CHAPTER 5
IMPACT OF RURAL ROAD CONSTRUCTION ON THE LOCAL LIVELIHOOD DIVERSIFICATION

5.1 Introduction

Conclusion of Chapter 4 shows that the income status criteria is one of the primary indicators which has been significantly impacted after the construction of rural roads. Thus there is an acute need to explore the change in income condition of the rural households in terms of diversification of their livelihood activities, so that the appropriate strategies and policies can be suggested to encourage rural households to adopt prolific income earning opportunities, thereby overcoming economic shocks. This chapter attempts to assess the impacts of rural road construction on livelihood diversification of rural households, it also illustrates the percent change in the diversification degree attained before and after the deliverance of rural (PMGSY).

Enhanced mobility and communication due to improvement in rural roads, impart significant social and economic benefits. Improvement in physical mobility helps in achieving sustainability outcomes in context with rural areas. The livability conditions of rural individuals with improvement in rural roads as they provide enhanced access to necessary education and health services, markets and increase food security. Moreover, in consideration with sustainable development point of view rural roads capacitate rural inhabitants with proper information. This helps in reducing the vulnerability of rural inhabitants, which assists them to participate in social development programs. They help in the development of sustainable livelihoods by paving access to numerous employment avenues for rural population (Hussein and Nelson, 1998). Improvement of rural road infrastructure and agricultural development have strong linkage, which also helps in reducing poverty of rural areas (Booth et al., 2000; Banister and Berechman, 2001). It also intensifies the commercialization of the agricultural products which in turn will help in enhancing the income earnings of the rural inhabitants (Bryceson et al., 2008). Rural roads also help rural households to overcome the economic constrains/burden, as they pave their access to jobs, employments, and with proper returns on agricultural produce due to reduced transport time and cost (Khandker et al., 2009; Asomani-Boateng et al., 2015; Wagale et al., 2016).

Improved rural road infrastructure provides access to non-farm employment opportunities and promote non-farm economy (Binswanger et al., 1993; Grootaert and Calvo, 2002). They enable higher income earnings from non-farm employment as compared to income incurred from farm or self-employment Isgut (2004). They also help rural inhabitants to incur higher returns by shifting to cash crops rather than completely relying on food crops, which also helps in improving their household income (Mohapatra and Chandrasekhar, 2007). With the improvement in access to the nearest markets and economic centres the rural inhabitants are able to maintain the quality of agricultural produce, which in return helps them to receive higher income earnings (Millward and Spinney, 2011; Banjo et al., 2012). A study by Tunde and Adeniyi (2012) show that due enhanced road conditions cost of transportation of agricultural produce decreased significantly, which helped the farmers to incur profit. Moreover, improved rural roads also facilitate access to prolific income-earning opportunities for rural inhabitants.

Agricultural and non-agricultural development due to the construction of rural roads has been the focus of most of the above-mentioned studies. However, the main impact (i.e., livelihood diversification) due to construction of rural roads remains to be addressed comprehensively. Therefore, considering this motivation an attempt has been made in the present to explore the impact of rural road construction on diversification of livelihoods of rural households, especially in case of rural region with arid climatic conditions. At first, livelihood diversification pattern has been investigated by considering before and after situations. Fuzzy Shannon entropy index of diversification measure has been used for the assessment, which help in comprehensive assessment. The impulse employing fuzzy Shannon entropy index is to consider the imprecision and uncertainty present in the data. Secondly, an investigation has been performed to assess the effects on household income by accounting diversification index along with various demographic and locational attributes. Quantile regression and ordinary least squares (OLS) regression technique have been employed to assess the effects, as household income is derived from sources and hence it is difficult to assess separately.

Thus, the improved quantile regression technique has been applied to identify whether diversification of livelihood has a positive or negative influence on the household income of rural inhabitants. All critical locational and demographic attributes have also been identified to understand their influence on household's income. To illustrate effectiveness of the proposed

research, a case study of rural area located in Jhunjhunu district of Rajasthan, India is taken as an example. These areas are connected by all-weather roads under Pradhan Mantri Gram Sadak Yojana (PMGSY) scheme. The data for the study is collected from the target focus group discussions, which were identified at different locations after thorough discussions.

5.2 Diversification Literature review

Livelihood activities are vulnerable as they are dynamic nature and change with respect to time and space. They are prone to vary with the change in local and external conditions. Livelihood which has ability to handle, enhance and recover the economic distresses and shocks with respect to both present and future conditions, is termed as ‘‘sustainable livelihood’’. Also, at same time it should not undermine the base of assets and natural resources available (Barbier, 1994), and they should be regenerative in nature. In context with rural areas, sustainable livelihood is dependent on five different aspects, such as financial assets (e.g., credits and bank savings), human assets (e.g., skills) natural resources, social networks, and physical infrastructure. The sustainable livelihood framework comprises of three distinct ‘clusters’ of activities which an individual may get involved: i) dependency on different livelihood approaches, ii) intensification of agricultural activities, iii) livelihood diversification Scoones (1998), of all these livelihood diversification is at its core.

Improvement in rural roads facilitate diversification of livelihood activities for the rural households. Through this the inhabitants can participate in variety of livelihood activities, which will help them in the development of social support and network system (Ellis, 1998). This support system also referred as risk management support system will assist the rural population to cope up with anticipated economic distress situations and actual economic shocks (Ellis, 2000; Tanle, 2014). In situations like environmental crisis such as droughts and floods diversification of livelihood activities act as risk transfer tactics, which enables the rural households to overcome economic distresses caused by such crisis Guvele (2001). It also helps the rural households to withstand in situations, viz., decline or stagnation in agricultural production, difficulties in having credits from the market, increased constraints on arable land due to the rise in population and in conditions when the labor markets are demand based (Reardon et al., 2000; Liu et al., 2008; Barbieri and Mahoney, 2009). Diversification of livelihood helps the rural households in stabilizing their income earnings through their participation in different income earning activities and can result into ‘‘economy of

scope''. Moreover, it helps in smoothing of capital constraints, thereby increasing food security and agricultural production (Babatunde and Qaim, 2010; Zhao and Barry, 2014; Gautam and Andersen, 2016).

Rural roads contribute significantly in livelihood diversification activities, due to the improvement in access to markets and technology (Mishra et al., 1999). They have ability to optimistically influence the income earnings of rural households through diversification of livelihood opportunities (Barrett et al., 2001). Rural roads facilitate income diversification, this enables rural inhabitants to have better livelihoods and to improve their living conditions. Rural road infrastructures help in the development of subsidiary and small-scale industries such as bee farming, dairy, and poultry, which will help the rural inhabitants to overcome the constraints associated with cash inflow (Joshi et al., 2005; Losch et al., 2012). With the newly improved road connectivity there is increase in the scope of new employment opportunities available to the rural inhabitants, which will help them to work in their immediate communities. This will help as add up to their income earnings as they will have access to new avenues of non-farm employments (Mohapatra and Chandrasekhar, 2007; Porter, 2012, 2014). Thus, leading to more diversified income structure.

Conventionally, studies explored and classified diversification of livelihood into different strategies of which single diversification strategy which assessed the livelihood diversification in terms of activities such as farm, non-farm, labor migration as singular or in combination (e. g., labor migration is associated with availability nonfarm activities) (Zhao, 2002; Uchida et al., 2009; De´murger et al., 2010). The other strategy of livelihood diversification assessment considered asset endowment (Ansoms and McKay, 2010). Most of these studies assessed livelihood by accounting only assets or activities, they did not capture the impact of rural road infrastructure which plays important role in transitioning of livelihoods. However, a few of the studies (Mu and Van de Walle, 2011; Berg et al., 2018) accounted the effect of rural road infrastructure, but the focal point of these studies had been development of markets due to road construction. Thus, it not only creates a need to explore comprehensively the impacts of rural road development which stimulates livelihood diversification, but also the need to identify the attributes which add up to livelihood diversification. This will help the concerned decision makers to imply policies which will assist in livelihood transitions of rural households, and also will help in poverty alleviation and achieving sustainable rural development.

Assessment of diversification of livelihood due to rural road construction is a complex process. The literature lags in providing proper information and knowledge on what variables to be considered to capture the impacts of rural road construction on livelihood diversification. The studies employ either one-dimensional or two-dimensional indices. In case of one-dimensional indices analysis, the variables which account number of business establishments are considered. The assessment of the diversification score is measured by considering the change in the extent of these business establishments, whereas in case of two-dimensional indices, variables which account number of business establishments along with their relative volume of earnings are considered. However, a few studies are available internationally, but no proper literature is available in context to India, which accounts impacts of rural road construction livelihood diversification.

5.3 Material and methods

5.3.1 Study area

In the present study, an attempt is made to assess the economic impacts (i.e., livelihood diversification) of the rural (PMGSY) roads. A total of 27 road connectivities are selected from 6 different blocks (viz., Buhana, Jhunjhunu, Khetri, Nawalgarh, Surajgarh, and Udaipurwati) of Jhunjhunu district of Rajasthan state, India, as discussed in section 4.3.4 of Chapter 4.

As discussed earlier, the study area belongs to the arid region of the state of Rajasthan and is located in the northern eastern part of the state as shown in Fig. 5.1. The climatic conditions of the selected study area are extreme in comparison with to other arid regions of Rajasthan state, as it has very cold winters and hot summers with deficient rainfall. Agriculture has been found as the main livelihood occupation in case of 90% of the households in the study area. Fig. 5.1 shows the map of study area with blocks, habitation location, and through routes.

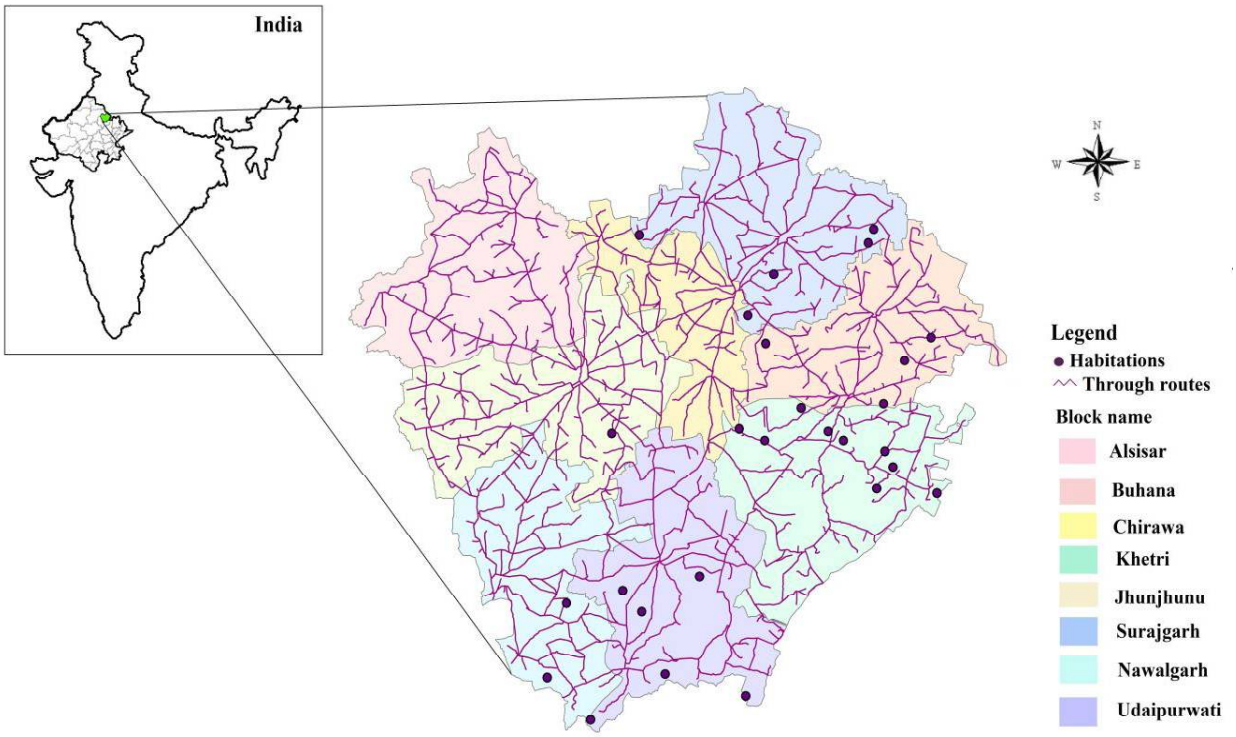

Fig. 5.1 Jhunjhunu district with blocks and through routes

5.3.2 Data collection

Panel/focus group discussions at habitation (village) level have been conducted during the months of April and May 2016, to collect the required data for the study.

Focus group discussions haven been conducted using questionnaire (Annexure II). While designing the questionnaire informal discussions with the inhabitants and extensive primary study have been conducted to administer it. Apart from this consultation and discussions had been done with the policy makers and experts. In addition to this, to relevant information extensive literature survey has been performed to have necessary knowledge of the attributes to be considered for the study. To determine sample size for the study stratified random sampling technique has been employed, as discussed in section 4.3.4 of Chapter 4. Thus, total 27 focus groups @ 14 participants each group are selected with respect to 95% of confidence level and 5% of marginal error. To maintain homogeneity of the focus groups to be selected, parameters such gender, age and occupations have been considered, total 34% of females and 66 % of males participated in focus group discussions.

During the data collection care has been taken to select those habitations which are in their third year from their year of construction, so that homogeneity in the data set is maintained. The questionnaire is designed with closed-end questions to capture both quantitative and qualitative information. The questionnaire accounts attributes such as farming practices (on-farm and off-farm), type of work (viz., self-employment and wage employment), and working-sector (agriculture and non-agriculture). Data for demographic and transportation features has also been collected. At the end of every focus group discussion, feedbacks are taken to eliminate erroneous information in the data set.

5.4 Data analysis

5.4.1 Diversification variables

Livelihood features and farm activities forms the basis to assess the diversification of the rural economy. To assess the livelihood diversification literature suggests wide range of attributes, viz., based on function (self-employment and wage employment), on location (on-farm and off-farm), and sector (agriculture and non-agriculture) (Elmqvist and Olsson, 2006; Mehta, 2009). Table 5.1 presents various livelihood diversification attributes employed for the assessment. Comprehensive assessment depends upon the selection of appropriate attribute, which are capable of defining the financial flow in the rural households in an inclusive manner. Moreover, it can be a complex process when attribute selected overlaps with another attribute of importance. Therefore, identifying appropriate attribute is essential so that it should be able to capture the necessary information. The attributes selected for the assessment should be easily quantifiable and understood by the stakeholders and layperson.

Table 5.1 Classification of the attributes of rural livelihood diversification

	Attributes	Definition
Sector wise	Farm /agricultural income	This category involves income generation activities such as livestock, unprocessed crops, forest products and income generated from farm wage labor. It also includes income generated from processing of agro- products and their trading
	Non-farm/non- agricultural income	This category includes all the sources other than agriculture production, which includes activities such as government services, manufacturing, commerce, utilities etc.
Function wise	Wage employment	This category includes income generation from avenues, which provide wage or salary to the person involved in any kind of employment. Here the employee works for their employer
	Self-employment	This category includes income generation by providing service by oneself. The income is earned by direct association of the individual with the activities (without salary or wage payment) rather than incurring income by working under an employer
Location wise	On-farm income	This category includes income generation on farm activities, for example, crops, milk production, poultry farms, domestication of honeybees, cashew processing, coconut-based business etc.
	Off-farm Income	This category includes activities assisting in income generation away from farmlands, for

	example, skilled and unskilled wage labors, small-scale rural industries such as candle making, milling business, paper bag making etc.

Source: Compiled from Ellis (1998); Barrett et al. (2001); Haggblade et al. (2010).

5.4.2 Diversification variables employed for the study

In the present study, to understand contribution of each attribute which facilitate the process of livelihood diversification preliminary informal discussions have been conducted. Further, to have proper comprehension and arrive at the final set of attributes opinions of the experts as well as literature on livelihood diversification have been accounted. The experts considered to for the study concerned decision makers, individuals from educational and research institutes, and government organizations. Thus, total six attributes which from the final set is attained. These are further divided in to two categories: i) income generated from non-farm activities and ii) farm employment activities. The first category is further sub divided into two sub-categories: a) individual income (I_{II}) and (b) income of un-skilled labor from non-agriculture activities (I_{UNA}). The individual income (I_{II}) refers to income incurred from service sector, army personals, small scale business activities etc.). However, it constitute only 1 to 2% of total population of the habitation. The second category consists of attributes such as self-employed income from agriculture (I_{SA}), income of wage labor from agriculture (I_{WA}), income from livestock (I_L), and income of un-skilled labor from agriculture (I_{UA}).

Accessibility plays an important role in significantly influences income earning activities of the rural households. The rural inhabitants may derive their income in different ways which corresponds to a type of attributes as shown in Table 5.1. Fig. 5.2 illustrated the classification of income activities considered for the study which contribute to the household income of rural inhabitants.

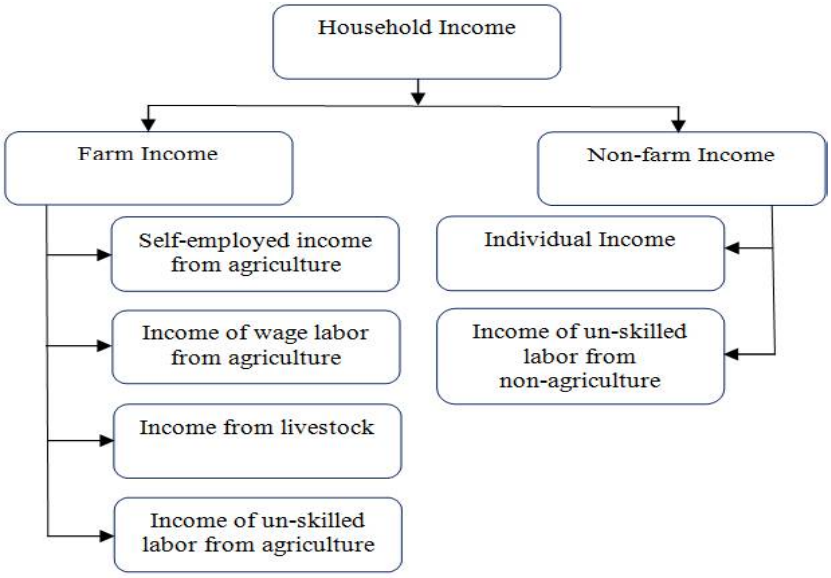

Fig. 5.2 Classification of income activities contributing to the household income of rural inhabitants

5.5 Measurement of degree of livelihood diversification

5.5.1 Application of fuzzy approach in group data assessment

The data for the study is real-life data, as it is based on the perceptions of the focus group participants. Such data is liable to have error induced in it, which may lead to erroneous and bias quantification. Moreover, such data is not binary and is difficult to define sharply, as it based on the perceptions of participants of the focus group discussion. Therefore, to overcome such imprecision in the data and to capture proper consensus of such data, fuzzy set theory can be employed. It helps in smoothening of the data by provide strong mathematical base which is capable of capturing the vagueness and ambiguity in the data in precise and rigorous manner (Zimmermann, 2010). Close-ended questions on a categorical scale (shown in Appendix II) have been used to capture the perception of focus group participants. Also, the data is collected using qualitative scale of highly satisfied to not acceptable, the scores are assigned from 1 to 5 (5 being highly satisfied and 1 being not acceptable), and for the assessment the collected data is fuzzified.

Fuzzy set theory is integrated with Shannon's entropy measure of diversification to achieve comprehensive assessment with precision and ease in the present study.

5.5.2 Fuzzy Shannon's diversification measure

The literature lacks common understanding on the application and suitability of the indicators that gauge income diversification. The composition of non-farm activities plays important role in assessing the diversification of livelihood instigated due to new road construction. Attempts have been made to assess diversification with an assumption that higher share of non-farm activities in the total household income leads to higher diversification. Income generating opportunities vary in their number and volume of distribution. Income from non-farm sources has different implications on household income of rural inhabitants. Thus, there is a need to consider both number and volume of income generating opportunities while assessing the livelihood diversification. The qualitative measure of diversification also leads to inconsistency and uncertainty associated with the data collection. Shannon's entropy method can be integrated with fuzzy set theory (Singh and Vidyarthi, 2008) to quantify livelihood diversification in effective and unbiased manner. The current study employs fuzzy entropy measure to assess the diversification of income/livelihood instigated by delivered rural road infrastructure.

The Shannon entropy measure/index of diversification is given in equation (5.1).

$$d_i = -d_0 \sum_{j=1}^{m} \left(S_{ij} \times \ln S_{ij} \right), i = 1, 2, ..., n \tag{5.1}$$

where d_i is Shannon entropy diversification index, S_{ij} is the contribution of the j^{th} income source to the household income, and d_0 is the entropy constant. The entropy measure/index approaches to zero when the income is derived from single source, whereas it increases with increase in number of activities. However, when traditional entropy measure is integrated with fuzzy set theory it provides better assessment. The main steps of fuzzy entropy index evaluation are given below:

Step1: In this step, the data collected from focus group discussions are converted into fuzzy number which are further transformed into interval data using α - level sets.

Consider a $\tilde{x}_{ij}$ = *(l, m, u)* as a fuzzy value, then the α - level sets of $\tilde{x}_{ij}$ can be expressed in the interval form as given in equation (5.2):

$$\left[\left(\tilde{x}_{ij}\right)_{\alpha}^{l},\left(\tilde{x}_{ij}\right)_{\alpha}^{u}\right]=\left[\min_{x_{ij}}\left\{x_{ij}\in R\middle|\mu_{x_{ij}}\left(X_{ij}\right)\geq\alpha\right\},\max_{x_{ij}}\left\{x_{ij}\in R\middle|\mu_{x_{ij}}\left(X_{ij}\right)\geq\alpha\right\}\right] \tag{5.2}$$

where $0<\alpha\leq 1$. By varying α values at different level of confidence, the fuzzy data can be transformed into different α-level sets as $\left\{\left(\tilde{x}_{ij}\right)_{\alpha}\middle|0<\alpha\leq 1\right\}$.

Step 2: The step follows normalization of $\left(\tilde{x}_{ij}\right)_{\alpha}^{l}$ *and* $\left(\tilde{x}_{ij}\right)_{\alpha}^{u}$ into p_{ij}^{l} and p_{ij}^{u}

$$p_{ij}^{l}=\frac{x_{ij}^{l}}{\sum_{j=1}^{m}x_{ij}^{l}},\ p_{ij}^{u}=\frac{x_{ij}^{u}}{\sum_{j=1}^{m}x_{ij}^{u}},\quad j=1,2,\ldots,\text{m},\ i=1,2,\ldots,\text{n}$$

where p_{ij}^{l} and p_{ij}^{u} represent the normalized lower and upper bound probability value of the data point.

Step 3: In this step the lower bound (h_i^l) and upper bound (h_i^u) of the entropy value are evaluated as shown in equations (5.3) and (5.4).

$$h_i^l=\min\left\{-d_0\sum_{j=1}^{m}p_{ij}^{l}\times\ln p_{ij}^{l},-d_0\sum_{j=1}^{m}p_{ij}^{u}\times\ln p_{ij}^{u}\right\} \tag{5.3}$$

$$h_i^u=\max\left\{-d_0\sum_{j=1}^{m}p_{ij}^{l}\times\ln p_{ij}^{l},-d_0\sum_{j=1}^{m}p_{ij}^{u}\times\ln p_{ij}^{u}\right\} \tag{5.4}$$

where d_0 is entropy constant and is equal to $\left(\frac{1}{\ln m}\right)$, and if $p_{ij}^{l}=0$ or $p_{ij}^{u}=0$, then $p_{ij}^{l}\times\ln p_{ij}^{l}$ and $p_{ij}^{u}\times\ln p_{ij}^{u}$ are delineated as 0.

Step 4: This step follows identification of degree of diversification in terms of lower and upper bound value as shown in equations (5.5) and (5.6).

$$d_i^l=1-h_i^u \tag{5.5}$$

$$d_i^u=1-h_i^l \tag{5.6}$$

where $i=1,2,\ldots,\text{n}$.

The final diversification degree can be evaluated by deriving optimism index as given in equation

(5.7) in which the optimism index (λ) represents satisfaction level of decision makers with their pessimistic or optimistic viewpoint, which can vary in the range from 0 to 1. The most pessimistic view can be represented with the minimum value of optimism index (i.e., $\lambda = 0$) whereas the most optimistic view can be taken if the maximum value of optimism index (i.e., $\lambda = 1$) is considered. In this study, optimism index value with $\lambda = 0.5$ has been taken into consideration to make a compromise and realistic attempt (Kim and Park, 1990).

$$d_i^{\alpha} = (1-\lambda) \times d_{il}^{\alpha} + (\lambda \times d_{iu}^{\alpha}) \tag{5.7}$$

where $\lambda = 0.5$.

The study evaluates Shannon's entropy index/ measure of diversification by considering diversification of income patterns before and after deliverance of rural road infrastructure. Fig. 5.3 illustrate the process followed to assess the diversification index.

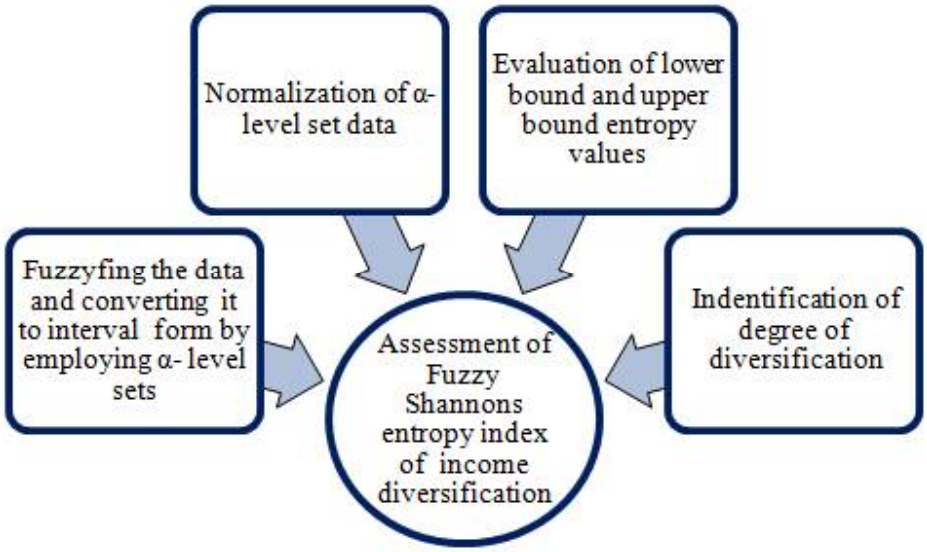

Fig. 5.3 Assessment of the diversification index

5.5.3 Econometric Models

The research aims to assess diversification index as well as its impacts along with various control variables (demographic and transport facility characteristics) on overall household income of the rural inhabitants. The study employs quantile regression approach for the assessment. Here, the

household income of inhabitants is taken as dependent variable and diversification index along with control attributes are considered as independent variables. Mean regression approach has been used extensively to assess impacts of control variables on household income. However, findings of these studies vary significantly (Katchova, 2005). The mean diversification measures as assessed in previous studies do not represent the diversification pattern in a comprehensive manner due to lack of hidden information. The quantile regression technique can be applied in such cases as it differs with other regression techniques in two ways: (i) it takes into account the entire data set as an input to assess the coefficient of variables for different quantiles and (ii) it is performed in a robust manner corresponding to outliers, unlike OLS regression which accounts only subset of the data. Furthermore, quantile regression minimizes the weighted sum of asymmetrical residuals, whereas OLS follows minimization of the sum of squared residuals for given data set. The equations (5.8) and (5.9) illustrate estimation of quantile and OLS regressions:

Quantile regression

$$Q_\tau(X_i'|d_i, X_i) = \alpha_\tau + \beta_\tau \times (d_i) + \gamma_\tau \times (X_i) \quad (5.8)$$

where $\tau \in (0, 1)$ and

OLS regressions

$$E(X_i'|d_i, X_i) = \alpha + \beta \times (d_i) + \gamma \times (X_i) \quad (5.9)$$

where X_i' is household income incurred from both farm and non-farm activities and d_i represent the diversification index. X_i represents control variable, whereas β and β_τ depict marginal outcomes at the mean and at predetermined quantiles of the household income and γ and γ_τ are the vector coefficients respectively. The dependent variable (household income) represents the monetary gains within the rural household for a given year after the deliverance of rural road infrastructure. This is dependent upon diversification index and various control variables (demographic and transport facility characteristics). The demographic characteristics can be considered as control variables which influence household income. Some of these variables are working age member's ratio (i.e. the ratio of population in habitation with age group between 15 to 64 years to the total population of the habitation), dependency ratio (i.e. the ratio of dependent

population with age less than 15 years and/or more than 64 years of age to the working population of age group from 15 to 64 years of age), and non-farm activity ratio.

Control variables referring to transport facility are travel cost and travel time required to reach nearest market or economy center. The effect of socio-economic environment, seasonality of agriculture produces, availability of surplus labor also plays important role in income diversification. Availability of job opportunities in the vicinity assure utilization of available connectivity thus leading to income/livelihood diversification. Thus, the regression analysis can be considered as one of the reliable techniques to capture insights of contributing factors in possible diversification of rural households.

5.6 Results and discussion

5.6.1 Livelihood/income Diversification Measure

Fuzzy Shannon's entropy measure of livelihood diversification is employed in the present study. In the present study diversification index has been evaluated before and after construction of rural (PMGSY) roads. In the assessment process of diversification measure, firstly, all the data gathered through focus group discussion is fuzzified. Further, the fuzzified data is converted into interval data by using equation (5.2). The interval decision matrix has been derived to assess impact of construction of PMGSY roads using $\alpha = 0.5$ as shown in Table 5.2.

Table 5.2 Interval Decision Matrix for the attributes

S.No.	I_{II}		I_{SA}		I_{WA}		I_{L}		I_{UA}		I_{UNA}	
1	1.000	1.500	0.000	0.500	0.000	0.500	0.000	0.500	0.450	0.585	0.450	0.585
2	0.710	0.875	0.450	0.585	0.000	0.500	0.450	0.585	0.710	0.875	1.000	1.500
3	0.450	0.585	0.450	0.585	0.000	0.500	0.000	0.500	1.000	1.500	0.710	0.875
4	1.000	1.500	0.710	0.875	0.000	0.500	0.225	0.292	0.710	0.875	1.000	1.500
5	1.000	1.500	0.583	0.708	0.000	0.500	0.000	0.500	1.000	1.500	1.000	1.500
6	0.710	0.875	0.710	0.875	0.000	0.500	0.225	0.292	0.710	0.875	0.710	0.875
7	0.367	0.450	0.367	0.450	0.184	0.225	0.184	0.225	0.300	0.300	0.367	0.450
8	1.000	1.500	0.583	0.708	0.000	0.500	0.583	0.708	1.000	1.500	1.000	1.500

9	0.710	0.875	0.450	0.585	0.000	0.500	0.225	0.292	0.710	0.875	0.710	0.875
10	0.583	0.708	0.000	0.500	0.000	0.500	0.000	0.500	1.000	1.500	1.000	1.500
11	0.710	0.875	0.450	0.585	0.000	0.500	0.450	0.585	0.450	0.585	0.710	0.875
12	0.583	0.708	0.583	0.708	0.000	0.500	0.000	0.500	1.000	1.500	0.583	0.708
13	0.583	0.708	0.583	0.708	0.000	0.500	0.000	0.500	1.000	1.500	0.583	0.708
14	0.583	0.708	0.583	0.708	0.000	0.500	0.000	0.500	1.000	1.500	0.583	0.708
15	0.583	0.708	0.292	0.367	0.000	0.500	0.000	0.500	0.583	0.708	1.000	1.500
16	0.583	0.708	0.292	0.367	0.000	0.500	0.000	0.500	0.583	0.708	1.000	1.500
17	1.000	1.500	0.583	0.708	0.292	0.367	0.292	0.367	1.000	1.500	1.000	1.500
18	1.000	1.500	0.292	0.367	0.292	0.367	1.000	1.500	1.000	1.500	1.000	1.500
19	0.710	0.875	0.225	0.292	0.000	0.500	0.450	0.585	0.450	0.585	1.000	1.500
20	0.000	0.500	1.000	1.500	0.000	0.500	0.450	0.585	0.450	0.585	0.450	0.585
21	0.583	0.708	0.000	0.500	0.585	0.710	0.000	0.500	0.585	0.710	0.585	0.710
22	0.450	0.585	1.000	1.500	0.710	0.875	0.000	0.500	0.450	0.585	1.000	1.500
23	0.292	0.367	1.000	1.500	0.000	0.500	0.000	0.500	0.585	0.710	1.000	1.500
24	1.000	1.500	0.710	0.875	0.710	0.875	0.450	0.585	0.710	0.875	0.710	0.875
25	1.000	1.500	0.000	0.500	0.292	0.367	1.000	1.500	0.585	0.710	0.585	0.710
26	1.000	1.500	0.710	0.875	0.710	0.875	1.000	1.500	0.710	0.875	0.710	0.875
27	1.000	1.500	0.710	0.875	0.710	0.875	1.000	1.500	0.710	0.875	0.710	0.875

Table 5.3 shows the normalized interval decision matrix for the attributes considered for the study.

Table 5.3 Normalized Interval Decision Matrix for the attributes

S.No.	I_{II}		I_{SA}		I_{WA}		I_{L}		I_{UA}		I_{UNA}	
1	0.240	0.789	0.000	0.263	0.000	0.263	0.000	0.263	0.108	0.308	0.108	0.308
2	0.144	0.264	0.091	0.176	0.000	0.151	0.091	0.176	0.144	0.264	0.203	0.452
3	0.099	0.224	0.099	0.224	0.000	0.192	0.000	0.192	0.220	0.575	0.156	0.335
4	0.180	0.412	0.128	0.240	0.000	0.137	0.041	0.080	0.128	0.240	0.180	0.412
5	0.161	0.419	0.094	0.198	0.000	0.140	0.000	0.140	0.161	0.419	0.161	0.419
6	0.165	0.285	0.165	0.285	0.000	0.163	0.052	0.095	0.165	0.285	0.165	0.285
7	0.175	0.255	0.175	0.255	0.087	0.127	0.087	0.127	0.143	0.170	0.175	0.255

8	0.156	0.360	0.091	0.170	0.000	0.120	0.091	0.170	0.156	0.360	0.156	0.360
9	0.177	0.312	0.112	0.209	0.000	0.178	0.056	0.104	0.177	0.312	0.177	0.312
10	0.112	0.274	0.000	0.194	0.000	0.194	0.000	0.194	0.192	0.581	0.192	0.581
11	0.177	0.316	0.112	0.211	0.000	0.181	0.112	0.211	0.112	0.211	0.177	0.316
12	0.126	0.258	0.126	0.258	0.000	0.182	0.000	0.182	0.216	0.545	0.126	0.258
13	0.126	0.258	0.126	0.258	0.000	0.182	0.000	0.182	0.216	0.545	0.126	0.258
14	0.126	0.258	0.126	0.258	0.000	0.182	0.000	0.182	0.216	0.545	0.126	0.258
15	0.136	0.288	0.068	0.149	0.000	0.203	0.000	0.203	0.136	0.288	0.233	0.610
16	0.136	0.288	0.068	0.149	0.000	0.203	0.000	0.203	0.136	0.288	0.233	0.610
17	0.168	0.360	0.098	0.170	0.049	0.088	0.049	0.088	0.168	0.360	0.168	0.360
18	0.149	0.327	0.043	0.080	0.043	0.080	0.149	0.327	0.149	0.327	0.149	0.327
19	0.153	0.283	0.049	0.094	0.000	0.162	0.097	0.189	0.153	0.283	0.216	0.485
20	0.000	0.213	0.235	0.638	0.000	0.213	0.106	0.249	0.106	0.249	0.106	0.249
21	0.152	0.303	0.000	0.214	0.152	0.304	0.000	0.214	0.152	0.304	0.152	0.304
22	0.081	0.162	0.180	0.416	0.128	0.242	0.000	0.139	0.081	0.162	0.180	0.416
23	0.057	0.127	0.197	0.521	0.000	0.174	0.000	0.174	0.115	0.247	0.197	0.521
24	0.179	0.350	0.127	0.204	0.127	0.204	0.081	0.136	0.127	0.204	0.127	0.204
25	0.189	0.433	0.000	0.144	0.055	0.106	0.189	0.433	0.111	0.205	0.111	0.205
26	0.154	0.310	0.109	0.181	0.109	0.181	0.154	0.310	0.109	0.181	0.109	0.181
27	0.154	0.310	0.109	0.181	0.109	0.181	0.154	0.310	0.109	0.181	0.109	0.181

In the next step, equations (5.3) and (5.4) have been used to assess the lower (h_i^l) and upper (h_i^u) bound entropy values. Further, equations (5.5) and (5.6) have been used to evaluate the diversification degree in terms of lower and upper bound value. Table 5.4 illustrates the values for entropy and diversification degree with respect to the condition after construction of PMGSY roads.

Table 5.4 Entropy values and degree of diversification

S.No.	$(\boldsymbol{h_i^l})$	$(\boldsymbol{h_i^u})$	$(\boldsymbol{d_i^l})$	$(\boldsymbol{d_i^u})$
1	-0.511	-1.222	0.222	1.511
2	-0.820	-1.217	0.217	1.820

3	-0.672	-1.235	0.235	1.672
4	-0.792	-1.175	0.175	1.792
5	-0.686	-1.220	0.220	1.686
6	-0.836	-1.212	0.212	1.836
7	-1.005	-1.162	0.162	2.005
8	-0.811	-1.218	0.218	1.811
9	-0.825	-1.218	0.218	1.825
10	-0.546	-1.205	0.205	1.546
11	-0.839	-1.257	0.257	1.839
12	-0.693	-1.244	0.244	1.693
13	-0.693	-1.242	0.242	1.693
14	-0.693	-1.339	0.339	1.693
15	-0.662	-1.212	0.212	1.662
16	-0.662	-1.181	0.181	1.662
17	-0.884	-1.139	0.139	1.884
18	-0.873	-1.160	0.160	1.873
19	-0.795	-1.179	0.179	1.795
20	-0.654	-1.232	0.232	1.654
21	-0.712	-1.309	0.309	1.712
22	-0.801	-1.204	0.204	1.801
23	-0.654	-1.178	0.178	1.654
24	-0.969	-1.203	0.203	1.969
25	-0.793	-1.176	0.176	1.793
26	-0.959	-1.220	0.220	1.959
27	-0.959	-1.200	0.200	1.959

In the next step, equation (5.7) has been used to evaluate the crisp values for degree of diversification. Table 5.5 shows the extent of degree of diversification for each of the habitation before and after the construction of rural (PMGSY) roads.

Table 5.5 Degree of diversification before and after the construction of rural (PMGSY) roads

S.No.	(d_i) Before PMGSY	(d_i) After PMGSY
1	0.504	0.866
2	0.785	1.019
3	0.673	0.954
4	0.631	0.983
5	0.673	0.953
6	0.793	1.024
7	0.811	1.084
8	0.787	1.014
9	0.788	1.021
10	0.531	0.876
11	0.788	1.048
12	0.659	0.968
13	0.549	0.967
14	0.654	1.016
15	0.673	0.937
16	0.570	0.922
17	0.690	1.012
18	0.700	1.016
19	0.670	0.987
20	0.504	0.943
21	0.785	1.011
22	0.673	1.002
23	0.631	0.916
24	0.673	1.086
25	0.793	0.984
26	0.811	1.089
27	0.856	1.079

From the diversification index evaluation performed, it is observed that the construction of rural roads has helped significantly in influencing the livelihood activities of target population. Newly constructed rural roads have helped the rural inhabitants to undergo diversification in their income earning activities. It is revealed that after the construction of rural roads only 22% of the total habitation considered for the study have achieved more than 60% of diversification in their livelihood activities, which is one of the significant outcome. However, the remaining 48% habitations achieved 40 to 55%, and remaining 40% underwent 35% change in their livelihood activities. It also reveals that even after the construction of PMGSY roads the 30% of the inhabitants though able to have access to new income earning opportunities are still dependent on agriculture for their livelihood. The reason may be due to higher returns on agricultural produce, and because of decrease in travel time to reach the nearest marketplaces. Fig. 5.4 illustrates the percentage change in the fuzzy Shannon' entropy diversification index employed for the study. Fig 5.5 depicts the extent of diversification in case of each habitation considered for the study, using ArcGIS tool.

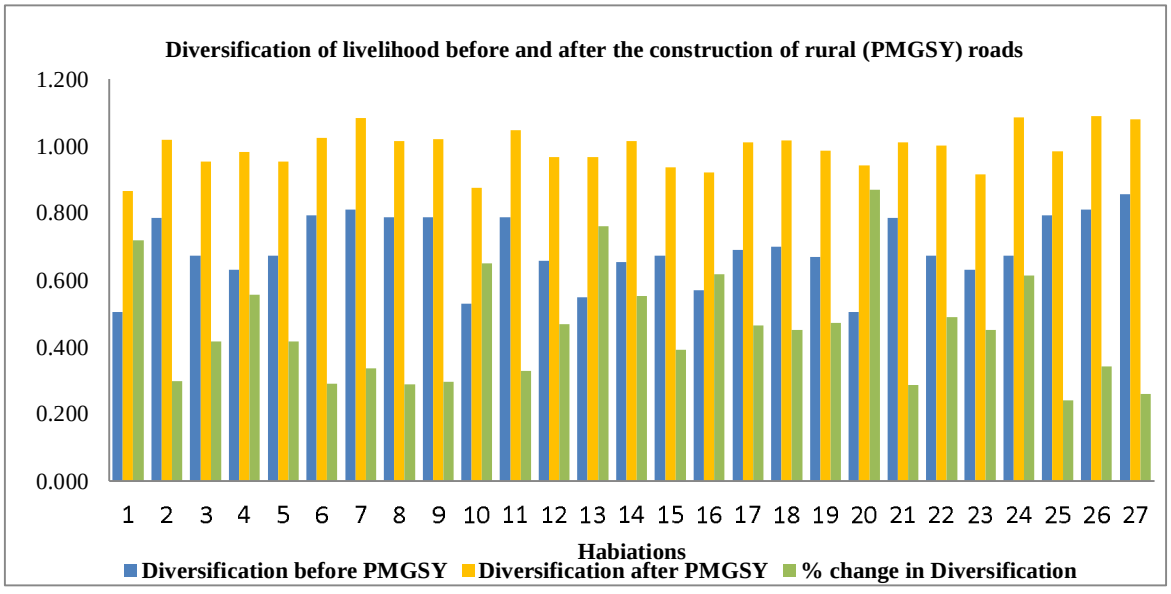

Fig. 5.4 Diversification of livelihood before and after the construction of rural (PMGSY) roads

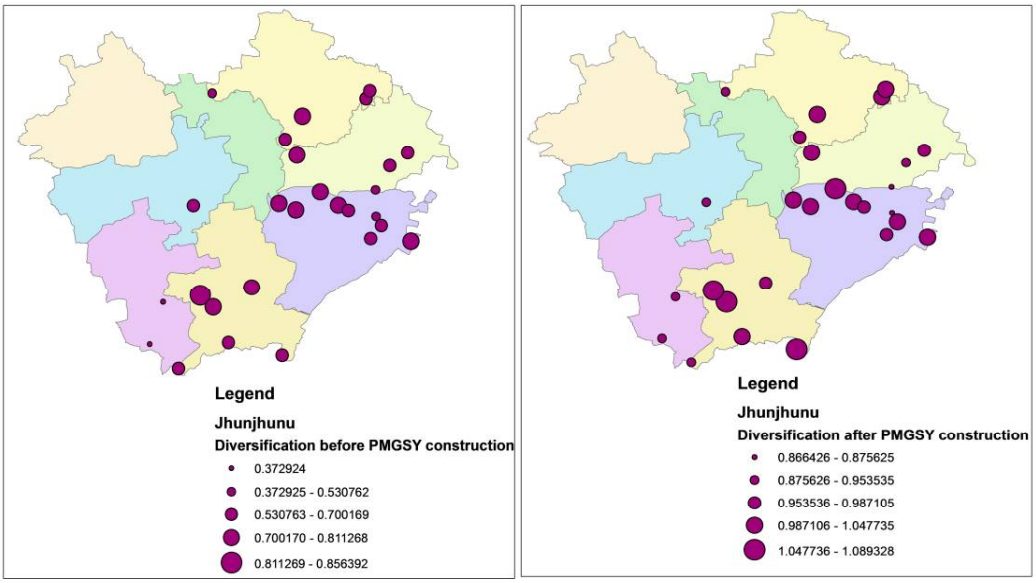

Fig. 5.5 Status livelihood diversification before and after the PMGSY road construction for the habitations

5.6.2 Impact of livelihood diversification on household income

In this study quantile and OLS regressions have been used to assess the economic impact of rural road construction. The economic impact has been assessed in terms of income/ livelihood diversification. An attempt has been made to estimate the marginal and mean impacts of income diversification. Table 5.6 illustrates the outcomes of the OLS and quantile regressions. The column 2 Table 5.6 shows the outcomes for OLS regression analysis. From this its understood that the estimate for diversification index has significant influence on household income, whereas estimate of non-farm activity ratio exhibits negative influence, which is contradiction. However, in case of the outcomes of quantile regression the estimates are positive but have little influence on the household income. Further, the analysis also reveals that only 22% of the population belonging to the study area has achieved diversification more than 60% and reaming 80% of target population are still in the process of diversification. It is also observed that the quantile regression estimates shown in column 3-5 of Table 5.6 differ from that of the estimate attained from the OLS regression, indicating difference in influence of every attribute accounted for the study, to assess income diversification.

Although, it is understood that the construction of rural roads has been significantly influencing income earnings of the rural inhabitants, they still lag in achieving complete diversification. This is well observed by the diversification coefficient which show less influence on household income corresponding to all the quantiles as shown in Table 5.6. The outcomes of the OLS regression show that the estimate for number of working age member's ratio is negative and negligible. This contradictory, because working age member's ratio has direct impact on the household income (i.e., working age member's ratio has positive influence on the income earnings of the rural household, household income increases as the number of working individual in the household increases). Further, the analysis also reveal that rural household income is significantly influenced by the non-farm activity ratio and travel cost attributes, which can be observed from the estimates of quantile regression (given in columns 3 to 6 of Table 5.6). Thus, it can be concluded that, with the construction of rural roads the cost of travel incurred by the rural households has decreased significantly, and it has helped rural inhabitants to avail prolific non-farm income opportunities.

Table 5.6 Determinants of rural household income diversification

Attributes	OLS	5^{th}	10^{th}	25^{th}	50^{th}
Diversification index	0.591	0.038	0.038	0.070	0.067
Travel time	-0.048	-0.026	-0.026	-0.087	-0.028
Travel cost	0.055	-0.359	-0.359	-0.120	-0.281
Working age members ratio	-0.017	0.474	0.640	0.429	0.298
Non-farm activity ratio	0.107	0.380	0.380	0.372	0.393
Dependency ratio	-0.198	-0.135	-0.135	-0.312	-0.195
Constant	0.298	0.460	0.014	0.144	0.335
R^2	0.233	-	-	-	-
p-value	0.024	-	-	-	-

5.7 Summary

Present study focuses on assessing how the construction of rural roads facilitates diversification of livelihood, rather than figuring out effect's roads on farm or non-farm diversification, which has been common focal point of previous studies. They considered strategies and assets in assessing

livelihood diversification of rural households, whereas the effect of infrastructure in shaping transition of livelihood activities received limited consideration. The focus of this study is to assess the impacts of rural road construction (infrastructure development) on livelihood activities, as exploration of the same has been limited, especially in context to India. Firstly, a novel approach which integrates fuzzy set theory with Shannon entropy measure of diversification has been applied. The approach has ability to quantify the data in an inclusive manner by considering the vagueness and imprecision of the data with ease and simplicity, enabling the model to be flexible. Secondly, the econometric assessment part of the proposed approached has been performed using quantile regression. Quantile regression performs evaluation at different quantiles of the given data set. Unlike OLS regression, which only mean values. The findings of the study reveal that major portion (i.e., 80%) of the target population is still dependent upon agricultural activities for their livelihood.

Based on analysis, it can be concluded that the construction of rural roads have intensified agricultural activities. The probable reason for this trend might be the result of improvement in the access to the nearest market centres and reflects that the scope of livelihood diversification through non-farm activities has been minimal. Further, from econometric analysis it is observed that livelihood diversification is in the process, which is ascertained from the positive influence of a number of working age member's ratio over household income. Thus, it can be concluded that with the improvement in accessibility to the nearest economic centres the rural inhabitants are able to avail new employment opportunities. Also, this influence on income earnings of the rural households may have been caused due to absorption of individuals belonging to working age group. The assessment performed in this chapter yield some important insights which will assist the concerned policy makers in the implementation of different schemes and policies. There is requirement of necessary steps to be taken by the concerned policy and decision makers by providing subsidies and aids. This will help rural inhabitants to establish small scale livelihood enterprises, as well as, it also help them to enhance their agricultural production. Moreover, with promotion of non-farm employments through small scale livelihood enterprises will provide help in absorbing available labor resources.