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Assessing the Influence of Farmer Social Networks on the Efficacy of Climate Changes in Agricultural Settings

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Abstract: In the face of escalating climate change impacts on agriculture, understanding the mechanisms by which farmers adapt and mitigate becomes imperative. This study investigates the role of farmer social networks in shaping adaptive capacities and resilience within agricultural communities. Employing a mixed-methods approach, including surveys and network analyses, we examine how information flows, resource sharing, and collective action dynamics within social networks influence farmers' responses to climate variability and change. Drawing on data from diverse agricultural settings, our findings shed light on the nuanced interplay between social networks and climate adaptation strategies. By elucidating the pathways through which social networks facilitate or constrain adaptive behaviors, this research offers valuable insights for enhancing the effectiveness of climate change interventions and fostering sustainable agricultural development. The research findings indicate that a minority of respondents, specifically 23% and 11%, lack access to financial services and climate adaptation knowledge, respectively. Assistance to farmers primarily encompasses dissemination of marketing information and provision of farm equipment by community-based organizations, whereas private institutions supply weather forecasting services. Public institutions exhibit limited presence in the network analysis. Additionally, extension services emerge as pivotal entities in the climate adaptation network, whereas agricultural credits, post-harvest services, and produce marketing dominate but exhibit weak interconnections in the financial support network. Moreover, the study reveals that as farm-level service provision increases, farmers not only enhance their adaptation efforts but also transition from low-cost and short-term measures to more advanced strategies. To enhance stakeholder networking and bolster adaptation to climate change, this study advocates for an integrated framework that fosters partnerships across various sectors.

Keywords: Farmers social networking, agricultural policy, climate change mitigation.

1. Introduction

Climate change poses significant challenges to agriculture in Bangladesh, a country highly vulnerable to its impacts due to its geographic location, low-lying topography, dense population, and reliance on agriculture as a primary livelihood source. Bangladesh is confronted with a multitude of climate-related hazards, including rising temperatures, changing rainfall patterns, increased frequency and intensity of extreme weather events such as cyclones and floods, and sea-level rise (Piya et al. 2022)

One of the most pressing concerns for agriculture in Bangladesh is the altered precipitation patterns, which lead to both droughts and floods. Erratic rainfall affects crop cultivation, causing crop failures, reduced yields, and loss of livelihoods for millions of farmers. Moreover, prolonged dry spells exacerbate water scarcity, threatening irrigation systems and water management practices crucial for crop production. Sea-level rise poses another grave threat, especially in coastal regions where salinization of soil and intrusion of saltwater into freshwater sources degrade agricultural lands, rendering them unsuitable for cultivation. This phenomenon not only reduces arable land but also jeopardizes food security by diminishing crop productivity and compromising the livelihoods of coastal communities dependent on agriculture (Asfaw et al. 2018; Jin et al. 2019.

Furthermore, the increased frequency and intensity of tropical cyclones, a consequence of climate change, result in widespread destruction of crops, infrastructure, and livelihoods. Cyclones often lead to saline inundation, crop damage, and soil erosion, exacerbating the vulnerability of farmers and communities already struggling with poverty and resource constraints. In response to these challenges, Bangladesh has been implementing various adaptation strategies to build resilience in the agricultural sector. These include promoting climate-resilient crop varieties, adopting sustainable agricultural practices such as conservation agriculture and agroforestry, enhancing water management systems, and investing in early warning systems and disaster preparedness measures.

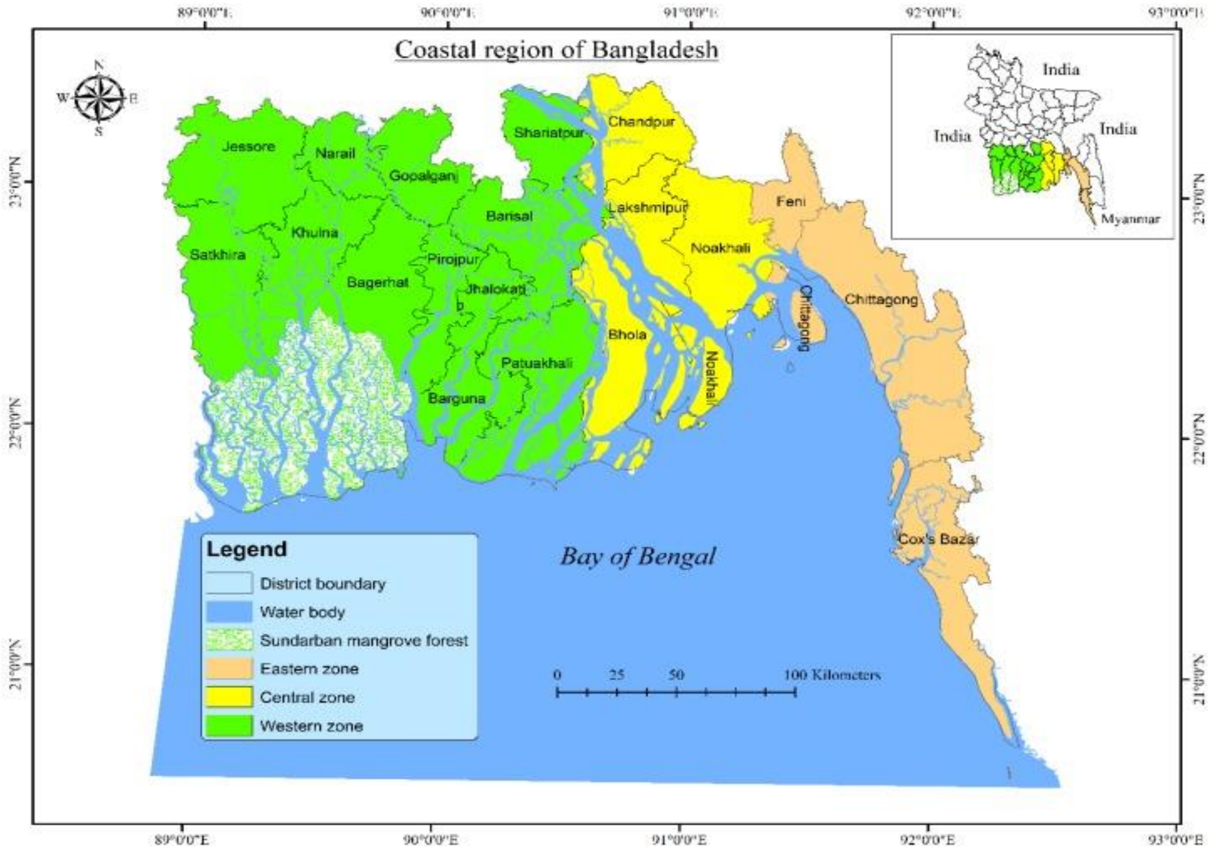


Figure 1: Case study area map showing the entire coastal region of Bangladesh with the different coastal zones and districts.

Sources: National Library of Medicine, National Centre for Biotechnology Information.

However, despite these efforts, significant gaps remain in addressing the complex and multifaceted impacts of climate change on agriculture. Access to financial resources, technical assistance, and knowledge dissemination are crucial for smallholder farmers to adopt and scale up climate-smart agricultural practices. Additionally, there is a need for integrated approaches that consider the interconnectedness of agriculture with other sectors such as water, energy, and infrastructure, to foster holistic and sustainable solutions to climate change adaptation in Bangladesh (Yila & Resurreccion 2023).

In this article, we quantify the economic and policy relevance of social networks for efficient GHG emission reduction in agriculture. We integrate behavioural and social aspects of farmers' mitigation adoption, based on a unique combination of census, survey and social network data, with economic decision-making in a bio-economic agent-based model, using a Swiss case study. More precisely, we quantify the impact of farmers' social networks on the effectiveness of a results-based payment scheme for mitigation in terms of overall reduced and income changes, accounting for farmers' individual preferences and farm level costs of mitigation measures (Thoai et al. 2023).

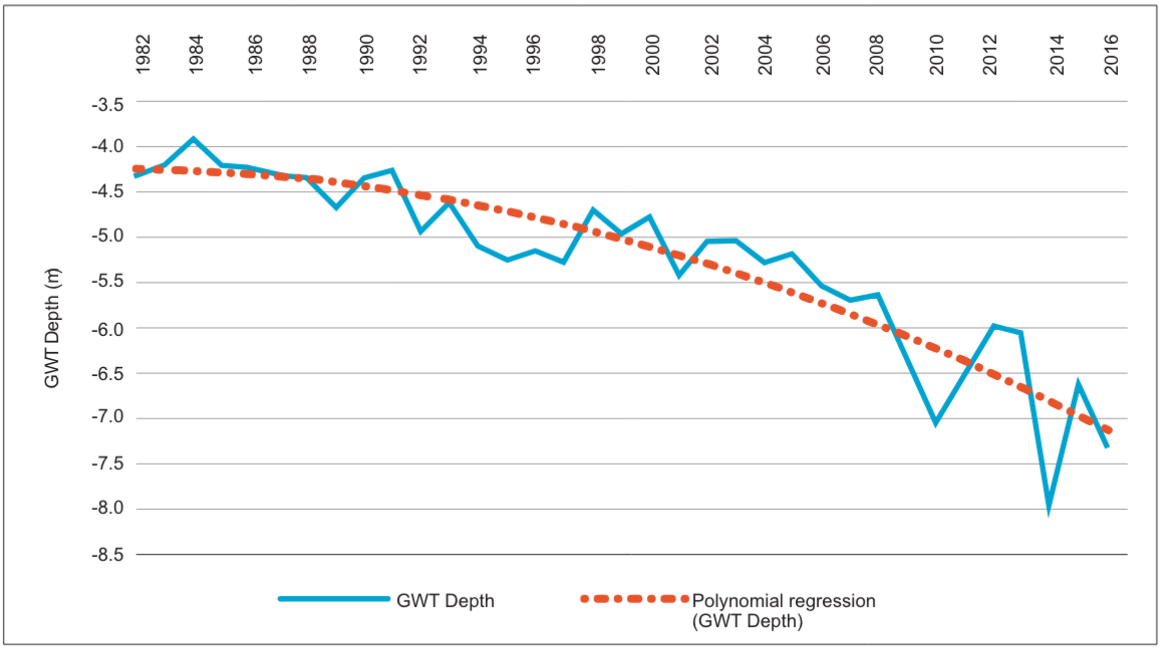
2. Background of the study

Agriculture, being one of the most climate-sensitive sectors, faces unprecedented challenges due to the escalating impacts of climate change. With changing precipitation patterns, increasing temperatures, and more frequent extreme weather events, farmers worldwide are compelled to adapt their agricultural practices to mitigate risks and maintain productivity. In this context, understanding the role of social networks among farmers becomes crucial in shaping adaptive capacities and resilience within agricultural communities (Deressa et al. 2023).

Previous research has highlighted the significance of social networks in facilitating information exchange, resource sharing, and collective action, which are essential for effective climate change adaptation in agricultural settings. Social networks serve as conduits for the dissemination of climate-related knowledge, innovative practices, and coping strategies, thereby influencing farmers' decision-making processes and adaptive behaviors. Moreover, social networks provide avenues for mutual support, collaboration, and collective problem-solving, enabling farmers to confront and overcome the challenges posed by climate variability and change (Yila & Resurreccion 2023).

However, despite growing recognition of the importance of social networks in climate adaptation, there is a paucity of empirical studies that systematically assess the influence of farmer social networks on the efficacy of climate change adaptation measures in agricultural settings. Existing research often focuses on individual-level factors or biophysical determinants of adaptation, overlooking the dynamic interactions and socio-cultural dimensions inherent in social networks (Nhemachena & Hassan 2022).

This study seeks to fill this gap by examining the nexus between farmer social networks and climate change adaptation in agricultural contexts. By employing a mixed-methods approach, including surveys, network analyses, and qualitative interviews, this research aims to unravel the mechanisms through which social networks shape adaptive capacities, knowledge diffusion, and innovation diffusion among farmers. The findings of this study are expected to contribute valuable insights into the design and implementation of targeted interventions aimed at harnessing the potential of social networks to enhance the efficacy of climate change adaptation strategies in agricultural settings.



GWT = groundwater table, m = meter.

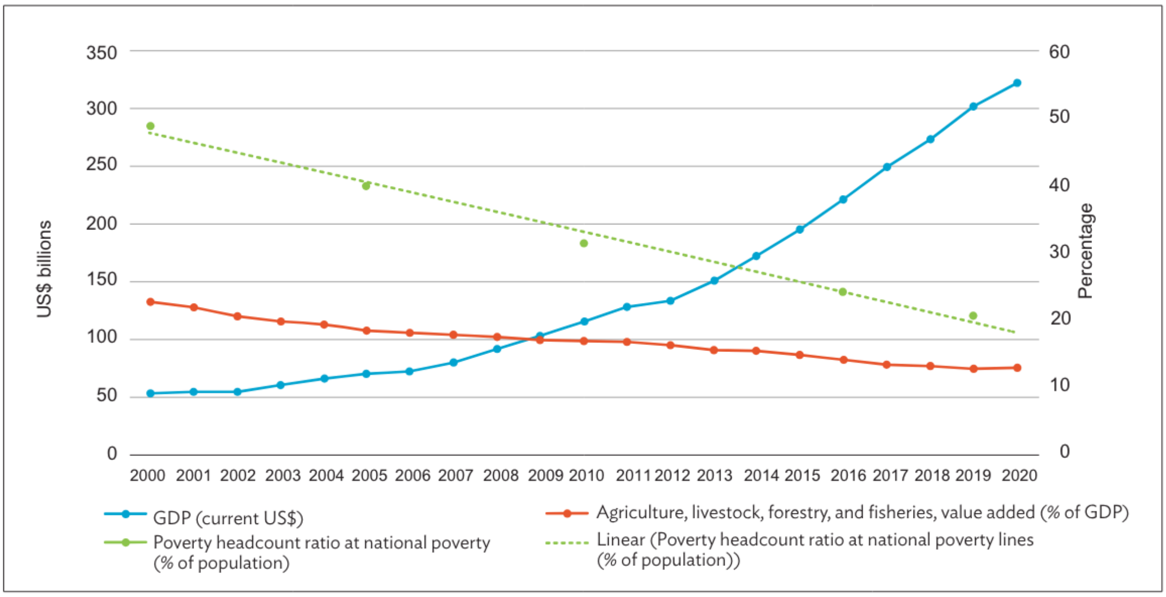
Figure 2: Groundwater Table Depth in Northern Bangladesh 1982-2016.

Source: Government of Bangladesh, Planning Commission, 2020.

Formal institutions play a significant role in implementing and funding various types of adaptation measures, which encompass knowledge enhancement (such as training and skill development), provision of information, and support in terms of technology, resources, and financial aid. Consequently, these initiatives have the potential to alter local perceptions of risk, thereby enhancing the adaptive capacities of local populations through both formal and informal institutional channels (Agrawal et al., 2008).

Government-led formal institutions are responsible for crafting and executing policies aimed at governing climate change adaptation (Gemmer et al., 2011; Engle and Lemos, 2010). This role is exemplified by studies like that of Wang et al. (2016), who demonstrate how formal institutions can influence adaptation policies in pastoral communities in northern Tibet. Additionally, when formal institutions also serve as social organizations, they facilitate connections between their own structures and other informal networks. This facilitation occurs through the transmission of knowledge, as observed among semi-nomadic pastoralists in Gujarat, India, where traditional ecological knowledge plays a crucial role (Salpeteur et al., 2016).

Both formal and informal governance systems regulate access to markets, thereby shaping adaptation strategies to climate change. Governments serve as pivotal actors in the adaptation process, leveraging their roles within international regimes and maintaining ongoing relationships with various local stakeholders, including public, private, and civic institutions. These interactions provide a platform for fostering adaptive capabilities within communities (Agrawal, 2010).



GDP = gross domestic product, US = United States.

Figure 1: Bangladesh's Gross Domestic Product, Agriculture and Poverty, 2000-2020

Sources: 2020 Value for poverty headcount ratio at national poverty is from Asian Development Bank, 2021; other values World Bank Data Bank, World Development Indicators, 2021.

In conclusion, the integration of formal and informal institutions, along with the recognition of indigenous knowledge systems, holds immense potential for enhancing the efficacy of climate change adaptation in agricultural settings. By harnessing the dynamics of farmer social networks, governments, NGOs, and local stakeholders can foster collaboration, knowledge-sharing, and collective action to address the multifaceted challenges posed by climate variability and change. Moreover, by leveraging the adaptive capacities embedded within traditional ecological knowledge networks, marginalized communities can build resilience, mitigate risks, and sustain agricultural livelihoods in the face of escalating climate impacts. Thus, this study seeks to assess the influence of farmer social networks on the efficacy of climate change adaptation, with the ultimate goal of informing policy interventions, fostering community resilience, and promoting sustainable agricultural development in Bangladesh and beyond (Uddin et al. 2022.

3. Methods

The study employs a mixed-methods approach, combining quantitative surveys and qualitative data collection techniques. A cross-sectional design is utilized to capture the current state of farmer social networks and their influence on climate change adaptation in agricultural settings.

Sampling Strategy

Stratified random sampling is employed to ensure representation across different agricultural regions and farming communities. A sample size of farm households is determined based on statistical power calculations and the desired level of precision. Surveys are administered to farm households to collect demographic information, social network characteristics, perceptions of climate change, and adaptation strategies. Survey instruments are developed based on existing literature and adapted to the local context through pilot testing and expert review.

Data collection methods

In-depth interviews and focus group discussions are conducted with key informants, including farmers, agricultural extension workers, community leaders, and policymakers. Qualitative data collection aims to explore nuanced aspects of social networks, adaptation practices, and institutional dynamics(Deressa et al. 2023). Key components of quantitative data analysis include descriptive statistics, which summarize the characteristics of the sample, and inferential statistics, which test hypotheses and make predictions about the larger population based on the sample data. Regression analysis, for example, may be used to explore the relationship between social network characteristics and climate change adaptation outcomes, controlling for potential confounding variables.

4. Results

Access to various institutional services plays a critical role in shaping farmers' resilience and adaptive capacity to address the challenges posed by climate change at the farm and household levels. Enhanced institutional access enables farmers to better prepare for and respond to climate-induced changes, allowing them to adjust farming practices accordingly to protect their crops and livelihoods from adverse impacts. Conversely, limited institutional access heightens farmers' vulnerability to climate change and hampers their ability to adapt effectively. In this discussion, we explore different types of institutions and the services they offer in the context of climate change adaptation.

Case Study 1: Farmer Cooperatives in Bangladesh

In rural Bangladesh, farmer cooperatives have emerged as vital components of the social network landscape, significantly influencing the efficacy of climate change adaptation in agricultural settings. These cooperatives, often facilitated by non-governmental organizations (NGOs) and local government bodies, serve as platforms for knowledge exchange, resource sharing, and collective action among smallholder farmers. A study conducted in the flood-prone regions of Bangladesh demonstrated that farmers engaged in cooperatives were more adept at implementing climate-resilient agricultural practices such as raised-bed farming, crop diversification, and integrated pest management. Through regular meetings, training workshops, and field demonstrations, cooperative members gain access to climate-related information, innovative farming techniques, and affordable inputs such as drought-resistant seeds and biofertilizers. Additionally, cooperatives provide avenues for accessing credit facilities, insurance schemes, and government subsidies, thereby enhancing the adaptive capacities of vulnerable farming communities. By harnessing the social networks within farmer cooperatives, Bangladesh's agricultural sector is better equipped to withstand the impacts of climate change, mitigate risks, and sustain livelihoods in the face of adversity.

Case Study 2: Indigenous Knowledge Networks in Coastal Bangladesh

In the coastal regions of Bangladesh, indigenous knowledge networks play a crucial role in shaping the efficacy of climate change adaptation in agricultural settings, particularly in the context of saline intrusion and sea-level rise. Indigenous communities, such as the Munda and Garo tribes, possess deep-rooted knowledge of local ecosystems, traditional farming techniques, and adaptive strategies honed over centuries of living in harmony with nature. A research study conducted in the Sundarbans region of Bangladesh highlighted how indigenous farmers rely on traditional ecological knowledge (TEK) networks to cope with climate-induced challenges, such as saltwater intrusion, cyclonic storms, and soil erosion. Through oral traditions, community rituals, and experiential learning, indigenous farmers exchange climate-resilient farming practices, saline-tolerant crop varieties, and water management techniques suited to the unique ecological conditions of coastal areas. Furthermore, TEK networks foster social cohesion, collective decision-making, and mutual assistance among community members, enabling them to navigate the uncertainties of climate change and preserve traditional farming heritage. By integrating indigenous knowledge systems with modern scientific approaches, coastal communities in Bangladesh are better prepared to adapt to the evolving climate realities and safeguard agricultural livelihoods for future generations.

Social Networking Analysis

The literature increasingly emphasizes the utility of social network analysis in studying resource governance and adaptation across various scales, from regional to local contexts. Social networks comprise interconnected actors engaged in the exchange of resources or information, facilitating one-directional or two-directional interactions. Rooted in empirical data, social network analysis seeks to identify the structural ties among interdependent actors, employing graphic visualization and computational models to reveal underlying patterns (Nhemachena & Hassan 2022). Unlike traditional social science research, which often emphasizes individual attributes, social network analysis focuses on the characteristics and connections between actors to uncover the theoretical underpinnings of social relationships shaping environmental outcomes and decision-making processes. Exploring the role of social networks in adaptation and governance can uncover gaps in existing farmer support systems, offering insights to bolster local adaptive capacities and resilience to climate change. Drawing on network theory, this study employs two measures, structural holes and density, to analyze interrelationship patterns and assess the level of collaboration among local stakeholders in agriculture and adaptation efforts (Ahmad & SeinnSeinn 2019).

5. Discussion

Social networking in the context of climate change adaptation among farmers involves leveraging interpersonal relationships and community networks to enhance resilience, share knowledge, and facilitate collective action in response to changing climatic conditions. Encouraging the formation of farmer groups, cooperatives, or community-based organizations fosters social cohesion and trust among members. These social networks serve as platforms for sharing experiences, exchanging information, and collectively addressing climate-related challenges. By strengthening social capital, farmers can access resources, support, and opportunities for collaborative adaptation. Social networking initiatives facilitate the exchange of climate-related information, best practices, and innovative solutions among farmers. Through workshops, training sessions, and peer learning activities, farmers can acquire new skills, technologies, and techniques for climate-smart agriculture. Building knowledge networks empowers farmers to make informed decisions, adapt to changing conditions, and adopt sustainable farming practices(Ahmad & SeinnSeinn 2019).

Social networks enable farmers to collaborate on adaptation initiatives, pooling resources, expertise, and efforts to tackle shared challenges. By coordinating collective actions such as water management projects, soil conservation measures, or crop diversification schemes, farmers can enhance resilience, minimize risks, and optimize agricultural productivity in the face of climate variability and change. Social networks provide channels for accessing financial assistance, technical support, and extension services that are crucial for climate change adaptation. By connecting farmers with government agencies, NGOs, research institutions, and private sector partners, social networking initiatives can improve access to credit, insurance, inputs, market linkages, and weather forecasting information, thereby enhancing adaptive capacities(Rakib et al. 2023, 2024).

Social networking efforts should prioritize inclusivity and equity, ensuring the participation and representation of marginalized and vulnerable groups such as smallholders, women, youth, and indigenous communities. By amplifying the voices of these stakeholders, social networks can promote inclusive decision-making processes, address social disparities, and enhance the resilience of the most vulnerable farming populations. In the era of digital connectivity, social networking can be facilitated through online platforms, mobile applications, and social media channels. Digital technologies offer scalable and cost-effective means of communication, knowledge dissemination, and collaboration among farmers across geographic distances. By harnessing digital platforms, farmers can access real-time weather updates, market information, and expert advice, facilitating timely and context-specific adaptation actions (Thoai et al. 2023).

Overall, integrating social networking approaches into climate change adaptation strategies empowers farmers to collectively address environmental challenges, strengthen adaptive capacities, and build sustainable and resilient agricultural systems for the future. By fostering collaboration, knowledge sharing, and community resilience, social networks play a vital role in enhancing farmers' ability to cope with the impacts of climate change and achieve food security and livelihood sustainability.

6. Limitations of the Study

Since vulnerability is a multidimensional concept and not directly measurable, it is associated with a high level of uncertainty in the indicator selection, measurement, and classification processes. First, it was challenging to select the specific indicators for crops, fisheries, and livestock, because different crops, fish species, and livestock varieties are found in different districts, and uniform indicators had to be adopted across the districts (Yila & Resurreccion 2023).

Secondly, the trend of agricultural production and the extent of technology use were considered in this study, rather than simply using an existing crop model to predict the future scenario of agricultural output. However, linking a crop model in multi-indicator approaches could be more useful for estimating the sensitivity and adaptive capacity of agriculture.

Thirdly, it was challenging to find district-level historical data on climate disasters and, most importantly, for the same period of time. Moreover, a few districts did not have any weather stations, and for those districts, data from the nearest weather station were used. Therefore, there is room for reducing the uncertainty of vulnerability assessment, if more specific data become available for the same period (Maddison 2011; Deressa et al. 2012).

Finally, we classified the vulnerability of a coastal district based on a beta distribution of vulnerability index scores. However, it is expected that the classification of vulnerability may not prevail over the long term because an improvement in adaptive capacity may moderate climate change impacts in the future.

7. Future Research Directors

In future research, exploring "Assessing the Influence of Farmer Social Networks on the Efficacy of Climate Changes in Agricultural Settings" could unfold across various dimensions. This might encompass in-depth quantitative analyses to unravel the structural intricacies of farmer social networks, while longitudinal studies could offer insights into their evolution over time amidst climate fluctuations. Comparative investigations across diverse geographical regions could shed light on contextual variations. Additionally, integrating technological platforms into these networks warrants exploration, alongside a critical examination of policy implications and potential interventions aimed at bolstering their efficacy. Embracing interdisciplinary approaches could foster a holistic comprehension of the multifaceted dynamics at play, and rigorous impact assessments could gauge the tangible outcomes of leveraging farmer social networks for climate resilience.

8. Conclusions

Social networks have the potential to significantly enhance farming communities' ability to adapt to climate change. This research utilizes a cross-sectional dataset comprising 450 farm households to explore local-level social networks and their role in the adaptation process, while also examining structural gaps in current institutional support at the farm level. The study uncovers that the majority of farmers have access to a range of institutional services. Nonetheless, a portion of respondents still do not engage with any services offered by various institutions. Both private, public, and community sources provide diverse forms of climate change adaptation and financial support services to farmers. However, findings from the social network analysis indicate a notably low network density, highlighting various loosely connected elements within the system (Piya et al. 2022; Ahmad & SeinnSeinn 2019).

The hot spot of vulnerability distribution was concentrated in the rural agricultural districts (Bhola, Patuakhali, and Lakshmipur), where livelihoods are mainly dependent on crop-based farming and are continuously threatened by multiple climatic disasters such as floods, erosion, and cyclones. On the other hand, the vulnerability cold spots were distributed along the world's largest mangrove forest, the Sundarbans, which offers numerous livelihood opportunities and reduces the vulnerability of surrounding districts (Satkhira, Khulna, Jessore, and Narail) by providing an ecological buffer against climatic disasters. Furthermore, the spatially heterogeneous vulnerability among the coastal districts was influenced by the indicators of exposure (rate of erosion, cyclones, and drought); sensitivity (infant mortality rate, distance to water source, unhygienic sanitation conditions, land degradation, soil phosphorus, rain-fed agricultural land, productivity of rice); and adaptive capacity (structurally sound housing and density of emergency shelters, open waterbody, adoption of improved crop varieties, pesticides, and irrigation facilities).

The proposed assessment method provides a concrete example of a set of potential adaptation measures for specific geographical units that will assist policymakers in prioritizing investments for intervention. For example, diversification of agricultural systems by allowing water-intensive crops; adoption of farming technology (crop variety, harvester use, irrigation pumps); construction of dams and roads, and enhancing the plantation mangrove forest program, are some of the potential adaptation options for the most vulnerable district, Bhola. These measures could reduce the sensitivity and modify the agricultural system's exposure to stressors such as flood, erosion, drought, and cyclones. Subsequently, findings of this study may accelerate the shift of adaptation efforts to areas with greater exposure, increased sensitivity, or lower adaptive capacity.

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