

## **ABSTRACT**

Development of rural roads in India had been intensified after the launch of Pradhan Mantri Sadak Gram Yojana (PMGSY) in December 2000. It is the first rural road development plan funded by the Government of India, later on the World Bank and Asian Development Bank funded the implementation of PMGSY. PMGSY roads had lasting impact in reducing rural poverty as compared to the subsidies and financial aids provided in the poverty alleviation of rural areas. Despite of this significant contribution, there has been discontent with the evidences which demonstrated the impacts of PMGSY roads on the target rural population. However, potential of PMGSY roads which assisted in transforming rural regions of India has been established by quite a few number of studies. Yet, most of these studies have been quite subjective in nature especially with respect to consistency and rigorousness of the analysis. The lack of consistency in the analysis had very little significance in influencing the planning and management by the concerned decision makers in achieving sustainable rural development. Thus, there is a need to develop an appropriate methodology by taking into consideration of the past impact assessment studies so that proper insights and better information can be provided to the concerned decision makers.

No doubt that over the last two decades there is growing recognition among policy and decision-making authorities, to involve rigorous impact evaluation of rural roads. However, there is need of considerable endeavors to be taken to develop an efficient support system which channelizes inputs from public participation (i.e., qualitative and quantitative information). They help in gathering of necessary knowledge, whether the intervention has positive impacts on the target population, and has it been cost-effective. It also yields insights on how it has impacted the sustainable development of rural households. Based on the facts mentioned above, present study attempts to develop several novel and robust model frameworks for assessing the impacts, using fuzzy integrated multi-criteria decision-making techniques and computational intelligence tools for selected habitations in Jhunjhunu district of Rajasthan, India. A conscious attempt is made to develop model frameworks, which inculcate both qualitative and quantitative data, based on the perceptions of the selected focus groups (rural inhabitants).

This study tries to assess the impacts of rural road construction on the rural households, which involves identification and exploration of the critical attributes, evaluating the scope of the

impacts, and development of appropriate methodological frameworks which integrates their qualitative and quantitative aspects comprehensively with global perspective. Herein, a decision support system is developed which combines advance fuzzy multicriteria decision making techniques along with computational intelligence and geospatial approaches. The methodological framework enables concerned decision makers to assess the effectiveness of the delivered road infrastructure, from sustainable rural development viewpoint by considering uncertainties associated with the critical indicators for impact assessment process. Applicability and effectiveness along with uniqueness of the proposed methodological framework is demonstrated by employing a case study for habitations connected by PMGSY roads (total 27 connectivities) in six different blocks, viz., Buhana, Jhunjhunu, Khetri, Surajgarh, Nawalgarh, and Udaipurwati in Jhunjhunu district of Rajasthan state, India.

The study primarily focuses on: (i) establishing critical impact indicators, and (ii) determining appropriate combination of assessment techniques and methods from global perspectives. Development of comprehensive and appropriate methodological framework, by considering data reliability requirement, has been focal point of the study. The study would be helpful for the concerned decision makers to formulate and implement appropriate schemes and policies, thereby achieving intended goal of sustainable rural development. Insights and conclusions derived from the study hold vital significance from viewpoint of mitigating the unintended impacts through corrective strategies by taking appropriate steps. Thus, keeping in view of sustainable rural development, in the present research, four model frameworks have been developed using real-life data from selected habitations of Jhunjhunu district, Rajasthan.

The first model framework (Chapter 3) employs mixed method approach which combines multi-variate analysis with fuzzy multicriteria decision making approach, i.e., fuzzy Technique Order Preference by Similarity to Ideal Solution (fuzzy-TOPSIS), to ascertain and explore impact indicators that contribute for the assessment of socio-economic status of rural households. In this chapter, impact indicators are identified by considering their variance and relative significance. In this model, Statistical Package for the Social Sciences (SPSS version 2015) and ‘Analyse it (version 2016)’ have been used to ascertain and assess cause-effective relationship of the important impact indicators. In the second model presented in Chapter 4, computational intelligence approach Adaptive Neuro-Fuzzy Inference System (ANFIS) along with fuzzy Delphi method (FDM)

technique are used to assess the possible impacts on the rural inhabitants belonging to selected habitations of the Jhunjhunu district. Initially, in this chapter ANFIS is applied to assess the possible impacts, and then results obtained from analysis are compared with FDM. The results are also represented in maps using ArcGIS tool 'version 10.0' to define the scope and extent of these impacts.

In the third model discussed in chapter 5, application of Fuzzy Shannon's entropy measure of diversification along with econometric modeling is demonstrated to assess the livelihood diversification. The study focuses on assessing the impacts of rural road construction on the livelihood and its diversification, for selected habitations in Jhunjhunu district. It considers transport and demographic characteristics. The results obtained are spatially represented using ArcGIS tool. The fourth model dealt in chapter 6, which uses fuzzy TOPSIS and improved fuzzy weighted average method, to assess the negative impacts of road infrastructure on rural households. This model framework initially, identifies impacts and investigates attributes contributing to them. Finally, salient points were highlighted, which can help the concerned decision makers to formulate necessary schemes and policies to mitigate negative impacts.

The outcomes obtained from each of these models have been validated by performing comparative analysis using different approaches. The results of analysis clearly indicate that all the developed models are practical and can incorporate the randomness and uncertainty associated with overall assessment process of rural road development. Though, all the models are unique as these are based upon the responses obtained from the rural households through focus group discussion. But, among these ANFIS model framework has distinct nature as it considers the positive aspects of both computational intelligence and fuzzy set theory to assess the impacts of construction of rural roads. As, the data collected based upon the responses of the focus group participants, adequate weightage has been given to the responses to achieve single efficient input for the selected habitations. The methodological aspects of the present study emphasize on certain vital aspects, which received less attention from in earlier studies available in the literature. These aspects are: (a) ability to incorporate uncertainty in the data by developing an integrated approach, (b) developing models which are robust, time and cost-effective, and easily understandable by the stakeholders (policy makers and concerned authorities involved in decision making).

The models presented in all the chapters are based on mathematical theories and are focused on addressing various aspects of the evaluation process by providing tangible command to the concerned authorities to assess the impacts effectively. Chapters 3, 4, 5, and 6 have been explained with relevant methodologies, and effectiveness of them is illustrated using case studies. The contribution and uniqueness of each model framework is highlighted in the summary of the respective chapters. Finally, in chapter 7 overall conclusions are illustrated in correspondence with the aim of the study. The study presented herein focuses current need of employing applied scientific approach in impact evaluation studies for assessing, monitoring and management. The proposed models provide basis to deepen the research work by incorporating even more comprehensive data and to obtain conclusive outcomes through innovative techniques presented here. Thereby, assisting concerned policy makers for formulating sustainable policies to enhance overall benefits of rural population by developing rural road infrastructure and services. Incorporation of impact assessment strategies before and after rural road infrastructure development can be a key element while making future investments for such mega projects. Thus, it is expected that, the study will form the basis for further research in rural planning and development, especially applicable for developing countries.