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Unveiling Climate Resilience of Peri-urban Agriculture: A Farming System-Based Assessment of Coastal Plains of Kerala, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Peri-urban agriculture is characterized by dynamic and synergistic interactions between urbanization and agricultural activities, making them pivotal for both food production and industries. However, one of the major concerns affecting its sustainability is climate change. One way to cope with climate change is to build resilience by identifying key areas that are most at risk, allowing for targeted interventions. With this objective, a study was conducted during the period 2019-2023, to assess the climate resilience of peri-urban agriculture in six agro-ecological units (AEUs) of Coastal plains, through the development of Climate Resilience Index (CRI). Data was collected through focus group discussions, personal and key informant interviews with farmers, and discussions with extension personnel. CRI was developed as the function of three dimensions- absorptive, adaptive, and transformative capacities, assessed in terms of 72 indicators. Absorptive and transformative capacities (0.592 and 0.568 respectively) contributed the most to the mean CRI of coastal plains (0.563). The major determinants contributing to better climate resilience of farmers included water sufficiency, lesser recovery time, better access to basic services, sustainable practices adopted, and other socio-economic and psychological characteristics. This research provides valuable information to enhance the resilience of per-urban agriculture considering the challenges of climate change.

Keywords: Peri-urban agriculture; absorptive capacity; adaptive capacity; transformative capacity.

1. INTRODUCTION

Peri-urban agriculture is characterized by dynamic and synergistic interactions between urbanization and agricultural activities, making them pivotal for both food production and industries [1,2]. However, one of the major concerns affecting the sustainability of peri-urban agriculture is climate change. Rapid urbanization and land use changes can put pressure on peri-urban agricultural land. A study conducted by Mishra and Vij [3] reported loss of common property resources and the emergence of urban canals in the peri-urban space as characteristics of the urbanization processes that are intensely operative in peri-urban Gurugram. Agro-ecological zone of the Coastal plains of Kerala comprise sandy beaches, sandy plains, coastal laterites, and low-lying areas such as estuaries, backwaters, submerged lands, swamps, marshes, *kayal* lands, and broad valleys [4]. Such an ecological zone faces challenge of climate change. Therefore, to cope with all these risks of climate change, one possible solution is to build resilience in the system. Identifying key areas that are most at risk is important in assessing the resilience of communities allowing for targeted interventions. Studying the resilience of communities will help decision-makers prioritize resources and allocate funding towards the areas or sectors that require urgent attention. Hence, the present study aims to assess the climate resilience of peri-urban agriculture in six AEUs of coastal plains through the development of the Climate Resilience Index (CRI).

2. RESEARCH GAP

Numerous studies had been conducted in the areas of vulnerability assessments of rural farming systems. But not much research has been conducted in India, especially Kerala, regarding the resilience of agriculture, especially peri-urban agriculture. Thus, study will contribute valuable insights regarding the strength and weakness of peri-urban agriculture of coastal plains of Kerala, which will help policy makers to formulate suitable developmental programmes.

3. METHODOLOGY

Alappuzha and Kannur were included among the districts identified as climate change hotspots and vulnerable as per Kerala State Action Plan for Climate Change [5]. Moreover, these districts also showed high rate of urbanization [6]. The study was conducted in six AEUs (AEU-1,2,3,4,5 and 7) of Alappuzha and Kannur districts coming under Agro-Ecological Zone Coastal plains. From peri- urban areas of each AEU, farmers affected by climatic hazards such as flood, drought, saline-water intrusion were identified and listed in consultation with extension personnel. From the prepared final list, 30 farmers were selected at random from each AEU. Thus, a total of 180 farmers from the six AEUs were selected for the study. The required data was collected through interviews with farmers in the local language. In addition, secondary data were collected from Krishi Bhavans and Krishi Vigyan Kendras.

4. RESULTS AND DISCUSSION

Climate resilience was operationally defined as the potential of the farming communities of AEUs to withstand, adapt to, and recover from the impact of climate change. The differentiation of three resilience capacities help to assess the possible resilience strategies and allows for the investigation of trade-offs and synergies between them [7]. In this study, climate resilience was expressed as a function of the three core dimensions: absorptive capacity, adaptive capacity and transformative capacity. Absorptive capacity was operationally defined as a set of measures exercised during and after a disturbance has occurred to reduce the immediate impact on people's livelihoods and basic needs. Adaptive capacity was operationally defined as a set of measures taken to react to evolving hazards and stresses (well in advance) to reduce the occurrence and/or the magnitude of harmful outcomes resulting from climate-related hazards. Transformative capacity was operationally defined as the determinants that bring intentional changes in farmers' values and choices and strengthen stakeholder capacities. The absorptive capacity index was constructed using thirty-one indicators, adaptive capacity index using eighteen indicators and transformative capacity index using twenty-three indicators. The dimensions and corresponding indicators were developed based on an intensive review of the literature and expert opinion. They were then pre-tested and checked within key informant interviews. Each of the three dimensions of climate resilience (absorptive, adaptive and transformative capacities) was calculated as the weighted mean of the corresponding indicators. CRI was calculated as the aggregate of three dimensions with the assumption that each dimension contributed equally to CRI. Based on the formulated index, the climate resilience of AEUs of coastal plains was assessed. The index value varied between 0 and 1, where a higher value indicates greater resilience. Table 1 shows the indices (absorptive capacity, adaptive capacity, transformative capacity and climate resilience indices) obtained through data analysis.

The mean CRI of AEUs of coastal plains obtained was 0.563, which depicts that the AEUs show a moderate level of resilience to climate change and associated risks. Among the AEUs, *Kaipad lands* (AEU-7) have the highest CRI (0.647), while *Kuttanad* (AEU-4) has the lowest CRI (0.496). This means that despite being a problem area facing frequent flooding and salt water intrusion, the farmers of *Kaipad lands* are building resilience against climate risks. On the other hand, even though Kuttanad lands have similar issues as *Kaipad lands*, the farming communities of *Kuttanad* lag in terms of resilience. While comparing the different dimensions of climate resilience, absorptive capacity has the major contribution (0.592), which means that for building and enhancing resilience, the interventions taken during or after the occurrence of a disaster play a crucial role. The results are similar to the results of Asmamaw et al. [8]. The study conducted in North Eastern hill region of India reported that farmers had higher adaptive capacity and low capability on formulating coping strategies. Also, the farmers had medium to low level of resilience to climate change in agriculture [9]. Transformative capacity also contributes to climate resilience (0.568), indicating that the farm households are bringing changes in their attitude, beliefs and practices, owing to strong extension interventions. Among the three dimensions, adaptive capacity has the least contribution (0.528), which clearly shows that communities need to act proactively to build and enhance their resilience.

To find out the major determinants of each dimension, Pearson's correlation analysis was done. The results are shown in Table 2.

The major determinants of absorptive capacity were timely repair of roads, water sufficiency, health check-ups, institutional support during the disaster, recovery time, crop loss, poverty status, credit, compensation from the government, risk orientation, environmental concern and self-confidence. Roads are crucial infrastructure for agrarian communities, and their condition and maintenance can significantly impact farmers' resilience. During disaster and post-disaster phases, well-maintained roads enable the easy movement of emergency response teams and relief supplies. Timely road repairs ensure that farmers have continued access to markets even after extreme weather events. Water sufficiency is a key determinant in assessing the resilience of a community. Access to and availability of clean and safe water for drinking, household chores and irrigating crops is crucial, before, during and after a disaster. Farmers' physical

Table 1. Indices of climate resilience (absorptive capacity, adaptive capacity, transformative capacity and climate resilience indices)

AEUs	Absorptive capacity index	Adaptive capacity index	Transformative capacity index	Climate Resilience Index
AEU 1 Southern Coastal plains	0.572	0.509	0.570	0.551
AEU 2 Northern Coastal plains	0.667	0.534	0.554	0.585
AEU 3 *Onattukara* sandy plains	0.579	0.516	0.585	0.560
AEU 4 *Kuttanad*	0.509	0.458	0.521	0.496
AEU 5 *Pokkali* lands	0.548	0.494	0.574	0.539
AEU 7 *Kaipad* lands	0.678	0.658	0.604	0.647
Mean	0.592	0.528	0.568	0.563
SD	0.067	0.069	0.028	0.051

Source: Data compiled and analysed by the researcher

Table 2. Correlation of indicators to respective dimensions of climate resilience

Dimensions	Indicators	Pearson's correlation coefficient
Absorptive capacity	Timely repair of roads	0.857*
	Water sufficiency	0.927**
	Health check-up	0.953**
	Institutional support during the disaster	0.966**
	Recovery time	0.883*
	Crop loss	0.930**
	Poverty status	0.916*
	Credit	0.834*
	Compensation from government	0.957**
	Risk orientation	0.909*
	Environmental concern	0.920**
	Self confidence	0.996**
Adaptive capacity	Type of housing	0.814*
	Sanitation facilities	0.833*
	Storage structures for seeds, feed and fodder	0.952**
	Soil and water conservation measures	.814*
	Soil testing	.826*
	Education	.858*
	Average monthly income	0.849*
	Subsidies	0.940**
	Attitude towards climate resilient strategies	0.935**
Transformative capacity	Participation in environmental conservation	0.869*
	Access to basic services	0.776*
	Minimum support price	0.765*

Source: Data compiled and analysed by the researcher in SPSS well-being directly impacts their ability to work in the field and manage agricultural tasks effectively. Regular health check-ups can help in early detection and prevention of health issues ensuring that farmers can continue their daily activities and maintain productivity. Prevalence of *leptospirosis* is a common problem in post-flood situations in almost all AEUs. Institutional support can enhance farmers' ability to absorb and recover from climatic hazards. Joint efforts of institutions and farmers are important for the development of sustainable farming practices, effective risk management strategies, and overall resilience in agricultural communities [4]. The lesser the recovery time, the more resilient the system is. Farmers who suffered a loss of less than half of the crop are more resilient than those who suffered a loss more than half of the crop. Socioeconomic conditions of people can significantly impact their ability to cope with challenges and shocks. Farmers living in poverty may have limited access to financial, natural, and human resources. Farming communities that are below the poverty line lack resources to cope with the hazards and might face difficulty in recovering from the shock, both economically and psychologically. Timely and easy access to credit allowed farmers to purchase quality inputs, and adopt climate-resilient practices, thus improving their productivity and resilience. Timely and adequate provision of compensation from the government adds to the financial support to the communities to recover from shocks. One of the most critical, yet obvious determinants of the resilience of farmers are psychological factors. Risk-oriented farmers are innovative to try new technologies and farming practices, seek opportunities to diversify their income sources and agricultural practices to spread out risks [10]. Farmers with higher environmental concern are more likely to adopt sustainable farming practices, erosion control measures, water conservation and efficient water management practices. Farmers with higher self-confidence may be more willing to make decisions and take risks under changing circumstances. Confident farmers will be effective leaders within their communities and collaborate with other farmers. The results are similar to the results of Asmamaw et al. [8]. A study conducted to assess the relationship between farmers' profile and their climate change perception revealed a positive and highly significant relationship between education, farming experience, access to weather forecast, extension participation, risk orientation, innovativeness, scientific orientation and decision-making ability and their level of perception about climate change on agriculture [11].

Adaptive capacity was majorly governed by the type of housing, sanitation facilities, storage facilities for seeds, feed and fodder, soil and water conservation measures, soil testing, education, average monthly income, subsidies and attitude towards climate resilient strategies. Concrete houses are found to be more resilient than thatched or brick or laterite-walled sheeted houses. Thatched houses will be more prone to leakage and collapse during heavy windy or rainy days. Concrete houses have added advantage that people can move to terrace or first floor during flood conditions, which can be utilised as temporary shelter for people as well as valuable assets. Sanitation facilities are an integral part of the resilience of human beings. Healthy environments and communities are formed where proper sanitation facilities are available. When toilet facilities are available inside the home or within their dwelling premises is healthier than open places. Improper toilet facilities will lead to the emergence of contagious diseases which will divert the household expenses to non-agricultural activities. Storage structures, such as warehouses and storage sheds, can significantly impact the adaptive capacity and thus climate resilience of farmers. Storage facilities provide a buffer against climate-related risks and unprecedented events, especially in the case of paddy, where most of the farmers leave it in open fields for drying. Farmers improved their resilience by practicing soil and moisture conservation measures, which contribute to their system sustainability. The higher educational status of the farmers, and higher monthly income than the state average (Rs. 17,915) helped the farmers to make deliberate and planned decisions to adapt to changing situations. Farmers having alternate sources of income other than agriculture were able to cope with impacts of a disaster, thus making them more economically resilient to disasters [2]. Farmers were able to increase their income, as well as food and nutrition security, because of reduced input costs, increased crop diversity, cultivating more than two crops despite floods during the summer, cropping intensification, and expansion of areas under cultivation [12].

Subsidies on agricultural inputs like seeds, irrigation equipment, machinery and renewable energy sources, make these resources more affordable for farmers, enabling them to reduce the financial risks by lowering the cost burden adopt improved practices and enhance their yields. A positive attitude of farmers towards climate-resilient strategies opens them to new ideas, practices and technologies that enhance resilience. Such farmers are more likely to adopt climate-smart technologies and practices. It also encourages farmers to participate actively in community-based adaptation efforts, fostering collective adaptive capacity. The results are following the results of Bryan et al. [13].

The transformative capacity of farm households of coastal plains was influenced by participation in environmental conservation, access to basic services and assurance of minimum support price. Engaging in environmental conservation practices like afforestation, soil conservation, and water management improve ecosystem services on the farm. Participation in conservation efforts promotes sustainable use of resources. Farmers who adopt conservation practices are less likely to exhaust soil fertility, degrade water sources, or deplete natural habitats. Due to technological advancement, communities with better access to information, health-care services, agri-extension services, veterinary services, education, markets, safety and security services (ambulance, police, fire safety etc) could bear and rebound. MSP assured farmers a minimum price for their produce, protecting them from market price volatility, discouraging distress sales and improving overall market conditions. The results obtained are in line with the observations of Anseera [14].

5. CONCLUSION

The results yielded from the study show that coastal plains showed a moderate level of resilience to climate change and associated risks. Among the AEUs, *Kaipad lands* were found to be the most resilient, while *Kuttanad* was the least resilient. The communities have learned to take appropriate measures in advance to reduce the possible adverse effects of climate change and associated events. Collective efforts of the local communities and the extension services played a crucial role in enhancing the climate resilience of coastal plains. Also, the communities have equipped themselves to cope with the disaster and reduce their sensitivity to climatic hazards. However, it is important to address each capacity to build climate resilience among farming communities. Sustained efforts and coordination between the local and scientific communities along with strong extension support played the paramount role in enhancing the climate resilience of the coastal plains. This study has significant ramifications for structuring the growth of per-urban agriculture in response to the challenges of climate change. It offers insightful information that helps local communities and extension agents to make decisions, that will have a positive impact in the future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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