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Role of Institutions in Agriculture and Food Security: A Social Network Analysis of the Bonda Tribal Communities of Odisha, India

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HIGHLIGHTS

- Social capital, local leadership, and community trust were critical mediators of institutional effectiveness.
- Institutional interventions focused on input delivery but lacked cultural sensitivity and participatory governance.
- Cross-institutional convergence and community-led approaches were essential for building resilient tribal food systems.

ARTICLE INFO

Keywords: Bonda, Agriculture, Food security, Culture, Institution.

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ABSTRACT

The study focuses on the Bonda tribe, a Particularly Vulnerable Tribal Group (PVTG) residing in the ecologically fragile Bonda Hills of Odisha, India. It explores the transformative role of institutions in agriculture and food security across three altitudinally distinct villages, Kadamguda, Badbel, and Andrahal, using a sequential exploratory mixed-method approach. Tools like focus group discussions, participatory rural appraisal, household surveys, and social network analysis were employed to map institutional presence and community interaction. Findings reveal varying levels of social cohesion and institutional embeddedness. Kadamguda demonstrates strong intra-village ties and effective institutional linkages, while Badbel and Andrahal reflect weaker community networks despite broader institutional outreach. The Bonda Development Agency (BDA) emerges as a pivotal actor connecting tribal households with service providers such as Integrated Tribal Development Agency (ITDA), Watershed Support Services and Activities Network (WASSAN), Madhyam, and the Agriculture Department, Government (Govt.) of Odisha. The study highlights that institutional presence alone is insufficient; local leadership, social capital, and community trust critically shape outcomes. For institutions to be effective, interventions must prioritise cultural sensitivity, participatory governance, and inter-agency convergence. Strengthening institutional responsiveness alongside local social networks is essential for building resilient, community-driven food systems in tribal regions.

INTRODUCTION

Institutions play a pivotal role in transforming agriculture and ensuring food security, particularly in regions marked by socio-economic vulnerabilities and ecological fragility (Nicoletis et al., 2019; Tambo et al., 2023). Across the globe, institutions ranging from state departments, cooperatives, and non-governmental organisations to grassroots organisations serve as vital channels through which farmers access inputs, credit, knowledge, infrastructure, and markets. (Kindness & Gordon, 2001).The institutions adopt a diverse set of priorities, acknowledging the multifaceted nature of entrepreneurial support (Kademani et al., 2024). Institutions have a synergising effect and effect on common programmes and activities (Singh et al., 2014). Institutions act as

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innovation mediators and facilitators of long-term resilience (Li et al., 2024). Their effectiveness, adaptability, and coordination determine the extent to which marginalised communities are empowered to overcome constraints and achieve food and livelihood security (Reid, 2017). The significance becomes even more pronounced in tribal and remote regions, where structural challenges such as geographic isolation, limited extension outreach, low literacy, and poor infrastructure hinder the flow of development benefits (Yoganandham, 2024; Lahiri et al., 2024). In such settings, institutional interventions serve as transformational mechanisms that bridge the divide between tradition and modernity (Adefila et al., 2024; Su et al., 2023), their ability to engage meaningfully with communities determines the success of agriculture-based livelihood interventions (Rout et al., 2020; Tambe, 2022; Chandegara et al., 2024).

In India, tribal communities continue to face chronic food insecurity despite a range of welfare schemes and agricultural programmes (Patel, 2025; Pindus & Hafford, 2019). Odisha, home to 13 Particularly Vulnerable Tribal Groups (PVTGs) (Das & Bose, 2015), offers a relevant setting to explore the role of institutions in addressing these issues (Panda et al., 2015). Many tribal communities rely on subsistence farming, shifting cultivation (*podu*), and forest-based livelihoods (Prateek & Punia, 2025; Rath, 2015; Hazari et al., 2023), and often integrated farming systems (Suman et al., 2025). These systems, though locally adapted, are increasingly stressed by environmental degradation (Das et al., 2022) and lack of institutional support (Aggarwal et al., 2009). Addressing food security in such areas demands institutions that are locally responsive and culturally appropriate (Brooks & Loevinsohn, 2011; Pothukuchi, 2004; Sari & Muslim, 2024).

The Bonda tribe, residing in the remote hills of Malkangiri district in southern Odisha, represents one such PVTG (Bhoi & Acharya, 2024) that depends on traditional agricultural practices, backyard farming, and non-timber forest products for its livelihoods (Altieri & Koohafkan, 2008; Pandey et al., 2016; Sahoo et al., 2023; Venugopal et al., 2019). Several government and non-governmental institutions operate in the region, including the Bonda Development Agency (BDA) (Anuradha, 2019), Integrated Tribal Development Agency (ITDA) (Bose et al., 2008), Agriculture and Horticulture departments, Govt. of Odisha, and NGOs such as WASSAN (Viswanath, 2021) and Madhyam (Madhyam Foundation, 2024) have introduced millet promotion and nutrition-sensitive farming interventions. However, disparities in outreach, consistency, and cultural integration raise concerns about the actual impact of these efforts on agricultural sustainability and food security (Renzaho & Mellor, 2010; Pavana Kumar et al., 2024). Despite a visible institutional presence, limited research has explored how these linkages function in practice and how communities perceive and interact with them (Kilpatrick et al., 2003).

METHODOLOGY

The study was conducted in the Bonda Hills of Khairaput block in Malkangiri district, Odisha, where the Bonda tribe, a Particularly Vulnerable Tribal Group (PVTG), resides in geographically isolated and culturally distinct hilltop villages. A sequential exploratory mixed-method research design was adopted, in which qualitative insights gathered during the initial phase guided the development of quantitative tools. The study area was purposively selected due to its ecological diversity and socio-cultural uniqueness. Three villages (hamlets) were chosen to represent varying altitudinal zones (i.e., 900 metres, 1000 metres and 1050 metres respectively) with different levels of resource access and institutional support: Kadamguda (Lower Bonda Hills), Badbel (Middle Bonda Hills), and Andrahal (Upper Bonda Hills). The sampling frame with the population size of 270 was developed in consultation with local stakeholders, including Panchayats, Self-Help Groups (SHGs), and the Bonda Development Agency (BDA), to ensure that different household types (e.g., male- and female-headed, migrant and non-migrant) were represented. A total of 270 households were surveyed, with 90 respondents from each hamlet, allowing for ecological and institutional comparison across the zones. Data collection involved both primary and secondary sources. Primary data were collected using structured household surveys to gather information on agricultural practices, food security, and institutional interactions, Participatory Rural Appraisal (PRA) techniques (Resource map, seasonal diagram, mobility map, Spider diagram for decisive roles) to explore community resource use and seasonal patterns, Focus Group Discussions (FGDs) to capture group-level insights, and Key informant interviews with village elders, institutional representatives and extension officials to understand governance and support structures. Secondary data were sourced from government publications, census and statistical handbooks, academic literature, and reports from organisations like FAO, UNDP, and ICAR to supplement and validate the field findings. Data were analysed using social network analysis (SNA) through UCINET software. This mixed-method and multi-source approach enabled a holistic understanding of how institutions influence agriculture and food security in the context of the Bonda tribal community. It investigates whether institutions are effectively contributing to agricultural transformation and food security or whether systemic gaps remain in their design and delivery. Through a context-specific case study, the research seeks to provide empirical evidence that can guide more inclusive, participatory, and sustainable development strategies in tribal regions.

RESULTS

The sociograms (Figures 1, 2 & 3 along with Table 1) represent the social and institutional network structures for 90 respondents each from the Bonda tribal villages of Kadamguda (Lower Bonda Hill), Badbel (Middle Bonda Hill) and Andrahal (Upper Bonda Hill) (Kumari et al., 2024). Each graph shows that every individual is socially connected and they are linked to key institutions working to promote agriculture and food security.

Network structure and interpretation

Kadamguda (Lower bonda hill): In Kadamguda, the village-level social network exhibits a well-connected institutional ecosystem. The village node, represented in green (Table 1), maintains direct connections with several key institutions, including the Bonda Development Agency (BDA), marked in red, which serves as the central authority for tribal development, the Integrated Tribal

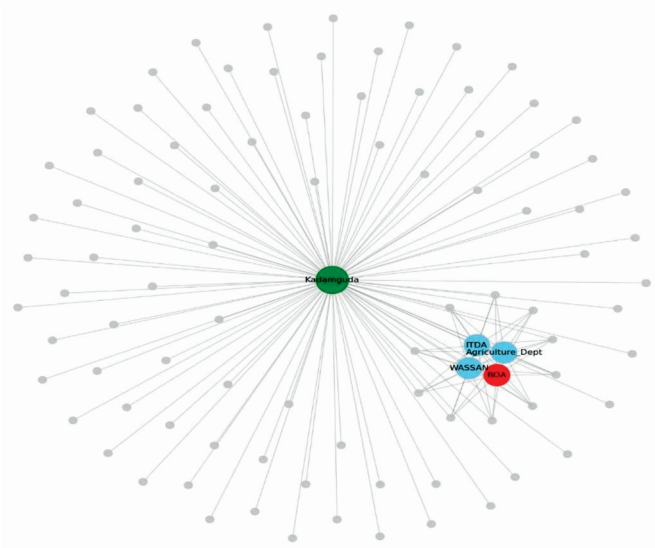

Figure 1. Social Network Analysis: Institutional role in promoting agriculture & ensuring food security in Kadamguda (Lower Bonda Hill)

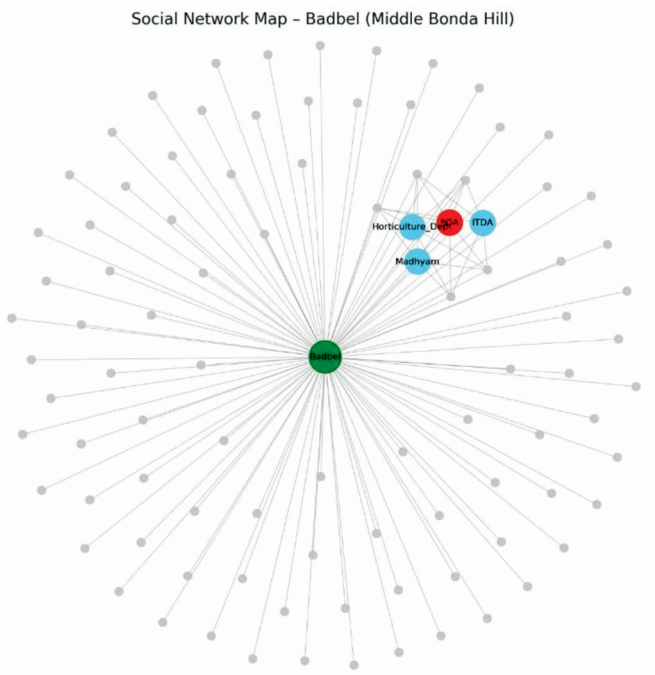

Figure 2. Social Network Analysis: Institutional role in promoting agriculture and ensuring food security in Badbel (Middle Bonda Hill)

Table 1. Nodes and colour coding (Figures 1, 2 & 3)

Colour	Represents
Green	Village centre node (Kadamguda, Badbel, Andrahal)
Red	BDA (Bonda Development Agency)–key institution
Sky Blue	Other institutions (ITDA, Agriculture Dept (Govt. of Odisha), etc.)
Light Grey	Individual respondents (P1 to P90 in each village)

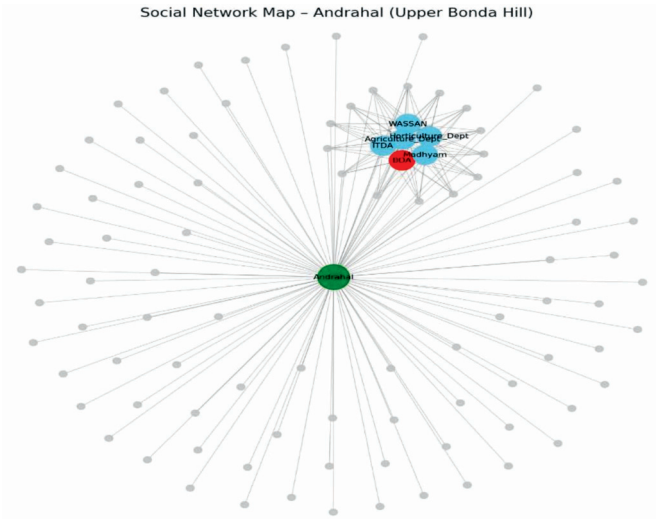

Figure 3. Social Network Analysis: Institutional role in promoting agriculture and ensuring food security in Andrahal (Upper Bonda Hill)

Development Agency (ITDA), responsible for implementing infrastructure projects and various tribal welfare schemes, the Department of Agriculture, which provides seeds, inputs and extension services and WASSAN, a civil society organization focused on promoting sustainable agricultural practices and millet-based farming (Table 2). Within the village, approximately 90 individuals are interconnected in a dense intra-village network, each person maintaining 2 to 5 social links. Many individuals also have direct ties with institutions, especially BDA and WASSAN, indicating active community participation in institutional programmes. This configuration reflects a well-functioning institutional interface, with BDA and WASSAN being particularly embedded in the community social ecosystem, enabling effective outreach and program delivery in agricultural development.

Badbel (Middle bonda hill): The institutional linkages in Badbel include BDA, ITDA, the Horticulture Department, Govt. of Odisha and the NGO Madhyam. The Horticulture Department, Govt. of Odisha is engaged in promoting backyard gardens and fruit tree cultivation, while Madhyam focuses on participatory communication and community awareness (Table 2). The village network comprises 90 individuals who are organised in natural clusters based on kinship and neighbourhood ties. Compared to Kadamguda, the institutional connections in Badbel appear less deep. Although BDA maintains a central role, the Horticulture Department, Govt. of Odisha and Madhyam show limited penetration across the broader population, suggesting either lower community awareness of these institutions or sporadic outreach efforts. This indicates that while there are communication and horticultural interventions present, the overall effectiveness and integration of institutions in Badbel may be constrained by uneven institutional visibility and engagement.

Andrahal (Upper bonda hill): Among the three villages, Andrahal exhibits the highest institutional link density. It is connected to all six key institutions identified in the study, that is, BDA, ITDA, the Departments of Agriculture and Horticulture (Govt. of Odisha),

WASSAN and Madhyam, highlighting targeted outreach efforts, likely due to the village's heightened vulnerability and remote location. Direct institutional ties with villagers are particularly strong for BDA, WASSAN, and Madhyam, reflecting active involvement in programmes such as Self-Help Groups (SHGs), millet promotion projects, and community awareness initiatives (Table 2). However, despite this strong institutional presence, the interpersonal network among the 90 respondents appears relatively loose, indicating lower levels of social cohesion. This fragmentation may be due to physical inaccessibility arising from challenging terrain or other socio-cultural factors. The weaker social ties could hinder collective action and affect the long-term sustainability of externally introduced programs. Nevertheless, institutions like WASSAN and Madhyam seem to be playing crucial bridging roles, helping to connect dispersed individuals and facilitate program participation in the absence of strong community bonding.

Based on the detailed centrality scores, provided for the three Bonda villages, Andrahal, Badbel, and Kadamguda, the role of key institutions and the level of embeddedness of the village node in each network are interpreted and analysed. These scores are organised under Table 2 and offer valuable insights into how information, services, and interventions flow within each community. Andrahal shows a highly institutionalised network, with five institutions equally central in terms of direct connectivity (degree centrality = 0.1146). The presence of both government (BDA, ITDA, Agriculture Department) and non-governmental actors (WASSAN, Madhyam) reflects a strong top-down and lateral outreach. However, the village node itself (Andrahal) has lower centrality, suggesting that while interventions exist, community-level cohesion or leadership engagement may be weak. This highlights a structural dependency on institutions, potentially limiting sustainability unless social capital within the village is strengthened. In Badbel, institutional involvement is more sectoral, focusing on horticulture and communication (Madhyam). Both WASSAN and the Agriculture Dept., Govt. of Odisha have no presence, indicating programmatic gaps in food systems sustainability. While all engaged institutions are equally central in terms of degree, Madhyam has the highest betweenness, implying a significant role in knowledge mediation and communication. The village node itself remains peripheral, pointing to a top-heavy structure where interventions are institutionally driven, but not necessarily community-embedded. Kadamguda reflects a more agriculture-focused network, with strong engagement from BDA, ITDA, Agriculture Dept (Govt. of Odisha), and WASSAN. The Agriculture Department shows the highest betweenness, signifying its influence in bridging various actors and possibly playing a key role in promoting improved cultivation practices and input delivery. Although the village node is not as central as the institutions, it has slightly higher centrality than in Badbel, indicating moderate internal connectivity. The absence of Horticulture and Madhyam suggests a lack of emphasis on nutrition gardens and communication-based capacity building.

Table 2. Centrality scores

Node	Degree Centrality	Betweenness Centrality
Andrahal		
BDA	0.1146	0.0282
ITDA	0.1146	0.0276
Agriculture Dept	0.1146	0.0291
WASSAN	0.1146	0.029
Madhyam	0.1146	0.0272
Andrahal	0.0521	0.0047
Horticulture Dept	0.0	0.0
Badbel		
BDA	0.1146	0.0259
ITDA	0.1146	0.0298
Horticulture Dept	0.1146	0.0294
Madhyam	0.1146	0.031
Badbel	0.0417	0.0027
Agriculture Dept	0.0	0.0
WASSAN	0.0	0.0
Kadamguda		
BDA	0.1146	0.028
ITDA	0.1146	0.0275
Agriculture Dept	0.1146	0.0305
WASSAN	0.1146	0.0249
Kadamguda	0.0417	0.0026
Horticulture Dept	0.0	0.0
Madhyam	0.0	0.0

DISCUSSION

The Social Network Analysis (SNA) of the Bonda tribal villages: Kadamguda, Badbel, and Andrahal, reveals critical insights into how institutional structures, particularly the Bonda Development Agency (BDA), shape the dynamics of agriculture development and food security in remote, vulnerable tribal geographies. The BDA, created specifically under the Integrated Tribal Development framework of the Government of Odisha, emerges as the most structurally central and influential actor in all three sociograms, with consistently high degree and betweenness centrality scores, functioning as a bridge between various departments (e.g., Agriculture, Horticulture, ITDA) and the tribal population. In line with Anuradha (2020) and the PVTG development strategy of the Ministry of Tribal Affairs, Govt of India, BDA's mandate includes ensuring access to basic services, livelihood support, and participatory planning in areas where mainstream institutions often falter due to logistical or cultural disconnects.

Table 3. Cross-village comparison: Institutional reach and network dynamics

Factor	Kadamguda	Badbel	Andrahal
Institutional Diversity	Moderate (4)	Moderate (4)	High (6)
BDA Centrality	High	High	High
Individual-Institution Links	Strong	Moderate	Highest
Intra-village Social Cohesion	High	Moderate	Low to Moderate
Focus Institutions	BDA, WASSAN	BDA, Madhyam	BDA, WASSAN, Madhyam

In Kadamguda, BDA's position as a central node directly connected to a large number of individual respondents signifies effective last-mile institutional delivery, particularly in agricultural input distribution, Public Distribution System (PDS) facilitation, and program awareness. This direct linkage is crucial in tribal regions where formal education is limited and dependency on oral communication and community influence is high. BDA's ability to embed itself within the social fabric enhances the uptake of millet promotion programs, kitchen garden schemes, and input subsidies, corroborating the findings of WASSAN's millet mission reports (Sreekanth, 2021), which highlight institutional proximity as a key factor for tribal farming revival. The role of BDA becomes more complex in Badbel and Andrahal. In Badbel, while BDA retains its formal centrality, the community-institution interface is more fragmented, with limited inter-individual ties. This may reflect a partial engagement model, where institutional presence is visible but community participation is mediated by local leaders or influencers, a phenomenon explored in Narayan's (2002) concept of "mediated trust." In Andrahal, located in the upper reaches of the Bonda hills and known for its socio-geographic isolation, BDA exhibits the broadest institutional connectivity, including collaboration with ITDA, Agriculture Department, WASSAN, and Madhyam. Yet, its impact appears diluted due to sparse community cohesion. This paradox aligns with Scoones' (1998) Sustainable Livelihoods Framework, which argues that institutional capital alone cannot guarantee sustainable outcomes if social capital (community trust, networks, and participation) is weak. The BDA, despite its effort to engage more actors and deliver multi-sectoral support, faces limitations in catalysing behavioural change or collective action without a corresponding strengthening of intra-community bonds.

In all three villages, BDA's influence is amplified or constrained by its relationship with knowledge partners like WASSAN and communication-focused NGOs like Madhyam. In Andrahal, where WASSAN's presence in agroecology and Madhyam's role in participatory awareness are more pronounced, BDA appears to serve as a platform for convergence, facilitating integrated and context-specific interventions. This layered interaction mirrors Klerkx & Leeuwis's (2009) concept of innovation intermediaries, where institutions like BDA become not just service providers but enablers of innovation networks. Yet, the success of such a role depends heavily on how embedded BDA is within the social networks of the community, not just administratively but relationally. The BDA's position as a high-centrality actor must be viewed not just through its quantitative network metrics but through its qualitative role as a boundary-spanner linking formal state mechanisms with informal tribal governance, aligning top-down schemes with bottom-up priorities. When BDA manages to maintain frequent interaction, inclusive planning, and responsive grievance redressal, it strengthens not only programme delivery but also community trust and collective efficacy, essential for food security outcomes. But when its engagement becomes transactional or superficial, even a structurally central position may yield minimal transformative change, as seen in villages with weak horizontal ties.

CONCLUSION

The vital but complex role that institutions play in transforming agriculture and guaranteeing food security was highlighted. The social fabric and community dynamics of each village have a significant impact on the effectiveness of agricultural interventions, even though organisations like the Bonda Development Agency, ITDA, and NGOs like WASSAN and Madhyam are essential, and BDA is the indispensable institutional backbone for agriculture and food security interventions. Cohesive social networks and solid institutional ties have improved programme delivery in *Kadamguda*, however, *Badbel* and *Andrahal e*xhibited limited community engagement despite having a larger institutional presence due to weaker intra-village ties and fragmented social cohesion, hence, coordination ought to be handled by the Bonda Development Agency. ITDA and NGOs like Madhyam and WASSAN may promote social cohesion and offer technical assistance. The agriculture and horticulture departments must make sure that funds are distributed, and encourage farming methods that can withstand climate challenges.

DECLARATIONS

Ethics approval and informed consent: Informed consent was sought from the farmer respondents of the study during the course of the research.

Conflict of interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The authors declare that during the preparation of this work, thoroughly reviewed, revised, and edited the content as needed. The authors take full responsibility for the final content of this publication.

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