Research on World Agricultural Economy
https://journals.nasspublishing.com/index.php/rwae

ARTICLE

# Assessing the Role of Kisan Rail on Agri-Supply Chain in India: Insights from Mixed-Method Research

*Abhishikt Chauhan* *, *William Nunes*

*Political Science, Gujarat National Law University (GNLU), Gandhinagar 382426, India*

## ABSTRACT

Agriculture plays a significant role in the country's economy still there are inefficiencies in logistics of sector which hinder farmers' profitability. The Government of India (GoI) has launched the Kisan Rail (KR) scheme in 2020 which aims to address these challenges by providing an affordable and accessible rail transport system for agricultural produce. This study evaluates the effectiveness of KR scheme in Madhya Pradesh. The evaluation uses four variables namely accessibility, affordability, awareness, market access, and income enhancement to assess the effectiveness of KR scheme. The convergent parallel mixed-methods approach was used and qualitative data was analysed using techniques such as word cloud & triangulation. The quantitative analysis was done using Pearson correlation and fractional logistics regression. The findings revealing that KR significantly improves affordability, market reach, and income stability, especially for small and medium farmers. However, infrastructure gaps, first-mile connectivity issues, scheduling inefficiencies, and inconsistent policy implementation hinder full adoption. Additionally, limited awareness and outreach, particularly among marginal and female farmers, restrict utilization. The study highlights KR's potential in reducing post-harvest losses and bypassing intermediaries but calls for stronger government intervention, infrastructure upgrades, dynamic pricing models, and digital integration to maximize impact. Future research should explore KR's long-term sustainability using longitudinal studies and advanced econometric models to enhance India's agricultural supply chain.

*CORRESPONDING AUTHOR:
Abhishikt Chauhan, Political Science, Gujarat National Law University (GNLU), Gandhinagar 382426, India;
Email: abhishiktphd202003@gnlu.ac.in

ARTICLE INFO
Received:11 February 2025 | Revised: 27 March 2025 | Accepted: 28 March 2025 | Published Online: 26 May 2025
DOI: https://doi.org/10.36956/rwae.v6i2.1726

CITATION
Chauhan, A., Nunes, W., 2025. Assessing the Role of Kisan Rail on Agri-Supply Chain in India: Insights from Mixed-Method Research. Research on World Agricultural Economy. 6(2): 629–651. DOI: https://doi.org/10.36956/rwae.v6i2.1726

***Keywords:*** Agriculture Policy; Agricultural Logistics; Supply Chain; Market Access; Mixed-Methods Approach; Logitic Regression; Farmer Income; Pearson Correlation

# 1. Introduction

Indian Railways (IR) with the history of 150 years is the nation's lifeline which facilitates connectivity for citizens and transportation of goods, serving as a crucial component in the country's logistical framework [1]. It is the fourth largest in the world after USA, China, and Russia. It has 67,856 kms route length and is considered to be the lifeblood of the economy. With a monopoly by the Railways Board, it remains the most popular mode of transportation in country for passenger and freight transportation. Over the years, there has been notable growth witness in IR. In the financial year 2024, the passenger traffic has increased by 5.2%, while the freight (FG) business has grew by 5.3% with 158.8 crore (cr) tonnes (tn) revenue from FG earnings [2]. Moreover, IR plays a significant role in country's agriculture economy by facilitating efficient PT of agriculture goods, enhancing market access, and thus, contributing to the development rural parts of the country. In the 2023, India has exported 17.7 million (mn) tn rice and IR has been instrumental by providing logistic support. Similarly, fertilizers supply chain (SC) across the country has been transported by IR ensuring its timely availability to the farmers (49.5 mn tn in FY 22) [3]. So, IR is pivotal in movements of bulk commodities for the agriculture sector. Furthermore its helps in linking agriculture produces with urban markets by ensuring timely and affordable delivery. IR reduces not only reduces the transit time but also reduces the post-harvest losses for the farmers ensuring that the A&AS becomes more resilience to global competitiveness. This could be observed by as the agriculture exports increase to $50 billon (bn) in 2022–23 [4] and positioning India as global leader in rice, spices and cotton production [5].

Further, the Government of India (GoI) determined about improving the supply chain in agriculture sector by putting continuous strategic efforts using the Ministry of Road Transport and Highways (MoRTH) and the Ministry of Railways (MoR). This is due to Agriculture and allied sectors (A&AS) contributes 18% to the GDP [6] and employs to 42.3% of the country's workforce and sustains livelihoods for over 700 million rural residents [4]. Furthermore, as per the estimates of NABSCON 2022 study the post-harvest losses consist of 2.35% of the total GDP at current price [7]. The major focus of the both the ministries is on improving and develop transport infrastructure for better connectivity, minimize post-harvest losses, and enhance supply chain efficiency. Despite of these efforts there has been inefficiencies recorded in the agri-supply chain which includes inadequate PT facilities, below-par storage facilities, lack of linkages with market, fragmented land-holdings, and many more. Additionally, according to Parwez, 2016 these inefficiencies results in post-harvest losses which has been estimated to be between 30%–35% of total production. Similarly, dominance of intermediators, and higher transportation cost are also other factors which leads to reduction in farmers income [8]. Further the NITI Aayog report further identifies challenges such as it takes 2–3 days longer than road, with increased transit time, procedural delays, absence of freight time-table, multi-modal handling due to lack of first and last mile connectivity, lack of terminal infrastructure, maintenance of goods sheds and warehouses, uncertainty in supply of wagons with adequate facilities are some rail based agri-supply chain issues [9].

But over the years, IR been an important cog in the wheel in the agri-supply chain. This has been identified by the inter-ministerial committee on doubling farmers income (2016) as part of its recommendation insisted on using the IR network to help bridge the logistics gaps [10]. Currently, one of the major commodities transported by IR food grains accounts of 21.27% as a share of total production which also included imports by 2023 [11]. This might seems to be the meniscal in current phase but with the GoI strategic restructuring and expansion plan of IR to increase the freight traffic by 47% from the current by 2030. Also, India wants to reduce its net logistics cost which is at 14%–15% whereas the global benchmark is at 8% [12]. IR will play a curative role due to advantage with cost and sustainability. IR with technological initiatives in terms of signally and project Kavacch, and advancing rail infrastructure through dedicated freight corridors (DFC), the National Rail Plan (NRP), Amrit Station Scheme, Multi Model Cargo Terminal and PM Gati Shakti Mission. Hereby, the National Rail Plan envisaging to increase the IR modal share by 45% in freight by 2030 from current share and reducing the freight cost by 30% [12]. Dedicated Freight Corridors, Amrit Station Scheme, electrification, automation, high-speed rail projects, and the PM Gati Shakti Plan for enhancement in infrastructure and industrial connectivity. Such modernization efforts by IR is paving the way towards robust, faster and resilient role of the IR in the freight share and in agri-supply chain.

Currently, the most recent and significant efforts of IR to improve the agri-supply chain is the Kisan Rail (KR), launched in August 2020, dedicated to transporting perishable agricultural commodities such as fruits, vegetables, dairy products, meat, and fish from production centres to consumption markets across the country [13]. By February 2023, Indian Railways had operated 2,359 KR services, transporting approximately 7.9 lakh tonnes of perishables [14]. To further support farmers, the "Operation Greens—TOP to Total" scheme by the Ministry of Food Processing Industries provides a 50% subsidy on freight charges for transporting fruits and vegetables via KR [13]. Additionally, Indian Railways has established temperature-controlled perishable cargo centres at key locations such as Nashik, New Azadpur, and Singur [15]. The "Operation Greens—TOP to Total" scheme, launched in 2020, also extends subsidies of 50% on transportation and storage to stabilize the supply of tomato, onion, and potato crops [14]. Furthermore, the Agricultural Marketing Infrastructure (AMI) Scheme, under the Integrated Scheme for Agricultural Marketing (ISAM), supports the construction and renovation of godowns and warehouses in rural areas to enhance storage capacity [1]. As of June 2024, 48,512 storage infrastructure projects, with a combined capacity of 940 lakh tonnes, have been sanctioned across 27 states [15]. These initiatives underscore Indian Railways' commitment to enhancing agricultural logistics, ensuring the timely delivery of produce, and improving the livelihoods of farmers across India [16].

By analyzing past initiatives, schemes, and programs, alongside the modernization efforts undertaken by IR to develop the agri-supply chain above, this study employs the theoretical framework of meta-policies advocated by Yehezkel Dror to assess the effectiveness of the KR scheme implemented by IR between 2020 and 2024. The evaluation primarily focuses on understanding farmers' perceptions. Thus examining the scheme's effectiveness by using four variables efficiency, accessibility, affordability, and awareness levels among beneficiaries. This study aims to provide valuable insights for policymakers, highlighting the key challenges faced by rail transport in the agri-supply chain and offering recommendations for integrating policy measures within IR's ongoing and future modernization strategy to enhance rail-based agricultural logistics.

The study use the geographical centred in the state of Madhya Pradesh (MP), India, which is strategically located in the central region of the country, serving as a key junction in the IR network, connecting all four regions of India. Additionally, MP's economy is agrarian, making it a critical focal point for this study. Furthermore, under the KR scheme, a total of seventy-four (74) trains operated from Madhya Pradesh until March 31, 2023, establishing it as a key railway junction facilitating train operations from various states across the country. Thus, the study assesses farmers' perceptions regarding the effectiveness of the KR scheme in enhancing the agri-supply chain in MP. It hypothesizes that the KR scheme has significantly improved agricultural logistics by increasing accessibility, affordability, awareness, and farmers' income, thereby strengthening the overall efficiency of the rail-based agri-supply chain in the MP region. The following are the research questions and hypothesis which guides the study:

1. *How effective is the Kisan Rail scheme in improving the agri-supply chain logistics for farmers in MP?*
2. *What are the key logistical challenges faced by farmers while utilizing KR scheme for their agriculture produce logistics?*
3. *To what extent has the KR scheme enhanced farmers' accessibility to rail-based agricultural transportation in MP?*
4. *How has the affordability of rail transport under the KR scheme impacted farmers' participation in agri-logistics?*
5. *What is the level of awareness among farmers regarding the KR scheme and its benefits?*
6. *Has the KR scheme contributed to an increase in farmers' income and overall agricultural productivity?*

**H1.** *There is no significant accessibility of KR scheme for farmers in MP.*

**H2.** *Farmers in MP has limited awareness about KR scheme and its associate benefits.*

**H3.** *The KR scheme has not improved the affordability and cost effectiveness of rail-based transportation in India.*

**H4.** *The KR scheme has no significant improved farmers access to distant markets for their agriculture produce in MP.*

**H5.** *The KR scheme has not significantly contributed to enhancing farmers income in MP.*

# 2. Literature Review

There has been a notable increase in scholarly literature examining the integration of visual tools and mixed-method approaches in policy evaluation. These studies highlight the advancements in policy assessment methodologies and the challenges associated with ensuring effective decision-making. This paper begins by exploring the significance of visual tools, such as triangulation, and word clouds, and cross tabulation in evaluating policy effectiveness within governance and policy analysis. The discussion then shifts to an examining five policy factors identified from the qualitative analysis using regression modelling and Pearson correlation (correlation). Thus, contributes towards strategic planning which constitutes the central focus of this study. Thus, the paper incorporates analysis of demographic comparison and leads to evidence-based policymaking. Furthermore, the study evaluates key variables, methodological frameworks, and empirical findings concerning the effectiveness of these tools in contemporary policy evaluation and governance practices.

## 2.1. Challenges of Transportation Systems in Agri-Supply Chain in India

The A&AS sector in India faces numerous challenges in transportation [17], including inadequate rural infrastructure [18], high transportation costs [19], lack of cold storage chain logistics [20], dependence on intermediaries, seasonal and weather-related disruptions, fragmented supply chains, limited access to modern transport facilities, and policy gaps [21]. Various studies shows that a significant portion of India's rural roads remain unpaved, and outdated transportation systems lead to increased post-harvest losses [22, 23]. Thus, investments in rural transportation and modern logistics networks are crucial to addressing these bottlenecks. Smallholder farmers, who constitute the majority of India's agricultural workforce, face disproportionate burdens due to lack of affordable transport options [24]. In India, the logistic costs constitute up to 14% for outbound food grain production, making it difficult for farmers to compete in urban markets [25]. Inefficiencies in logistics, such as fragmented supply chains and lack of cold storage linkages, further escalate costs and lead to significant losses [21]. Despite government initiatives like the Pradhan Mantri Gramin Sadak Yojana (PMGSY) for rural road development and KR for agricultural freight transport, gaps in policy implementation [21] and technological adoption continue to hinder efficient agricultural transportation [26]. The adoption of smart logistics solutions, such as GPS-enabled tracking systems and digital marketplaces, remains limited due to poor digital infrastructure and lack of awareness among rural farmers [26].

## 2.2. Role of PT In Agri-Supply Chain in India

The PT systems, encompassing railways and government-operated bus services, offer a cost-efficient alternative to commercial logistics, especially for small-scale farmers who lack access to cold storage and expedited freight choices. The access to vital PT infrastructure and services is crucial for agricultural growth globally, as it enhances market competitiveness, prices stability and promotes efficient and inclusive agricultural value chains both locally and internationally [27, 28]. Furthermore studies highlight that inadequate rural transport infrastructure leads to post-harvest losses and increased transaction costs for farmers [28]. In India, the deficiency in the PT forces farmers to depend on exploitative intermediaries, resulting in diminished profit margins and economic hardship [29]. Many studies has provide support to the improved PT has leads to better agriculture and rural development [30–32]. Additionally, the improved subsidies which reduces transportation cost and travel time improves farmer participation in markets and helps not in improving the farms productivity but increases the income of farmers [33]. The reduce these inefficiencies recently the IR has introduce the KR as a game-changer, facilitating the rapid movement of perishable agricultural goods across states [34].

## 2.3. Relevance of IR in Agri-Supply Chain

IR is an essential player in India's PT system. It one of the key player in agri-supply chain management by ensuring cost-effective and large-scale transportation of farm produce. Initiatives like KR and Dedicated Freight Corridors (DFCs) have enhanced logistics efficiency, improved market access for farmers, and reduced post-harvest losses [35]. In India IR is more economical than road transport for bulk agricultural commodities, and its ability to handle high-volume shipments reduces logistics costs per unit [36]. The implementation of DFCs has improved freight efficiency by decongesting passenger routes and allowing faster movement of essential commodities. KR, launched in 2020, provides dedicated railway services for perishable commodities, reducing transit times and post-harvest losses. Government subsidies and flexible freight rates have encouraged small and marginal farmers to utilize railway services for accessing distant markets [13].

However, IR faces challenges in cold chain logistics, particularly the limited availability of refrigerated wagons and cold storage facilities at railway stations [9]. To strengthen its role in agri-supply chains and public transport, the railways must focus on improving last-mile connectivity, expanding cold chain infrastructure, and integrating digital solutions. Fostering public-private partnerships in railway freight operations can attract investment in logistics hubs, modern storage facilities, and dedicated agri-freight corridors [36].

## 2.4. Role of KRs in Improving Agri-Supply Chain

The primary objective of KR, established in August 2020, was to mitigate post-harvest losses, enhance market accessibility for farmers, and facilitate the expedited transportation of both perishable and non-perishable agricultural goods [13]. It leverages the vast network of IR and provides a cost-effective alternative to road transportation, which is often unreliable and expensive for small farmers [37]. In India, traditionally small and marginal farmers have faced transportation limitations, resulting in excessive dependence on local markets and intermediaries [38]. KR as a freight concession scheme enable the farmers to bypass the intermediaries and ensures fair pricing of the agri-commodities in turn ensuring increased profitability to them [12]. Furthermore the IR integrated cold chain logistics which resulted in reduction of post-harvest losses to 15%–20% , especially for the perishable commodities [9, 35]. But inadequate cold storage infrastructure at terminal level is a major challenge [39]. Additionally, another improvement in the KR which other studies has highlighted that rail-based logistics reduces cost by 20%–25% and greenhouse gases to 30% compared to road [9]. Thus, looking at various significance of KR it still has operational challenges make such as last-mile connectivity [25], limited awareness among farmers [26], lack of digital logistic management [26], storage facilities (terminal) [9, 35].

## 2.5. Theoretical Framework—Meta Policies

Yehezkel Dror's Meta-Policy Approach is a higher-order policy framework that guides and shapes sectoral policies, ensuring adaptability and long-term effectiveness [40]. Meta policies refer to policies on how to make policies, focusing on characteristics of policy making systems and mega policies. They can be used behaviourally to describe and explain actual phenomena, providing better frameworks for data identification and interrelating policy variables. Similarly, metapolicy can be used normatively to indicate meta-policy arrangements needed for better policymaking. Both uses are interrelated, with all normative recommendations based on behavioural knowledge. To apply the metapolicy concept effectively in social science, comprehensive knowledge on actual social science meta-policies, their relationships with outputs, and the values aimed at advancing social science is required. The main utility of social science metapolicy is to stimulate research, study contemplation, design, and analysis at the metapolicy level [39].

As, policy sciences aims towards instrumental-normative policymaking refinement within morally acceptable values. Furthermore, it emphasizing the importance of explicit consideration of social science metapolicy issues in all social science policy concerns [41]. Thus, this conceptual model, policymakers can design integrated, future-ready solutions that maximize the potential of KR and enhance overall agri-culture.

## 2.6. Measure and Methods of Assessing the Effectiveness

The measuring and assessing the effectiveness of the public policy (schemes and programme) is crucial process and requires a multi dimension approach in sectors such as health-care, education, transportation, agriculture and many more [42]. Mix Methodology amalgamate qualitative insights with quantitative data, facilitating a more nuanced comprehension of policy efficacy. This method tackles external validity and generalisation concerns, bolstering results via triangulation [43]. In public health, mixed approaches have been utilised to evaluate programs aimed at high-risk populations, highlighting the complex nature of health treatments [44]. Bohatá et al. (2017) assesses the social effectiveness through principles of good public administration, open government, and social and ethical auditing. Furthermore use of binary analysis, by using dichotomous questions, distil intricate concerns into digestible data points, facilitating the rapid identification of areas requiring enhancement [45, 46]. In recent times visual instruments such as triangulation, and word clouds have become increasingly popular in public policy research and qualitative evaluation because they simplify intricate data and improve decision-making. The triangulation method incorporates several data sources, methodologies and theoretical discussion into a valid datapoints which enhances the validity of policy. This method revamps the policy efficacy by corroborating data via qualitative sources and thus mitigate the biases [47, 48]. In qualitative research another method of analysis is to condensing major themes from stakeholder comments, policy papers, and public sentiments using word clouds. Thus, this methods of visualizing helps in enable rapid identification of policy priorities [49, 50].

Furthermore review of literature reveals that in quantitative analysis were dependent variable is proportion and often bound between 0 and 1 then modelling is done using fractional multinomial logistic regression model (FMLOGIT) [51]. This model is implemented using quasi-maximum likelihood estimates which allows the authors to estimated different explanatory variables influencing the proportion of demographic variables. This form of analysis gives insights into which factors incentivize or limits diversification strategies, which helps the policy makers to identify targeted areas for intervention [52]. Further, such analysis has deployed in Habib et al. (2023) were examination of livelihood diversification patterns among rural households in Pakistan. Here dependent variable was modelled as fractions of income from different sources which are valued as 0 and 1 [51]. Studies suggest fractional logistic regressions which offers analytical insights for identifying overlaps, inconsistencies and complementarities across multiple policy variables. Further this analysis support multi-criteria evaluations and enhances stakeholders dialogue. Thus, clarifies the relative influence of policy dimensions [53].

Thus, among various research methodologies, mix method proves to be an effective method for this study. As it measures effectiveness depending on the domain and specific evaluation criteria [53]. Traditional methods of effectiveness measurement rely heavily on quantitative regression metrics, while recent advancements incorporate qualitative and mixed-method approaches to provide a more holistic assessment [52].

## 3. Research Methodology

The study deploys the convergent parallel mixed-method research design. According to this design both quantitative and qualitative data are collected simultaneously and analysed independently before being integrated for interpretation [54]. During the study both the phase were conducted simultaneously. In the qualitative phase, data collection was conducted through focus group discussions (FGDs) using semi structured questionnaire, with farmer groups, each consisting of average five participants, across three railway stations in the state of MP, India [55].

The quantitative phase of the study was conducted concurrently with the qualitative phase, aligning with the research design. A simple random sampling technique, a form of probability sampling, was utilized in this phase [56]. Given that only three railway stations in the state facilitated KR operations and all three stations were part of data collection [55]. There were four different teams deployed two for each type of methods (qualitative and quantitative). Post the data collection for both data-set cleaning and analyses were done by their respective teams. Finally, post completion of analysis both data were integrated for final interpretation. Thus, this research design enables a comprehensive assessment of the KR scheme's effectiveness and facilitates the identification of areas requiring improvement. The geographical selection of the area (MP state) has been justified in the above introduction.

The data collection was done using semi-structure questionnaire for qualitative phase and for the quantitative phase a questionnaire with forty-two question was developed from the literature review. This questionnaire consist of six sections, section 1 consist of demographic details collect respondent data on age, gender, education, caste, landholding, and irrigation. Section two evaluates accessibility using ease of access, station proximity, and booking challenges. The affordability variable was examines in section three using KRs cost-effectiveness, including subsidized freight rates and comparative transport costs. Awareness assesses farmers' knowledge, promotional exposure, and information needs. The fourth section was tried to explore the market accessibility factor using expanded market reach, middlemen elimination, and bulk transport. The last section was about income enhancement analyses through profitability, post-harvest loss reduction, and earnings. The binary questions were use to facilitates assessment of efficiency, challenges, and policy recommendations for optimizing railway-based agricultural logistics.

The data collection process was implemented in two parallel phases which were conducted simultaneously. A total of four teams were formed for data collection, with two teams assigned to qualitative data collection and two teams to quantitative data collection. Each team comprised four members, resulting in the engagement of twelve (12) field staff and four (4) researchers in the overall data collection process. The qualitative teams were responsible for conducting FGDs with farmers, while the quantitative teams administered surveys among beneficiary farmers. To ensure accuracy and minimize survey bias, the qualitative and quantitative teams conducted their respective data collection activities at different time periods to facilitate an independent analysis of the effectiveness of the KR scheme.

Four teams (one qualitative and two quantitative) were assigned to survey three railway stations, namely Indore and Ratlam, due to their geographical proximity, while the remaining teams were deployed at Chhindwara railway station. A pilot study was conducted at Indore station on December 17th and 18th, 2023, to assess the validity of both the qualitative and quantitative questionnaires. Based on the findings of the pilot study, minor modifications were made to the questionnaires to enhance data accuracy. The final survey was conducted at the three selected stations between December 19th and 26th, 2023 (**Figure 1**).

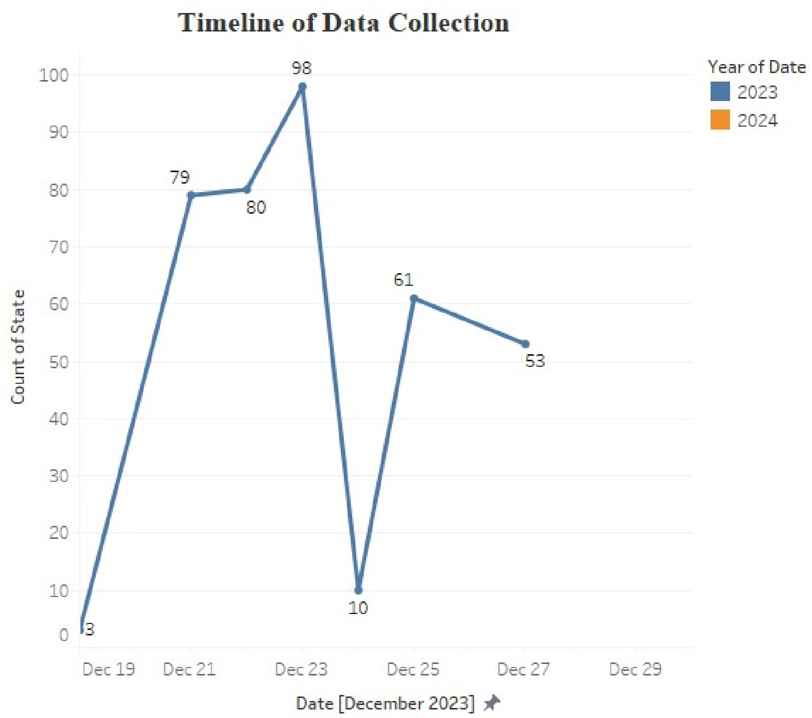


**Figure 1.** Timeline of the data and number of FGD and Survey Respondents collected daily.
Source: Compiled by Author using Tableau.

To maintain methodological rigor, the qualitative team first conducted FGDs in Indore, while the quantitative team simultaneously conducted surveys in Ratlam, and the process was later reversed. Similarly, in Chhindwara, the qualitative team initially conducted FGDs, followed by quantitative data collection from December 22nd to 27th, 2023. This systematic approach to data collection was meticulously planned to mitigate researchers biases and ensure the integrity of both qualitative and quantitative datasets.

The population of the study was identified based on 2011 Census data, the total population of farmers in Madhya Pradesh (MP) is 9,844,439 (approximately 9.84 million). The sample size was determined using statistical inference principles and the Central Limit Theorem (CLT) [57], which is a widely employed method in social science research, including market surveys, public policy studies, and health sciences. The sample size was computed using a standard statistical formula—CLT sample size calculation Formula (Equation (1)), yielding an estimated requirement of 385 respondents. CLT is particularly useful in evaluating the proportion of success in a binary outcome variable (e.g., yes/no responses) within a single study group [57].

$$n = Z_2 p(1-p)/E_2 \qquad (1)$$

Where: n = Required sample size; Z = Z-score corresponding to the desired confidence level (e.g., 1.96 for 95% confidence); p = Estimated population proportion (if unknown, assume 0.5 for maximum variability); 1−p = Complement of the proportion; E = Margin of error (e.g., 0.05 for ±5%).

A total sample of 388 respondents was collected, comprising 15 FGDs with an average of six participants per group, resulting in 90 respondents during the qualitative phase. Whereas in the quantitative phase, 298 farmers were surveyed across the three selected stations by the quantitative research teams (**Figure 2**).

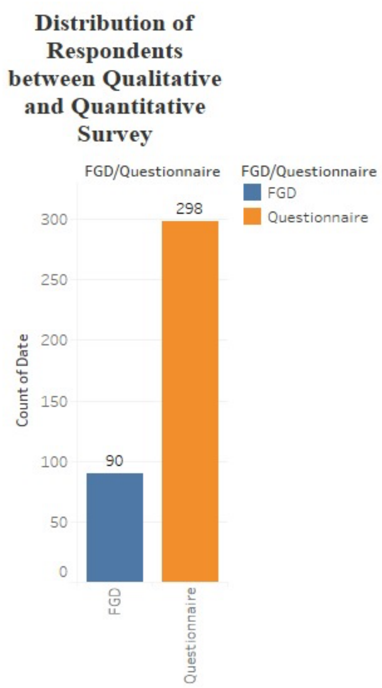


**Figure 2.** Distribution of Respondents between Qualitative (FGD) and Quantitative Survey (Questionnaire).
Source: Compiled by Author using Tableau.

As per **Figure 3**, the distribution of respondents across the selected railway stations was 204 respondents in Indore, 80 in Ratlam, and 104 in Chhindwara. The highest collection of data was done from the Indore station been the busiest railway station and most connected station of the state. Chhindwara (FGD 25.56 % & Survey 27.18%) and Ratlam (FGD 28.89% & 18.12%) have comparable yet lower participation levels.

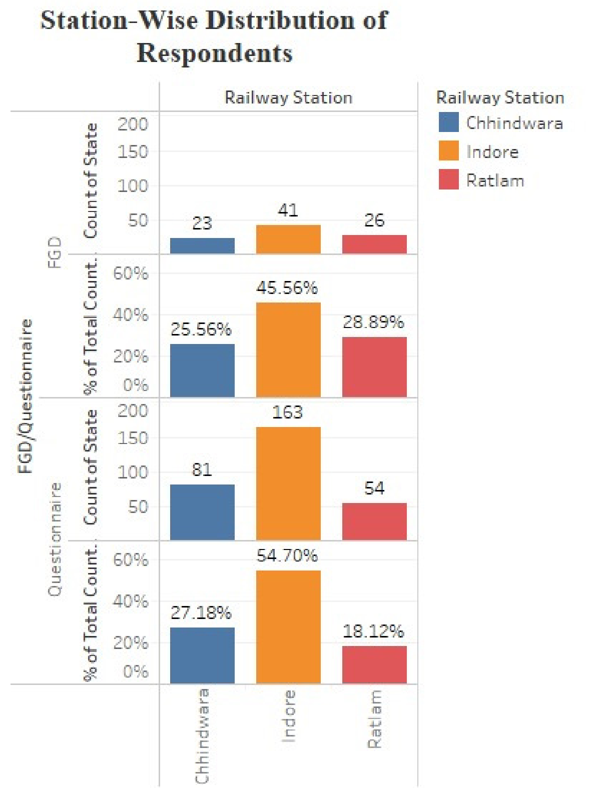


**Figure 3.** Station-wise Distribution of Respondents.
Source: Compiled by Author using Tableau.

The **Table 1** in terms of gender distribution reveals there is significance dominance of male respondents in the study with 83.89% and female participation remained low at 16.11%. Further for other demographical categories like age, case and type of farmer the middle-aged, OBC, medium-farmer population has a predominance then their other sub-categorises. Largest age group being 45–53 years old with 41.95%. Caste distribution is OBC with 37.58%, followed by Scheduled Tribes (27.18%), Scheduled Castes (17.11%), and General category (16.444%). Over half of the farmers are classified as medium farmers, with small and semi-medium farmers also present.

**Table 1.** Demographical Distribution among respondents based on gender, age, caste and type of farmers (in % and no).

| Demographic Category | Subcategory | Count | Percentage (%) |
|---|---|---|---|
| Gender | Male | 325 | 83.89 |
| Gender | Female | 62 | 16.11 |
| Age | 27–35 | 46 | 12.08 |
| Age | 36–44 | 122 | 31.54 |
| Age | 45–53 | 162 | 41.95 |
| Age | 54–62 | 53 | 13.76 |
| Age | 63–71 | 2 | 0.67 |
| Caste | Do not want to disclose | 8 | 1.68 |
| Caste | General | 63 | 16.44 |
| Caste | OBC | 145 | 37.58 |
| Caste | SC | 67 | 17.11 |
| Caste | ST | 105 | 27.18 |
| Farmer Type | Do not want to disclose | 20 | 5.41 |
| Farmer Type | Large Farmer | 21 | 5.41 |
| Farmer Type | Marginal | 2 | 0.26 |
| Farmer Type | Medium | 223 | 57.73 |
| Farmer Type | Semi-Medium | 46 | 11.6 |
| Farmer Type | Small | 76 | 19.59 |

Source: Compiled by Author using Excel.

# 4. Results and Discussion

This study adopts a convergent parallel mixed-methods approach to integrate qualitative and quantitative findings for a rigorous assessment. The qualitative analysis includes word cloud and triangulation analysis from 15 FGDs, processed using Python and Excel. The quantitative analysis is conducted using cross-sectional tabulation method which examines farmer classifications and gender disparities across accessibility, affordability, awareness, market access, and income enhancement. The quantitative analysis centres around the Pearosn Correlation and FMLOGIT where the dependent variable represents proportions i.e., the fractional outcomes lies between 0 and 1 and collectively sums to 1 across variables. In this paper FMLOGIT estimate the non-linear conditional mean function, reflects how the expected value of five dependent variables (accessibility, affordability, awareness, market access and income enhancement) changes with explanatory variables like age, gender, type of farmers, education level, and caste categories. Finally, both qualitative and quantitative findings are converged to provide a holistic interpretation, enhancing the depth and reliability of the research insights.

## 4.1. Qualitative Analysis

The qualitative analysis was conducted utilizing both primary and secondary sources. Secondary sources included policy guidelines, scholarly literature, and an analytical review of 15 FGDs with farmers. The study employed two analytical approaches: (i) a word cloud analysis derived exclusively from transcribed FGDs, and (ii) a triangulation analysis integrating insights from both primary (FGDs) and secondary (literature and policy documents) data sources. This methodological approach ensures a comprehensive evaluation, capturing thematic patterns emerging from farmer discussions while validating findings through a broader policy and academic framework [58].

The analysis from **Figure 4**, the word cloud emphasises the key themes related to KR scheme are its role in market access, transportation, and logistics for farmers. Major concerns include affordability, cold storage, freight charges, and government subsidies which suggest a focus on cost-effective and efficient agricultural transport. Terms like supply chain, intermediaries, and connectivity indicate the importance of an integrated infrastructure. Additionally, income enhancement and policy implementation highlight the economic impact on the rural economy, stressing the need for better capacity building and last-mile connectivity. Similar word cloud-based analyses have been conducted on rail transportation for agricultural supply chains in other countries. Similarly, studies on U.S. freight rail system and UK high-speed rail underscores rail-based agricultural transport's role in cost efficiency, logistics optimization, and sustainability, enhancing market accessibility, reducing transportation costs, and ensuring efficient supply chain management for agricultural commodities [59, 60].

The findings from the triangulation analysis given in **Table 2**, identifies multiple challenges encountered by farmers in executing the KRs. These encompass accessibility and infrastructural challenges, little awareness of KRs schedules, subsidies, and processes, as well as affordability concerns. Farmers with greater freight volumes discovered KRs to be more economical, however small and marginal farmers faced challenges regarding pricing. Certain farmers collaboratively conveyed food via KRs; nevertheless, current incentives failed to consider small-scale carriers. Market access and reliance on intermediaries reduced to 30%–40% and were advantageous factors; however, partial disintermediation and inadequate last-mile transit options posed challenges. Income augmentation via KRs was identified as a key driver; nevertheless, seasonal income variability was noted. The research identified that KRs impact may be categorised into three areas: entirely aligned with policy aim, somewhat realised, and significant implementation deficiencies. The results underscore the necessity for comprehensive logistics solutions that extend beyond railway transit alone. The study suggests that KR's real-world impact is affected by various elements, including accessibility, awareness, cost, and affordability.

**Table 2.** Triangulation Analysis: Key Themes and Findings.

| Key Themes | Findings from Interviews | Policy Gaps Identified |
|---|---|---|
| Accessibility and Infrastructure Challenges | Farmers highlighted lack of first-mile connectivity to railway stations;<br>absence of integrated storage facilities forces reliance on intermediaries. | Unloading delays and inadequate railway infrastructure limit efficiency;<br>no first-mile transport support. |
| Awareness and Farmer Adoption | 60% of farmers reported low awareness of KR schedules, subsidies, and procedures; reliance on word-of-mouth rather than structured outreach. | Limited government outreach through Krishi Vigyan Kendras (KVKs) and agri-extension officers;<br>passive promotion strategies. |
| Cost and Affordability Perception | Large freight users find KR cost-effective, but small farmers struggle with affordability;<br>pooling strategies are used to reduce costs. | Subsidies do not account for small-scale transporters, making KR financially inaccessible to them. |
| Market Access and Dependence on Intermediaries | Farmers experienced improved direct market access; middlemen dependency dropped by 30–40% but remains due to unloading complexities. | Lack of last-mile logistics from railway stations to wholesale markets limits full market integration. |
| Income Enhancement through KR | 70% of regular KR users reported higher profits due to reduced transportation costs; income benefits varied seasonally based on crop type. | No price stabilization mechanisms, leading to seasonal fluctuations in farmer earnings. |

Source: Compiled by Author using Excel.

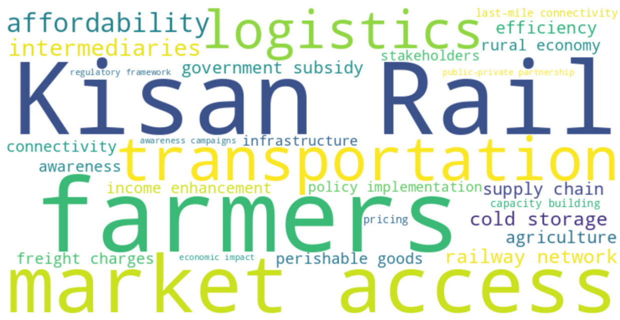


**Figure 4.** Word Cloud Analysis of from 15 FGDs.

Source: Compiled by Author using Python.

## 4.2. Quantitative Analysis

The quantitative analysis was conducted using data-sets which were derived from the primary survey using structured - questionnaire. The structured-questionnaire was derived from through extensive literature review of journal and book chapters. Total of 388 responses were collected for the quantitative phase of the study and analysis of this phase is done using Pearson Correlation (correlation) and FMLOGIT. As, both of these analysis approach provides a robust exploratory and predictive analysis for evidence based- policy evaluation of KR scheme. The correlation unable in identifying linear relationship variables such as age, gender, caste, type of farmers, education and their perceived benefits from KR scheme. On the other hand the FMLOGIT models offers a deeper insights into the factors influencing adoption of the scheme.

**Table 3.** Analysis of Dimensions and Explanatory Variables using Pearson Correlation.

| Dimensions Correlation/Explanatory Variable | Accessibility Correlation | Affordability | Awareness | Market Accessibility | Income Enhance ment |
|---|---|---|---|---|---|
| Variable | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Railway Station | –0.037 | –0.008 | 0.024 | 0.025 | –0.039 |
| Age | 0.008 | –0.002 | –0.080 | –0.028 | –0.092 |
| Gender | –0.015 | 0.035 | –0.055 | –0.025 | –0.046 |
| Education | 0.030 | –0.006 | 0.068 | –0.024 | 0.033 |
| Caste | –0.013 | –0.067 | –0.026 | –0.014 | 0.091 |
| Type of Farmer | –0.011 | –0.007 | –0.064 | –0.134 | 0.096 |

Source: Compiled by Author using SPSS.

### 4.2.1. Pearson Correlation Analysis

The study uses correlation analysis to assess the relationship between social-economic and demographic factors with key five key outcome variables: Accessibility, Affordability, Awareness, Market Accessibility, and Income Enhancement. This bivariate analysis helps identify meaningful linear relationships and guide hypothesis formulation [61]. This form of bivariate analysis is particularly useful for detecting preliminary patterns and associations prior to more advanced regression modelling [62]. Furthermore, such bivariate analysis is particularly useful for detecting preliminary patterns and associations prior to more advanced regression modelling [63].

**Table 3** indicates that there is weaker correlation among the five social-economic and demographic factors namely age, caste, education, gender, and type of farmers and five core dimensional variables. This findings aligns with an Italian study on role of logistics in promoting agri-business were no socio-demographical variables dominates policy outcome [64]. The relationship of KR scheme type of farmer has the most significant negative correlation with dimensional variable market accessibility, suggesting that larger farmers the KR scheme was not effective as they have resources to access the market even without KR scheme. Similarly, age factor has weak negative correlations with awareness dimension and income enhancement, indicating that older farmers may be less informed about available KR scheme and its supportive mechanisms. Gender also shows slight negative correlations with awareness and income enhancement, highlighting ongoing gender disparities in the scheme participation. Whereas, education factors had a positively correlates with awareness and income enhancement, while caste has a minor positive correlation with income enhancement. Thus, the findings suggest that interventions aimed at improving agri-supply change using rail based transportation (KR scheme) must address structural inequalities and systemic barriers. Further, similar results have been showcase were age, caste, and education show marginal effects, while farmer type strongly predicts market access [65], and railway access alone is insufficient without policy alignment [66–68].

#### 4.2.2. FMLOGIT Analysis

The FMLOGIT analysis is used to understand the relationship between a dichotomous variable and one or more independent variable. Thus, this type of analysis is essential for predicting the outcomes that are binary. The FMLOGIT regression analysis is different from linear regression as it provides probabilities that fits withing 0 to 1 range using logistic function.

The FMLOGIT analysis presented in **Table 4** investigates the influence of various socioeconomic and demographic factors on the perceived effectiveness of the KR scheme. Variables such as age, gender, education level, caste, farmer classification, landholding size, and proximity to railway stations were included to test the underlying hypotheses. Although the overall model fit is modest, with Pseudo $R^2$ values ranging from 0.004 to 0.009, the regression results reveal meaningful directional associations. These findings are consistent with patterns reported in prior empirical studies, suggesting nuanced but relevant linkages between respondent characteristics and perceived scheme outcomes. Following are the analysis of key outcome variables of the KR scheme based on FMLOGIT analysis:

**Table 4.** FMLOGIT Regression Analysis based on the five independent variables.

| Factors | | Variables | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Accessibility | | Affordability | | Awareness | | Market Accessibility | | Income Enhancement | |
| | | Coefficient | p-Value | Coefficent | p-Value | Coefficent | p-Value | Coefficent | p-Value | Coefficent | p-Value |
| Railway Station | Indore | 0.154 | 0.226 | –0.108 | 0.357 | 0.063 | 0.613 | 0.068 | 0.588 | –0.115 | 0.396 |
| | Ratlam | –0.103 | 0.428 | –0.003 | 0.981 | 0.108 | 0.425 | 0.033 | 0.804 | –0.168 | 0.275 |
| Age Range | 36–44 | 0.024 | 0.875 | 0.083 | 0.614 | –0.140 | 0.395 | –0.036 | 0.833 | –0.338 | 0.04 ** |
| | 45–53 | –0.036 | 0.826 | 0.106 | 0.520 | –0.114 | 0.491 | –0.044 | 0.805 | –0.359 | 0.04 ** |
| | 54–62 | 0.000 | 1.000 | 0.143 | 0.450 | –0.152 | 0.436 | –0.130 | 0.538 | –0.441 | 0.025 |
| | 63–71 | 0.610 | 0.289 | –0.367 | 0.226 | –0.970 | 0.001 *** | –0.200 | 0.534 | –0.783 | 0.006 ** |
| Gender | Female | –0.003 | 0.985 | 0.060 | 0.665 | –0.098 | 0.478 | –0.082 | 0.521 | –0.061 | 0.673 |
| Education | Able to do their signature only | –0.032 | 0.827 | –0.264 | 0.053 * | 0.295 | 0.043 ** | 0.042 | 0.766 | –0.132 | 0.385 |
| | Primary Education | –0.011 | 0.931 | 0.068 | 0.615 | 0.117 | 0.357 | –0.072 | 0.604 | –0.042 | 0.751 |
| | Secondary Education | 0.082 | 0.593 | 0.009 | 0.955 | 0.169 | 0.301 | 0.016 | 0.921 | –0.167 | 0.339 |
| | Graduate | 0.192 | 0.293 | –0.098 | 0.586 | 0.199 | 0.241 | –0.240 | 0.174 | 0.093 | 0.681 |
| | No Education | 0.174 | 0.395 | –0.235 | 0.381 | 0.169 | 0.503 | –0.046 | 0.844 | 0.003 | 0.989 |
| Caste | General | –0.378 | 0.088 * | –0.121 | 0.690 | –0.257 | 0.361 | 0.201 | 0.492 | –0.216 | 0.424 |
| | OBC | –0.231 | 0.267 | –0.100 | 0.737 | –0.263 | 0.341 | 0.346 | 0.232 | –0.080 | 0.752 |
| | ST | –0.200 | 0.354 | –0.280 | 0.373 | –0.418 | 0.141 | 0.232 | 0.443 | –0.010 | 0.968 |
| | SC | NA | NA | –0.223 | 0.457 | –0.328 | 0.240 | 0.230 | 0.426 | 0.072 | 0.781 |
| Total Land | | 0.016 | 0.550 | –0.051 | 0.073 * | –0.039 | 0.194 | –0.006 | 0.844 | –0.051 | 0.120 |

Table 4. *Cont.*

| Factors | | Variables | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Accessibility | | Affordability | | Awareness | | Market Accessibility | | Income Enhancement | |
| | | Coefficient | p-Value | Coefficent | p-Value | Coefficent | p-Value | Coefficent | p-Value | Coefficent | p-Value |
| Type of Farmer | Small Farmer | –1.632 | 0 *** | –13.188 | 0 *** | –0.864 | 0.001*** | 0.958 | 0 *** | 0.482 | 0.055 * |
| | Semi-Medium | –1.595 | 0 *** | –13.121 | 0 *** | –0.996 | 0.001 *** | 0.725 | 0.005 ** | 0.406 | 0.115 |
| | Medium | –1.762 | 0 *** | –12.929 | 0 *** | –0.677 | 0.036 ** | 0.679 | 0.014 ** | 0.736 | 0.009 ** |
| | Large | –1.778 | 0 *** | –12.560 | 0 *** | –0.495 | 0.350 | 0.425 | 0.399 | 1.388 | 0.006 ** |
| | Do not want to disclose | –1.714 | 0 *** | –13.012 | 0 *** | –1.029 | 0.003 ** | 0.647 | 0.051 * | 1.069 | 0.002 ** |
| Pseudo R2 | | 0.004 | | 0.008 | | 0.006 | | 0.006 | | 0.009 | |
| Log Pseudolikelihood | | 267.551 | | 261.751 | | –265.867 | | –265.881 | | –260.867 | |

* p < 0.01; ** p < 0.05; *** p < 0.01. Source: Compiled by Author using SPSS.

(1) Accessibility

**H1.** *There is no significant accessibility of KR scheme for farmers in MP.*

The primary determinant of accessibility was the category of farmer. All categories (Small, Semi-Medium, Medium, and Large) had markedly negative and statistically significant coefficients (p = 0.000). For instance, small farmers exhibited a significant reduction in accessibility (β = –1.63), suggesting that those with bigger landholdings encounter more substantial obstacles in obtaining KR scheme services and support systems. This may appear paradoxical but is consistent with the observations of Chamberlin and Jayne (2013), who indicated that smallholders are more inclined to participate in local, informal institutions for access, whereas larger landowners tend to function in more isolated or commercial environments [69]. The caste category "General" approached significance (p = 0.088), indicating possible caste-based disparities in access to agricultural resources, while lacking robust statistical support in this dataset.

(2) Affordability

**H2.** *The KR scheme has not improved the affordability and cost effectiveness of rail-based transportation in India.*

In MP the types of farmers showed highly significant negative effects (p = 0.000), with small farmers particularly affected (β = –13.19), indicating serious financial barriers to affording KR scheme inspite of subsidies provides by the government. This aligns with findings that smaller farmers face capital constraints limiting participation in modern agriculture [70]. Those with only signature literacy had a nearly significant negative effect (p = 0.053), suggesting lower education compounds affordability challenges.

(3) Awareness

**H3.** *Farmers in MP has limited awareness about KR scheme and its associate benefits.*

In the given model predicting awareness, age emerged as a key factor. Here, farmers aged 63–71 had a strong, negative, and significant effect on awareness (β = –0.97, p = 0.001), showing that older farmers are less informed, consistent with the digital divide noted by Aker (2011) [71]. All farmer types—except large—also showed significant negative associations, highlighting the informational disadvantage of smallholders. Interestingly, functionally illiterate farmers had a positive and significant effect (β = 0.29, p = 0.043), possibly due to targeted extension efforts. Farmers who did not want to disclose their land size showed a significant negative effect (β = –1.03, p = 0.003), suggesting vulnerability or marginalization showing reluctant to participate fully in formal surveys or systems.

(4) Market Accessibility

**H4.** *The KR scheme has no significant improved farmers access to distant markets for their agriculture produce* *in MP.*

In the market accessibility factor , small, semi-medium, and medium farmers showed positive and significant associations with market accessibility ($p \leq 0.014$), due to the KR scheme which earlier were limited to local and markets for selling their produce. This finding diverges from the narrative that market access favours larger producers and supports the idea that proximity and social capital can compensate for resource limitations in market engagement [72]. Other variables in this model were not statistically significant, highlighting that market access is a multifaceted issue not solely determined by socio-demographic characteristics.

(5) Income Enhancement

**H5.** *The KR scheme has not significantly contributed to enhancing farmers income in MP.*

For income enhancement variable age had a negative and significant effect across all groups ($p < 0.05$), indicating older farmers earn less, likely due to reduced labour capacity and innovation adoption [73]. In contrast, medium, large, and farmers who did not want to disclose their land had positive and significant effects on income ($p < 0.01$), reaffirming that larger landowners benefit more economically through scale and market leverage [74].

Thus, the FMLOGIT analysis reveals that the type of farmer (a proxy for landholding size) emerges as the most consistently significant factor across all models, underscoring the centrality of land-based inequalities in shaping agricultural livelihoods. While age and education had selective influence—primarily on awareness and income—the effects of gender, caste, and location were statistically non-significant across all models.

## 4.3. Convergence of Qualitative and Quantitative Analysis

The convergence has qualitative and quantitative analysis is important for parallel convergent method of mix method design is given in **Table 5**. Studies have identify the relevance of it as essential for recognising numerical patterns and experiential accounts in human behaviour, policy execution, and socio-economic research, facilitating contextualisation and minimising the danger of misinterpretation [75, 76].

**Table 5.** Convergence Analysis of Quantitative and Qualitative Methodologies.

| No. | Variable | Sub Variable | Alignment | Remarks |
|---|---|---|---|---|
| 1 | Accessibility-1 | Use of KR | Fully Aligned | Both qualitative and quantitative findings align on high KR usage. |
| 2 | Accessibility-2 | Proximity of KR | Partially Aligned | Partially aligned, quantitative data shows proximity while qualitative highlights accessibility gaps. |
| 3 | Accessibility-3 | Challenges Faced while Booking the slot | Significantly Deficient | Qualitative highlights major slot booking issues; quantitative lacks granular breakdown. |
| 4 | Accessibility-4 | Service Delays in KR | Significantly Deficient | Service delays acknowledged qualitatively; quantitatively data lacks specificity. |
| 5 | Accessibility-5 | Staff Assistance in KR | Partially Aligned | Some staff assistance recognized, but inconsistencies in accessibility. |
| 6 | Affordability-1 | Cost Effectiveness of KRs vs Road Transportation | Fully Aligned | Cost-effectiveness confirmed both qualitatively and quantitatively. |
| 7 | Affordability-2 | Benefit from Subsidised Rate under KR Scheme | Fully Aligned | Strong alignment;<br>subsidy benefits are well documented in both approaches. |
| 8 | Affordability-3 | Enhanced Profit Margin and Cost Reduction | Partially Aligned | Profit margin improvement partially reflected in qualitative data. |
| 9 | Affordability-4 | Reasonableness of KR vs Private Transport | Partially Aligned | Quantitative data highlights pricing concerns; qualitative lacks specific cases. |
| 10 | Affordability-5 | Encounter to Hidden Charges and Unexpected Cost for KR | Significantly Deficient | Significant gaps in hidden cost identification between methods. |

Table 5. *Cont.*

| No. | Variable | Sub Variable | Alignment | Remarks |
|---|---|---|---|---|
| 11 | Awareness-1 | Basic Awareness about KR scheme | Partially Aligned | Awareness issues partially aligned; qualitative data stresses deeper gaps. |
| 12 | Awareness-2 | Access to information and guidance | Significantly Deficient | Limited access to guidance recognized in qualitative, but quantitative figures lack depth. |
| 13 | Awareness-3 | Requirement of more information | Significantly Deficient | Demand for information recognized but less emphasized quantitatively. |
| 14 | Awareness-4 | Awareness through Mass Media Channels | Significantly Deficient | Low engagement through mass media channels reflected across both. |
| 15 | Awareness-5 | Sufficiency of Outreach Program for KR | Significantly Deficient | Outreach strategies not sufficiently covered quantitatively. |
| 16 | Market Access-1 | Expansion to New or Distant Markets | Fully Aligned | Market access improvement strongly supported in both analyses. |
| 17 | Market Access-2 | Enhanced Network Buyers | Partially Aligned | Some increase in buyers noted quantitatively; qualitative data lacks specifics. |
| 18 | Market Access-3 | Bypassing of Middleman due to KR | Fully Aligned | Middleman reduction confirmed both qualitatively and quantitatively. |
| 19 | Market Access-4 | Ease of Transporting Bulk Quantity through KR | Partially Aligned | Bulk transportation ease partially acknowledged in qualitative data. |
| 20 | Market Access-5 | Timely Delivery of Agriculture Produce due to KR | Fully Aligned | Timely delivery impact fully reflected in both approaches. |

Source: Compiled by Author using Excel.

### 4.3.1. Similarities Between Qualitative and Quantitative Analysis

(1) Accessibility Constraints—Both datasets highlight infrastructural bottlenecks affecting KR scheme uptake. Quantitative FMLOGIT analysis shows a significant negative association between farmer type and accessibility ($\beta = -1.63$; $p = 0.000$), reinforcing qualitative reports of challenges such as KR booking difficulties and inadequate first-mile connectivity. Notably, 66.24% of farmers reported slot booking delays, which aligns with interview accounts of inconsistent train scheduling and logistical hurdles.

(2) Affordability and Cost Burden—Quantitative data reflects significant affordability gaps for small farmers ($\beta = -13.19$; $p = 0.000$), despite existing subsidies. This supports qualitative narratives that subsidies fail to cushion smallholders, while larger farmers find KR economically viable. For instance, 57.14% of large farmers view KR as cost-effective, compared to only 42.86% of small farmers.

(3) Market Access and Disintermediation – Both analyses indicate KR's role in enabling direct market access. Logistic regression reveals that small and medium farmers benefit significantly in market accessibility ($p \leq 0.014$), while qualitative responses confirm reduced reliance on middlemen. Quantitatively, 65.79% of small farmers reported enhanced market access, echoing qualitative data on 30%–40% reduction in intermediary involvement.

(4) Income Enhancement and Seasonal Utility—The FMLOGIT model confirms that larger and medium farmers see significant gains in income ($p < 0.01$), validating qualitative accounts that farmers experience profit improvements through reduced transport costs. Around 70% of users reported income enhancement, though both sources highlight seasonal variability as a limiting factor—reinforcing findings from earlier case-study-based research [12].

### 4.3.2. Variances Between Qualitative and Quantitative Analysis

(1) Awareness and Information Access—Quantitative results show significant awareness gaps among older farmers ($\beta = -0.97$; $p = 0.001$), and among smallholders, though functionally illiterate farmers showed surprising awareness benefits ($\beta = 0.29$; $p = 0.043$). In contrast, qualitative findings stress wider knowledge gaps, particularly among female and marginal farmers, revealing a broader awareness deficit than what statis-

tics capture.

(2) Gender Inclusion Disparities—While gender showed no significant effect in the regression models, qualitative insights highlight male dominance in scheme adoption. Quantitative data quantifies the gap (male: 47%–57%, female: 3%–14%), whereas qualitative inputs emphasize barriers such as mobility, decision-making autonomy, and lack of targeted outreach.

(3) Hidden Costs and Policy Transparency—Qualitative interviews noted unanticipated costs as a major adoption barrier. This is supported by quantitative findings, with 66.52% of medium farmers encountering hidden charges, confirming the financial opacity within KR implementation that the regression model does not fully capture.

(4) Implementation Gaps and Policy Discrepancies—While qualitative findings classify policy effectiveness into three tiers—fully aligned, partially realized, and deficient—quantitative models highlight specific areas (e.g., awareness and affordability) with low model fit (Pseudo $R^2 < 0.009$), pointing to deeper implementation inefficiencies not accounted for by the current variable set.

So, the convergence of both analytical approaches confirms that the KR scheme positively impacts affordability, market access, and income enhancement, validating hypotheses H3, H4, and H5. However, accessibility and affordability gaps persist, especially for smallholders, older farmers, and women, leading to rejection of hypotheses H1 and H2. These results call for targeted interventions, including subsidy restructuring [77], gender-responsive programming [78], and improved first/last-mile connectivity through digital platforms [79]. Overall, a combined methodological approach strengthens the policy relevance and operational insights drawn from the KR scheme evaluation.

The analysis from both qualitative and quantitative findings addresses the research questions and hypothesis and indicates the existence of several policy gaps that need to be addressed to enhance the effectiveness of the KR scheme. Under the KR scheme, rail-based solutions have been implemented to provide faster logistics support, ensuring timely and scheduled transportation of agricultural products. A major challenge in integrating subsidies under the Ministry of Food Processing and Industry's (MoSPI) Operation Green Top is the lack of clear subsidy slabs for different categories of farmers and to all crops, which limits inclusion [80, 81]. Furthermore, the GATI Shakti Mission should offer a more comprehensive logistics solution for the agricultural supply chain by incorporating both first- and last-mile connectivity, thus expanding the scope beyond the rail network [82]. Infrastructure development under the AMI scheme should not only focus on enhancing physical infrastructure but also integrate Central Warehouse Corporation and private storage facilities, offering subsidies to farmers. The incorporation of geo-spatial tagging, along with the use of real-time technological data on the availability of storage facilities, could improve the agricultural supply chain and significantly reduce post-harvest losses during rail-based logistics under the KR scheme [83]. Thus, there is a clear departmentalization of the scheme and its associated subsidies across various ministries and departments, it is essential to implement a more detailed action plan for each department. Additionally, the integration of a standardized, target-driven approach, incorporating Total Quality Management (TQM) and Cost of Inaction (COI), should be prioritized within the scheme to enhance its operational efficiency and effectiveness.

## 5. Limitation of the study

The study has used a comprehensive methodology to framework to derive the given results but still it has several limitation which should be acknowledge so that further research on KR scheme could enhance their findings. The limitation are the inheriting constrains of convergent parallel mix-method design, scope of study, use of analytical tools like cross tabulation, word cloud and triangulation analysis, to assess the effectiveness and efficiency of the KR scheme,

The use of parallel convergent mix-method research design its own limitation in terms of discrepancy in data interpretation and integration using both qualitative and quantitative methods. Such epistemological has been highlighted by Creswell and Clarke, 2007 discussing the disagreement between the qualitative narratives with quantitative measurements effecting the data coherence [40]. Though the current study has not encounter such issue but further studies should considered other systematic methodological approach. Secondly, the study scope is limited to MP which limits the generalizability of findings for the KR scheme, In India given the regional disparities among the federal states specially in terms of the agri-supply infrastructure [83], market dimensions [84], awareness levels [84], income levels [85] the outcome of the study will not reflect national trends .

The use of qualitative tools like word cloud and triangulation analysis also confront with validation issues earlier. The triangulation analysis though has robust cross verification process but does not guarantee comprehensive validation and some elements may be overlooked [85]. Furthermore, the word cloud captures frequency from the interviews which may ignore the contextual meaning and bring out misinterpreted key themes [85]. The quantitative technique of Pearson correlation, though useful in identifying linear relationships between variables, lacks the ability to establish causal direction or account for confounding variables [86]. Similarly, fractional logistic regression, while more robust in handling bounded dependent variables (between 0 and 1), is sensitive to issues of multicollinearity, omitted variable bias, and often assumes that relationships are consistent across the fractional range [87]. Unlike structural equation modelling or multilevel models, it may fail to account for latent constructs or hierarchical data structures [88]. Further refinement in model design, statistical control, and geographical coverage is needed to enhance causal inference and validate the broader impact of the KR scheme.

## 6. Conclusion

The primary aim of this study was to assess the effectiveness of the KR scheme in enhancing agricultural logistics, market access, and economic viability for farmers in India. The study explored critical aspects such as accessibility, affordability, awareness, market access, and income enhancement using a mixed-methods approach.

For this purpose, a convergent parallel mixed-methods design was adopted, allowing for the integration of qualitative insights with quantitative data. The study was conducted in a single-state setting, limiting generalizability but offering a micro-level perspective. The qualitative phase involved thematic analysis through focus group discussions (FGDs), interviews, and word cloud analysis, while the quantitative phase used structured surveys with a sample size of 388 farmers. Two independent teams collected the qualitative and quantitative data to ensure robustness and minimize bias. Data triangulation was employed to enhance validity.

The study analysed key variables, including KR usage, accessibility barriers, affordability, awareness, market access and income enhancement. The Pearson correlation analysis used reveals weaker correlations between social-economic and demographic factors like age, caste, education, gender, and type of farmers and core dimensional variables. The study suggests that larger farmers may not benefit from the KR scheme, as they have resources to access the market. Age and gender also show weak correlations, while education positively correlates with awareness and income enhancement. The findings suggest that interventions involving rail-based transportation must address structural inequalities and systemic barriers. Further validation was done using FMLOGIT analysis which examine the perceived effectiveness of the KR scheme using socioeconomic and demographic factors. The type of farmer was the most consistent significant factors across all models. This highlighted the centrality of land-based inequalities in shaping the effectiveness of the KR scheme. Further, it suggest that KR scheme has improved the affordability in agri-supply chain due the rail-based transportation in MP state. The smaller farmers who only education (able to sign) shows negative effects due to low quantity of produce causing higher transportation cost despite of subsidies provided by the GoI. Although the results shows market accessibility has not significantly improved but small, semi-medium and medium farmers has shown positive association. This indicates that these categories of farmers have been able to move beyond local market and explore far markets for selling their produce. Income enhancement has been seen slight improvement but with age having a negative effects across all the groups.

Despite of having some positive outcomes, the study identified significant limitations. Firstly, the quantitative techniques of Pearson correlation and fractional logistic regression lack the ability to establish causal direction or account for confounding variables. Secondly, limiting the study to a single state restricted the generalizability of findings, given the heterogeneity of agricultural infrastructure across states. Thirdly, while measures were taken to ensure data integrity, reconciling qualitative and quantitative datasets posed epistemological challenges. Lastly, the word cloud analysis, while effective in identifying key themes, lacked the depth to fully capture contextual nuances. Thus, further refinement in model design, statistical control, and geographical coverage is needed to enhance causal inference and validate the broader impact of the KR scheme in the country.

Future research should adopt a multi-state approach to capture broader national trends in KR's effectiveness. A longitudinal study across multiple states would help assess the scheme's long-term impact on farmer incomes and market access. Moreover, an exploration of digital integration in KR operations, such as online booking and real-time tracking, could further optimize its effectiveness. The study underscores the need for targeted policy interventions, including first-mile and last-mile connectivity improvements, enhanced farmer awareness programs across all the categories, and dynamic pricing models which should accommodate smaller and marginal farmers to ensure greater inclusivity and economic sustainability of the KR scheme for future policy intervention

## Author Contributions

Conceptualization, paper development, quantitative analysis, questionnaire development and convergent analysis, A.C.; concept development, literature review, qualitative analysis and semi-structured questionnaire development, W.N. All authors have read and agreed to the published version of the manuscript.

## Funding

This work received no external funding.

## Institutional Review Board Statement

Not applicable.

## Informed Consent Statement

Informed consent was obtained from all subjects in-volved in the study.

## Data Availability Statement

The datasets generated during and/or analysed during the current study are available from the corresponding author upon reasonable request.

## Acknowledgments

We acknowledge and express our gratitude to all the farmers, government officials, other stakeholders, re- search staff and field investigators of Madhya Pradesh state a because of whom the herculean task could be accomplished smoothly.

## Conflicts of Interest

The authors declare no conflict of interest.

## References

[1] Bureau of Research on Industry and Economic Fundamentals (BRIEF), 2018. Improving Rail Efficiency and Share in India's Freight Transport. Available from: https://www.niti.gov.in/sites/default/files/2023-03/Efficiency%20and%20

competitiveness%20of%20Indian%20Railways.pdf (cited 19 December 2024).
[2] Ministry of Finance, 2024. India's Services Landscape Witnesses Rapid Technology Driven Transformation in Domestic Services Delivery and Diversification of Exports. Available from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2034919 (cited 19 December 2024).
[3] Ministry of Railways, 2023. Indian Railways Year Book (2022–23). Available from: https://www.thehinducentre.com/resources/68976376-Resources_Year-Book.pdf (cited 19 December 2024).
[4] Union Finance, 2024. Agriculture Sector has Registered an Average Annual Growth Rate of 4.18 Per Cent Over the Last Five Years: Economic Survey. Available from: https://pib.gov.in/PressReleasePage.aspx?PRID=2034943 (cited 16 December 2024).
[5] Ornaghi, A., Budani, M., 2024. Effect of agricultural exports on India's economic development. International Journal of Financial Management and Economics. 7(1), 43–45. DOI: https://doi.org/10.33545/26179210.2024.v7.i1.258
[6] Department of Agriculture and Farmers Welfare, 2024. Department at Glance Available from: https://agriwelfare.gov.in/en/Dept#:~:text=Agriculture%20and%20Allied%20sector%20accounts,development%20in%20a%20sustainable%20manner (cited 20 December 2024).
[7] NABCONS, 2022. Study to determine post-harvest losses of agri produces in India. Available from: https://www.mofpi.gov.in/sites/default/files/study_report_of_post_harvest_losses.pdf (cited 21 December 2024).
[8] Parwez, S., 2016. A Conceptual Model for Integration of Indian Food Supply Chains. Global Business Review. 17(4), 834–850. DOI: https://doi.org/10.1177/0972150916645681
[9] Bureau of Research on Industry and Economic Fundamentals (BRIEF), 2023. Improving Rail Efficiency and Share in India's Freight Transport. Available from: https://www.niti.gov.in/sites/default/files/2023-03/Efficiency%20and%20competitiveness%20of%20Indian%20Railways.pdf (cited 13 September 2024).
[10] Department of Agriculture, Cooperation and Farmer's Welfare, 2018. Report on Doubling Farmers Income (Report No. 14). Available from: https://agriwelfare.gov.in/Documents/DFI_Volume_14.pdf (cited 21 December 2024).
[11] Statista, 2025. Commodities carried by Indian Railways as a share of production plus imports FY 2023. Available from: https://www.statista.com/statistics/1029255/india-commodities-carried-by-trains-share/ (cited 22 December 2024).
[12] Ministry of Railways, 2023. Indian Railways Year Book (2022–23). Available from: https://www.thehinducentre.com/resources/68976376-Resources_Year-Book.pdf (cited 19 December 2024).
[13] Ministry of Railways, 2020. National Rail Plan 2030. Available from: https://www.indembassy-tokyo.gov.in/public_files/assets/pdf/NRP.pdf (cited 16 December 2024).
[14] Press Indian Bureau (PIB), 2021. To boost farmers' income, additional commodities (Mandarin & Turmeric) included for the subsidy through Kisan Rail transportation. Available from: https://pib.gov.in/PressReleasePage.aspx?PRID=1697118 (cited 20 December 2024).
[15] Kohli, P., 2017. Railways mode of Transport for Cross-regional Trade of Perishable Agri-produce. Available from: https://www.nccd.gov.in/PDF/Railways%20and%20Cold-chain.pdf (cited 16 December 2024).
[16] Ministry of Agriculture & Farmers Welfare, 2024. Provision of storage facilities to farmers. Available from: https://pib.gov.in/PressReleasePage.aspx?PRID=2037655 (cited 20 December 2024).
[17] Ali, M.S., Singh, R., 2018. Passenger Transportation in Indian Railways: Facilities & Challenges. Journal of Commerce and Trade. 13, 83–92. DOI: https://doi.org/10.26703/JCT.V13I1-12
[18] Kapoor, A., Anand, M., Joshi, K., 2024. Infrastructure deficit in land transport infrastructure in India (EAC-PM Working Paper Series). Available from: https://eacpm.gov.in/wp-content/uploads/2024/05/Infrastructure_Deficit_In_Land_Transport.pdf (cited 22 December 2024).
[19] Lokesha, M.N., Mahesha, M., 2016. Impact of Road Infrastructure on Agricultural Development and Rural Road Infrastructure development programmes in India. International Journal of Humanities and Social Science Invention. 5(11), 1–7.
[20] Adam, S.A., Anthony, S.A., 2023. Economic Development and Agriculture in India. Available from: https://www.rba.gov.au/publications/bulletin/2011/jun/3.html (cited 21 December 2024).
[21] Negi, S., Anand, N., 2015. Cold chain: A weak link in the fruits and vegetables supply chain in India. The IUP Journal of Supply Chain Management. 12(1), 48–62.
[22] Chand, R., 2019. Transforming agriculture for challenges of 21st century. Available from: https://www.niti.gov.in/sites/default/files/2020-01/Presidential_Address.pdf (28 December 2024).

[23] Gulati, A., Das, R., Winter-Nelson, A., 2024. Reducing Post-Harvest losses in India. Available from: https://icrier.org/pdf/Reducing_Post-Harvest_Losses_in_India.pdf (cited 22 December 2024).
[24] Aggarwal, S., 2018. Do rural roads create pathways out of poverty? Evidence from India. Journal of Development Economics. 133, 375–395. DOI: https://doi.org/10.1016/j.jdeveco.2018.01.004
[25] World Bank, 2023. India: Issues and priorities for agriculture. Available from: https://www.worldbank.org/en/news/feature/2012/05/17/india-agriculture-issues-priorities (cited 24 December 2024).
[26] NITI Aayog, 2017. India: Three Year Action Agenda (2017–18 to 2019–20). Available from: https://www.niti.gov.in/sites/default/files/2023-03/Three-Year-Action-Agenda-2017-19.pdf (cited 22 December 2024).
[27] NITI Aayog, 2023. Gearing up to Solve Food Security Challenges: Building agritech ecosystem for the Global South. Available from: https://www.niti.gov.in/sites/default/files/2023-04/Report-UNCDF.pdf (cited 23 December 2024).
[28] The World Bank Group, 2015. Enabling The Business Of Agriculture (2015). Available from: https://documents1.worldbank.org/curated/en/674471468125681789/pdf/940330WP-0P145200of0Agriculture02015.pdf (cited 28 December 2024).
[29] Raut, R., Gardas, B., Narkhede, B., et al., 2019. Analysing the challenges in sustainable agricultural supply chain system in India. International Journal of Business Excellence. 18(3), 336–359.
[30] Kumar, G.C., Murugaiyan, P., Madanmohan, G., 2017. Agri-food supply chain management: Literature review. Intelligent Information Management. 9(2), 68–96. DOI: https://doi.org/10.4236/iim.2017.92004
[31] Minten, B., Kyle, S., 1999. The effect of distance and road quality on food collection, marketing margins, and traders' wages: evidence from the former Zaire. Journal of Development Economics. 60(2), 467–495. DOI: https://doi.org/10.1016/s0304-3878(99)00049-8
[32] Muto, M., Yamano, T., 2009. The Impact of Mobile Phone Coverage Expansion on Market Participation: Panel Data Evidence from Uganda. World Development. 37(12), 1887–1896. DOI: https://doi.org/10.1016/j.worlddev.2009.05.004
[33] Shamdasani, Y., 2021. Rural road infrastructure & agricultural production: Evidence from India. Journal of Development Economics. 152, 102686. DOI: https://doi.org/10.1016/j.jdeveco.2021.102686
[34] Negi, D.S., Birthal, P.S., Roy, D., et al., 2018. Farmers' choice of market channels and producer prices in India: Role of transportation and communication networks. Food Policy. 81, 106–121. DOI: https://doi.org/10.1016/j.foodpol.2018.10.008
[35] Saini, A., 2022. Kisan Rail: Contributing towards doubling farmers' income in India. Available from: https://www.globalrailwayreview.com/article/135294/kisan-rail-a-social-endeavour-of-indian-railways-to-contribute-towards-doubling-farmers-income/ (cited 28 December 2024).
[36] Ministry of Food Processing Industries (MoFPI), 2022. Study to Determine the Post Harvest Losses of Agri-Products in India. Available from: https://www.mofpi.gov.in/sites/default/files/study_report_of_post_harvest_losses.pdf (cited 21 November 2024).
[37] Singh, V., Borisagar, D., Singh, O.P., et al., 2024. Enhancing agricultural competitiveness: Harnessing Value Chains and Agro-Processing for Sustainable Growth. Available from: https://doi.org/10.4018/979-8-3693-4330-2.ch002 (cited 26 December 2024).
[38] Patel, D.K., Dwivedi, S., Lal, S.P., 2024. A 3600 status analysis of Doubling Farmers' Income Post stipulated deadline in India. International Journal of Theoretical & Applied Sciences. 16(1), 7–14.
[39] Dror, Y., 1972. Social Science Meta-policy. Available from: https://www.taylorfrancis.com/chapters/edit/10.4324/9781315014210-15/social-science-meta-policy-yehezkel-dror (cited 21 December 2024).
[40] Dror, Y., 1975. Some Features Of A Meta-Model For Policy Studies. Policy Studies Journal. 3(3), 247–255. DOI: https://doi.org/10.1111/j.1541-0072.1975.tb01314.x
[41] Dror, Y., 1970. Social science metapolicy: Some concepts and applications. Available from: https://www.rand.org/pubs/papers/P4372.html (cited 21 December 2024).
[42] Vekshin, A.S., Vekshina, O.I., 2021. Methodological Aspects Of Assessing The Effectiveness Of Program-Target Planning In Public Administration. Economics and Entrepreneurship. 1(38), 48240002. DOI: https://doi.org/10.34925/EIP.2022.138.1.054
[43] Barnow, B.S., Pandey, S.K., Luo, Q., 2024. How Mixed-Methods Research can Improve the policy relevance of impact evaluations. Evaluation Review. 48(3), 495–514. DOI: https://doi.org/10.1177/0193841x241227480
[44] Thompson, K., Cramer, R., LaPollo, A.B., et al., 2020. Using mixed methods and multidisciplinary research to strengthen policy assessments

focusing on populations at high risk for sexually transmitted diseases. Public Health Reports. 135(1_suppl), 32S–37S. DOI: https://doi.org/10.1177/0033354920931832

[45] Bohatá, M., Bédiová, M., Cebáková, A., et al., 2017. Measuring Social Effectiveness of Public Institutions: A contribution to Methodology. Available from: https://doi.org/10.1007/978-3-319-68285-3_2 (cited 30 December 2024).

[46] Bryman, A., 2006. Integrating quantitative and qualitative research: how is it done? Qualitative Research. 6(1), 97–113. DOI: https://doi.org/10.1177/1468794106058877

[47] Flick, U., 2018. Triangulation in data collection. In: Flick, U. (eds.). Triangulation in Data Collection. SAGE Publications Ltd.: Los Angeles, CA, USA. pp. 527–544.

[48] DePaolo, C.A., Wilkinson, K., 2014. Get Your Head into the Clouds: Using Word Clouds for Analyzing Qualitative Assessment Data. TechTrends. 58(3), 38–44. DOI: https://doi.org/10.1007/s11528-014-0750-9

[49] Nowell, S., White, J., Patton, M., 2017. Word Clouds: A Tool for Qualitative Policy Analysis. International Journal of Qualitative Methods. 16(1), 1-15. DOI: https://doi.org/10.1177/1609406917719359

[50] Mullahy, J., 2015. Multivariate fractional regression estimation of econometric share models. Journal of Econometric Methods. 4(1), 71–100. DOI: https://doi.org/10.1515/jem-2012-0006

[51] Habib, N., Rankin, P., Alauddin, M., et al., 2023. Determinants of livelihood diversification in rural rain-fed region of Pakistan: Evidence from fractional multinomial logit (FMLOGIT) estimation. Environmental Science and Pollution Research. 30, 32791–32808. DOI: https://doi.org/10.1007/s11356-022-23040-6

[52] Papke, L.E., Wooldridge, J.M., 1996. Econometric methods for fractional response variables with an application to 401(k) plan participation rates. Journal of Applied Econometrics. 11(6), 619–632. DOI: https://doi.org/10.1002/(SICI)1099-1255(199611)11:6<619::AID-JAE418>3.0.CO;2-1

[53] von Wyl, V., Bonhoeffer, S., Bugnion, E., et al., 2020. A research agenda for digital proximity tracing apps. Swiss Med Wkly. 150, w20324. DOI: https://doi.org/10.4414/smw.2020.20324

[54] Creswell, J.W., Clark, V.L.P., 2007. Analysis and Interpreting Data in Mix Method Research (Chapter 7). In Designing and conducting mixed methods research. Sage Publications: Los Angeles, CA, USA. pp. 209-258.

[55] Press India Bureau, 2023. Railways have operated around 2,359 Kisan Rail services till January, 2023. Available from: https://pib.gov.in/PressReleasePage.aspx?PRID=1897375 (cited 11 November 2024).

[56] Cyr, J., 2015. The pitfalls and promise of focus groups as a data collection method. Sociological Methods & Research. 45(2), 231–259. DOI: https://doi.org/10.1177/0049124115570065

[57] Rahman, M.M., 2023. Sample Size Determination for Survey Research and Non-Probability Sampling Techniques: A Review and Set of Recommendations. Journal of Entrepreneurship, Business and Economics. 11(1), 42–62.

[58] Castleberry, A.N., Nolen, A., 2018. Thematic analysis of qualitative research data: Is it as easy as it sounds? Currents in Pharmacy Teaching & Learning. 10(6), 807–815. DOI: https://doi.org/10.1016/j.cptl.2018.03.019

[59] Hendrickson, C., Matthews, H.S., Cicas, G., 2006. Analysis of Regional Supply Chain Economic and Environmental Effects of Expansion of the U.S. Freight Rail System. Journal of Infrastructure Systems. 12(3), 123–130. DOI: https://doi.org/10.1061/40799(213)123

[60] Liu, R., Stefanovich, A., Kaewunruen, S., 2021. Sensitivity of a High-Speed Rail Development on Supply Chain and Logistics via Air-Rail-Road Freight Transportation. Frontiers in Built Environment. 7, 685884. DOI: https://doi.org/10.3389/fbuil.2021.685884

[61] Pallant, J., 2020. SPSS survival manual: A step by step guide to data analysis using IBM SPSS (7th ed.). McGraw-Hill Education: Columbus, OH, USA. pp. 126–139.

[62] Field, A., 2013. Discovering statistics using IBM SPSS statistics (4th ed.). Sage Publications: Los Angeles, CA, USA. pp.271–274.

[63] Dancey, C.P., Reidy, J., 2017. Statistics without maths for psychology (7th ed.). Pearson Education: London, UK. pp. 384–403.

[64] Carlucci, F., Corcione, C., Mazzocchi, P., et al., 2021. The role of logistics in promoting Italian agribusiness: The Belt and Road Initiative case study. Land Use Policy. 108, 105660. DOI: https://doi.org/10.1016/j.landusepol.2021.105560

[65] Baffoe, G., Zhou, X., Moinuddin, M., et al., 2021. Urban–rural linkages: Effective solutions for sustainable development in Ghana. Sustainability Science. 16, 1133–1148. DOI: https://doi.org/10.1007/s11625-021-00929-8

[66] Sinha, B., Ghosh, M., 2019. Institutional imperatives for promoting trees outside forests (TOFs) to enhance timber production in India. Small-scale Forestry. 18, 333–349. DOI: https://doi.org/10.1007/s11842-018-9407-4

[67] Ricciolini, E., Tiralti, A., Paolotti, L., et al., 2024. Sustainable development according to 2030 Agenda in EU countries. Sustainable Development. 32(3), 1894–1912. DOI: https://doi.org/10.1002/sd.2758

[68] Semenza, J.C., Hall, D.E., Wilson, D.J., et al., 2008.

Public perception of climate change: voluntary mitigation and barriers to behavior change. Am J Prev Med. 35(5), 479–487. DOI: https://doi.org/10.1016/j.amepre.2008.08.020

[69] Chamberlin, J., Jayne, T.S., 2013. Unpacking the meaning of 'market access': Evidence from rural Kenya. World Development. 41, 245–264. DOI: https://doi.org/10.1016/j.worlddev.2012.06.004

[70] Doss, C., Kovarik, C., Peterman, A., et al. 2015. Gender inequalities in ownership and control of land in Africa: Myths versus reality. Agricultural Economics. 46(3), 403–434. DOI: https://doi.org/10.1111/agec.12171

[71] Aker, J.C., 2011. Dial "A" for agriculture: A review of information and communication technologies for agricultural extension in developing countries. Agricultural Economics. 42(6), 631–647. DOI: https://doi.org/10.1111/j.1574-0862.2011.00545.x

[72] Barrett, C.B., 2008. Smallholder market participation: Concepts and evidence from eastern and southern Africa. Food Policy. 33(4), 299–317. DOI: https://doi.org/10.1016/j.foodpol.2007.10.005

[73] Asfaw, S., Shiferaw, B., Simtowe, F., et al., 2012. Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. Food Policy. 37(3), 283–295. DOI: https://doi.org/10.1016/j.foodpol.2012.02.013

[74] World Bank, 2007. World development report 2008: Agriculture for development. Available from: https://documents1.worldbank.org/curated/en/587251468175472382/pdf/41455optmzd0PA18082136807701PUBLIC1.pdf (cited 28 December 2024.

[75] Higgins, A., McFallan, S., Marinoni, O., et al., 2018. Informing transport infrastructure investments using TraNSIT: A case study for Australian agriculture and forestry. Computers and Electronics in Agriculture. 154, 187–203. DOI: https://doi.org/10.1016/j.compag.2018.09.008

[76] Schroeder, M., Braun, I., Schnieder, E., 2000. Modern revenue management strategies for railway slots. IFAC Proceedings Volumes. 33(9), 141–146. DOI: https://doi.org/10.1016/s1474-6670(17)38137-5

[77] Östlund, U., Kidd, L., Wengström, Y., et al., 2011. Combining qualitative and quantitative research within mixed method research designs: A methodological review. International Journal of Nursing Studies. 48(3), 369–383. DOi: https://doi.org/10.1016/j.ijnurstu.2010.10.005

[78] Vaishnav, H., Divi, S., Reddy Minampati, V.R., et al., 2024. Increasing Role of Women in Agriculture: Unveiling Perceived Impact of the Pradhan Mantri Fasal Bima Yojana (PMFBY) Scheme using Multivariate Regression Approach. Research on World Agricultural Economy. 5(4), 620–636. DOI: https://doi.org/10.36956/rwae.v5i4.1278

[79] Akber, N., Paltasingh, K.R., Mishra, A.K., 2022. How can public policy encourage private investments in Indian agriculture? Input subsidies vs. public investment. Food Policy. 107, 102210. DOI: https://doi.org/10.1016/j.foodpol.2021.102210

[80] Janarthanan, B.S., 2024. Saving farm subsidies with smart climate interventions: the case of transition to a millet-based agriculture. China Agricultural Economic Review. 16(2), 249–266. DOI: https://doi.org/10.1108/caer-05-2023-0129

[81] Kumar, P., Kumbhare, N.V., Nain, M.S., et al., 2023. Factors for Value Realization of Tomato, Onion, and Potato (TOP) under Operation Greens Using DEMATEL Method. Indian Journal of Extension Education. 59(4), 72–76. DOI: https://doi.org/10.48165/ijee.2023.59415

[82] Singh, S., Manoharan, S., n.d. PM Gati Shakti National Master Plan: India's Move Towards 5 Trillion Dollar Economy. Google Scholar. Available: https://www.researchgate.net/profile/Dhanabalan-Thangam/publication/378076254_On_INDIA'S_5_TRILLION_ECONOMY_THE_VISION_CHALLENGES_AND_ROADMAP_5TE-2024/links/65c5b8fc1bed776ae337b8cf/On-INDIAS-5-TRILLION-ECONOMY-THE-VISION-CHALLENGES-AND-ROADMAP-5TE-2024.pdf#page=265 (cited 22 December 2024).

[83] Kaur, P., Dhillon, S.S., 2017. Disparities in Agriculture Income Across the Indian States. In: Bathla, S., Dubey, A. (eds.). Changing Contours of Indian Agriculture. Springer: Singapore. pp. 133–148.

[84] Nowell, L.S., Norris, J.M., White, D.E., et al., 2017. Thematic Analysis: Striving to Meet the Trustworthiness Criteria. International Journal of Qualitative Methods. 16(1). DOI: https://doi.org/10.1177/1609406917733847

[85] Agresti, A., 2013. Statistical Inference for a Proportion. In Categorical data analysis (3rd ed.). John Wiley & Sons: Hoboken, NJ, USA. pp. 5–10.

[86] Schober, P., Boer, C., Schwarte, L.A., 2018. Correlation coefficients: appropriate use and interpretation. Anesthesia & Analgesia. 126(5), 1763–1768. DOI: https://doi.org/10.1213/ANE.0000000000002864

[87] Papke, L.E., Wooldridge, J.M., 1996. Econometric methods for fractional response variables with an application to 401(k) plan participation rates. Journal of Applied Econometrics. 11(6), 619–632. DOI: https://doi.org/10.1002/(SICI)1099-1255(199611)11:6<619::AID-JAE418>3.0.CO;2-1

[88] Long, J.S., Freese, J., 2014. Regression Models for Categorical Dependent Variables Using Stata (3rd ed.). Stata Press: College Station, TX, USA. pp. 344–405.