



# Investment and Crop Diversity: An Empirical Evidence from Rural-Urban Interface of Bengaluru

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## **Authors' contributions**

*This work was carried out in collaboration between both authors. Author MSU designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author KBU managed the analyses of the study. Both authors read and approved the final manuscript.*

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## **ABSTRACT**

The study was undertaken in North of Bengaluru to analyse the investment pattern, crop diversification and farm household's income across rural-urban interface. The required data was collected from randomly selected 80 farmers each under rural, transition and urban gradients. Tobit regression was used to determine the drivers of investment and Herfindahl index was used to capture the extent of crop diversification across rural urban interface. The per farm investment was relatively higher on water resource and irrigation structure across all the gradients. Around 56, 51 and 45 percent of farmers have invested on water resource and irrigation structures in transition, urban and rural gradient, respectively followed by animal husbandry (40% in rural gradient) and plantation and horticulture (25% in transition and urban gradients). There has been an investment led crop diversification from food crops to vegetables, flower and fruit crops in rural gradient between 2014 and 2019. Whereas, in transition and urban gradients, diversification was from food and vegetable crops to high value fruit crops during the same period. During 2019, the extent of diversification was more in transition (0.21) and rural (0.25) gradients compared to urban (0.29) gradient. Age of head of family, farm income and borrowed capital were the chief drivers which significantly affected the investment in agriculture. The study concludes that, investment led high value crops cultivation and crop diversification played significant role in augmenting the farm income leading to improvement in farmer's welfare assuring food and livelihood security.

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## 1. INTRODUCTION

The Indian agricultural sector provides livelihood directly and indirectly to nearly 54 per cent of the population in rural areas, where poverty is more pronounced. According to Census 2011, out of the total workers of 481.7 million, there are 118.7 million cultivators and 144.3 million agricultural laborers. Though major chunk of the population is engaged in agriculture its contribution to national income has reduced to 16.5 percent in 2019-2020 from 18.2 percent in 2014-2015 due to better performance of other sectors [1]. But still, with majority of the population relying on agriculture it holds the predominant position in Indian economy.

According to National Sample Survey Office (NSSO) survey 2012-2013, farm business (cultivation and farming of animals) contributed nearly 60 percent of the average monthly income of the rural farm households and 32 percent of the income was from non-farm employment. The average monthly income of agricultural household was Rs. 6426. With deteriorating soil health, fragmented land holdings, frequent droughts, traditional technology, urbanization, migration, climate change and lower investment there is drop in agricultural growth. With the growing population the average size of land holdings has declined to 1.08 ha [2] and this has negatively impacted the investment in agriculture and adoption of technologies. According to NABARD (National Bank for Agriculture and Rural Development) All India Rural Financial Inclusion Survey (NAFIS), agricultural households made an investment of 10.4 percent during the year 2016-2017 and investment was positively associated with increasing land holding size [3]. With all these ailments the socio-economic status of farm households is deteriorating and their income level has been drastically knocking down to lower expenditure, savings and poverty. The income inequality between the farm and non-farms sector has been increasing over the years causing the migration of rural youth to urban areas in search of better employment opportunities to have improved standard of living [4].

To improve the economic wellbeing of farm households there is a need for enhancing the productivity, efficient use of resources, cropping intensity, investment at farm level, adoption of modern technologies with diversification of crop

and farm (Anon, 2018). Land, labour, capital and organization are the main four factors of production. Higher capital-labour ratio increases land and labour productivities in agriculture which in turn raise incomes of the farmers and reduction in poverty and hunger [5]. Capital is one of the primal factors that influences the agricultural productivity. Studies have revealed that there is positive association between agriculture growth and capital investment [6].

Investment in agriculture can be defined as addition to the stock of productive capital over time viz., buying new machinery, construction of new buildings, irrigation structures, development of orchards, polyhouses, etc. The investment may be made by private or public sectors, about 76 percent is from private sector (with farm household investment forming over 70%) and 24 percent from public sector [7]. The magnitude of private investment in agriculture and allied activities gained momentum over the decade from 2002-2003 to 2012-2013 compared to the 1980s and the 1990s and grew at an average annual rate of 9.3 percent. The private investment in agriculture and allied activities are positively influenced by public investment in agriculture and irrigation [8].

Crop diversification is growing variety of crops in order to overcome the risk of crop loss. It increases the income of small farm holdings; less risk for price fluctuation, climatic variability etc.; balancing food demand; increasing the production of quality fodder for livestock animals; beneficial for conserving natural resources; minimize environmental pollution; reduce dependence on off-farm inputs; and community food security can be increased [9]. Persistent low farm income will have adverse effect on the future agriculture. To meet/ensure the food security in the near future and enhance the income of farmers' there is a need for prioritizing crop diversification and the private investment at farm level. Considering the importance of farm investment and crop diversification, the current study was taken up. This study examines the pattern of investment in agriculture, production diversity and income of farm households and factors/ drivers for investment in agriculture.

In this backdrop, the present study was carried out with the following objectives:

1. To assess the pattern of investment in agriculture by farm households.

2. To estimate the crop diversity of farm households.
3. To analyze the drivers/ factors responsible for investment in agriculture.

## 2. METHODOLOGY

The study was carried in rural-urban interface of north of Bangalore in Karnataka. North transect was further divided into three layers namely rural, transition (peri-urban) and urban gradients. The distinction of the transect into rural, transition (peri-urban) and urban gradient was made based on the survey stratification index [10] developed by considering percentage of built-up area and its linear distance from the city centre. The building of the state legislature, Vidhana Soudha was used as the reference point to measure the distance. Up to about 20 to 25 km away from the city center building density was strongly correlated to distance (the closer to the city, the higher the percentage of built-up area). Beyond that, however, the two parameters were negatively correlated. The villages were selected randomly across all the three transects. The random sampling method was adopted for the selection of farmer households. The sample frame consisted of 240 farmers representing 80 each from the rural, transition (peri-urban) and urban gradients, respectively. In order to address the objectives of the study, data was obtained from the selected farmers using a pre-tested well-structured schedule developed for the study through personal interview. The information elicited from the respondent farmers pertained to cropping pattern, land holdings, asset position, family size, educational level, decision making. Further, the data on the investment in irrigation infrastructure, land purchase and development, farm machinery and equipment, farm infrastructure, plantation and horticulture and animal husbandry was collected. Investment made by farmers from 2014 was collected from the farmers. Data pertaining to cropping pattern in two intervals i.e. during 2014 and 2019 was collected from the sample respondents on memory recall to know the crop diversity across rural-urban interface of north of Bengaluru.

### 2.1 Analytical Tools

#### 2.1.1 Investment

It is defined as investment made in agriculture on items such as investment in irrigation infrastructure, land purchase and development,

farm machinery and equipment, farm infrastructure, plantation and horticulture, animal husbandry and others. Investment on these leads to creation of productive assets directly or indirectly on the farms. The actual investment by the respondents in acquiring the capital assets from 2014 to 2019 (study reference period) was considered. The investment on each asset was brought to current prices of 2018-2019 using Wholesale Price Index (WPI) as deflator to account for inflationary effects. Considering the WPI for all commodities for the period 2014-2015 to 2018-2019 with the base year 2011-2012, the new index was constructed with 2018-2019 as base year.

$$\text{Index with the base year 2018 – 2019} = \frac{\text{WPI value of } i^{\text{th}} \text{ year}}{\text{WPI value of base year 2018–2019}} \times 100 \quad (1)$$

The current value of capital assets was obtained by using the following formula

$$\text{Current values of capital assets at 2018 – 2019 prices} = \frac{\text{Capital asset value in } i^{\text{th}} \text{ year}}{\text{Index value of } i^{\text{th}} \text{ year with base 2018 – 19}} \times 100 \quad (2)$$

The investments that were included in this study are defined below.

#### 2.1.1.1 Water resource and irrigation structure

This includes new investment made for sinking of bore wells, purchase of pump set and pipes and construction of farm pond, deepening of bore wells, installation of drip and sprinkle irrigation set, electricity connection to bore wells, etc.

#### 2.1.1.2 Land purchase and development

This comprises the cost of purchase of new agricultural land. It also includes items of investment such as bunding and land leveling etc.

#### 2.1.1.3 Investment on farm building

Investment made on construction of cattle shed, pump house, tractor shed and silk worm rearing house was considered under this category.

#### 2.1.1.4 Investment made on farm machinery and equipment

This encompasses expenditure incurred for the purchase of bullock cart, tractor, power tiller, ploughs, sprayers, JCB, tractor equipment's, implements and others etc.

**2.1.1.5 Farm infrastructure**

Investment made for construction of farm house, cattle shed, poly house and storage structures

**2.1.1.6 Plantation and horticulture**

Initial establishment of perennial crops like arecanut, coconut, grapes, sapota, mango etc., were considered as capital investment.

**2.1.1.7 Animal husbandry**

The new investment made for purchase of local cow, cross-breed cow, bullocks, buffalo, sheep, goat, etc. were considered here.

**2.1.1.8 Others**

Investment on oil distillation unit and petty shops.

**2.1.2 Herfindahl Index (HI)**

It is the sum of the squared proportions of acreage under each crop in relation to the gross cropped area, as given in equation (3)

$$HI = \sum_{i=1}^N P_i^2 \quad (3)$$

Where,  $P_i$  represents the acreage proportion of the  $i^{th}$  crop in the total gross cropped area.

The Herfindahl Index takes the value of one when there is specialization and approaches zero when there is diversification. HI was calculated at the area level for all the three regions.

**2.1.3 Tobit regression analysis**

A sample in which information on the dependent variables are available only for some observations is known as a censored sample and in such cases tobit is used [11]. In view of the fact that the investment in agriculture was zero for few farmers, tobit model was estimated to find the factors affecting the investment in agriculture. Censored tobit regression commands in the Stata 14.2 version software were used to find the maximum likelihood estimation of the independent variables.

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 D_1 + \beta_8 D_2 + u_i \quad (4)$$

if  $RHS > 0$  and  $Y_i = 0$ , otherwise...

Where,

- $X_1$ = Age (years of experience)
- $X_2$ = Total land holding (acres)
- $X_3$ = Education attainment (years of schooling)
- $X_4$ = Farm income (Rs.)
- $X_5$ = Off and Non-farm income (Rs.)
- $X_6$ = Borrowed capital (Rs.)
- $D_1$ : Dummy variable as '1 0' for transition farm households
- $D_2$ : Dummy variable as '0 1' for urban farm households and dummy '0 0' for rural farm households
- $u_i$ : Error term
- $b_1, b_2, \dots, b_6$  are the regression co-efficient for the variables  $X_1, X_2, \dots, X_6$ , respectively.
- $b_7$  and  $b_8$  are the regression coefficients for dummy variables  $D_1$  and  $D_2$ , respectively.

**3. RESULTS AND DISCUSSION**

**3.1 Pattern of Investment on Different Farm Capital Assets**

The pattern and extent of investment by farm households depends on many factors such as income of farmers, availability and accessibility of credit, farmer technical knowhow etc. Results pertaining to investment pattern are represented in Table 1. The farm capital assets comprised water resource and irrigation structure, land purchase and development, farm machinery and equipment, farm infrastructure, plantation and horticulture, animal husbandry and others. Per farm investment across the gradients (rural, transition and urban) were compared. In case of rural gradient, majority of the farmers invested on water resource and irrigation structure (45%) with an average investment of Rs. 3,29,518 per farm followed by animal husbandry (Rs. 1,63,252) by 40 per cent of households. Percentage of farmers invested in animal husbandry was prominent in rural (40%) gradient compared to transition (21.25%) and urban (15%) gradients. Dairy was the significant allied activity in rural and transition areas as is provided continues incomes to sustain the normal expenses of the family and also generated employment. So, quite considerable share of investment was observed. The results are in line with study conducted by Parameswarappa [12] wherein he reported that major portion of the investment was made on irrigation structures, which accounted for about 50 percent of the total farm investment followed by investment on livestock assets. Only 10

percent of farmers invested on plantation and horticulture crops in the rural gradient with an average investment of Rs. 2,09,274 per farm. In transition and urban gradients, major investment was on water resource and irrigation structures (56% and 51%, respectively) as seen in rural gradient. It is interesting to note that investment on plantation and horticulture (25%) was second major area since high value horticulture crops yield assured returns which is sufficient enough to meet their household expenditure when compared with the normal crop enterprises. Availability of market because of urban conglomeration, investment was more on plantation and horticulture in transition and urban gradient. Across the gradients, per farm investment on infrastructure (21.25%) and farm machinery and equipment (23.75%) was noticeable in urban gradient with an average per farm investment of Rs. 1,07,812 and Rs. 8,20,512, respectively. Investments in farm infrastructure and machinery equipment are indispensable for cultivation of high value low volume commercial crops. So, transition and urban who took up cultivation of flowers, fruits and vegetables have considerable share in this regard.

Across the gradients, per farm investment was relatively higher on water resource and irrigation structure as it was one of the critical inputs in crop production and plays the paramount role among all the input. Due to plummeting of ground water levels too deep due to overexploitation and other unsustainable activities, investing in this regard is indeed imperative as it was truly reflected in the study. Increasing demand for water in agriculture and allied enterprises, which coincided with lack of normal rainfall in the recent years could be another reason for investment on water resource and irrigation structure. The outcomes indicated that, irrigation was a major component of capital formation which enabled farmers to take up commercial and high value crop enterprises. Venkataramana and Chinnappa [13] also reported that the priority of investment was more or less on irrigation structures and which enabled the farmers to take up commercial and high value enterprises.

### 3.2 Crop Diversification by Farm Households

The diversification of crops by farmers across rural urban interface is presented in Table 2. The

percent change in gross cropped area was to the extent of 40.39 percent, 65.40 per cent, and 85.90 per cent in rural, transition and urban gradients respectively, from 2014 to 2019. The increase in cropping intensity was to the extent of 42.35 percent, 80.30 percent, and 106.58 per cent in rural, transition and urban areas, respectively during the reference period. The herfindahl index values in the year 2019 were approaching zero rather than the values in the year 2014 which indicates higher crop diversification during 2019.

During 2019 the extent of diversification was more in transition (0.21) compared to rural (0.25) and urban (0.29) gradients. The cropping intensity between 2014 and 2019 clearly shows that farmers cultivated their land more than once in a year. By investing on water and irrigation structures the land is put under cultivation almost round the year. The farmers growing fruit and perennial crops had increased from 2014 in transition and urban gradients. Also, vegetables were cultivated by more number of farmers across the rural urban interface. It is evident from the results that agriculture was transforming from traditional subsistence agriculture to high-value agriculture [14].

Diversification was more in transition gradient. Farmers of transition gradient had good access to farm information and technology and were more confident in reaching the consumers with their produce. Transition and urban farmers choose direct marketing activity to market their produce which fetched them high income and this was also the major reason for more diversification towards commercial crops. Crop diversification is important to farmers to mitigate the risk on one hand, on the other hand diversification is necessary to meet different needs and demands of the consumer class. Having diversification is always beneficial in farming business. The more the diversification the more will be the profit and less chance of incurring losses due to crop failures.

### 3.3 Average Annual Farm Income of Households during 2014 and 2019

The average farm income of households during 2014 was Rs.1,36,831, Rs.1,85,334 and Rs.1,57,368 in rural, transition and urban gradients, respectively. Whereas, during 2019

farm income has increased to Rs. 4,00,883, Rs. 392874, Rs. 360159 in rural, transition and urban gradients, respectively (Fig. 1). The farmers across all the three transacts shifted from food crops to vegetables and high value crops over the past five years. This resulted in increased income and standard of living of farmers. As a result of urbanization, high-value horticulture crops have assured market and have more potentiality in increasing farm income. The results are similar with the study conducted by Birthal et al. [15]. The increase in average farm income of households during 2019 was more in rural (192.9%) gradient compared to transition (111.9%) and urban (128.8%) gradients over the reference period. This is because, most of the rural farmer's dependent on agriculture for their livelihood whereas, the transition and urban farmers shifted to non-farm activities due to urbanization.

### 3.4 Factors Influencing Investment in Agriculture

An attempt was made to identify the drivers/factors responsible for investment in agriculture using tobit regression analysis. The tobit regression function estimates are presented in

Table 3. Results indicated that, the estimates for age (years of experience), farm income and borrowed capital were significantly different from zero at five percent level of significance. It is noteworthy that, among the significant factors, farm income and borrowed capital positively influenced the investment in agriculture whereas, age had negative influence on the investment in agriculture. The results are in line with Hamsa [16] where it was reported that farm income and borrowed capital were the major positive drivers of investment in agriculture. For every one-rupee increase in farm income, the investment in agriculture increases by 0.13 Rs. Showing the impact of farm income in capital formation. The study endeavors that increase in farm productivity and profitability had positively impacted farm investments. The increase in investments was mainly due to increased farm and household incomes [17]. If the borrowed capital increases by one rupee, the investment in agriculture increases by Rs. 0.04. The results are in line with study conducted by Chand and Kumar [18] wherein authors reported that institutional credit supplied to agriculture as short-term or medium and long term loans was an important determinant of private capital formation.

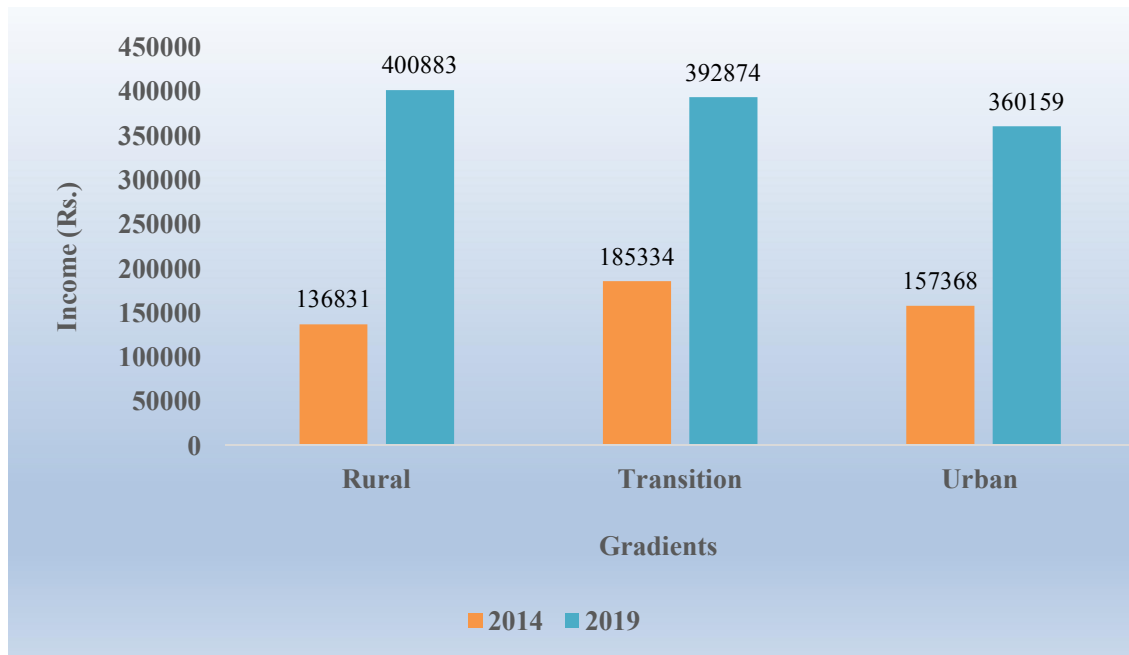


Fig. 1. Average annual farm income of households during 2014 and 2019

**Table 1. Pattern of investment in irrigation and other infrastructure across rural urban interface in North of Bengaluru (Period: 2014 to 2019) (in rupees)**

Assets	Rural (n=80)			Transition (n=80)			Urban (n=80)		
	Per farm	No. of farmers	Percent of farmers	Per farm	No. of farmers	Percent of farmers	Per farm	No. of farmers	Percent of farmers
Water resource and irrigation structure	3,29,518	36	45.00	1,99,055	56	70.00	1,98,523	51	63.75
Land purchase and development	22,47,655	02	02.50	1,63,757	01	01.25	7,67,359	02	02.50
Farm machinery and equipment	7,08,631	04	05.00	4,09,001	11	13.75	8,20,512	19	23.75
Farm infrastructure	79,899	08	10.00	1,10,867	16	20.00	1,07,812	17	21.25
Plantation and horticulture	2,09,274	08	10.00	2,07,750	20	25.00	2,73,991	20	25.00
Animal husbandry	1,63,252	32	40.00	3,42,424	17	21.25	1,41,516	12	15.00
Others	2,24,167	04	05.00	1,45,670	05	06.25	0	00	00.00
Average land holding (ha)	1.59			1.50			1.42		

*Note: 1. Water resource and irrigation structure: "Irrigation pump set, bore well, deepening of bore well, drip irrigation, pipes and electrification connection"; 2. Land purchase and development: "Purchased new agricultural land, reclamation, leveling and Fencing"; 3. Farm machinery and equipment: "Tractor, JCB, Tractor equipment's, Implements and others"; 4. Farm infrastructure: "Farm house, Cattle shed Poly house and storage structures"; 5. Plantation and horticulture: "Grape orchard, Sapota orchard, Mango orchard, Guava orchard and Forest trees"; 6. Animal husbandry: "Crossbreed cow, local cow, local buffalo, sheep, goat and poultry"; 7. Others: "Petty shops and distillation unit"*

**Table 2. Crop diversification across rural urban interface in north of Bengaluru**

Particulars	Rural (n=80)		Transition (n=80)		Urban (n=80)	
	2014	2019	2014	2019	2014	2019
Gross cropped area (ha)	152.48	214.07 (40.39)	178.84	295.79 (65.40)	160.04	299.71 (85.90)
Net cropped area (ha)	128.86	127.09	131.00	120.18	125.83	113.23
Cropping intensity (%)	118.33	168.44 (42.35)	136.51	246.13 (80.30)	128.13	264.69 (106.58)
Herfindahl Index	0.56	0.25	0.33	0.21	0.37	0.29

Note: 1. Herfindahl Index: Value ranges from 0 to 1, value approaching zero indicates diversification.  
2. Figures in parentheses represent percentage change

**Table 3. Drivers for investment across rural urban interface in North of Bengaluru**

Particulars	Coefficients	t value
Dependent variable	Investment in farming (Rs./farm)	
Independent variables		
Intercept	3,25,403***	4.53
Age (years of experience)	-1.242***	-3.98
Total land holding	8591.057 <sup>NS</sup>	1.04
Education	2388.37 <sup>NS</sup>	0.50
Farm income (Rs.)	0.139***	2.41
Off and Non-Farm income (Rs.)	0.103 <sup>NS</sup>	1.39
Borrowed capital (Rs.)	0.0408**	2.01
D <sub>1</sub> (Transition)	2,30,836***	4.58
D <sub>2</sub> (Urban)	3,22,468***	5.89

Note: \*\*\* Significant at 1 per cent level of significance, \*\* Significant at 5 per cent level of significance and NS- Non-significant

To find the extent of investment across urban, peri-urban and rural farm households, two dummy variables were used viz., D<sub>1</sub> for transition farmers, D<sub>2</sub> for urban farmers. The intercept indicates the threshold investment in farming in rural area, which was Rs. 3,25,403 per farm. Due to urbanization and better accessibility to market and new technologies, the farmers of transition and urban gradients invested more on high value crops like grapes, sapota, rose, chrysanthemum etc., which requires huge investment. The threshold investment in agriculture per farm has shifted by Rs. 2,30,836 as given by the coefficient of the dummy variable (D<sub>1</sub>) used for farmers in the transition gradient and was significant at one per cent. Hence, the threshold investment per farm in transition gradient was = Rs. 3,25,403 + Rs. 2,30,836= Rs. 5,56,239 per farm. In urban gradient, threshold investment per farm shifted by Rs. 3,22,468 per farm indicating that the threshold investment per farm in urban area was Rs. 6,47,871 (Rs. 3,25,403 + Rs. 3,22,468). The results clearly indicated that, threshold investment in agriculture was more in urban farmers followed by transition and rural farmers.

#### 4. CONCLUSION

Investment on irrigation infrastructure was a major component of capital formation in rural-urban interface of North of Bengaluru which enabled farmers to take up commercial and high value enterprises resulting in crop diversification. This resulted in improved farmer's welfare through increased income. Herfindahl index and change in income provided evidence on the role of capital injection on crop diversification and farm income. This is mainly because the crop diversification improves food availability for the household and also income which translates to improved food consumption through food purchases. Crop diversification benefits the farmer mainly in the sense that cultivating several crop species helps to manage both price and production risks, which ensures more food options for the household and income through market participation from the surpluses. Having diversification is always beneficial in farming business. More the diversification more will be the profit and less chance of incurring losses due to crop failures. Hence, there is a need to increase the awareness on the crop



diversification and scientific cultivation of high value crops. Farm income and borrowed capital have strong association with investment in farming. Hence, farmers should avail financial support from institutions for investment on high value crops. Investment was more in urban followed by transition and rural gradients. Hence, efforts are needed to enhance the investment in rural areas to retain the youth in agriculture and to augment household income.

## CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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