, millets are 24.38, 8.33, 5.18 and 3.65% less likely to adopt in the case of a farm cultivating oilseeds, pulses, vegetables, and fodder crops, respectively. Also, cultivation of cereal and oilseed crops leads to more than half of millets area at the conditional level.

It's also worth noting that non-farm income generating activities are inversely related to the area expansion under millets. In the case of a farmer generating income from non-farm activities, there is a possibility of area under millets being reduced by 0.208 acre at the conditional level and 0.069 acre at the unconditional level. This shows that the scope for area adoption under millets is less, if farmers are engaged in income generating business activities outside of the farm.

Impact of changes in the institutional factors

We were also interested in finding the effect of institutional characteristics like extension contact, training attended, membership with famers' organisation, minimum support price, credit availing and insurance on the choice of millets and area expansion. The results show that only awareness regarding MSP and insurance has a significant effect on the choice of millets. Farmers being aware of MSP are 9.54% less likely to choose millets production, while farmers being aware of crop insurance schemes are 4.36% more likely to choose millets. It is observed that both credit and insurance positively and significantly affect the area expansion under millet crops. For instances, the area under millets shows an increase by 0.174 acre at the conditional level and 0.046 acre at the unconditional level in the case of farmers availing of credit facilities. Surprisingly, a positive effect of credit on millets production is noteworthy. Jerop et al., (2020) found that finger millet growing households' credit availing strongly correlated with its adoption decision, while credit availability supported the production of cash/commercial crops (Kokoye 2013; Porgo et al. 2018; Rashid 2002).

Conclusion

In the recent years, more attention has been placed on millets production and consumption for a variety of reasons. Millets can be used as an instrument for addressing various problems such as global malnutrition, poor diet, poverty, climate change, nutritional security, environmental problems associated with agriculture. Further, millets require low amounts of input, short-term period and are drought resistant. Whenever there is a failure of rains, farmers tend to use growing-millet crops as animal fodder. Further, millets are climate-resilient, compared to other crops like paddy and wheat. However, the choice of millets cultivation is subject to farm household, economic, demographic and institutional characteristics. In this study, we have made an attempt to contextualize the millets production in India by estimating the major determinants of millets cultivation at the farm level.

Although the increased price of millets has contributed for higher probability of millets adoption, the magnitude of area expansion under millets is found very less. In line with this, awareness about MSP for millets is negatively associated with the choice of millets though the MSP is 1.5 times more than the cost of cultivation. Moreover, the findings also reveal that though higher educational levels of farmers have had a significant effect on millets choice, there is no

significant effect on the area expansion under millets. This highlights that millets are still seen as inferior crops, even by farmers who already grow them. On the other hand, extension activities are found to have no significant role in the decision making behaviour towards millets production. It is recommended to encourage agricultural extension workers, scientists, and other agricultural stakeholders towards organizing campaigns, training programs, and frequent contacts with farmers in order to raise awareness regarding the benefits of millets in terms of nutrient richness, production efficiency and environmental benefits in comparison to the production of other cereal grains. Moreover, skill development programmes in the areas of production, processing and value addition of millet products need to be organised for all the millet growing farmers, specifically female farmers.

The study revealed that leased-in practice encourages more area coverage under millets, indicating that cultivable land, in particular rain-fed area suitable for millets, may be made available at a cheaper rate to increase the area. It is also observed from the estimated results that farmers depending on irrigation sources of any kind for crop production are negatively interested in millets production, as compared to rain-fed farmers. All these indicate that a wide, holistic and inclusive policy needs to be developed to integrate and encourage rain-fed and rental farming with promising new technologies in millets production, processing and marketing. Cultivation of other crops such as cereals, pulses, oilseeds, vegetables and fodder has affected tremendously the choice and area extent under millets. The main reasons behind the shift from millets production to other crops might be low productivity and remuneration, inadequate input subsidies and credit, price incentives and changes in taste and preferences of consumers. Specifically, subsidised supply through the public distribution system (PDS) is one of the major reasons for increased area adoption under cereals, but millets are underutilized in the PDS system. Hence it is important to create a generalised demand for millets-based products, along with productivity enhancement to help millets growing farmers in realising better prices for their products in the market. Moreover, value addition and modernization of the processing sector of millets may be created in the major millets growing regions. This could help boost the demand for millets and millets-based food products. Improvement and dissemination of post-harvest processing technologies for millets in rural areas could create employment and agribusiness opportunities and subsequently increase the use of millets based food items.

The study findings demonstrate that credit for agricultural purposes and insurance policies have encouraged millets production. This positive effect should be noted, as it is well-known that credit encourages only commercial crops or commercial farming. Hence, it is recommended that eliminating constraints in accessing formal agricultural credit from the nationalised and cooperative banks may help increase the area under millets. Also, governments, combined with bank officials, should organise special loan-melas for the stakeholders involved in the millets production and processing, so that millet growing farmers and processors are able to avail of credit facilities easily and increase the millets based food production.

As millets are the major source of many nutrients, removing barriers to their production, distribution and consumption can help reduce the problem of nutrition-related insecurity and malnutrition cases in the country. The study results are intended to benefit agricultural policy makers, extension services, government and private agencies towards undertaking appropriate measures related to the production and use of millets in India.

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ABSTRACTS

Constraint analysis of Jhora fish farmers in Darjeeling Himalayan hilly region

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This study examines constraints faced by Jhora fish farmers. Primary data was collected from 120 respondents practicing Jhora fisheries in three types of ponds: cement, mud, and cement with mud bottom using a structured interview schedule. Rank-based quotient was used to quantify the technical, environmental, infrastructure, and economic constraints. Results indicated that non-availability of quality feed, hatchery, predation, and lack of credit were the most important constraints. Non-parametric Kruskal-Wallis test revealed a significant difference in the median rank scores of eight out of twenty-seven constraints. The study suggested suitable strategies for enhancing fish production in Darjeeling hilly region, so that Jhora fisheries get popularised among rural youth.

Competitiveness in the trade of spices

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India is known as home of spices. It is the largest producer, consumer and second-largest exporter of spices. The main purpose of this study is to analyse exports and imports of spices. The study is based on secondary data obtained from Spices Statistics at a Glance, Directorate of Arecanut and Spices Development, Ministry of Agriculture and Farmers Welfare, Government of India. India is the birthplace of several spices, including chilli, turmeric, cumin, coriander, ginger, fenugreek, cardamom, curry powder and garlic. Global export performance of spices estimated through Revealed Comparative Advantage (RCA) indicated a trade surplus with occasional fluctuations. Since 2015, the exports of cumin and ginger have increased by 177%, and followed by small cardamom (150%), chilli (111%), turmeric (81%), celery (80%), and large cardamom (28%). The nominal protection coefficients show that exports of turmeric, chilli, and ginger have a comparative advantage.

How vulnerable is Punjab agriculture to climate change? A district-level analysis

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The study analysed the vulnerability index of 22 districts of Punjab state at four different points of time i.e., 1990, 2000, 2010 and 2020. The uneven weight approach of Iyengar and Sudershan is used to calculate the vulnerability index, which is the sum of exposure and sensitivity minus adaptive capacity. The mapping of vulnerability index provides a wider approach to understand its dynamics across space and time. The results revealed that SBS Nagar (1.51) as the most climate-vulnerable district, whereas Jalandhar the least (0.27). The study also indicated that adaptive capacity is less dominant than exposure and sensitivity, indicating that adaptive capacity lessens vulnerability. The vulnerability has also decreased due to dissemination of climate-resilient technologies.

Role of agricultural extension on adoption and attitude towards organic farming: a study among rice farmers in Kerala

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Enhancing the efficiency of agricultural extension services is an important institutional strategy for sustainable agricultural development. Agricultural sector needs alternatives to combat the harmful effects that chemical pesticides and fertilizers have caused. The study by looking into the availability of extension services and adoption of organic practices in rice farming in Kerala found that effective adoption of organic farming is possible through institutional changes including significant changes within the extension system like strengthening communication among farmers, providing more training and connecting through social media.

Total factor productivity and supply-demand gap analysis of rice in sub-tropics of Jammu region of Jammu and Kashmir Union Territory, India

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An investigation entitled, Total Factor Productivity and Supply Demand Gap Analysis of Rice in Subtropics of Jammu Region was conducted in Jammu and Kathua districts of J&K UT. The results related to cost and returns revealed that per hectare cost of cultivation for rice was Rs. 55642.45, Rs. 51729.92, Rs. 59543.40 and Rs. 57446.37 for Bishnah, Marh, Mahreen and Nagri with an overall average of Rs. 56090.40. The per hectare gross returns of rice cultivation of Bishnah, Marh, Mahreen and Nagri were Rs. 114782.60, Rs. 114904.60, Rs. 120820 and Rs. 120809.90 with an average return of Rs. 117829.28 respectively. The cost of cultivation of rice was found to be highest (Rs. 59543.40/ha) in Mahreen block of Kathua district with an overall average of Rs. 56090.40. The cost- benefit ratio was found to be highest (1:2.22) for Marh block with an overall ratio of 1:2.10. The results regarding trends in productivity growth of the rice showed that efficiency change was one for the overall period whereas technical change and TFP change were more than one for 2016-2017 which is 1.044 with a mean of 0.953 for overall period. After calculating the demand and supply in sampled rice farms, both districts were found to be in surplus stage which was highest in Jammu district (282033 kg). On the basis of secondary data, it was also found that Jammu, Samba and Kathua district had surplus production of rice, i.e., 1006559.94 kg, 15029.80 kg and 21208.40 kg, respectively while all other districts of Jammu are deficit. Jammu region as a whole was also found to be deficit in rice with requirement of 183329.33 tonnes.

Research priority setting for agricultural commodities by districts of Saurashtra region

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This paper describes priority setting for crop research across districts in Saurashtra region of Gujarat. We used secondary data on experimental station yields; demonstration trial yields; district wise estimated area, production, yields, and prices of agricultural, horticultural, vegetables, and spices crops, population census, animal census, animal products *etc.* for the period from 2015-16 to 2020-21 from the various published sources and University Research Stations. The multi-criteria scoring model was used for priority setting. The final base line constructed taking extensity and intensity dimensions of efficiency, equity, sustainability and foreign trade indicated the highest priority to Bhavnagar district, followed by Surendranagar, Rajkot, Amreli, Jamnagar and Junagadh.

A study on factors influencing the performance of FPOs in Koraput district of Odisha

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The study was conducted in Koraput district of Odisha during 2019-20. A total of 120 respondents were selected. Governance and management, membership commitment, external linkages, group composition, and types of FPO were the factors identified to determine the performance of the FPOs. The results of DEA analysis confirmed that there has been an increase in the efficiency of FPOs. Based on Principal Component Analysis, the factors that had a positive influence on the performance were: youth participation, governance and management, overall participation of men and women as well as the membership commitment. The components which depicted negative influence were: family influence and land contribution. The results further showed that with the increase in the size of FPOs, the likelihood of interaction with other organizations and stakeholders increased.

Viability and sustainability of pulse sector in Maharashtra: a case of pigeon pea

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A critical evaluation of costs and returns showed positive and significantly high returns from pigeon pea in Maharashtra only over variable cost. However, a significant and steady increase in variable cost over time has resulted in lower profitability. Labour and insecticide costs, in particular, have grown significantly. The rising variable cost has led to highly fluctuating profitability in pigeon pea cultivation. The fluctuation in profitability is also on account of unsteady yield. These discouraging observations coupled with loss of crop during various pre-harvesting, harvesting and post harvesting operations are a matter of great concern for sustainability of pigeon pea cultivation. To boost cultivation of pigeon pea, there is a need to reduce cost, increase yield and enhance MSP, apart from initiating other measures like bringing more area under its cultivation accompanied by package of practices, replacement of non-descriptive local varieties with high yielding pest and disease resistant varieties, and transfer of technical knowledge.

Delayed conception among bovine heifers causing a huge economic losses to dairy sector in Bihar

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This research paper analysed the extent and magnitude of economic losses due to delayed conception among bovine heifers in Bihar in 2021-22 using survey data from Bhojpur and Kaimur districts . A total 63 heifers were selected for data collection . The average age of sexual maturity of heifers ranged was 28-30 months in the case of buffaloes ,24-27 months for indigenous cows and 19-22 months for crossbreed cows. The observed sexual maturity age in general was found much delayed by 2-4 months. The average number of AI services was quite high- more in buffalo heifers, followed by crossbreed heifers and indigenous heifers. The extent of average economic loss was higher in the case of buffalo (INR 17742), followed by crossbreed cows (INR 15250) and indigenous cows (INR11441).

Statutory IP laws in India vis-a-vis agri-based technologies management: a review

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This study attempts to review that status of IP laws in India and their application in transfer of agricultural technology commercialization for the benefits of researchers and R& D institutions. It emphasised the fundamental ideas behind IPRs and how they apply to agricultural innovations and technologies. In general, intellectual property rights are described as legitimate legal rights over unique and innovative ideas. These legal protections could stop unethical use of IPR innovation from exploiting original idea. The Copyright, Trademarks, Geographical Indications, Industrial Designs, Patents, Integrated Circuits, and Trade Secrets are the many IPR categories. IPRs generally forbid commercial disclosure of concealed and protected content by third parties without the creator's consent for a set amount of time. Because they offer the best protection for patentable plants, animals, and biotechnological techniques used in their production, patents are currently the most significant IPR for agricultural goods and services. To safeguard efforts made in traditional plant breeding, many nations have established plant breeder's rights. The promotion of seeds and spraying services uses trademarks. Hybrid plant types can be protected under trade secret protection in the agricultural sector. Licenses and material contract agreements (MTAs) have effect of transferring ownership rights over tangible materials. Anyone whose research has the potential to result in an invention as well as research administrators who have to deal with intellectual property issues during both the acquisition and deployment phases need to have a basic awareness of these methods.

Performance of women in various sericulture operations

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The paper evaluates women's participation in various sericulture operations against their male counterparts based on survey conducted in 2017-18. A sample of 270 silkworm rearers, selected randomly from three districts namely Kathua, Rajouri and Udhampur which were selected based on highest number of silkworm rearers and cocoon production was taken. The binary logistic regression model was used to examine women's involvement in sericulture and the estimates of binary logistic regression model indicated that bed cleaning, feeding of leaves, chopping of leaves and sorting of cocoons had significantly influenced adoption of the work by women in sericulture. The t-test with equal or unequal variances to examine the participation of men and women in different sericulture activities revealed that the average performance of females was more in activities like separation and chopping of leaves, bed cleaning and feeding of leaves, application of bed disinfectants and harvesting of cocoons. These findings clearly indicate that the participation of females was more in indoor activities requiring soft skills while that of males was more in outdoor activities requiring more energy.

Land use dynamics and its implication for the agricultural sector in Indian Punjab

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This paper examines the dynamics of land use and its implications for the agricultural sector of Punjab based on secondary data from different land classes. The findings reveal a significant land shift from a desirable ecological and agricultural sector to an undesirable non-agricultural sector. The net sown area in the state had increased till the 1990s and then showed declining growth. The land put to non-agricultural uses, permanent pastures and other grazing lands, land under miscellaneous tree crops not included in area sown, and the net sown area show a significant positive impact on cropping intensity, and the net irrigated area, the average size of holdings and an average yield of rice have a positive determining factor for cropping intensity. For proper management and conservation of land resources, it is recommended that a scientific and institutional framework be established in the state.

Inclusive agricultural development through Agri-export institutionalising by cooperatives/FPOs and technology interventions in Jammu and Kashmir

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Increasing globalization and liberalization have led to a rapid growth in agricultural trade. India is performing below its potential in agri-exports. Its share in global exports of agricultural products stood at 2.5% in 2020, and even lower at 1.4% for processed food products. In recognition of this fact, the government announced the Agriculture Export Policy (AEP) to double agriculture exports to US$ 60 billion by 2022, also serving to improve farmers' incomes, there exists a huge scope to tap this market. The AEP lays emphasis on farmer-centric approach. During the course of implementation of AEP, considerable progress has been made in giving Farmer Producer Organizations (FPOs) and farmers a stake in the export of their produce. Direct linkage of cooperatives and FPOs with the export market has not only improved farmers' incomes but has also resulted in better farming practices due to requirements of catering to the international markets. J&K's total export value stood at approximately Rs7,000 crores from April 2014 to Jan 2021.There are 130 commodities, which have been exported to 161 countries in last seven years. In fact, agricultural products not only yield over 50% of the Union Territory's Gross Domestic Product (GDP), it provides raw materials to several industries. Fruit-canning, edible oil extraction, flour mills, rice husking factories, bakery and alcohol preparation draw their raw materials from agriculture. J&K is a major exporter of fruits, pulses, rice, handlooms and handicrafts. It is the sixth largest producer of walnuts in the world and an important producer and exporter of a wide variety of dry fruits. This is the reason why J&K has been declared as 'Agri Exports Zone for Apples and Walnuts'. Besides, these it is a leading exporter of pashmina and raffle shawls. There is an emerging, yet highly unexplored, foreign market for local products and the government is making efforts to tap the source through innovative incentives to the sector. The study concluded with following recommendations focusing on technologies interventions and creating a diverse business model for cooperatives in Jammu and Kashmir through the agri-export opportunities from farm to fork model. Some recommendation came out of the training was to have Centre of Excellence of Fruits in J&K, NABL accredited Labs for Walnut and Apples establishment on the lines of (India International Kashmir Saffron Trading Centre) IIKSTC for saffron, Cooperative Marketing enhancement through ODOP selected fruits crops in Jammu and Kashmir, Floriculture infrastructure development within the Srinagar or Jammu Airport for feasibility of Grading and Standardization to export for the same, One crop one Cooperative/FPO ecosystem must be promoted to frame up viable value chain of crops to export platforms, Meat Value chain with Secondary Agriculture prospective must be encouraged among the stakeholders, District Export Hubs must be developed for Walnuts, Apples and Saffron as per the ongoing scheme for Export Promotion Council, Export oriented CBBOs with SFAC/NABARD/NRLM support to develop Cooperatives/FPOs fully exploring the export ecosystem, As per WDRA Warehouse Receipts same scenario for Cold Storage/CAS platform which will provide Cold storage receipts for apple growers which will make apple supply chain broad and viable throughout the year, Organic certification platform on the lines of NPOP in Jammu and Kashmir and Facilitative Business models focusing on market functions like trade logistics, grading and standardization, processing and value addition, market intelligence and market information, market investment and insurance for the cooperatives/FPOs which will assist the stakeholders in the export ecosystem

A study on identification of bottlenecks perceived among the members of FPOs of Puri district of Odisha

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The aggregation of small and marginal farmers into FPOs has helped increase market linkages to improve farmers' economic strength. This study was conducted in Puri district of Odisha during the period 2020-21. Data were collected from a total of 50 respondents from eight FPOs from 2 blocks i.e., Nimapara and Brahmagiri. The data were analysed through Garrett ranking technique and the challenges were ranked under socio -political, organizational, economic and other constraints. The constraint, lack of co-ordination between members of FPO for different group activities was ranked "first" and non – availability of timely credit ranked last.

Assessing the impact of farmer producer organizations (FPOs) on the livelihood of farmers in the state of Meghalaya

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The major aim of FPO was to accelerate the technology, augment productivity and increase the accessibility of investment, inputs services and markets, ultimately improve the livelihood of famers. This study has been carried out on Ri-Lajong Farmer Producer Organization (FPO), Nongpoh, Meghalaya to examine the factors that influence income of member farmers of FPO. The study included primary data which collected from 65 sample farmers (member of FPO). The Heckman selection two-stage model was applied. It was found that FPO has impacted positively and significantly the income of farmers.

Institutional interventions in production and value addition of climate-smart millets: An economic analysis in eastern dry zone of Karnataka, India

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The study aims at finding the profitability of millets *Panicum sumatrense* (Little millet), *Setaria italica* (Foxtail millet), and *Paspalum scrobiculatum* (Kodo millet) cultivation in eastern dry zone of Karnataka and their value-added products. The institution chosen for research was "Kolar and Chikkaballapur districts regional cooperative organic farmers' association federation limited". The results revealed that returns per rupee of expenditure in small millets cultivation were Rs. 1.31 for little millet, Rs. 1.17 for foxtail millet and Rs. 1.20 for kodo millet. With respect to value added products, returns per rupee of expenditure was higher in organic millet malt (Rs. 2.11), followed by foxtail millet papad (Rs. 1.64), upma mix (Rs. 1.45) and dosa mix (Rs. 1.40). The research highlights that value addition in millets through institutional support helped in increasing farmer's income significantly.

Performance of different districts of Assam: in the perspective of cropping intensity and irrigation intensity

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The crop production of an area is largely dependent on the water facilities available in that area. This paper studies the impact of irrigation on cropping Intensity of different districts of Assam from the year 2009-10 to the year 2018-19 using the data collected from the different official government sites. The compound annual growth rate and the coefficient of variation were calculated for the cropping intensity and irrigation intensity and their relationship is found out through Karl Pearson's correlation coefficient. There exists a moderate positive relationship between cropping intensity and irrigation intensity.

Community based organizations and financial inclusion in India: prospects, challenges and the way forward

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The role of financial inclusion in empowering marginalized rural populace has gained considerable recognition among academia and social researchers. This has been largely possible owing to the several joint initiatives, programs, and research being executed by the Government, civil society, private players, and communities across the globe. The study tries to explore the role of community-based organizations like SHGs in ensuring economic security for the rural populace in India. Considering that agriculture is one of the chief sources of sustenance for the majority of such populace the study discusses the potential role that CBOs can play in raising agricultural productivity and securing livelihood. The process of economic growth, especially when it is on a high growth line, must attempt to involve all sections of society. Lack of access to financial services for small/ marginal farmers and weaker sections of society has been recognized as a serious threat to economic progress, especially in developing countries like India. To target comprehensive financial inclusion in rural India the challenges that such CBOs are facing need to be arrested. Focus Group Discussion and Key Respondent Interviews were conducted in the Kalahandi and Koraput districts of Odisha where such challenges were discussed. Based on discussions with multiple Government and CSO stakeholders a list of possible suggestive measures has been documented to effectively address these challenges.

Seed multiplication ratio (SMR) revision and its significance in seed planning

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Quality seed production system of India has got great opportunities and scope in future seed planning and forecasting from improved Seed Replacement Rate (SRR) and Seed Multiplication Rate (SMR). This is possible through use of improved varieties and hybrids with respect to yield, other genetic potential concerning to climate, soil and geographic adaptation and also in response to improved management using advanced technology adoption. Regarding farmers' adoption of quality seed production and use of quality seed per se, major constraints are coming from lack of awareness on use of quality seed, supply shortage of quality seeds at right time. The report on state of agriculture (State of Indian agriculture-2012-13, DAC, GOI) stated that seed multiplication ratio from breeder seed to foundation seed and from foundation seed to certified seed needs to be addressed by all the seed

producing agencies, both in public and private sectors. Comprehensive database on seed production and distribution in India by public and private sectors needs to be built for the benefit of all the stakeholders. In this regard this study analyses the SMR of various crops using data compiled from ICAR Seed project, which clearly depicts the improvement in productivity of various crops through advances in technology. The SMR data, which was already in use for various crops, was compared with the data obtained from varied centres of ICAR Seed Project. The comparison shows a need to revise the old / obsolete SMR, which is currently used for estimating demand and supply requirement of quality seed in the country and more importantly an essential cog in seed certification for seed yield realization from unit area.

Assessing the impact of farmer producer organizations and price policies in uplifting income of agricultural households in India

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Using a household-level survey, this paper examines the impact of market support mechanisms and farmer producer organizations in accentuating income among agricultural households in India. It is found that income from the cultivation of agricultural households has increased at a slow pace of 3.3% per annum during 2002-03 and 2018-19. However, farmers who have participated in FPOs reported having higher income as compared to non-farmers. So, FPOs have enabled the small and marginal farmers to derive higher income through collective bargaining. Thus, the study emphasizes the need to promote FPOs by providing them incentives and adequate support and training facilities.

Role of FPCs in accessing inputs, marketing and improving household economy: evidences from Alipurduar district from West Bengal

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Due to lack of sufficient bargaining power in the competitive business environment, the small and marginal farmers are facing the problem of marginalization in both input and output markets and also severe challenges in accessing improved inputs and credit at reasonable cost. Due to adherence to traditional production practices and lack of proper value chains, their marketable surplus is also small. The present paper aims to examine the impact

of the Farmer Producer Companies (FPCs) in the household economy of the farmers using field survey data from the Indian state of West Bengal. The farmers aggregate in FPCs to enjoy economies of scale and to mitigate their risks through the way of access to improved inputs, technologies, storage, marketing and credit. The member farmers have higher linkages and higher temporal and informational efficiency.

How efficient are the FPOs in eastern India: a quantitative introspection

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The present study was carried in Birbhum district of Bengal with all the 19 FPOs promoted through NABARD and SFAC. Data envelopment analysis was applied to obtain the extent of efficiency across the FPOs. Probit regression model was applied to identify different factors influencing farmers to join FPOs in the study area. Further, to obtain the constraints faced by the FPOs, Garrett ranking technique was used. The findings indicate that there is considerable scope to improve the efficiency across FPOs by rearranging the available resources. With appropriate policy intervention towards addressing the constraints faced by the FPOs can play pivotal role in improving efficiency of the FPOs and consequently the livelihood of the member farmers.

Are aspirational districts socio-economically vulnerable? a case of district Nandurbar, Maharashtra

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NITI aayog's Transformation of Aspirational Districts Programme prioritises 112 impoverished districts across India to reduce regional disparities, this study assesses the vulnerability in Maharashtra's aspirational district (Nandurbar) using a novel Socio-economic Vulnerability Index (SEVI) to evolve customised developmental interventions. Using the Census of India 2011 dataset, a composite index of socio-economic vulnerability was

constructed for all 930 villages in Nandurbar. Social sensitivity (0.58) and economic sensitivity (0.59) were *high* while the social adaptive capacity (0.36) and economic adaptive capacity (0.39) were *lower*. Nearly 446 villages (48%) were found to be *highly* vulnerable, which is masked by the aggregate district score of 0.41, which indicates *low* vulnerability and indicating the need for granular analysis. Key drivers that *increased* sensitivity were a higher proportion of ST/SC population, and longer distance to town and hospital, while those that *reduced* adaptive capacity were poor housing conditions and amenities, and poor transportation and communication, which need targeted interventions. The study validates the utility of SEVI as a handy tool for micro-level development planning.

Dynamics of co-integration and forecasting models in the tea markets

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The study analyses the dynamics of tea prices in Guwahati, Kolkata, Mumbai, Delhi, Colombo, and Mombasa markets. The descriptive statistics reveal a promising growth rate in all the domestic markets, despite of wider price range. The markets are well associated in the short run, whereas Johnson's co-integration test indicates zero co-integrating vectors. The lack of integration implies an absence of strength and stability of price linkages in the tea markets, which should be corrected by improvising transparency and flow of information in tea markets. For forecasting, EEMD-ARIMA is found best fit and thus suggested to use for forecasting the tea prices.

Extent of technological change in pulses and oilseeds production in eastern India over last decade

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This study quantifies the extent of technological change and factors responsible behind the production of pulses and oilseeds in eastern India over last decade (2009-10 to 2018-19). Output-oriented DEA-Malmquist techniques have been applied and has registered that the TFPCH is more or less stagnant and is dominated by the technical substitution of input use and not for efficiency changes. Step-wise regression has revealed that the technological change may be guided by the plant protection measures and adequate supply of inorganic fertilizer. Suitable policy and strategy measures have been suggested to enhance the productivity of pulses and oilseeds in Eastern India.

Agricultural scenario of Nepal: performance and SWOT analysis

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This study aimed to determine the performance of agriculture sector of Nepal which would help in formulating policies and regulations for the growth of this sector. Based on 20 years' trend data from 2001-02 to 2020-21, the growth and instability of different crops, livestock population and products were calculated by dividing the selected time in two periods i.e., period-I (2001-02 to 2010-11) and period-II (2011-12 to 2020-21). The study showed that the growth of production of almost all the crops increased during the period-II. Oilseeds showed the highest increase in production with growth rate of 6.26% whereas millet and coffee showed decreasing rate of production in the period-II. The area under wheat and millet decreased drastically in period-II. Highest transition in production was seen in coffee as it reduced from 10.04% in period-I to -3.68% in period-II. Although instability in area increased in period-II for almost all the crops, tea experienced highest increase. Instability in coffee production decreased from 41.85% in period-I to 15.92% in period-II which was still the highest among selected crops. The instabilities in production were due to natural calamities, lesser and untimely availability of inputs, less priority in the research sector for minor crops and so on. Livestock subsector has been performing well as compared to the crop sector. Prioritization by the government and wide climatic conditions are the major strengths of the sector whereas unavailability of inputs in time and lack of investment frameworks are the weaknesses. Farm mechanization, topography and agri-tourism are some opportunities and climate change, fragmentation of arable land, brain-drain etc. are the threats to this sector in Nepal.

Agricultural trade performance: a case study of Indian oilseeds

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The present study is an attempt to study the growth trend, variability and the comparative advantage of major oilseeds export from India using revealed comparative advantage, trade specification coefficient, revealed symmetric comparative advantages and revealed competitive advantage indices. Growth trend analysis for export and import values indicates that, with the exception of export quantity of oilseed nes and import quantity and value of linseed, all showed a positive trend with high inter-annual variability over the period of the study. Following the TSC analysis, the value of export exceeded the value of import for all oilseed crops except linseed, and certain years of fluctuation were observed in the case of oilseed nes over the period of the study. The analysis of competitiveness of oilseeds export showed a favourable competitive scenario except in the case of linseed where in early 2000's India was inefficient in export and for oilseed nes competitive advantage indices showed negative values for some years revealing lack of export competitiveness.

Future trading of agricultural commodities in Punjab: prospects and problems

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Price risk management and price risk reduction for small and marginal farmers have always been the most important issues for agricultural policy of agriculturally dominated states, particularly, Punjab. In order to manage the price volatility, the Government of India has been encouraging commodity futures markets. Further, it is very difficult for the small and marginal farmers to trade in commodities futures because of small quantum of their produce, however, if they join together and set up some collective organizations such as FPOs then they can hopefully trade their produce in commodity markets and minimize the price risk. This study was conducted among 67 FPOs registered in Punjab in the year 2020-21. About 57% of FPO members were totally unaware about the future trading, 32% considered it to be a gambling practice, while remaining 11% considered it to be a profession of big players like ITC, Wallmart, Adani, etc. It was observed that the collection centers of NCDEX were quite far away from the location of FPOs, moreover there was problem of grading and standardization as well. It was recommended that maximum number of FPOs should combine together and take up future trading on large scale as it will minimize the risks and losses, further governments should provide infrastructural support for future trading of agricultural commodities.

Sustainable rearing of Eri silkworm (*Samiaricini*) in Bishnupur district of Manipur

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The research was to analyse the sustainability of rearing Eri silkworm. The study was carried out in two blocks and five selected villages of Bishnupur district of Manipur with purposive sampling method. One hundred respondents were interviewed. The majority of the farmers took agriculture as their primary occupation also rearing livestock. Marketing of Eri-silk cocoon was disposed through a single marketing channel, Channel-I, Government procured cocoons from the farmers. On an average, the cocoon produced per 100 dfls was 80kgs, 85 kgs and 90 kgs for marginal, small and semi-medium farm categories, respectively. The price of the Eri was fixed by the state department viz; Rs 150 per kg of cocoon. The total cost of Eri-silk cocoon production was highest in semi-medium farm category Rs 8530 per 100 dfls. The highest gross and net returns realized from Eri-silk were found in semi-medium farm category Rs 13,500 and Rs 4,970 respectively. The major constraints faced by them during its production and marketing were lack of knowledge and non-availability of market in the locality, followed by lack of organization, absence of market information, etc.

Trend of capacity, production and utilization in fertilizer industry

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India's capacity of nitrogen (N) fertilizer production was 14299.10 thousand tonnes in 2019-20 whereas the total production of nitrogen (N) was 13685 thousand tonnes which were 95.71% of total production. India's total capacity to produce phosphate (P_2O_5) was 7279.20 thousand tonnes. During 2019-20 India's utilization was only 65.82% of the total capacity and produces only 4791 thousand tonnes of phosphorus. The per annum growth in capacity, production and capacity utilization was 1.88%, 2.16% and 0.27% respectively for nitrogen. While capacity utilization of phosphate showed negative signs and declined by 1.37% annually. The per annum increase in capacity and production was attained by 3.99% and 2.56% respectively. Capacity utilization for both nitrogen and phosphorus was decreased from 2011-2021 due to one of the new urea Plant remaining shut down during the entire year due to lack of availability of natural gas. Another urea plant remains non-operational due to financial constraints

Seri-bioscience recent trends: its prospects in contemporary sericulture

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The latest developments in the many branches of bioscience, such as crop protection, bio-nanotechnology, and seri-biotechnology, have completely changed the way that sericultural science is researched globally. Despite genuine yet segmented efforts, India has yet to gain from the use of seri-bioscience to produce goods in the form of technology as the field is still in its infancy. Given this situation, we must intensify our efforts to create technology that will benefit silkworms and host plants. Dependent on elements including weather, pests and diseases, and agricultural techniques, significant seasonal fluctuations in the host plant's nutritional content and composition occur, which in turn have a significant influence on the growth and development of the silkworm. Since lesser animals lack highly developed humoral immunity, vaccine production may not be particularly helpful in these cases. However, in these lower animals, substances that stimulate the immune system may be quite helpful for disease resistance. Supporting the use of silkworm models in scientific research will offer fresh approaches to old problems and new perceptions of how to approach problem-solving, which will be extremely beneficial to both science and society. The current approaches provide a summary of the progress made in seri-bioscience research as well as recommendations for the future.

Institutional introduction of okra in Tapi district of south Gujarat: a step towards sustainable agricultural development

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Okra commercialization in Tapi district is the outcome of institutional interventions during the previous forty years. These interventions have been proven to be successful in converting the parochial paddy cultivation to commercial okra cultivation. The export promotion agencies' significant marketing-focused institutional initiatives have been instrumental in highlighting the value of institutional innovations in promoting okra in the area. The study has demonstrated the potential advantages of extensive institutional changes persuaded by the export agency. The comparative assessment of marketing shows marketing channel for okra via an exporting company as most effective. The study has demonstrated the benefits of an informal community participation under the right supervision and guidance.

Challenges of 'situational assessment of agricultural households survey' in adjudicating the cooperative agencies' status quo in India

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The study scrutinizes, whether situational assessment surveys (SAS) are suitable to judge the state of cooperatives in India and further is it advantageous to sell livestock products through cooperatives in India, and which variables influence their decision to use a particular marketing channel. We evaluated data on the disposal of livestock products to various channels using milk and egg disposal information from the 77th round of the NSSO's situation assessment survey, which comprises a sample of 58040 households. Results show that farmers are only selling a small fraction (less than one-fifth) of their overall disposal to the organized sector. The sale of eggs and milk is dominated by the unorganized sector. According to our findings, selling milk (from cows and buffalo) through cooperatives results in lower prices for households. However, the evidence reveals an inverted tendency. The study proposes that the situation assessment survey is not giving a holistic picture to analyse the compensation of organized marketing channels due to numerous complex assumptions that had been made, in determining the cost of production for in-milk cattle. Due to this the impression of non-profitability via cooperatives as compared to unorganized is fuelled. Nevertheless, cooperatives bring producers many unrecognized perks. Our study explored whether SAS is effective in this context and also offers some recommendations about how to deal with the concerns in this direction and suggested a more comprehensive survey.

A study on the status of the cloud kitchen business in Hyderabad and factors affecting it

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Cloud kitchens are commercial kitchens that prepare food only for delivery purpose and do not provide dine-in facility for customers. In the cloud kitchen model, a brand owns or rents a space where its chefs work and uses its own or third-party order and delivery systems. It may also provide a takeaway service where customers can wait to collect their food. The cost incurred to establish a cloud kitchen is much lesser than conventional restaurant and can be situated with in a small area and it has less operational costs due to which cloud kitchens are more profitable than normal restaurants. In this perspective, the study is conducted to analyze the current status of cloud kitchen firms, factors affecting cloud kitchen business. Hyderabad city was preferred as the study area. For the analysis, data was collected through personal interviews from the selected cloud kitchen firms with the help of structured questionnaire. Data regarding the factors affecting cloud kitchen business are taken from customers of cloud kitchen. Regression analysis is used to analyze the factors that affect cloud kitchen business.

Farmer producer organization (FPO) formation and credit inclusion in bamboo business: a prospect for North Eastern Region

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The study was carried out in Assam and Meghalaya of North Eastern Region of India. The total respondents considered was 380. In Assam, a few of the progressive stakeholders were availing credit from institutions but was negligible. In Meghalaya, the credit inclusion was observed only in bamboo shoot business. Formation of FPOs in bamboo business which was not observed in the region and credit accessibility through institutions to get proper market infrastructure and opportunities in global market is much needed of the hour to boost the sector.

Food security scenario of Jammu, Kashmir & Ladakh: status, issues and policy implications

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Over the past three decades, India's agriculture sector diversified significantly, introducing new crops and varieties along with newer enterprises and opportunities for farmers and farm sector. Despite growth and prosperity due to diversification, food-grain field crops are still looked upon as the pillar for the food security of the nation. A number of initiatives under different programs were taken by the two farm universities for breeding new varieties of cereals, pulses and field crops besides horticultural fruit and vegetables to cater the growing demand of food and livelihood security of the UT of Jammu & Kashmir. These varieties have improved yield traits and having durable resistance against biotic and abiotic stresses. In the climate of uncertainty, there is a need to re-visit the issue of food security from regional perspective in order to build synergies across the food production chain. The issue becomes more important when we face supply chain disruptions due to geo-politico-climatic and pandemic incidences. Policy strategies for realizing the real varietal impact of improved varieties through putting an effective seed supply chain management and also fixing other issues will be useful to policy planners, practitioners and development agencies working in the domain of food production and its distribution for achieving the regional food security.

Cropping pattern, marketing chains and food security status in rural-urban interface of Bengaluru

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The study was conducted in rural-urban interface of Bangalore to examine the participation of farm households in different marketing chains and production diversification on food security status among selected households. Our results show that, among the different crops cultivated in the study area,%age of area under ragi was the highest followed by maize. In case of ragi, majority of the farm households sold their produce directly to consumers (farmers market) realized better price (Rs. 2350/q) and their food security status was also higher in both the transects. In case of maize, producers residing in south transect realized higher food security (70.2%) than the north transect households (68.7%). Our results suggest that, more crop diversified area is more food secured area, hence efforts should be made to promote crop diversification in north transect to enhance food security status. For better price realization, producers need to be encouraged to adopt direct marketing or selling their produce through regulated markets.

An analysis of trade performance of the fisheries sector in India

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In Indian context fisheries sector is one of the fastest growing sectors and known as a 'Sunrise Sector' which provides the income and employment along with nutrition and food security to the millions of peoples of the country (PIB, 2021). Fisheries contributed about 1.21% of the total GVA and 6.56% of the GVA from agriculture sector in 2019-20. Fish and fish products have emerged as the largest group in the agricultural exports of India. It is influenced by the demand, domestic production, consumer preference, trade agreements between countries and trade policies. In view of the increasing importance of fisheries sector in the national economy, the study was undertaken to examine the trade performance of the sector. India's Share in World Trade of Fisheries Products has increased from 4.12% in 2002-03 to 5.60% in 2019-20. From the calculation of Revealed Comparative Advantage (RCA) and Revealed Symmetric Comparative Advantage (RSCA), it has been observed that fisheries sector has been quite competitive over the years with relative comparative advantage in exporting in most of the fisheries products. Markov chain approach has been used to identify important relationships that exist among importing countries of Indian Marine products, the structural change in the volume of marine products export from India was examined using transitional probability matrices.

Production and marketing of betel leaf in Odisha: an economic analysis

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Betel Leaf is a commercial horticultural crop with unleashed economic potential. It is not only part of our cultural traditions but also has great significance in the Ayurveda. Odisha being one of the prominent betel leaf growing state the crop has economic impact on the betel leaf growers of the state. In the initial first year the cost incurred by respondents is more because of additional cost incurred on baroj construction. But in the following years the net return amplifies with increase in economic life of the crop. All the resources used are significant but seed is the only resource whose use is being ill afforded. Of the two major marketing channels prevalent in the area, the channel that was comparatively more efficient was Producer-Wholesaler- Retailer – Consumer. The prime constraint that causes hindrance in optimum production and marketing of betel leaf were disease severity and price fluctuations respectively. The crop despite the capacity to earn foreign currency has been of less interest to both researchers as well as policy makers. This paper tends to analyse the economic potential of this horticultural crop to enable the policymakers understand its role in the rural economy.

Comparative analysis of profit efficiency of farm households under livestock-based farming systems in saline and normal areas of West Bengal using stochastic frontier approach

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The present study analysed the impact of salinity by comparing the economics of different livestock-based farming systems in saline and normal areas of West Bengal. The study also identified the factors affecting profit and inefficiency functions which will help the policy makers and farmers to adapt to this natural hazard. The study revealed that, in saline areas, as concentrate price and farm capital used was increased by one%, profit would reduce by 0.40 to 0.71% and 0.41 to 0.45%, respectively. In case of normal areas, one% increment of concentrate price and farm capital used would reduce the profit by 0.24 to 0.46% and 0.43 to 0.52%, respectively. Gamma (ã) value indicated that 90 to 96%, was also statistically significant. Likelihood Ratio (LR) statistics for all the farming systems were significant. From the mean of profit efficiency scores, it is revealed that households under all the farming systems except cattle+goat+crop+fish (S3) were on an average less than 70% efficient in the saline area, but in normal areas the households under different farming systems were on an average 70% or more efficient. Irrespective of the saline and normal areas, it was found that age, level of education, farming experience, household size, number of animals, land under cultivation, access to credit and access to information had a negative effect on profit inefficiency. Number of animals and croplands had a greater effect on the reduction of profit inefficiency than other variables. In saline areas, one% increase in the number of animals and cropland would reduce profit inefficiency by 0.22 to 0.59% and 0.22 to 0.35%, respectively. One% increase in the number of animals and cropland would reduce profit inefficiency by 0.28 to 0.81% and 0.29 to 0.93%, respectively in normal areas.

Long term growth of freshwater aquaculture in India-drivers and policy

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Freshwater aquaculture in India is one of the fastest growing food production segments. Available data for production of inland fisheries constitutes information on inland, brackish water capture and culture resources. Among them, freshwater aquaculture is a fastest growing and having largest share to inland fisheries. Analysis is

made on past and present growth rates of inland fisheries in India as proxy to freshwater aquaculture. The drivers of the aquaculture growth in India are resource availability, technology, organisation, entrepreneurship, climate and environment, market and price, governance and policies. Five scenarios are built with 50% deceleration, 25% deceleration, continuation with present, 25% acceleration, and 50% acceleration of the present growth rates by 2030. The paper made an analysis of critical factor responsible for the sustained growth of freshwater aquaculture in India.

Capital investment: institutional versus non-institutional credit in farm and non-farm capital formation in southern Karnataka

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This micro level study, conducted in the Southern Karnataka specifically focusing on progressive (Tumakuru district) and less progressive (Ramanagara district) areas with an objective of understanding the institutional and non-institutional sources of farm and non-farm capital formation with a total sample size of 240. If the results were looked at irrespective of institutional or non-institutional sources, relatives/friends were the major sources of borrowings in both progressive (39%) and less progressive area (56%) in farm investment because of easy access for immediate requirement. Analysis revealed that the credit delivery to the agriculture farm investment sector continues to be still relatively inadequate. It appears that the banking system (Institutional source) is still hesitant on various grounds to purvey credit to small and rainfed farmer's farm capital investment. And among the institutional sources, the co-operative credit structure needs revamping to improve efficiency of the credit delivery system in rural areas (in study, needs in less progressive area). Therefore, from the study to reduce dependency of farmers on non- institutional sources of credit in both areas and in particular to less progressive area, the loan procedural formalities (administrative costs) should be made simple and farmers friendly and create awareness among farmers is vital in order to improve the accessibility of credit (mobile banking) for medium and long terms loans for farm capital investments.

Contract farming in India: what do we know and don't?

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Contract farming (CF) can catalyse demand driven agricultural production. CF is practiced by 5.5 lakh farmers in India. A law was introduced by the Government of India in 2020 to promote CF in India but was repealed after year-long protest by farmers. We review the evidence on CF, map evidence gaps, and discuss policy implications. Meta-analysis revealed that CF reduced farmers' input costs by 28%, increased productivity by 20%, and profits by 51%. Furthermore, evidence gaps in outcomes such as educational attainment, nutritional security, diversification, sustainability, livelihood resilience, saving, and capital formation are discovered. Public policy implications are also discussed.

Bioenergy from crop residues in India - potential, opportunities, challenges and policy imperatives

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This paper explores the trend in crop residue availability and the surplus quantity available for bioenergy generation and its potential at the national and regional levels. We selected 26 crops for the analysis based on residue generation capacity and feedstock suitability for energy generation and analyzed the data for the periods 1995-96 and 2015-16. The bioenergy potential based on all crop residues was 1892 PJ in 2015-16 and it is equivalent to 6.7% of the total primary energy consumption or 34% of the total electricity consumption of India. We also illustrate the double loss caused by on-field burning of crop residue in terms of bioenergy potential foregone (1210PJ) and GHG emission (4508 Gg) for the three major crops (rice, wheat, and sugarcane). The opportunities and challenges faced by biomass power projects are discussed. Growing energy demand, underutilization of bioenergy potential, and favourable policy climate create significant opportunities while techno-economic feasibility and community acceptance emerge as the major challenges for crop residue-based power generation. We discuss policy implications from these aspects and present a case for considering the net environmental benefits in fixing tariffs or the cost of production of energy from crop residue to promote sustainable energy production.

Determinants and level of diversification in agriculture across marginal and small farmers of villages of Jammu and Kathua districts

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An attempt has been made to assess the level of diversification across sixteen villages of four blocks namely Akhnoor, Jammu, Kathua and R.S Pura of Jammu and Kathua districts. Along with assessing the level of diversification, factors/determinants of diversification were also analysed. By determinants here means, different socio-economic factors which act as push/pull factors for farmers to move towards diversification in the area under study. Transformed Bhatia Index was used to Measure the level of diversification across villages. On the other side logit model was applied to analyse the determinants of diversification in agriculture among Small and marginal farmers of villages under study. It was found that level of diversification among marginal and small farmers across sixteen villages was high. The different significant factors were also observed which impacted the decision of farmers of moving towards diversification to enhance their income and sustained livelihood.

Soil carbon stock and its economic valuation in different agro-climatic zones for productivity enhancement in Karnataka

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Soil Carbon (SC) storage is a key indicator of soil function used to monitor and predict crop response to management decisions. Under the SUJALA-3 Watershed Development project, a total of 202 soil series representing major pigeon pea growing soils were studied in seven agro-climatic zones of Karnataka. The organic and inorganic carbon stock status was estimated at different soil depths to arrive at the economic value and assessed its relation with crop production. The SOC and SIC stock was 23.8 and 11.2 t ha^{-1} at 0-30 cm, 42.0 and 32.1 t ha^{-1} at 30-100 cm and 66.9 and 42.8 t ha^{-1} at 0-100 cm depth, respectively. The yield of pigeon pea was high (12.18 q ha^{-1}) under high OC status of clay textured soils followed by medium SOC (11.11q ha^{-1}) and low OC soils (11.52 q ha^{-1}) in NETZ region. Using the agglomeration method, five groups were derived to determine the soil organic carbon management clusters. The soil organic carbon deficit (t ha^{-1}) calculated to arrive investment requirement showed the order of cluster-4>cluster-3>cluster-1>cluster-5>cluster-2 and the investment required to bridge the gap was Rs. 30228, 26508, 26190, 22674 and 21990, respectively. As soil structure stability has an important role in carbon sequestration, the polynomial equation was constructed between soil carbon density and soil structural stability index, which yielded a threshold soil carbon stock value of 66.6 t ha^{-1} to attain a stable soil structure index value of nine. The ANOVA analysis showed statistically significant differences in SOC stock

between regions (p = 0.022) and soil subgroups (p = 0.001). The study concludes an average investment of Rs 25,000 /ha/yr for 20 yr is required for enhancing soil carbon status in Karnataka and to achieve the Pigeon pea potential yield of 20 q ha^{-1}

Disposal pattern of honey and benefit-cost analysis of beekeeping in district Baramulla, Jammu and Kashmir

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A cross-sectional survey study was conducted in district Baramulla, Jammu and Kashmir in 2021 to work out producer's share in consumer's rupee, marketing efficiency and benefit-cost ratio of beekeeping using ex-post-facto research design. Primary data were collected from 102 registered beekeepers using pre-tested and well-structured interview schedule. The study revealed that four marketing channels of honey were followed by the beekeepers in the region. "Producer-consumer" channel was adopted by 81.37% of the beekeepers and had the highest producer's share in consumer's rupee (100.00%). The same channel had the highest marketing efficiency of 9.23. The benefit-cost ratio for beekeeping enterprise was found out to be 1.46.

Crop variety valuation: an application of Real options pricing method for licensing deals

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A technology is a tangible or intangible asset that includes patents, copyrights, technical know-how that helps in efficient utilization of the resources. Agricultural technologies developed by institutions under NAREES are commercialized through licensing to private companies for the faster dissemination to the ultimate users. High potential of technologies calls for appropriate valuation of the technology which may be used as a base for deriving licensing fees and royalty. However, the paucity of studies was observed serving crop variety valuation in the literature. Hence, this study tried to develop a crop variety valuation model which was tested for the valuation of basmati rice variety PB 1718. To construct the model, a systematic review was carried out and an analogy was made between the variables used in existing technology valuation techniques and crop variety valuation. With the help of these variables, Real options pricing model 'Black Scholes method' was identified as

the best fit for crop variety valuation. The model determines the value of crop variety from the perspective of the buyers. To test the model, primary data on the variables was collected by surveying 23 licensees by convergent interviewing. The variable has resulted in the valuation range of Rs 11 to 33 crore for PB 1718. The results were also tested for undervaluation by comparing the same with the cost of development of the variety. This valuation model can be applied to similar crop varieties developed by the public system for licensing purpose in order to devise suitable strategies for rapid dissemination and value realization.

Farmers-market encouraging local food systems with potential for better knowledge sharing and ensuring financial sustainability

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The concept of Vocal for Local can play a vital role in agricultural development by addressing the issue of poor marketing access through development of local food systems. Realising the importance of providing markets close to production and reducing the long chain of intermediaries, the Government has introduced various reforms in agricultural marketing to encourage direct contact of producer with buyers at local level leading to emergence of marketing models like farmers-market. An attempt has been made in the present paper to analyse the potential of farmers-market for improving integration with supply chain, ensuring financial sustainability, facilitating knowledge sharing and bringing market orientation among farmers. The findings are based primarily on descriptive analysis of information collected from selected farmers visiting Siddipet Rythu Bazaar operating successful in Siddipet district of Telangana. The analysis reveals that the Siddipet Rythu Bazaar is the only channel for marketing of produce for majority of the selected farmers. Farmers perceive that direct contact without the involvement of any intermediary is one of the biggest benefits offered by the market. Direct contact not only has helped them in getting better price for their produce but also helped them in getting feedback from the customers leading to preparing the produce as per their requirement. More than two-third of the selected farmers have started preparing the producer as per market requirement. Better price realisation has helped in income enhancement to the tune of 9.42%. These findings highlight the potential of farmers-market for better supply chain integration and financial suitability of farmers.

Willingness to pay for crop insurance in Jammu and Kashmir

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In Kharif season 2016, The Indian government introduced the Pradhan Mantri Fasal Bima Yojana (PMFBY), a new crop insurance scheme to provide substantial financial support and coverage to the country's farmers in the case of crop failure and ensure credit flow to the agriculture industry. Enrolments in this program will be entirely voluntary beginning in 2021. As a basis, this research was carried out in the Jammu region of Jammu and Kashmir to determine the farmers' Willingness to Pay (WTP) for crop insurance. Primary data were collected using a face-to-face survey questionnaire, and the Stated Preference method was used to draw farmers' WTP for crop insurance. The double Bounded Dichotomous Choice (DBDC) method evaluated the WTP. Results of the study revealed that the awareness about crop insurance (79.16%) was high in the study area. However, knowledge about this scheme's modalities and components was much less among the farmers. Overall, 66 (57.50%) of farmers out of 120 sampled farmers showed a willingness to join PMFBY in the upcoming seasons, out of which 51 farmers (77.27%) were those who have received compensation in the past. Estimation of DBDC model for paddy resulted in the mean WTP Rs. 873 per hectare. DBDC model for wheat resulted in a mean WTP of Rs. 846 per hectare. This study concludes that farmers were unaware of the modalities and components of the scheme, and coverage of this crop insurance scheme is limited. To sustain this scheme, awareness about PMFBY needs to be extended further. Estimated results of the DBDC model suggest that experience in farming, total operational land holding, family size of farmers, and whether they received compensation in the past have a significant impact on their willingness to pay for crop insurance.

Growth and decomposition analysis of banana in south Gujarat: impact of National Horticulture Mission

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Banana is considered as one of the most important fruit crop in terms of production, productivity and export potential in India. South Gujarat is the main banana producing hub in Gujarat. To capture the impact of NHM (National Horticulture Mission), the study period was re-categorized into: Pre- NHM Period; Post- NHM Period and Overall Period. Major banana producing districts of South Gujarat were selected for analysis. The major analytical tools employed were compound growth rate, Cuddy-Della Vella index and decomposition model. Growth rate analysis showed that on an average, the growth rate of all districts with respect to area, production

and productivity of banana was high in period II compared to period I. Instability analysis revealed that, all districts in instability were low in period II compared to period I, except Navsari in terms of area and production. Further, growth-instability analysis showed that most desirable situation in Narmada district was observed in terms of production. Area contribution was more in Bharuch and Surat district and yield contribution was more in Narmada and Navsari district in period I. Whereas, area contribution was more in Narmada and Navsari district and yield contribution was more in Bharuch and Surat district in period II. Area contribution was more in all districts except Bharuch which showed yield contribution was more in production of banana in overall period.

An analysis of household income and consumption of rural communities in Mexico

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The study aimed to study the food consumption patterns of village communities, including women and children, in Mexico. The objective is to study food consumption and food security in the village community. For this, the survey was conducted among 141 respondents from three municipalities in Puebla: San Salvador el Verde, Tlapanalá, and Coatzingo. A descriptive data analysis and an ANOVA model were used in this analysis. The monthly food expenditure on Tlapanalá was $767, which was less than the recommended minimum spending of CONEVAL. The minimum amount of money required to attain common benefits was around $881.39 (September 2014). Daily consumption of foods was estimated and also, the daily consumption of calories is key for food security; it was 2633 kcal in Coatzingo.

Use of information and communication technology (ICT) in agriculture - a study in Sivasagar district of Assam

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There is a high prospect of improving the livelihood of rural farmers by using ICT. But the use of ICT in agriculture is very poor in a country like India. Of late, internet connectivity mobile phones have been widely used by the people. It is a great concern to what extent and how these modern tools can be used in agriculture by

farmers for increasing production and improving their livelihood. In a state like Assam use of ICT in Agriculture is very few. Similarly, very studies have been initiated to regarding use of ICT tools in farming. Therefore, the present study tries to understand the use of ICT in agriculture among rural farmers in Sivasagar District of Assam. The study covers around 30 participants in the said District. Farmers were selected randomly and structured questionnaire is used to collect data. Relevant Statistical tools are used to analyse the data.

Influence of psychological and institutional factors on adoption of soil and water conservation practices: an analysis using structural equation modelling

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The aim of this paper is to explore the role of psychological factors on the intension to adopt the soil and water conservation practices, and then examine the effect of intension to adopt and institutional factors on actual adoption using structural equation modelling. Primary data of 445 farmers from the drought prone areas of Karnataka State were collected. We found that perceived economic benefits followed by risk perception are key factors, and were positively associated with intension to adopt. Further, intension to adopt and institutional factors such as subsidy, contact to extension agencies and visit to model watersheds were significant factors governing actual adoption of soil and water conservation practices in rainfed areas.

Marine fisheries insurance in India: retrospect and prospects in the context of climate change

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The marine fishing one among the riskiest professions in the world. Fishers often face risks to their life and fishing assets. Sudden changes in the weather in the form of cyclones, incidents like tsunami, collision of fishing vessels, accidental firings and other mishaps while fishing constitute major perils that affect the fishers. The weather fluctuations impart instability to the income flow of fishers, as they are unable to venture into the seas. Deepening the marine fishing insurance would help to protect the fishers and transfer the heavy risks, particularly

in the context of climate change. The insurance in fisheries sector has several learning lessons from the crop insurance schemes being implemented in the country. In this context the article is undertaken with the objectives of: (a) reviewing the status of marine fisheries insurance in India; (b) investigating the adoption profile of marine fisheries insurance and the constraints thereof; and (c) examining the prospects of reforming the marine fisheries in India in the light of experience from the crop insurance schemes. The study uses both primary and secondary data. The primary data was collected by using a snowball sampling technique from 200 fishermen of Kerala, with 100 each from traditional fishers and trawl fishers. The data was supplemented by a case study of the *Njarakkal-Nayarambalam* Fishermen Welfare Cooperative Development Society in Ernakulam, Kerala who facilitates insurance coverage to traditional fishers. Also three focused group discussions with the fishermen were carried out. The leaning lessons for fisheries insurance from crop insurance in Kerala was derived following a literature review. The fishery insurance in India is not well developed. All the traditional vessels (100%) in the sample were insured due to the operation of *Matyafed*, a cooperative venture supported by government of Kerala, which provides credit to the traditional fishermen where the insurance is bundled with credit. Vessels insurance have only marginal coverage with trawl fishers. The main reasons for the low subscription are high premiums, inadequate coverage of the loss, and previous experience of delays in settlement of indemnities. Lack of suitable insurance products and difficulty in verifiability affects also affects its deepening. Further, fishers perceive insurance as an additional expenditure, and are of the opinion that the community would take care of the loss to a certain extent. A weather index-based insurance scheme vogue in crops insurance is an alternative solution. For this, measures such as harnessing the potential of technology and bringing about attitudinal changes are important. The study calls for initiation of steps for piloting weather-based insurance schemes for marine fishers.

Joint liability groups (JLGs) - an embryonic scheme of microfinance

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Joint Liability Groups (JLGs) in microfinance play quite a significant role in financial inclusion of collateral-less community in India. The present study analysed loan use and repayment pattern in Bank-BC model of JLG financing, impact on employment of member households and of members and also enquired about constraints and suggestions in the functioning of JLGs. JLG loans were mostly invested in livestock and tailoring. JLG members experienced a considerable reduction in unemployment and increase in number of days employed per year. Hiking the first loan amount per JLG member, activity-specific expertise for microenterprises were necessary if members were expected to productively utilize their very first loan. Financial literacy, educating gender equality, capacity building of clients and staffs would promote more viable JLGs.

Sericulture: an agro-based business opportunity

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Silk is distinctive from all other fibres, both natural and artificial, due to a number of its intrinsic qualities. It has incorporated resemblance for vibrant hues, a natural sheen, a low heat conductivity that keeps it cool in the summer and warm in the winter, high absorption and has light weight but stronger than a comparable filament of steel and has an outstanding drape. The sector includes a variety of on and off-farm activities that involve diverse social groups. Both educated young people in semi-urban and metropolitan areas, as well as the majority of rural residents, can find profitable employment in this sector. Growth in sericulture will undoubtedly boost the rural economy by fostering chances for businesses to generate cash. More than 70% of the population in India depends on agriculture and related farm operations for their livelihood, thus the success of these industries has a significant impact on the country's economy. The sericulture business has been acknowledged as one of the most suitable paths for socio-economic development because of its rurally focused on-farm and off-farm activities and significant employment generation potential. It has many perspectives that have an impact on the net returns. Effective management of natural and human resources is necessary to the greatest product at the lowest cost.

Women cultivators' access to institutional credit and effect on agricultural productivity-profitability: a case study in West Bengal

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Women are integral part of food production process. Their importance in agriculture is paramount and their roles in agriculture vary from performing as farmers with legal land right (de jure female farmers) to working as family farm labour in spouses' land (de facto female farmers) to operating purely as agricultural labourer in farm wage market. With study area as west Bengal and sample size of 150 comprising de jure female farmers, de facto female farmers and a control group of male farmers 100 in each category chosen through 'Random Sampling Method', analysis on access to institutional farm credit and its effect on farm productivity and profitability reveal that However, unlike the male counterparts, the prime problem confronted by the female farmers is access to credit. They are resource-poor and lack adequate collateral assets to mortgage and procure loan. Inadequate collateral security to place as mortgage to formal-informal loaner institutions coupled with poor repayment capacity, owing to low financial status form formidable bottleneck in borrowing loans. For illiterate and vulnerable groups like women farmers institutional loan by form of Kisan Credit Card is a good option because it has additional advantages over other formal loans. However, it also sees limited accessibility because off unnecessary prolonged government procedure to obtain it. As a result they have to seek credit from private moneylenders

even being aware that the informal moneylenders charge exorbitant interest rates. On consequence, they suffer from low farm productivity and thereby profitability, well below district average. On the other hand, de facto female farmers performed better both in terms of yield and economic returns per unit of land over the de jure. Such families received remittances from the migrated head of the household and the land owner. So such families managed better household monthly income, possessed more assets to mortgage and concomitantly had higher credit worthiness to their benefit. As a result, more than 80% of the de facto female farmers households resorted to crop loan, the male head and the land owner helping in this regard by making himself available for successful completion of the loan borrowing process. More importantly, more than 60% of such families derived advantage of formal crop loan characterized by highly subsidized interest rate. However, of the three groups male farmers outshone in every respect which is reflected in the level of yield and economic return per unit area. Interestingly, this coincides with the fact that, as high as 94% male farmers had taken crop loan to meet timely input cost, effectively instrumental in augmenting farm productivity and thereby profitability and 65% of it was borrowing from formal sources. In concise, higher the amount of crop loan borrowed for timely availability of farm inputs with preferable source being formal banks, more is the assurance of greater yield per unit of land

Perception of the participant extension functionaries towards training programmes conducted by SAMETI, SKUAST-Kashmir

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The present study has been carried out to know the perception of participant extension functionaries towards the SAMETI (State Agricultural Management and Extension Training Institute) training programmes. A list of trainees was obtained from SKUAST-K and three departments (department of Agriculture and department of Horticulture and department of Animal Husbandry) have been purposively selected for the study because the extension functionaries from only these departments have undergone training programmes. An ex-post facto design was adopted for the study and 110 extension functionaries were selected by proportional allocation method. The findings of the study revealed that majority (55.9%) of trainees from agriculture department, 65.7% from horticulture department and 56.1% from animal husbandry department were moderately satisfied with the training programmes. Also, 30 statements were used to check the level of satisfaction of trainees in different areas of trainings (viz., nature of the training programme, management of training programmes, content of training programmes, medium of instruction and usefulness of training programme) and the ranks of the statements were found. We can conclude that training programmes organized by SAMETI-Kashmir were very effective and participants were satisfied with the training programme.

Analysis of relationship between futures prices and mandi spot prices of spices in India

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The study analyses the relationship between futures prices and spot prices of spices employing Johansen's cointegration, and Granger causality tests. There was a positive trend in prices of selected spices. Seasonality was observed in these. The price series were cointegrated at 1% significance level and a uni-directional causality existed indicating futures prices as a means of price discovery process. Proper storage facilities through improvement in warehouse structure, storage chambers were suggested in order to improve the retention capacity of the farmers.

Performance of farmers producer organization (FPO) in development of apiary enterprise in Karnataka

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This study analyses performance of beekeeper association in production and marketing of honey in Karnataka in 2020-21. Most of beekeepers depend on farmer producer organisation (FPO) for marketing of honey. In order encourage the bee keeping activities for enhancing income and employment the study suggests the following policy options: 1). There is need to provide adequate loan at reasonable rate of interest with subsidy to boost honey and its products industry in the plain areas of Karnataka state. 2). Indian honey is having good international demand due to its special feature of medicinal flower nectar source hence engaging in exporting activities will widen marketing choices for beekeepers. 3). To create interest, awareness and providing rural employment in beekeeping activities, there is need for promotion of more FPO's at bee keepers level and federation at state/ national level should be formed.

Production performance of maize in India: an assessment of maize value chain in Karnataka

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The main aim of present study is to analyze production performance of maize in India, to map out different value chain of maize in Davangere district of Karnataka and also to assess the impact of value chain on farmers' income. In India, during 1991-2020 maize area grew at an annual rate of 1.96% with low instability. Marketing through FPOs had high net returns of Rs 55372/ha

Growth of cashew research in Konkan region of Maharashtra

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This paper has assessed developments in cashew productivity in the Konkan region of Maharashtra. The total factor productivity indices were estimated using Tornqvist index for the period 1998-99 to 2017-18. TFP increased at 3.13% per annum. During the same period, output index grew by 2.18% per annum and input index declined at the rate of 0.92% per annum. The improvement in the total factor productivity was may be due to non-input factor such research investment and extension efforts. The results indicate that research investment (0.23), rainfall (0.84), road density (0.56) and rural literacy (1.62) have significantly contributed to TFP growth. Investment of one rupee in cashew research generated additional income of Rs 25.31. The inverse of TFP elasticity to research gives flexibility to research investment. The estimated value was 4.35 which mean that to achieve one% growth in TFP, the investments in research need to be increased by 4.35%. The investment made in cashew research is generating rate of returns of 42.77% annually. Here the IRR is greater than the borrowing rate, hence the investment made in cashew cultivation was economically viable.

Impact of market access on input use and agricultural productivity: evidence from Indian North-western Himalayas

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This study has analysed the specialization and intensification effects of market access on input use and agricultural productivity in North-western Himalayas. We used stratified multistage sampling technique to collect cross-sectional data from 240 farmers. The data was analysed using three stage least square regression model. The findings reveal that the farmers practiced six major farming systems and the use of inputs as well as agricultural productivity under all the farming systems increases with improvement in market access.

An economic outlook of institutional interventions and the revival of rice economy in J&K

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Despite the fact that rice forms a staple food crop in J&K, a good proportion of area under this crop is under land races or obsolete varieties. Considering a crucial role of sharp edge technologies, SKUAST-Kashmir has been developing elite rice varieties and have scaled up their seed production. In this backdrop, this study analysed the impact of institutional interventions in the revival of rice economy in Kashmir valley. The findings revealed that participatory seed production programme has played a vital role in the dissemination of improved varieties, enhancement of seed replacement rate and strengthened of the rice economy. The participating farmers in seed production not only adopt improved varieties at their farms but also helped their dissemination. The adoption of technologies lowered the cost of production. Adoption of frontier technologies increased farm incomes. The study also deliberated upon a 'seed plan' and a 'road map' drawn by SKUAST-Kashmir for increasing farm income. The study emphasized on institutional mechanisms for prompt Seed Replacement Rates, participatory crop improvement programme, and seed village scheme.

Role of seed quality parameters in determining cumin prices

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India is the largest cumin producer and exporter. Its cultivation is concentrated in Gujarat and Rajasthan. This study analysed the role of seed quality parameters in determining prices of cumin in major markets in Rajasthan (Jodhpur and Medtacity) and Gujarat (Unjha, Thorad and Nenawa). Above markets were chosen based on major cumin arrivals. 75 samples were collected from above APMC yard with different spot price during April and May, 2022 and taken to ICAR-NRCSS Ajmer for lab analysis. Seed quality parameters, namely, seed purity, inert mater, other crop seeds, insect damage, pedicel, seed weight, moisture content, germination and seed vigour index were recorded and regressed against price received using multiple linear regression. Results revealed that 71% variation in the cumin spot prices was determined by seed quality parameters. Purity %age and test weight of the cumin lot increased the cumin prices significantly. On the other hand, presence of inert material decreased the prices received for cumin lot significantly, keeping other things constant. Dummy variable was used to differentiate the role of markets and found significant. Results highlighted that for same quality lot, mandis in Rajasthan provided higher prices than in Gujarat. Further, 77% of the cumin farmers from those samples were collected brought their produce for sale without primary grading. Finding suggests that quality parameter plays an important role in determining the prices in cumin hence farmers are advised to adopt grading to harness higher prices.

Technological advancement for delayed conception among bovines and analysis of major determinants responsible for the income variation of dairy farmers in Bikaner

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The present paper reveals the magnitude of economic losses amongst dairy farmers rearing breedable cattle and buffaloes in Rajasthan. The study was carried out on primary data collected from dairy farmers (sample size N=200) through a sample survey in the Bikaner district. A total number of 264 milch animals were surveyed and of these, 133 were affected by delayed conception. The results show that repeat breeding, treatment costs and milk yield are extremely significant and have a negative impact on the farmers' income. During the summer and winter seasons, dairy farmers did not have access to green fodder.

What drives FPOs towards success: evidence from Punjab

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The current study aims to investigate the challenges the farmers in Punjab encounter as members of an FPO organization registered with NABARD. These limitations include a lack of extension services, a lack of help from funding agency representatives, a lack of knowledge, weak communication links, ensuing intermediary corruption, challenges with trust, and more. The study took place in the state of Punjab during 2020–21. Data were gathered from 263 farmer members and 32 chosen FPOs that are registered with NABARD. The study used a logit regression model to pinpoint the variables affecting Punjabi FPOs' success or failure. Out of the 67 FPOs in Punjab, the survey indicated that 48% were operational, 28% were closed or non-operational, and 24% were untraceable. The study identified a number of factors that contributed to the collapse of FPOs in Punjab, including loss of business, dissolution of farmer membership, excessive delays in funding in many instances, and switching to another industry due to very low-profit margin, lockdowns, a lack of funding, and other administrative factors. The profitability of FPO was found to be significantly impacted by pricing. Additionally, working officers in that district or area had a significant impact on the success of FPO/FPC.

Agricultural marketing information of regulated market functionaries in Meghalaya: need to develop strategies

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Agricultural marketing information is crucial to the farmers to make decisions about what to grow, when to harvest, and to which market produce should be sent. An attempt has been made to identify the various patterns of collection, documentation, dissemination and constraints of agricultural marketing information (AMI) of regulated market functionaries in the study area. Two regulated markets namely, Mawiong Regulated Market in Mylliem Block of East Khasi Hills and Garobadha Regulated Market in Selsella Block of West Garo Hills district of Meghalaya were selected purposively for the AMIS study. From the findings of the research study, it was indicated that the commodities notified in Garobadha regulated market were Jute, Ginger, Chillies, Arecanut and Cashewnut where as in case of Mawiong regulated market, these were Broom sticks, Bay leaf/ Tejpatta, Potato, and Torchwood. It was revealed that market arrivals and prices (maximum, minimum and modal) were the only two major types of market information documented and made available to the farmers and other intended beneficiaries in sample regulated markets. It was found that there was no documentation of information like area under cultivation, production, post-harvest handlings of agricultural produce, value addition and pattern of packing in the selected markets. The arrivals and prices information were documented both in written form and electronic

form at the main market of Mawiong and sub markets of Garobadha regulated market. Moreover, such arrivals, prices and quality aspects of information were documented on daily basis in Mawiong regulated market and weekly basis in Garobadha regulated market. These AMI were compiled and reported on weekly, fortnightly and monthly basis to the farmers/end users in Mawiong market. It revealed that personal visit to the main market and sub market yard by the personnel and regular employees was the major method of collection of market information on arrivals and prices in both the selected regulated markets. However, area under crop, production, import-export related information was collected through internet. It was observed that grade, standards, quality and post-harvest related information were collected by sampling as well as entire population method in Mawiong regulated market. In general, the methodology adopted for generating arrivals and prices information was based on entire population recorded from the entry point and commission agent's transactions of the day in both the selected regulated market. Unable to evaluate and document the agricultural market information by the farmers due to illiteracy and poor communication ability, lack of auction system, no grading from the farmers' point and cess was taken in random were the major constraints in management of AMI in the selected regulated markets. There is need of proper dissemination of market intelligence and information through all possible means of communication for improving the marketing efficiency. Revitalise of APMCs, proper integration of various agencies for adequate and efficient dissemination of vital agricultural marketing information so that it will act as a 'one-stop solution' for the needs of the farming community.

Status of Jammu and Kashmir's economy with special reference to agriculture

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Agriculture plays a significant role in the economic development of J&K. It provides a living for approximately 70% of the population. J & K has been categorized into three agro climatic zones, Cold arid Ladakh, temperate Kashmir valley and humid sub-tropical region of Jammu. The average holding size is very small (0.545 hectares). Rice, maize, wheat, pulses, fodder, oilseeds, potato and barley are the main crops. There is a shift toward cultivating low-volume, high-value cash crops like flowers, vegetables, quality seeds, aromatic and medicinal plants, mushrooms, and so on. Bee- keeping, fodder, saffron, 'Basmati' rice, 'Rajmash', off-season vegetables and potatoes are also being cultivated.

Economic feasibility of different integrated farming system models in Jammu & Kashmir

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Integrated farming system (IFS) ensures efficient utilization of available farm resources, increases productivity and income, essential for sustainable livelihood of small and marginal farmers. In Integrated farming system, agriculture can be integrated with livestock, poultry and fish are maintained at same place to generate employment and also get additional Income. Under IFS, various enterprises having lower dependency on severe weather circumstances, the farmer is comparatively on safer side as far as the adversities of crop losses are concerned There are many advantages to integrated farming systems (IFS), such as a more efficient use of farm resources and an eco-friendlier strategy to farming. In Integrated Farming System wastes or by-products from each subsystem are used as inputs to other subsystems to improve the productivity and lower the cost of production of the outputs of the various subsystems. Integrated farming systems seems to be the possible solution to continuous increase of demand for food and nutrition, income stability and livelihood upliftment particularly for small and marginal farmers with little resources. There are different components involved in different IFS Model. As the number of components increases in different model, the net profit margin also increases which in turn leads to better management of environmental pollution.

A study on consumer preferences for Savory snack food in Jammu city

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Savory snacks are food products that have a salty or spicy flavour instead of a sweet profile. They are manufactured using various ingredients such as vegetables, fruits, nuts, grains, vegetable oils and seasonings. They are rich in nutrients, minerals, vitamins and fibres. Usually consumed in-between meals in small quantities, the most prevalent variants include salted biscuits, potato and corn chips, popcorns, pretzels, meat snacks, nuts and seeds. The growing food and beverage industry, along with an increasing preference for on-the-go snacking options, is one of the key factors driving the growth of the market. The global market for savory snacks is fiercely competitive and rapidly evolving. Snacking is a common pastime among millennial and a significant contributor to the global savory snack industry. The savory snacks market in India, which includes nuts, seeds, potato chips and meat snacks, showed an increasing trend from 2019 and is expected to reach almost US$ 13 billion by 2026. Manufacturers are also offering a diversified product range to expand their consumer base and meet individual requirements in terms of flavour preferences and dietary needs. The present study focuses on consumer preferences for savory snack food in Jammu city. The snacks share of Jammu city ranged at 0.4% for ethnic savories, sweets at 0.3%, western snacks at 0.7% and papad at 0.4% in 2021.

An economic evaluation of rice processing mills in Jammu district of J&K UT

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The study was conducted in Jammu district. We have selected two Rice mills in R.S. Pura belt for our study. The Jammu district was purposively selected as the R. S. Pura area is well known for paddy production. The study was of exploratory nature and convenience method of sampling was used. Both primary as well as secondary data was used. Primary data was collected through a well prepared questionnaire by interviewing the respondents. We have used CACP Cost concept for analysing the data. The results of our study were revealed that the mill-1 & mill-2 involves two types of channels for procuring the paddy viz; commission agents-millers(channel-1) & farmers-millers(channel-2). The total cost involved in rice mills through channel-1 and channel-2 was Rs. 2720.28/ qtl. and Rs. 1926.21/qtl. for mill-1. In case of mill-2, the total cost incurred was Rs. 1963.60/qtl. and Rs. 3894.35/ qtl. for both channel-1 and channel-2 respectively. The gross returns the mills obtained for both channels were Rs. 2902.50/qtl and Rs. 4261.50/qtl for both mill-1 and mill-2 respectively. Thus the net return mill-1 gained was higher in case of channel-2 (Rs. 976.29/qtl.) and for mill-2, net return was higher through channel-1(Rs. 2297.90/ qtl.). Therefore, from the study, we have concluded that for mill-1, channel-2 is more efficient and for mill-2, channel-1 is more beneficial.

Sericulture for livelihood security of rural women

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Growing agricultural crops is not enough to sustain a living. As a result, diversification of agriculture into various income-generating enterprises has become the norm. Sericulture, a traditional agro-based activity has played an important role in rural livelihood security, particularly among marginalized and weaker sections of society, benefiting over 8 million people in rural and semi-urban areas in India. It is ideal for rural areas because it requires little capital, is labour intensive, and is commercially appealing. It has been the leading source of world silk, and being the finest and softest of all the silks, can be used to create a variety of gorgeous and alluring garments. Rural women, in addition to their daily household activities, can use their leisure time in practicing sericulture. In reality, it is an occupation by women and for women because women form more than 60% of the workforce and 80% of silk is consumed by them. In general, women in the house, while attending to household activities, also look after silkworm rearing activities like leaf chopping, bed cleaning, feeding the silkworms, maintenance of hygiene, picking the ripe worms and placing them on mountages and so on. Silkworms are more delicate and have to be handled with proper care. Thus, the entire process of silkworm rearing needs expertise, patience and high skill. Women possess the above qualities abundantly and are more suitable. The activities not only help to increase their household income but also assist many of them in escaping from extreme poverty. Furthermore, these women gain economic and social empowerment.

Impact assessment of Basmati varieties released by SKUAST Jammu

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Rice is the one of the most important food crop of India and second in the world. It feeds more than 50% of world population. Rice is grown in almost all the states in the country. Basmati rice, indigenous to the Indian sub-continent and endowed with unique quality traits are palatal delights of the rice connoisseur world over. Basmati is known as queen of rice. These virtues of Basmati rice command them premium price in domestic and international markets. Basmati is preferred by consumers all over the world due to its flavour and palatability. As regards, Jammu and Kashmir it plays an important role in the livelihood of people of this hilly and sub-mountainous region. Jammu district is mainly comprised of sub-tropical regions and one of which is considered unique to the district is the Basmati rice. Thus, the cultivation of Basmati rice offers a great potential. Basmati rice has occupied a prominent place in Ranbir Singh Pura (R. S. Pura) area of Jammu region of Jammu and Kashmir not only because of their high quality but also that they had been considered auspicious. More-ever, lower sub-tropical part of Jammu region falls inside geographical indicator (GI) area of basmati where number of traditional Basmati land races are being cultivated.

Cultural heritage consciousness as a catalyst for agri tourism (a case study of Jammu region in J&K)

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Culture is a bed rock of place consciousness and aesthetics that shapes the civilizational moorings of the people. Crystallisation of cultural landscape leads to the heritage development. Himalayas have nurtured the rituals, rites and socio-economic undercurrents of the people. Both tangible and intangible heritage are predominant in Jammu region of Jammu and Kashmir that have pan Sanskrit civilizational moorings. Villages of Jammu are rich in aesthetics and religious activities that are integrated to the daily lives of the people. This paper explores the scope to integrate the heritage and culture of the rural Jammu into the product mix that leads to the multiplier effect. Richness of the rural landscape with the temples and forts besides the traditional skills offers a plethora of tourism products. The challenge lies in evolving a comprehensive strategy to restore the rural heritage by preservation and conservation. Paper argues that there is a need to incorporate the internationally stipulated guidelines by the organizations like ICOMOS and ICCROM to devise community involvement programmes. Need for segmentation of the cultural traditions and their utility in the market to boost the Agri business. So that it leads to increase in income and preservation of the cultural heritage in the rural landscape. Leading to strategy

that markets the cultural heritage and at the same time reinforces the rural economy based on agriculture. The focus is to bring the gaze back to the villages without damaging the eco system and carrying capacity. Paper is an attempt to arrive at a synergy between cultural heritage, economy, Agri Business, marketing and tourism. Allowing Jammu to adopt the international innovations meant for rural development through cultural heritage as a sustaining model for Agri Tourism.

Indigenous technical knowledge (ITK) and its relevance in the present day farming

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The increasing attention that indigenous knowledge is receiving by academia and development institution has not yet led to a unanimous perception of the concept of indigenous technical knowledge. ITK is the local knowledge- knowledge that is unique to a given culture or society. Indigenous Technical Knowledge (ITK) has immense potential for innovation, especially at the grassroots level. ITK is the basic knowledge of rural people for social upliftment of small and marginal farmers which provide sufficient information that may help in decision making procedures. India is a country populated by a number of indigenous communities, most of which have their own set of unique traditional knowledge and technology base. Many of these knowledge and technologies are at par with the modern knowledge and technology system and have been provided the indigenous communities with comfort and self-sufficiency. These traditional knowledge and technologies have played a significant role in the overall socio- economic development of the communities. A study on some of the aboriginal knowledge and technologies, with special reference to the concept of indigenous technical knowledge, prevalent among a number of indigenous communities was carried out and the significance of the same in innovation has been evaluated. The study was conducted within the framework of "sectoral system of innovation". A wide range of diverse sectors including agriculture, animal husbandry, fishing and textile were considered for the purpose of the study as all these sectors are imperative in Indian context. During the course of the study, it has been observed that there is an instant need to document and preserve the indigenous technical knowledge of different communities, many of which are at brink of extinction. There is a lack of proper alliance between the practice of indigenous and modern knowledge. There are serious issues related to intellectual property rights. An appropriate association between the traditional and modern knowledge and technology system has immense potential to benefit the society.

Agricultural and backyard farming: a tool for rural women empowerment and poverty reduction

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Poverty is widespread in developing countries and more prevalent in rural areas. Indeed, most of the poor in developing countries live in rural areas with agriculture being the centre of their lives. Women play important roles as producers of the food, managers of the natural resources, income earner and caretaker of household. Women are now coming out of their seclusion and are assuming greater responsibilities in national reconstruction activities. They constitute nearly fifty% of our population. Most of the women are unskilled but it has been observed that rural women contribute more than men in agriculture as well as in poultry sector. Empowerment implies intellectual enlightenment, economic enrichment and social emancipation of women. The core strength of empowerment lies in the ability of a woman to control her own destiny. An empowered, woman must have equal opportunities, equal capabilities and equal access to resources. Furthermore, she should be enabled to use those rights, capabilities, resources and opportunities to make strategic choices and decisions in her life. The concept of women empowerment is associated with gender equality. In India research conducted indicates that sex ratio is grossly un-favourable for females. Wide disparity exists between male and female literacy rates. Employment and work participation rates are also poor for women. Researches also indicate that this discrimination against females is borne out of cultural and religious values that spring from the patriarchal ethos dominant in most parts of our country. In the food security the rural women over the world play a major role in agricultural production and development but women face a number of constraints in approaching agricultural extension sources especially in developing countries. Rural women along with men play an important role in the agriculture sector like crop production, livestock as well as poultry especially backyard poultry production. Importance of backyard poultry has been globally recognized to overcome the worsening problems of poverty, hunger and malnutrition in developing countries. Backyard poultry farming in Jammu region can provide an excellent opportunity for gainful employment to rural women. The present study was focused on the role of women in agricultural sector including poultry farming and their constraints, which were being faced by our rural women of Jammu region.

Effect of cultivars and nutrient levels on productivity and profitability of rice

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A field experiment was conducted during *kharif* season of 2019 to assess the effect of cultivars and nutrient levels on productivity and profitability of wheat. The experiment was conducted in randomized block design with three replications. The treatments consisted of four cultivars of rice *Viz.* Basmati-370, Jammu Basmati-123,

Jammu Basmati -118 and Jammu basmati-138 and four levels of nutrient viz. Control, 15:10:5 kg/ha N:P_2O_5:K_2O, 30:20:10 kg/ha N:P_2O_5:K_2O and 45:25:15 kg/ha N:P_2O_5:K_2O. The soil of the experimental site was sandy clay loam in texture, slightly alkaline in reaction (7.42), low in organic carbon (4.73 g/kg) and available nitrogen (247.06 kg/ha), but medium in available phosphorus (14.28 kg/ha) and potassium (149.60 kg/ha). The experimental results revealed that Jammu Basmati-138 (41.62 q/ha) recorded higher grain yield which was followed by Jammu Basmati-123 (39.82 q/ha) and Jammu Basmati-118 (38.35 q/ha) at fertility levels of 45:30:15 kg N:P_20_5:K_2O/ha and the% increase of these Basmati cultivars over Basmati-370 were to the tune of 12.46, 16.87 and 22.05%. Likewise, Jammu Basmati-138 recorded highest net returns (Rs 78078.98/ha) and B:C ratio (1.71) with 45:30:15 kg N:P_20_5:K_2O/ha.

PMMSY: encouraging change in policy and scheme for sustainable and resilient fisheries

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Fisheries and aquaculture plays an important role in the economy and development of many countries due to its critical contribution to employment, food & nutritional security, foreign exchange earnings and income for millions, especially the rural populations because fish is an affordable and rich source of animal protein. The sector has immense potential to enhance incomes and usher in economic prosperity to fishers, fish farmers, fish vendors and other stakeholders involved in fishing and fisheries related allied activities. Governments and civil society were increasingly aware of the need for improvement of management frameworks to achieve greater economic, social and environmental sustainability and resilience, notably in the face of the lost opportunities due to mismanagement, the overexploitation of ocean ecosystem, and the anticipated effects of climate change. Therefore, changes in Indian fisheries policy and government schemes were essential to achieve greater economic, social and environmental sustainability and resilience. The Government of lndia brought a scheme 'Pradhan Mantri Matsya Sampada Yojana (PMMSY)' to bring Blue Revolution through sustainable and responsible development of fisheries sector in India at total investment of Rs. 20,050 crores for holistic development of fisheries sector including welfare of fishers during 2020-21. PMMSY is implemented in all the States and Union Territories for a period of five years from FY 2020-21 to FY 2024-25. The beneficiary oriented activities supported under the PMMSY include development of hatcheries, construction of Grow-out and rearing ponds, input cost for culture activities, Re-circulatory Aquaculture System (RAS), cage culture in reservoirs, open sea cages, sea weed culture, bivalve culture, construction of raceways for trout farming, ornamental and recreational fisheries, support for acquisition of deep sea fishing vessels, up-gradation of existing fishing vessels, support for providing safety kits for fishermen of traditional and motorized fishing vessels, providing boats and nets for traditional fishermen, support for purchase of communication and/or Tracking devices and PFZ devices. The PMMSY also supports for construction of cold storage, ice plants, fish meal plants/mills, construction of fish retail markets, kiosks, fish value added enterprises units, e-platform for e-trading and e-marketing, establishment of disease

diagnostic and quality testing labs, insurance to fishermen and fishing vessels, livelihood and nutritional supports for socio economically backward active traditional fishers etc. This important policy change has started showing its impact in the total fish production of various states. The fish production of Jammu and Kashmir reflected 19% higher production during 2021-22 in comparison to previous year 2020-21. In coming future, more positive growth is anticipated from the fisheries sector due to the major policy change and new schemes under PMMSY.

Agricultural equipment and brand selection: evaluation of farmers' choice pertaining to selection of different brands in Jammu district of J&K (UT)

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The paper discusses about three farming equipment that are mostly used by farmers for cultivation of crops i.e., Rotavator, Disc plough and Cultivator with relevance to the brands that were mostly chosen by the farmers. The results of the study reflected that brand named "Sonalika" for rotavator had the most preference with around 66% market-cap. For the similar study in cultivator reflected that brand named "Agro King" had the most market-cap with around 62% of total share. Study was also conducted for Disc plough in the similar aspect which showed that brand name "Land force" had the major stake with approximately 26% of the market-cap.

Economic assessment of changing input use behaviour under PM-KISAN scheme in Jammu region-a comparative study

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PM-KISAN Samman Nidhi was introduced in December 2018 to help farmers purchase various agricultural inputs such as seeds, fertilizers, etc. Payment disbursement under the scheme started from February 2019. It provides each eligible farmer's family an amount of 6000 Rupees (Rs.) per year in three installments of Rs.2000 each. Initially, farmers who had less than 2 hectares (ha) of land were eligible were covered under the scheme; subsequently, in the beginning in June 2019, the scheme was extended to all farmers which accounted for about 140 million across India. In India, more than half of its farming households do not had access to formal credit system. In such situation, introduction of cash transfer scheme (Pradhan Mantri Kisan Samman Nidhi, or PM-

KISAN) in December 2018 to ease the liquidity constraints of Indian farmers for farmers for procuring inputs is quite salient. This paper analyses the impact in the change in consumption pattern of farmers who have been benefited from the Scheme in Jammu region. It also elaborated the changes in consumption of agri-inputs for the production of local paddy in remotely located border out post (Indo-Pak border) villages in R.S Pura sector.

Use of nano-fertilizer technology for achieving higher nutrient use efficiency in crops

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Fertilizer being the major determinant of yield has gained much attention in research since long time. Though the research has achieved high productivity still the nutrient use efficiency (NUE) is surprisingly low. The nutrient use efficiency of N, P and K stand still at 30-35%, 18-20% and 35-49% respectively. Nanotechnology is a new emerging and fascinating field of science that permits advanced research and nanotechnological discoveries which could open up novel applications in the field of biotechnology and agriculture. Nanotechnology, utilizes nanomaterials of less than 100 nm size, may offer an unprecedented opportunity to develop concentrated sources of plant nutrients i.e., Nano-fertilizers having higher-absorption rate, NUE and minimum losses. Nano-fertilizers or nano-encapsulated nutrients might have novel properties that are effective to crops, controlled release of chemical nutrients and release nutrients on demand that regulate plant growth and enhance target activity. Nano-fertilizers accrue their unique properties from their smaller size, high specific surface area, high surface energy and high solubility. Owing to these unique properties, their uptake by plants is increased. Studies show that the use of Nano-fertilizers such as nano zeolites, nano NPK, IFFCO nano N, Zn, Cu etc., causes an increase in growth characters, yield and yield attributes, NUE, crop quality and minimizes the potential negative effects associated with over dosage and reduces the frequency of the application of chemical fertilizers. Two approaches were established for the synthesis of nano-materials; they are synthesized either by the Top-down approach (i.e., breaking down of bulk materials into small pieces by applying an external force), or by the Bottom-up approach (combining and gathering of gas or liquid atoms or molecules). Nano-fertilizers can be applied easily through soil, foliar spray or drip irrigation. Foliar spray of one kilo dose of nano chelated super fertilizer containing 12 nutrients was optimum for growth, yield, nutrient uptake and agronomic efficiency of one-hectare wheat crop compared to conventional fertilizer and bio stimulators. Nano fertilizer have large surface area and particle size less than the pore size of root and leaves of the plant which can increase penetration into the plant from applied surface and improve uptake and NUE. Nano-fertilizers can improve the physical, chemical and biological properties of soil and sustain the soil productivity. By providing balanced nutrition, Nano-fertilizers enable the induced systemic resistance in plants for combating various biotic and abiotic stresses. Moreover, Nano-fertilizers reduces the requirement of conventional chemical fertilizer by 50%, increases the crop production by 15-30% and also reduces the emission of greenhouse gases. Therefore, the use of Nano-fertilizers is likely to increase the crop productivity and may prove to be economical for the farmers.

Determinants of availing veterinary services in India: a regional perspective

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The study is based on the secondary data available from NSSO conducted in the year 2013. Decision to use veterinary services and its choice was hypothesized to be affected by access to veterinary services, milk production, operational land holding, principal income source, milk price, training, extension along with demographic factors. Considering the diversity of India, the data were divided into six regions and data were analysed for each of six regions and at all-India level using multinomial logit method. At all-India level, exposure to extension agencies encouraged the dairy farmers to avail institutional services. The marginal sections of the society were likely to not avail veterinary services, thereby affecting the productivity of the animals. Households with higher milk production levels were more likely to avail veterinary services. The presence of veterinary hospitals/dispensaries in villages of Hills, East, and NE regions increased the probability of availing their services by 9%, 6%, and 21%. Households with higher milk production were more inclined to avail veterinary services from both (institutional and non-institutional) sources of veterinary services in North and West regions. Training in agriculture increased the probability of availing institutional veterinary services in Hills and West regions by 16% and 7%, respectively.

Intellectual property rights and agricultural innovation

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Intellectual property rights (IPRs) are legal privileges attached to particular types of creative expression in the fields of business, science, and culture. The major objectives of granting IPRs are to provide a framework of rules that will stimulate technology transfer and to create a limited window of commercial exclusivity during which the expenditures of research and development (R&D) can be recovered. In the bulk of technology transfer agreements, IPRs including patents, plant variety rights, trademarks, and geographical indications are at the centre. The majority of the time, these IPRs are sold in packages that also include relevant know-how agreements, raw material supplies, and technical and business services like marketing and advertising. In modern agriculture, intellectual property rights (IPRs) are essential. They contribute to the attraction of agricultural R&D by producing tradable assets and offering investment security in those assets. The primary intellectual property rights (IPRs) that are relevant to agricultural innovation are (I) patents, which protect inventions; (ii) rights for plant varieties, which helps in protecting the breeding of new advanced and distinctive plant varieties; and (iii) trademarks and

geographical indications, which support product marketing by protecting the symbols of their manufacture or place of origin. Although less significant, the following points are also pertinent: (i) Industrial designs protect the aesthetic appeal of products like agricultural machinery; (ii) Integrated Circuit layout designs are also relevant to smart agricultural technologies; (iii) Confidential Information Law helps in protecting trade secrets; and (iv) Intellectual Property Rights (copyright) protecting the cultural creative works like books, articles, scientific papers, and data structures.

Crop residue: a potential source for bio energy and high value bio-products in India

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Farming activities generate huge amounts of crop residues annually worldwide. These residues constitute a large biomass which includes non-edible parts left over after harvest. Crop residue are two types, first are primary residues which are associated with crop production e.g. stalk, husk, bagasse, straw, stover, leaves and roots. While secondary residues are by products of processing and comprise of e.g. seed, skin, rind, and pomace, pit, shell, peeling, husk, and bagasse. Crop residues are valuable resource and primary material for secondary agriculture and we can protect the environment as well as reduce pollution in the biosphere by its eco-friendly disposal. Ministry of New and Renewable Energy estimated that about 500 Mt of crop residues are generated annually in India. Among different crops, Cereal crops (rice, wheat, maize, millets) contribute 70%, while rice crop alone contributes 34% Sugarcane residues consisting 2% of the crop residues in India. Traditionally, crop residue has been used as animal feed, domestic fuel, packaging material, roof thatching, soil mulching and bedding material. Now via novel ways it can be used for preparation of diverse products *viz.,* fortified livestock feed, compost, biofuel, bio-oil production, bio-refinery based biochar production for its efficient utilization. We have to promote its use as a raw material for secondary agriculture. Amongst the various technologies, anaerobic digestion is a fascinating process for the recovery of nutrients and renewable energy from various agriculture residues and an important way for handling waste. These technologies not only enhance its use efficiency but also promote new ventures for entrepreneurs.

Global trade in fruits and frozen fruits

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Rising consumer income and changing lifestyles are creating bigger markets for high-value horticultural products in India as well as throughout the world. Among these, the most important high-value export products are fruits and vegetables. Fruits contain large amounts of vitamins, minerals, fibre and antioxidants, which impart protection against chronic diseases such as heart disease and cancer. Therefore, the consumption of fruits is highly recommended for a balanced diet around the world. The exchange of products and services between countries is referred to as international trade. The global fruit industry plays an important part in today's agricultural production around the world. The total global fruit trade market has grown by an average of 40% over the last ten years. It has increased from 45 million tons to 63 million tons. Asia has the highest growth rate in global fresh fruit trade. Among the most traded fruit products, bananas account for a considerable part in the global fruit trade. It makes up 30% of this sector. Guatemala is one of the world's top bananas exporters with the highest growth rate in bananas exports over the past decade. There was also strong growth in the large net bananas importing countries including United States, Russia, and China. An estimated 80% of all fruits grown globally are sold as whole fresh fruit. That fresh fruit market is still growing, mainly outside the US and the EU. In markets, consumer preferences seem to be shifting towards fruit with a more natural and fresh image, including frozen fruits. This is at the expense of shelf-stable products like juice and canned fruits. Global demand for frozen fruit has increased by 5% a year. Trade in these products has risen dramatically over the recent years.

Role of geographical indication in rural development

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Geographical indication is stronger tool for rural development and protects the IP rights associated with agricultural products originating in specific geographical region. It helps in creating relationship between the agricultural products and the area to which it belongs. The unique agricultural products of rural communities associated with GI needs for rural development. Most of the geographical region are surrounded in rural areas due to it is create more chances for rural development. GI tag provides legal protection to the product and also prevents unauthorized use of GI tag products by others. GI tag helps consumers to get quality product. There are three types of geographical indication like protected designation of origin, protected geographical indication and traditional specialties guaranteed. Total there are 96 GI tagged in agricultural produce. Among them gir kesar mango is second variety to get GI tag after dashehari and its specific feature is pulp is like saffron so it's called kesar mango. Alphanso from Ratnagiri, Sindhudurg, Palghar, Thane and Raigad districts of Maharashtra, are registered as geographical indication and its fruit quality is excellent and keeping quality is good. Muzaffarpur state's shahi litchi has got the GI tag for its sweetness, juicy and unique flavour and aroma. One of the major advantages of GI is that it gives direct information to consumers conveying the origin as well as the quality possessed by it. The residents in rural area from the major recipients of GI product which generates more income and employment opportunities.

Integrated nutrient management (INM): a way to improve ecological balance and farm income

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The transformation of agriculture subsistence farming with the use of efficient varieties, pesticides, fertilizers and mechanization has increased the production, but at cost of natural resources destruction. In the present context, therefore there is need to sustain and enhance the physical, chemical and biological health of the ecosystem. Through Integrated Nutrient Management which refers to the maintenance of soil fertility and of the plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of all possible sources of organic, inorganic and biological components in an integrated manner. The main aim of Integrated Nutrient Management is to integrate the use of natural and man-made soil nutrients to increase crop productivity and preserve the soil productivity for the future generations, rather than focusing nutrition management on one crop. INM is an ideal combination of agronomical, biological, chemical and other method in a planned sequential and sustainable manner to achieve the desired objectives. It encompasses organic manures (FYM, Compost, vermicompost, animal wastes, green manure, plant residues, agro-industrial by-products etc.), biofertilizers (N-fixing, P-solubilizing and different consortia),inorganic fertilizers (simple, mixed, complex fertilizers and nano fertilizers, slow release fertilizers, liquid fertilizers etc.).The adoption of INM leads to increased net return of the farmers, development of rich biodiversity including soil micro- organisms and ecosystem, quality food and fodder production as well as sustainable output growth and adequate buffer stocks.

India's food processing industry: a changing paradigm

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India is a major producer of a wide range of agricultural and food products, but only less than 10% of it is processed. In India, demand for processed foods is expected to rise in the coming years, providing opportunities for more value addition, reduced waste, and alternative employment opportunities. In terms of production, growth, consumption, and export, the food processing industry stands as one of the largest sectors in India. Food Processing has grown at an average annual growth rate of10% over the last five years ending in 2018-19. The Indian food processing industry has experienced substantial expansion and change in recent years, owing to shifting market trends, consumer categories, and regulatory requirements. These trends, such as changing demographics, population growth, and fast urbanization, are projected to continue in the future, influencing demand for value-added goods and, as a result, for the food processing industry in India. The government of India is emphasizing on

the food processing industry as a priority sector and has floated various policies & schemes under *"Atmanirbhar Bharat Abhiyan"* initiative to encourage the investment in FPI and so to attract more FDI. Due to the critical linkages and synergies that it promotes between the two pillars of our economy *vis-à-vis* industry and agriculture, the food processing industry is extremely important for India's development. Fruits and vegetables, meat, poultry, and fishery, dairy products, packaged food, and RTE/RTC items are some of the more appealing areas. India has significant competitive advantages over other countries in this industry, as it has access to a massive pool of natural resources and a developing technical knowledge base.

Adoption of recommended strawberry cultivation practices in sub-tropics of Jammu region

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The present study entitled "Adoption of Recommended Strawberry Cultivation Practices in Sub-tropics of Jammu Region" was conducted in Jammu, Samba and Kathua districts of Union Territory (UT) of Jammu and Kashmir (J&K). Proportionate random sampling technique was employed to draw a sample of 80 strawberry growing farmers. Semi structured interview schedule was used for collection of the primary data. The results reveal that majority of the strawberry farmers were matriculate with average strawberry farming experience of 4 years. Majority (57%) of the farmers had marginal land holding. Electric pump set was the main source of irrigation for strawberry farmers (84%). Majority (55%) of the respondents had agriculture as their main occupation. Majority (59%) of the respondents adopted recommended variety (Chandler) of strawberry and 50% of them adopted runners treatment. 49%, 45% and 38% of the respondents were applying DAP, Urea and MOP respectively. Besides, 16% and 18% of the farmers were applying insecticides and fungicide in strawberry cultivation.

Economics of agro-processing industries in Jammu & Kashmir

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For horticultural products, the Union Territory of Jammu and Kashmir has already established a market. It comes naturally for the cultivation of horticulture and other high-value food and non-food products due to the diversity of agro-climatic conditions. However, little investment, weak marketing ties, and inadequate infrastructure capacity

limit the expansion of these high-value commodities. These valuable crops' full potential is currently being underutilized and underexploited. This study analyses the state's agricultural processing facilities and evaluates their effectiveness, inclusivity, and growth potential. While different statistical approaches are utilized to quantify the associated data from the agro-processing sectors, the Cobb-Douglas method is employed to assess the marginal productivity of labour and capital. The results demonstrate that the agro-processing industry is labour-intensive, dominated by small-scale businesses, and lacking in capital investment and market connections. To offer the necessary incentives to push the industry to reach its full potential, it is necessary to attract investment, upskill the labour force, and enhance the marketing infrastructure in the area.

Functional analysis of marketing of black gram in Lalitpur district of Uttar Pradesh

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An investigation entitled "Functional Analysis of Marketing of Black gram in Lalitpur District of Uttar Pradesh" was conducted in Black gram grown in four different development blocks of Lalitpur district during the agricultural year 2014-15. Five villages from each block, 15 farmers from each village were selected randomly, so as to constitute an ultimate sample size of 300 farm households. Primary data were collected by the survey method by interviewing the black gram growers as well as different market functionaries involved through an especially structured and pre-tested schedule. In the study, the three types of marketing channels were identified to be followed by the black gram growers, the first one channel was the Producer – Village trader – Processor – Wholesaler –Retailer - Consumer, second channels was the Producer – Commission agent – Processor – Retailer – Consumer and third was the Producer – Processor – Consumer. Functional analysis of marketing of black gram reveals the highest traders' profit in channel-III in terms of%age. But traders' profit per quintal declined from channel-I to channel-III. This ranged from Rs. 2241.65/qtl. to Rs. 2523.46/qtl. In spite of the highest number of intermediaries in Channels-I, the highest marketing cost recorded in channel-II can be explained in terms of nonexistence of some functions in the former channel. The marketing efficiency was higher in marketing channel-III as compared to marketing channel-II and marketing Channel-I because of relatively low marketing cost and marketing margin in channel-III. These were estimated at 1.35, 1.46 and 1.78 in Channel-I, channel-II and channel-III respectively.

Institutional arrangements promoting diversified agricultural for higher income

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Transfer of improved agriculture technologies to the farmers' fields is the cornerstone for transformation of the farming sector. The sound transfer policy makes it imperative to assess and test the technologies repeatedly at the local farmers' field. It calls for a systematic and planned programme of development, creating an enabling environment for all the stakeholders to participate as well as the change agencies to converge and collaborate in the process of change. IARI, New Delhi, a premiere institution in developing crop technologies, is implementing National Extension Programme in partnership with University of Agricultural Sciences, Dharwad (Karnataka) for promotion of improved crop technologies in the jurisdiction area of University for higher crop productivity and income to the farmers in the region. As per a study estimate, only 30% of the scientific knowledge reaches the actual field. The present study has been carried out to assess the efficacy of IARI crop technologies in promoting higher productivity and income from the farm sector. IARI, New Delhi has been assessing and promoting some of the developed crop technologies in wheat, spinach (palak), pea and carrot in the jurisdiction area of UAS Dharwad. Improved varieties of some of wheat HD 2932 has been tested at the farmers' fields at multiple locations, Agriculture Extension Education Center Dharwad and KVKs (Bagalkat, Vijaypur, Mudhol) under UAS Dharwad regularly for 3 rabi seasons during 2014-2015 to 2016-17. During the same period, spinach (All Green) was demonstrated at the farmers' fields in different locations, AEEC Dharwad and KVKs (Bagalkot, Hanumanammatti, Mattikoppa and Dharwad). Likewise, pea (Pusa Pragati) and carrot (Pusa Rudhira) were demonstrated at select locations during 2013-14 to 2015-16. Farmers were purposively selected for laying out demonstrations and it was regularly monitored by the experts from UAS Dharwad and IARI, New Delhi. Review workshops were organized regularly before each season to discuss the crop performance and plan subsequent activities. As many as 7 demonstrations conducted on wheat HD 2932 during 3 seasons, resulted in average yield of 24.4 to 33.5 q/ha in 2015-16 and 2014-15, respectively with corresponding increase in crop yield of -0.52 to 19.6% in 2015-16 and 2014-15. The average net income accrued from the crop was to the tune of Rs 37858.00 and Rs. 68800.00 per ha in 2016-17 and 2014-15, respectively. Spinach (All Green) was demonstrated at 9 locations during 2014-15 to 2016-17. The crop performed very well, exceeding the local check in productivity from 13.34 to 19.40%. The highest yield realized was 110.95 q/ha in 2014-15 with the maximum net profitability of Rs. 70,464 per ha. The b/c ratio was also the highest (2.57) in this year. Pea (Pusa Pragati) was demonstrated at 6 locations during 2 rabi seasons 2014-15 and 2015-16. The crop performed well, producing highest yield of 47.60 q/ha in 2015-16 with an increase in yield of 19.99% over local variety and the highest net income of Rs. 46733.00 per ha in 2014-15. Carrot (Pusa Rudhira) was demonstrated at 2 locations during rabi 2013-14 and 2014-15. The crop performed well with an average yield of 184.8 q/ha and net income of Rs. 94430.00 per ha. It may be concluded that through Institutional convergence of IARI, New Delhi and UAS Dharwad, potential crop technologies in wheat, spinach, pea and carrot was successfully assessed and promoted among the farming community in the region, resulting in higher productivity and profitability for the farming community.

India's role in LIFDCs food security during pandemic

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COVID-19 Pandemic has proved to be a fatal hit to world leading to economic downfalls. Supply chain disruptions were the major cause of economic disintegration. Imports and exports were impacted due to supply chain disruptions. India since green revolution has been growing its food production. India feeds the whole nation with the largest food distribution system in the world. On the other hand, it exports food to a range of countries. India is not only one of the largest exporters of cereals but also of cereal products. Trade in agricultural commodities and food is crucial to ensuring domestic food availability, but it can only increase food security if food is affordable and accessible. Our research has underlined the importance of India's rice and wheat exports during very crucial time of crisis in LIFDCs import food basket. This work has revealed that major exporters of cereals imposed bans and reduced exports to LIFDCs and contributed to already existing food insecurity problems of these countries. In coming days, food security will be one of the most critical aspects of global demand and diplomacy and India has the potential to grow a lot of food than most parts of the world and can become world's food basket.

High yielding turmeric (*Curcuma longa* L.) cultivars: a viable alternative to enhance rhizome productivity, resource-use efficiency and rural livelihood in monkey–menace affected areas of Reasi district

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Turmeric (*Curcuma longa* L.) is a major spice crop in India in general and north-western (NW) Himalayas in particular where it is grown mostly organic by default using local strains having low productivity. This crop is becoming an alternate crop in monkey–menace areas in NW Himalayas (Mid hills of Jammu region) transferring into gigantic fallow-lands otherwise. There is a dire need to boost turmeric productivity in the region by introducing high yielding turmeric cultivars (HYTCs). Thus, extensive '*On–farm*' experimentation was done by KVK, Reasi at 6 identified locations in monkey–menace affected villages (Panthal, Dera Baba, Katra, Pouni, Bharakh and Aghar Ballian.) of district Reasi, Jammu and Kashmir as the study area. For this purpose, two newly recommended annually harvested HYTCs (Salem and *IISR Pragathi* alongwith a widely grown local strain in mid hills of Jammu (as check), were planted alongwith organic manure *i.e.* FYM @ 20 t ha^{-1} on oven dry weight basis. Mean data of two years revealed that *IISR Pragathi* resulted in highest rhizome yield (32.94 t ha^{-1}) followed by *Salem* (32.35 t ha^{-1}) compared to '*Local Cvs*' (12.45 t ha^{-1}). Likewise, *IISR Pragathi* resulted in highest net returns and net B: C ratio (Rs 416,548 ha^{-1}; 5.38) followed by *Salem* and *Local Cvs*, respectively. The curcumin content was higher in '*Local Cvs*' (5.18%), but the curcumin yield was significantly higher in *IISR Pragathi*

and Salem. The monetary-efficiency indices revealed that organic turmeric cultivation using HYTCs may fetch about 1243–1270 Rs ha^{-1} day^{-1} to the Himalayan farmers. Overall, the turmeric rhizome yield was enhanced by about three–folds, profitability by 3–4 folds, resource-use efficiency (RUE) by 2–3 folds in terms of production– and monetary efficiency and partial factor productivity of applied nutrients (NPK) by the adoption of HYTCs coupled with FYM @ 20 t ha^{-1} over '*Local Cvs*'. Higher technology adoption rate (72–98%) and net income gains (2.3–2.5 folds) in the study area advocated for employing '*Participatory-mode*' adaptive research methodologies following intensive technology transfer programme in mid hill agro-ecologies. In nutshell, the newly developed HYTCs exhibited great potential in boosting the turmeric productivity, profitability, curcumin yield and RUE vis-à-vis wider adaptability in monkey–menace areas to improve rural livelihoods and make organic turmeric cultivation a promising agri–entrepreneurship in NW Himalayas.

Assessment of teaching competencies needed by agriculture teachers for increasing competency of faculty in SAUs

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The research was be conducted in six SAUs viz., SKUAST-Jammu, SKUAST-Kashmir, PAU, Ludhiana, CCSHAU, Hissar, CSKHPKV, Palampur and MPUAT, Udaipur. A random sample each of 15 Assistant Professors, Associate Professors and Professors from each selected SAU was drawn by using simple random sampling technique without replacement, thus, making a total sample size of 270 respondents. Majority of the respondents perceived items viz. 'plan the content of a lesson', 'obtain textbook, references, and other instructional materials' and 'plan instructional material to accommodate identified learner needs' as most important instructional planning competencies. Regarding execution of instructions, majority of the respondents perceived items viz. 'giving clear explanations and directions to students to clear their doubts/problems', 'maintaining conducive classroom environment for students active participation' and 'encourage students to ask questions (doubt clearance) most important. With regard to evaluation competencies, items viz. 'keeping oneself updated with the ICAR evaluation criteria for assessment of students' and 'evaluate individualized assignments completed under directed study' were perceived most important by the respondents. Likewise, under guidance competencies, items viz. 'guiding P.G students in timely completion of their dissertation' and 'assist students in developing good study habits' were perceived most important by the respondents. With regard to professional role and development competencies, respondents perceived items viz. 'maintain the ethical standards expected of a professional educator', 'promote the attainment of the goals of the teaching profession' and 'use the information contained in professional journals and literature in agricultural education, most important. However, with regard to management competencies, items viz. 'implement an effective classroom management system for positive student behaviour (discipline)' 'record agriculture students' grades according to University policy' and 'maintain individual P.G. student file documenting his academic performance' were perceived most important by the respondents.

Role of marketing channels in price realization: analysis of selected crops in India

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The provision of fair and remunerative prices to farmers through the government intervention is one of the key debates in India. This is also an essential component of sustainable income provision within agriculture in India. This article identifies primarily, how marketing channels are responsible for higher price realisation by farmers over the officially announced minimum support price (MSP). Our major findings indicate that there are two factors which importantly determines this. Firstly, for crops which are covered by MSP, such as Paddy, Maize, Wheat and Cotton, government agencies do provide better prices. However, the probability of receiving higher prices increases if the farmers belong to upper land size-classes. Secondly, for Jowar and Bajra, two other important crops, which doesn't benefit from the government agencies, this perhaps requires higher levels of procurement at state level. The probability of better price provision improves with increase in land size and access to institutional credit.

Challenges and innovation in supply chain of fresh fruits and vegetables in India: review of tech-driven supply chain platforms

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India is the second-largest producer of fruits as well as vegetables, accounting for 11.3% and 11.8% of global production each, respectively. India's post-harvest losses of fruits and vegetables range from 4.58- to 15.88% of the country's horticulture production. The supply chain of fresh fruits and vegetables to the end user is a complex network that affects pricing and food security. A sustainable supply chain stimulates the overall development process of the economy, promotes production, eliminates unnecessary fluctuation of price, and reduces the loss of the produce in the course of the supply chain. The present work is exploratory and uses secondary sources. The paper attempts to explore the problems faced in the supply chain of fresh fruits and vegetables through a review of the basic and contemporary literature available. The study found that the supply chain of fresh fruits and vegetables is characterized by the number of intermediaries, improper standardization of produce, poor infrastructure for storage and transportation, lack of proper cold chain, the problem of demand and supply mismatch, and lack and market information. This creates the issue of post-harvest losses and wastage, high marketing costs, fluctuating prices, and an unfair share of income to farmers. This paper also examines the application of information technology in the supply chain of three successful tech-driven supply chain businesses, Ninjacart, Crofarm, and Agrofarms, each focusing on a different marketing channel for fresh fruits and vegetables. The modern horticulture sector is highly information-driven which enhances the production, distribution, and market. Models reviewed

in this paper show how technology integrated with each step supply chain of fruits and vegetables enhances the efficiency, traceability, and total quality management of the produce. Tech-driven supply chain platforms are using big data analytics, remote sensing, and real-time tracking for an efficient supply chain of fresh fruits and vegetables.

Nano-food is the economic prospective of the food industry

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For a decade, there has been tremendous interest in studying and advancing the food business using nanotechnology. Nano food aims to produce food items that are more nutritious, tasty, and cost-effective while also being safer. It has also reduced the amount of food that spoils. Using nanotechnology, an effective colloidal system for the correct encapsulation, safety, and distribution of nutraceuticals and functional meals has been developed in more significant portions. The use of nanotechnology in food is gaining popularity and offers the food business a vast array of opportunities. The improvement of plastic material barriers, the incorporation of active components that can deliver functional attributes beyond conventional active packaging, and the sensing and signalling of pertinent information are the three basic categories of nanotechnology applications and functionalities currently used in the development of food packaging. Nanotechnology-based food packaging materials have the potential to improve food safety, lengthen the shelf life of foods, patch tears in packaging, and even release preservatives to prolong the shelf life of the food inside the container. Nanotechnology applications in the food sector can provide more robust flavours and colours, increase barrier characteristics, and increase safety by detecting microorganisms in packaging.

LAB-grown meat: economics, challenges and prospects

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In the cultured meat production system is a strange idea to produce meat without involving animals; the use of animals here is to donate a suitable cell. The technology behind this new idea is just the extension of biotechnology, that is, tissue engineering techniques. In vitro meat is an innovative and emerging technology to produce animal-free meat by culturing stem cells derived from farm animals in a laboratory within a bioreactor under artificial

conditions. In vitro, the meat production system is a recent area that has astonished everyone with its benefits for ecological and animal welfare issues. Cell and tissue culture are the most commonly used tissue engineering techniques to produce in vitro meat. Other new methods, such as Organ printing, Biophotonics and Nanotechnology, will be more theoretical in upcoming years. A current meat production system is associated with several adverse consequences, such as the poor nutritional value of meat, food-borne diseases, depletion of environmental resources, pollution, and ethical issues. This new way of animal-free meat production may offer health benefits by reducing the ill effects of the current meat production system and will also ensure sustainable production of designer, chemically safe and disease-free meat as the conditions in an in vitro meat production system are controllable and changeable. The current meat scenario is increasing rapidly in terms of public demand; thus, this new method could supply the global market for meat. However, there are many challenges in producing in vitro meat as a sustainable product at an industrial scale. A significant body of research on consumer acceptance and low cost is at the central point of the production system. Many materials used in product development are novel and untested and demand urgent regulatory and safety assessment systems. In vitro, the meat production system is still in the early stages of development. It requires in-depth research and advanced skills to make this production system feasible commercially.

Economising resources in banana cultivation through drip irrigation: a case of south Gujarat

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Banana is a water intensive plant with a large total requirement and frequent supply of water. Its cultivation is dominated by conventional irrigation methods with inherent constraints like loss of water and nutrients through evaporation, transpiration, run off and deep percolation beyond the root zone. Moreover, water is a scare resource with water crisis reeling across different regions of state. The adoption of technological interventions like drip irrigation in such crops could play a significant role in improving the water use efficiency and ensuring water security in the region. Thus, the present study aimed at assessing the economic impact of drip irrigation in banana cultivation in terms of increase in yield, income, resource use and allocative efficiency besides decomposing the income difference between the drip and conventional methods of irrigation. The results showed that the returns per rupee of investment on banana under drip and conventional methods were 1:2.60 and 1:1.91, respectively indicating higher profitability and economic viability of banana cultivation under drip method. The variables like banana seedlings, plant protection chemicals and FYM were found to be underutilized while chemical fertilizers, human labour, bullock and machine labour as well as irrigation were being over-utilized during drip irrigation. Moreover, decomposition analysis revealed that the adopters of drip irrigation technology produced 17.26% higher income from banana production than conventional methods with the technology alone contributing 24.02% increase in income. This indicated that income of banana growers practicing drip irrigation would be higher even if they used the same mean level of inputs as farmers practicing conventional irrigation methods. Hence, there is a need to create awareness about the benefits of investment on drip irrigation as an economically viable, resource efficient and environmentally sustainable technology over conventional irrigation methods.

Socioeconomic status of farm women and constraints encountered by them in agriculture and allied systems in Jammu district

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Current paper focuses on sociodemographic situation of farm women and constraints they face in agricultural sector of Jammu district. Using multistage sampling technique three blocks were purposively selected from both irrigated and unirrigated areas. Two villages from each block and 10 households from each village were randomly selected and interviewed using pre-tested schedule. Results revealed that average age of farm women was between 30 and 50 years; 58.33% of farm women lacked literacy and only 22.5% had any form of intermediate education. Of the marginal farmers, 85.83% were women, and 57.50% of those women had 30 or more years of expertise in agriculture. Poor prices of the output and lack of timely financing availability were biggest obstacles for farm women in unirrigated and irrigated ecosystems, respectively.

Economics of mustard cultivation in Jammu district of J&K

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The study was conducted in Jammu district of Jammu and Kashmir UT. We have used multistage random sampling method. We have selected two blocks namely; R.S. Pura and Bishnah from Jammu district and from each block, four villages were randomly selected and finally ten farmers from each village were chosen. Both primary and secondary data has been collected. The results of the study has revealed that the variable cost, fixed cost, managerial cost and total cost for overall mustard farms was recorded at Rs. 21912.19, Rs. 11291.22, Rs. 3320.34 and 36523.75 per ha, respectively. The gross returns and net return obtained from this was Rs. 53953.98 and Rs. 20750.58 per ha respectively. The cost benefit ratio was found to be 1:1.62. The efficient resources used for producing mustard crop were machine labour ($\beta = 0.69$) at 5% level of significance, seeds ($\beta = 1.52$) and fertilizer ($\beta = 0.61$) at 1% level of significance and these factors collectively explained 70.10% variations in the output ($R^2 = 0.7010$). The marketing pattern was also evaluated during the study and have found that two marketing channels viz; "Producer – Village trader –Processor" (Channel–I) and "Producer –Processor" (Channel-II). Channel–II is more efficient than channel-II with marketing efficiency 51.91%. From this we have concluded that the mustard crop is economically viable and profitable and producer's share in consumer rupee can be increased through channel-II.

Women participation in various sericulture operations and their determinants

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The paper evaluates women's participation in various sericulture operations against their male counterparts based on survey conducted in 2017-18. A sample of 270 silkworm rearers, selected randomly from three districts namely Kathua, Rajouri and Udhampur which were selected purposively based on highest number of silkworm rearers and cocoon production was taken. The binary logistic regression model was used to examine women's involvement in sericulture and the estimates of binary logistic regression model has indicated that bed cleaning, feeding of leaves, chopping of leaves and sorting of cocoons had significantly influenced adoption of work by women in sericulture with the highest probability for bed cleaning (0.254) followed by sorting of cocoons (0.242), chopping of leaves (0.118) and feeding of leaves (0.011). The t-test with equal or unequal variances to examine the participation of men and women in different sericulture activities revealed that the average performance of females was found more in activities like separation and chopping of leaves, bed cleaning and feeding of leaves, application of bed disinfectants and harvesting of cocoons. The t-values were highly significant for all the operations. So the findings clearly indicate that the participation of females was more in indoor activities requiring soft skills while that of male's participation was found more in outdoor activities requiring more energy. This way the sericulture enterprise helps to tap the unutilized female family labour as most of the sericulture operations are home bound which they can easily perform.

Strategies to strengthen climate-resilience and livelihood of smallholders

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Climate change is a major ecological, economic, and societal issue. Climate change threatens sustainable agriculture. Due to rapid and unpredictable climate change, agricultural systems must be flexible and strong to meet population and urbanization- driven food demand. Climate change will affect people and the environment worldwide. However, emerging countries, especially small-holder farmers, would be severely hurt. Small-scale farmers are struggling to feed their family and the nation due to climate change. Small-holder farmers' climate change adaptation depends on livelihood management. To increase food security, slow climate change,

and protect the natural resource base and essential ecosystem services, we must switch to agricultural production systems that are more productive, use inputs more efficiently, have less variability and more stability in outputs, and are more resilient to risks, shocks, and long-term climate variability. Sustainable management and efficient use of scarce resources like soil and water, livelihood diversification, farm adaptation strategies, promotion of climate resilient zero budget natural farming, women empowerment, and diverse national and international approaches are the strategies to sustain livelihood vis-a-vis climate resilience and are briefly elaborated in this chapter.

Economic analysis of containerized growing strawberries with the use of different growing medias in a sub-tropical environment

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The present study sought to determine the economics of soilless containerized strawberries planted in different types of containers with various dimensions using different ratio combinations of growing media. The experiment was carried out at Research Farm, Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Main campus, Chatha, during the year 2020-21. Three replicates of each plant were tested using six types of containers having different dimensions (i.e. Polyethylene bags, PVC pots, Plastic baskets, Root trainer tray, Plastic tray and Earthen pots) in factorial randomised block design. The strawberry plants were planted in containers filled with a growing media of coco peat, perlite and vermicompost in the following ratios: 1:1:1, 2:1:1, 3:1:1, 4:0:1, 4:1:0, 4:1:1, respectively, and control. At the end of the study, the significant differences were observed with respect to benefit cost ratio in strawberry due to influence of various media combination and size of container. Economically, the polyethylene bags with combination ratio (3:1:1) of growing media gave highest (1:1.70) benefit cost ratio while lowest (1:0.40) benefit cost ratio was reported in Root trainer tray with combination ratio of 4:1:0 (T_5). But overall performance provided by plants raised in PVC pots with a growing media ratio of 3:1:1 (C_2T_3) had significantly greater height, higher growth, maximum flowering and fruiting with benefit cost ratio of 1:1.56. Economically, it is recommended that the polyethylene bags with growing media of ratio 3:1:1 gave better results and can be used for commercial cultivation with higher returns.

A study on the evolution and functioning of e-Nam with special reference to J&K

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e-NAM was launched in April, 2016 as a tool of marketing reforms in agriculture to strengthen the network of regulated markets and augment it with alternative marketing channels. The present study aims to understand the evolution of e-NAM, its implementation and working. It also aims to understand the progress of e-NAM in J&K UT. A steady progress of integration of mandis across the country and conversion of warehouses, farm-gates and FPO collection centres as e-trading points under e-NAM is pointing towards success of the moto of 'One Nation One Market'. J&K has also seen rapid integration of mandis & registration of stakeholders under e-NAM in the beginning of the year 2022.

Incremental benefits of complete vaccination against Newcastle Disease in layer farms in Haryana

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The state of Haryana has been the worst affected with maximum number of total Newcastle Disease (ND) cases reported (66.52%) in the country during 2010-2019. Therefore, a study was undertaken to estimate the total economic losses due to ND in the commercial layer farms along with incremental benefits of vaccination against ND in Haryana based on primary data obtained from 90 farmers of Panchkula district following multistage purposive random sampling over a period of 72 weeks. The confirmation of ND and status of vaccination against ND on the layer farms was done based on a standard checklist of symptoms duly validated by the experts. The layer farms were categorised into 3 categories namely, (57) completely vaccinated, (33) ill-vaccinated farms, whereas none of the layer farm was un-vaccinated against ND. The completely vaccinated farms were those on which vaccination was done strictly as per schedule, and the ill-vaccinated farms were those which defaulted from the schedule or on which vaccination against ND was incomplete. The majority of the layer farms (74) were ND-infected. The proportion of ND outbreaks on ill-vaccinated farms (97%) was comparatively higher than the completely vaccinated farms (73.7%). The occurrence of ND on the farm was significantly associated with the vaccination status against ND ($S\chi^2 = 7.73, p = 0.005$). A significant difference was observed in the vaccination cost incurred ($t = 2.103, p = 0.038$), mortality of birds due to ND ($t = -1.943, p = 0.057$), and the gross profits generated ($t = 2.272, p = 0.026$) on complete and ill-vaccinated farms. The overall incremental benefit of complete vaccination was estimated to be ~INR22 per bird over the incomplete vaccination. Therefore, it is suggested that poultry farmers must follow complete vaccination on their farms as a standard management practice.

Intuitional innovation in water resource management under ILSP programme in Uttrakhand: a case study

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This study pertaining to Integrated Livelihood Support Project (ILSP) which was implemented though structured institutional arrangement in Uttarakhand. Under the project institution innovation through community institutions development and capacity building was strengthened. The project activities were received overwhelming response from the people in terms of association to support the project. Overall, villagers were increasingly taking ownership of the project and were being progressively equipped with the skills to manage it. The Low-Density Polyethylene (LDPE) as an intervention was introduced under the ILSP project to rain water harvesting and using for agriculture production. The water resource development works for sustainable agriculture production, resource conservation, microclimate improvement and inclusive growth of the project area. The water resource development has created the opportunity of diversification of agriculture, increase income, employments, improvement in cropping intensity and motivated the farmers to make agriculture as profitable venture. They have been introduced to market opportunities and are acquiring the knowledge and skill sets to respond to and benefit from these. Most of the Producer Groups (PGs) and Livelihood Collectives (LCs) have been introduced to block/ district administration and public agencies/ institutions and have become familiar with government functioning, programs and pathways to accessing them. These interactions with markets, developmental and governance agencies are opening up avenues to maintain project assets post project. The study clearly indicate that community institution is the key for success of development government schemes.

Analysis of farmers' perception for enhancement of crop insurance scheme

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Uneven distribution of monsoon leads to yield/price volatility and hence increases farmers' exposure to risk and uncertainty. In this scenario of high risk and uncertainty of rain-fed agriculture, allocating risk is an important aspect of decision-making for farmers. The risk burden of the farmers can be reduced through crop insurance, which is primarily a way of protecting farmers against the losses in crop production. Crop insurance spreads crop losses over space and time, provides social security to the farmers, helps in maintaining their dignity, offers self-help, and encourages large investments in agriculture for improving crop yield and increasing agricultural production. In this direction, Pradhan Mantri Fasal Bima Yojana (PMFBY), scheme has been implemented since

Kharif 2016. Its main purpose was to provide insurance coverage to farmers suffering crop loss due to any natural calamities and other risks for sustainable income. This ambitious scheme is open for all types of farmers and tenants in all states and UTs of India. Since implementation in the Kharif 2016, the scheme has entered the thirteenth season in Kharif 2022 and has made very good progress. To know farmers' view about this scheme, primary data were collected from 200 farmers of UP and Rajasthan for year 2020-21. The farmers were divided into two groups as beneficiary and non- beneficiary. The farmer's perception indicated that 24% of non-beneficiary farmers have even not heard the name of the scheme and 89% of farmers are not knowing the different steps and processes of the scheme. 86% of non-beneficiary farmers and 62% of benefitted farmers responded that the promotion of the scheme is insufficient. 62% of non-benefitted farmers have suggested that there should be at least two meetings per year for the promotion of the scheme. 36% of benefitted farmers have responded that payment of claims is given in 3-4 months while 64% received it in 4-5 months. 44% of non-benefitted farmers have asked for claims settlement within two months. 78% of farmers who have received one or two claims for losses are found satisfied with the scheme, and most of the farmers are satisfied with the registration process. Thus, the incorporation of the responses of farmers is necessary for the success of the crop insurance scheme.

Determinants of business performance and challenges faced by the farmer producer organizations (FPOs) in India

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Farmer Producer Organization (FPO) is believed to improve the livelihood of farmers by collectivizing them for input purchase and providing forward linkage. Survival and then business scaling-up and expansion are considered to be the goals of FPO. In order to understand the determinants of business performance and the challenges faced by the FPO, the study has been undertaken by surveying 125 FPOs of Andhra Pradesh, Madhya Pradesh, Telangana, Maharashtra and Uttar Pradesh. It is found that most of the FPOs are engaged in input supply as the only business activity. Members number, BoD size and years of existence are found to be the determinants of paid-up capital of FPO. Paid-up capital is found to be significant predictor of turnover of FPO. Capital requirement is found to be the biggest challenge by the FPO.

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