Mysore J. Agric. Sci., 56 (1) : 244-251 (2022)

Drivers of Crop Diversification : An Empirical Evidence from Eternally Drought Prone Area of Karnataka

K. N. Pavithra and G. M. Gaddi
Department of Agricultural Economics, College of Agriculture, UAS, GKVK, Bengaluru - 560 065
e-Mail : pavithraharsha6@gmail.com

Abstract

The paper has examined the crop diversification and factors affecting it in the Koramangala-Challaghatta (KC) valley project (KCVP) area and non-KC valley project (NKCVP) area of Kolar district, Karnataka using primary data collected from 140 randomly selected farm-households comprising of 70 each in KCVP and NKCVP area. The data were analysed using crop diversification index and fractional probit to assess the extent of crop diversification and factors affecting crop diversification. The empirical results revealed that herfindahl index of crop diversification was comparatively higher in KCVP irrigated area (0.423) than non-KC valley area (0.686) indicating higher degree of diversification in KCVP area. However, even under non-KC valley area too about 40 per cent of the respondents showed diversification index of 0.50. The results of fractional probit indicated that age, education, farm income, dummy for irrigation and access to extension services were found to be the major factors contributing to crop diversification in the study area. Thus, more emphasis on creating irrigation infrastructure and strengthening extension services would help diversification and minimize risk and stabilize farm income.

Keywords : Crop diversification, Herfindahl index, Farm income, Irrigation, KCVP, NKCVP

The risk is very inherent in any production process and it is more visible in farm sector especially in dry Agro-climatic zones. Farmers are advised to follow various measures to counteract the expected loss against the losses caused on account of various production, marketing and other risks. Hence, the adoption of diversified cropping pattern in one of the widely advocated strategy to the farmers. The crop diversification refers to a mix of farming systems rather than the shift from one given enterprise to another (Inoni *et al.,* 2021). It is also known by growing series of multiple crops mainly in one growing season on the same piece of land. As diversification being one of the possible strategy for farm households in stabilizing farm income and reducing various risks, like weather and market shocks by spreading both production and income risk over wide range of crops. Many a times climatic conditions like rainfall variability and risk aversion behavior of farm households makes farmer to go for diversification. Hence, crop diversification could be viewed as a hedge against risk due to shocks from extreme weather conditions, crop diseases & pests and unexpected fall of market prices, etc. The inherent characteristics of crop diversification that are widely accepted in the literature implies that it reduces potential risk against uncertainty by reducing high dependency on monoculture, reduces economic losses due to diseases, weed & infestation, and increases soil fertility through crop rotation (Krupinsky *et al*., 2002). Crop diversification has become one of the viable option for resource sustainability, ecological balance, output growth, employment generation and above all the risk coverage.

Crop diversification is intended to give a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops and also to lessen risk (Satish and Umesh, 2017). Crop diversification in India is generally viewed as a shift from traditionally grown, less remunerative cops to more remunerative crops. It is a strategy of shifting from less profitable to more profitable cropping pattern (Rathod *et al.,* 2011). The crop shift may include incorporation of high value crops through either vertical or horizontal diversification approach, more water consuming with less water consuming crops, replacing

low yielding and low value crops with high yielding and high value crops like vegetables or pulses. Generally, diversification is an interactive effect of many factors like, resource related factors like fertility status of soil, rainfall; technology adoption related to seeds, fertilizer, storage, marketing and processing; investment capacity; economic factors like input and output prices, trade related policies, Government intervention; Institutional and infrastructure factors like research, extension and marketing. Although these factors are inter-related, the factors influencing area allocation to different crops depends mainlyon resource constraints along with economic considerations of relative crop prices rather than by other non-economic considerations. Similarly, economic factors play a relatively stronger role than non-economic factors in influencing the crop pattern in areas with a better irrigation and infrastructure potential.

Given the drawback of intensification and specialization of agricultural production has caused traditional crops upon which farm households' livelihoods have depended over the years and the consequent vulnerability and hunger in rural farming communities have made farmers to adopt crop diversification farming system (Inoni *et al.,* 2021). Apart from being a strategy against risk, crop diversification also reduces the vulnerability of agricultural production to climate variability and improves the household income. Therefore, this study was conceived to address various research questions like what is the extent of crop diversification? And what factors made farmers to diversify their farm fields? In eternally drought prone district *viz.,* Kolar district of Karnataka.

Kolar is a semi-arid drought prone district with an annual rainfall of less than 700 mm. In dryland areas, farmers are initially cultivating millets, groundnut, pulses, vegetables and mango due to scarce groundwater availability. Considering the significance of waste water on production and productivity of agriculture, Government of Karnataka had taken an initiative to implement Koramangala-Challaghatta Valley Project (KCVP), considered to be an unique project in the country. The scheme envisages filling of several tanks in Kolar and Chikkaballapur districts with treated sewage situation water from Bengaluru. The KCVP was initiated during November 2016 to supply treated sewage water to a total of 126 irrigation tanks situated in different clusters of Kolar and Chikkaballapur districts in a phased manner. Bengaluru Metropolitan and Karnataka State Government authorities have been grappling with the ever growing sewage problems. The KCVP thus has been designed to attain double benefits of help address the ever growing problem of Bangalore city's drain and sewerage water problems on one hand and on the other to rejuvenate the steadily declining groundwater table in the surroundings of the irrigation tanks in rural areas.

After implementation of KC valley project in the district, there is an improvement in diversification of crops, in addition and a study by Ramesh (2020) reported decreased depth of borewell drilling in the region as the project has led to replenishment of groundwater. In this backdrop present study is an attempt to know the extent of crop diversification and drivers of crop diversification in the study area.

Study Area and Selection of Farmers

The study was carried out in the Kolar district of Karnataka. Purposive random sampling design was employed for the selection of respondents. The primary data were collected from 140 farm households, consisting of 70 farm households in Koramangala Chellaghatta Valley Project (KCVP) area and 70 from Non-Koramangala-ChellaghattaValley Project (NKCVP) area, *i.e.,* area outside the KCVP area. The distinction between two categories of respondents was on the basis of implementation of KC Valley Project (KCVP) implementation (village tanks filled) in the district. The data were collected from the respondents through personal interview method using pre-tested, well-structured schedule to achieve the objective of the study. The villages were selected randomly based on the area in which tanks were filled under the project in the district. The required information regarding age, education level, average land holdings, cropping pattern, marketing practices pertained to the agricultural year 2020-21and farm income pertaining to previous year were collected. The sample villages included Chowdadenahalli, Doddavallabbi,

The Mysore Journal of Agricultural Sciences

Singenahalli, Dinnehosalli, Uddapanahalli, Lakshmisagara and Narasapura in KCVP area, while Imarakunte, Dasarathimmanahalli, Baipanahalli, Nukkanahalli, Hoodali, Bangarpete, Mulbagal and Mallasandra were the villages selected in NKCVP area.

Analytical Tools Used

The extent of diversification on the sample farmers was estimated using the standard methodologies as detailed below.

Herfindahl Index (HI): It is the sum of square of the proportion of area under each crop to the total cropped area and was estimated using the following equation:

$$HI = \sum_{t=1}^{N} P_i^2 \quad \text{..... (1)}$$

Where,

$P_i = \frac{Ai}{\sum Ai}$ is the proportion of area under i^{th} crop in the net sown area.

Then based on the index value, inference can be made as region is specialized if the value is closer to one and region is said to be adopting diversified copping pattern if index value approaches zero.

Simpson Index (SI): This measure of index is another widely used method for measuring diversification of crops of the region using the following equation:

$$SI = 1 - \sum_{t=1}^{N} P_i^2 \quad \text{..... (2)}$$

Where,

$P_i = \frac{Ai}{\sum Ai}$ is the proportion of the i^{th} activity in acreage

The interpretation of results obtained from the Simpson Indices would be quite opposite to the interpretation of results obtained using HI, where, the value of index nearer to zero indicates area is marching towards specialization in growing of few crops and if index is closer to unity, that indicates zone is adopting diversified cropping pattern.

Fractional Probit Model : The fractional probit has been introduced by Papke and Wooldridge (1996) and has been extended to panel data by Papke and Wooldridge (2008).

Fractional probit model was used to identify the factors influencing crop diversification in the present study. The values of crop diversification indices obtained using Simpson Index of Crop Diversification (SICD), which ranges from 0 to 1 were used as dependent variable. This was regressed against various relevant regressors identified in consultation with the experts and previous literature related to the domain of the present study.

Fractional probit regression written as: $E(y/x)=\phi(x\beta)$

The model specification for the fractional probit regression model is given as:

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7D_1+\beta_8D_2+\mu \quad \text{....(3)}$$

Where,

Y = SICD score

X_1 = Age (years)

X_2 = Education (No. of formal years of education)

X_3 = Farm income (Rs.)

X_4 = Average size of land holdings (acres)

X_5 = Distance to market (Kms)

X_6 = Human labour (Man-days)

D_1 = Region dummy (1 = irrigated area, otherwise '0')

D_2 = Access to extension services (1=Yes, otherwise '0')

Output-elasticities : Marginal effects of the explanatory variables at the mean could be obtained by:

$$\text{Marginal effect of } X_i = \frac{dy}{dXi} * \frac{\overline{Xi}}{\overline{Y}} \text{ (or) } b_i * \frac{\overline{Xi}}{\overline{Y}} \quad \text{.....(4)}$$

Where,

B = Parameter estimate (partial elasticity associated with each independent variable)

x = Mean of independent variable

y = Mean of dependent variable

Results and Discussion

Extent of Crop Diversification

The results on analysis of extent of diversification using the Herfindahl Index and Simpson Index are presented in Table 1. The value of Herfindahl index was 0.423 in KCVP area and 0.686 for NKCVP area, while, the

TABLE 1

Crop diversification in Kolar district of Karnataka

Index	KC valley irrigated area	Non-KC valley area
Herfindahl Index (HI)	0.423	0.686
Simpson Index (SI)	0.576	0.325

value of Simpson index was 0.576 for KCVP area thereby indicating that the region showed more diversification compared to in NKCVP area (0.325) revealing prevalence of less diversified crop pattern. In other words, crop pattern followed in NKCVP area was towards specialized farming and farmers have concentratedon few selected crops. The results of Ramesh (2020) also revealed similar findings of higher degree of diversification in KCVP area than NKCVP region.

Distribution of Respondents Across different Levels of Diversification

The values of Herfindahl indices were used in the present study to classify the sample farm households into five quartiles as relatively more diversified farms as one extreme category and the least diversified farms as another extreme category in both KCVP and NKCVP areas (Table 2). The comparison between the two situations is also presented in Fig.1. It could be observed from the table that, majority of the respondents in KC valley area (61 %) fall in the category of higher degree of diversification index of less than 0.50, followed by 25 per cent showed a diversification index in the range of 0.5-0.6 and rest of the 25 per cent of the respondents belonged to diversification categories of 0.6-0.7 (1.42 %), 0.7-0.8, 0.8-0.9 and more than 0.90 (7.14 %). Hence, it can be inferred from the findings that majority of the respondents in KC valley have adopted relatively more diversified crops due to various reasons such as assured irrigation availability and better farm incomerealisation.

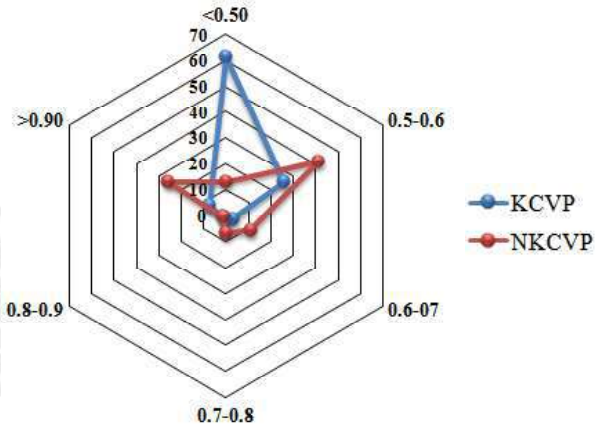

Fig. 1: Distribution of respondents according to diversification index

In contrast to KCVP area, 12 per cent of respondents in NKCVP area fall in the category of less than 0.5, indicating adoption of diversification by relatively smaller proportion of the respondents. The largest proportion of farmers (41 %) of the NKCVP area fall in the diversification index range of 0.5-0.6. However, one-fourth of the respondents fall in the category of adopting highly specialized cropping pattern. More than ten per cent and seven per cent of the respondents showed the HI index range of 0.60-0.70 and 0.70-

TABLE 2

Distribution of respondents according to Herfindahl diversification index

Herfindahl Index	KC valley area		Non-KC valley area	
	No. of respondents	Percentage	No. of respondents	Percentage
<0.50	43	61.42	9	12.85
0.5 - 0.6	18	25.71	29	41.42
0.6 - 07	2	2.85	8	11.42
0.7 - 0.8	1	1.42	5	7.14
0.8 - 0.9	1	1.42	1	1.42
>0.90	5	7.14	18	25.71
Total	70	100.00	70	100.00

0.80, respectively. Overall distribution of respondents in non-KC valley area infers that majority of respondents are towards the specialization or respondents adopted less diversified cropping pattern compared to KC valley area.

Determinants of Crop Diversification

The description of the variables having possible impact on the crop diversification have been identified and are presented in Table 3. The age of the farmer respondents ranged between 16 and 69 years, with an average age of 44 years. The number of years of schooling education of respondents was about eight years; however, formal year of education was ranged between zero to 15 years, indicating presence of illiterate respondents. The size of landholding is another important factor influencing diversification. The respondents in the study area own a farm size ranging between 0.5 acres to 20 acres with average acreage of 3.78. The number of man days of human labour used on the sample farmswas 39 man-days.

While considering the distance to market from the respondents' farms, they were located at an average distance of 12.46 kilometers to market with the farthest farm distance of 62 kilometers. Irrigation dummy and access to extension services were the other two variables considered to estimate their influence on crop diversification. The variables considered for the model are expected to have significant influence on the crop diversification and were selected based on the previous literature and consultation with the expert on the subject.

The results of the fractional probit model calculated using the model presented in the methodology section (Equation 3) are presented in Table 4. Majority of the selected predictor variables have shown positive and significant effect on crop diversification in the study area. The test statistics showed that the model chosen for estimating the crop diversification and its determinants found to be well fitted the data, with Wald's criteria, $\chi^2(8)$ found to be 296.44 and was highly significant. The estimated results have shown that crop diversification of the desired attributes was triggered by heterogeneity of the different farming systems adopted and socio-economic characteristics of the respondents.

The estimated coefficients for age (0.027), farm income (4.022), Irrigation dummy (0.287) and access to extension services (0.445) revealed positive and significant influence on the crop diversification (Table 4). While, size of land holdings and the distance to market had negative impact on crop diversification in the study area as revealed by the negative

TABLE 3

Summary statistics of variables used in fractional probit model

Variable	Variable description	Mean	Standard deviation	Minimum value	Maximum value	Expected sign
CDI	Intensity of crop diversification	0.44	0.257	0	1	
FARMAGE	Age of the respondents (Years)	43.00	14.56	16	69	+
EDUC	Education level (years of formal education)	8.44	3.53	0	15	+
FARMINCOM	Farm income (Rs.)	187920.22	108756.12	12950	823145	+
FARMSIZE	Size of farm (acres)	3.78	2.99	0.5	20	+
ACCESEXTEN	Access to extension services (1 = Yes, 0 otherwise)	0.56	0.49	0	1	+
ACCESIRRI	Access to irrigation (1=Yes, 0=otherwise)	0.49	0.50	0	1	+
DISTMARKT	Distance to market (Kms)	12.46	12.14	0	62	+
HUMLBR	Human labours used (Md)	39	27.29	8	96	+

TABLE 4

Estimates of fractional probit model on factors affecting crop diversification

Variables	Parameters	Coefficients	z value	P value
FARMAGE	X_1	0.027	6.80	0.0002*
EDUC	X_2	0.017	1.77	0.0760***
FARMINCOM	X_3	4.022	2.56	0.0101*
FARMSIZE	X_4	-0.034	-2.49	0.0192*
ACCESEXTEN	D_1	0.287	3.67	0.0001*
ACCESIRRI	D_2	0.445	5.18	0.0023*
DISTMARKT	X_5	-0.006	-0.36	0.7204
HUMLBR	X_6	0.0008	1.45	0.1483
Constant	β_0	0.461		
Log pseudo-likelihood value	-80.04			

Note: *, *** indicates significance atone and ten per cent probability level, respectively

coefficients for these variables. Although coefficient for education level found to be positive but fail to exert any significant influence on the crop diversification.

The chosen independent variables were regressed against the SI of crop diversification as dependent variable. It could be inferred based on the coefficient for age of the respondents that as people grow older, with acquired experience would change their objective from profit maximization to risk minimization by diversifying the crops. As one per cent increase in age of respondent would increase the practicing crop diversification by about 22 per cent as revealed by the marginal effect for the variable (Table 5). These results are consistent with the findings reported by Rehima *et al.* (2013). As expected, education level of the respondents had positive and significant influence on the diversification and these results are in-line with study conducted by Inoni *et al.* (2021). As income of farmer increases he tend to invest more on the farm by taking up many crops suitable to the region, which provides him assured income. Results on influence of previous years' farm income indicated that one per cent increase in farm income would increase the diversification by 24 per cent. But the study made by Das and Kumar (2017) revealed that diversification upto some level helps improve farm income but excessive diversification might lead to misallocation of resources and hence a fall in income. Increase in average land holdings would result in decreased crop diversification, *i.e.,* with the increase in land holdings farmers tend to go for more specialized crops in the study area, as they could go for practicing greater degree farm mechanization and benefits of economies of scale and cut down the overhead cost in the usage of services of durable assets in production. The increase in average land holdings would decrease the diversification on farm marginally by 3.1 per cent as revealed by marginal effect. These results are contradictory to the results of Sichoongwe *et al.* (2014), who reported that an increase in the size of landholding would better enable a farmer to diversify. With the extra size of landholding, the farmer can decide how many crops to grow based on his or her production decisions.

TABLE 5

Marginal efficiency of factors affecting crop diversification

Variables	Elasticity	Marginal effect
FARMAGE	0.027	0.227
EDUC	0.017	0.335
FARMINCOM	4.022	0.244
FARMSIZE	-0.034	-0.031
ACCESEXTEN	0.278	0.314
ACCESIRRI	0.445	0.566

Distance to the market had negative effect on crop diversification. This implies availability of market in the nearby places would favour the crop diversification, as marketing of produce would beeasy. This findingis in consistent with Monika *et al.*(2017). Access to extension service, measured in frequency of contacts made with extension service providers like Department of Agriculture (RSK), Input dealers, discussion with neighbours and friends were also the important factors found to influence a household's decision to diversify, *i.e.,* every contact with extension service provider had resulted inabout 31 per cent increment in crop diversification above average. Similar impact of access to extension services on diversification was reported by Mandal and Bezbaruah (2013).

Irrigation being one of the major factors influencing crop production, farmers using irrigated water from borewell recharge of KCVP area showed positive and significant influence on the crop diversification. It implies that with the availability of irrigation water farmers can grow more number of crops per unit area (mainly vegetables) with increased cropping intensity. In addition, it induces him to go invariably realize benefits from crop rotations beside maintenance of soil health. In addition, it can avoid damage by the soil born insects, pests and diseases due to practice of diversified crops. Usually in non-KC valley area farmers go for less water requiring crops due to inadequate groundwater. This may be attributable to the fact that they are not being benefitted by groundwater recharge through filling of tanks as in the case of KCVP area. Every per cent increased access to irrigation water in the study area could result in increased crop diversification by 56 per cent, as revealed by the marginal effect (Table. 5).

Agriculture being seasonal in nature and highly sensitive to various shocks like weather, market and poor access to irrigation. Crop diversification has been considered as one of the important strategy to stabilize farm income and reduce the extent of risk involved. Hence, the present study which was aimed examining the crop diversification and its determinants, found out that the crop diversification was found to be higher in KCVP area compared to NKCVP. Thus irrigation proved to be one of the major determinants of diversification. The results from the fractional probit model depicted a positive and significant association of age, education, farm income, access to extension services and irrigation dummy with crop diversification, while farm size and distance to market were negatively associated with diversification. The study concludes that irrigation and education are major determinants of crop diversification in the study area.

Extending the irrigation tanks filling opportunity to other areas and replication of similar kind of projects of treating sewage water use for irrigation would help to go for diversified cropping pattern, enhanced income and livelihood security of the farmers.

REFERENCES

DAS, V. K. AND KUMAR, G. A., 2017, Drivers of farmers' income : The role of farm size and diversification, working paper, Indira Gandhi Institute of Development Research, Mumbai, pp. : 1- 40.

INONI, O. E., GANI, B. S. AND SABO, E., 2021, Drivers of crop diversification : Evidence from small holder farmers in Delta state Nigeria. *Acta Universitatis Agriculture etsilvicultureae Mandelianae Brunensis*, **69** (1) : 59 : 70.

KRUPINSKY, J. M., BAILEY, K. L., MCMULLEN, M. P., GOSSEN, B. D. AND TURKINGTON, T. K., 2002. Managing plant disease risk in diversified cropping systems. *Agronomy. J.,* **94** : 198 - 209.

MANDAL,R. AND BEZBARUAH, M. P., 2013, Diversification of cropping pattern : Its determinants and role in flood affected agriculture of Assam plains, *Ind. J. Agri. Econ.,* **68** (2) : 169 - 181.

MONIKA, A., RAM, S., FEROZE, S. M., SINGH, N., UTTAM, SINGHR, J. AND SINGH, A. K., 2017, Identifying the determinants and extent of crop diversification at household level, An evidence from Ukhurl district of Manipur. *Economic affairs*, **62** (1) : 89 - 95.

RAMESH, N., 2020, An economic impact assessment of supplying treated sewage water to irrigation tanks on

farming in Kolar district under KC valley project. *M.Sc. (Agri.) Thesis* (Unpub.), Univ. Agric. Sci., Bangalore.

RATHOD, S., SURENDRA, H. S., MUNIRAJAPPA, R. AND GOWDA, D. M., 2011, Statistical appraisal on the extent of agriculture diversification in different district of Karnataka. *Mysore J. Agric. Sci.*, **45** (4) : 788 - 794.

REHIMA, M., BELAY, K., DAWIT, A. AND RASHID, S., 2013, Factors affecting farmers' crop diversification : Evidence from SNNPR, Ethiopia. *International Journal of Agricultural Sciences*, **3** (6) : 558 - 565.

SATISHKUMAR, M. AND UMESH, K. B., 2017, Dynamics of cropping pattern and crop diversification in southern dry zone of Karnataka - An econometric analysis. *Mysore J. Agric. Sci.,* **51** (2) : 233 - 239.

SICHOONGWE, K., LAWRENCE, M., ONGOLA, D. N. G. AND TEMBO, G., 2014, The determinants and extent of crop diversification among small holder farmers-a case study of southern province, Zambia. Working paper-05, *International food policy research institute.*

(*Received :* August 2021 *Accepted :* January 2022)