P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating (2025): 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 10; October 2025; Page No. 465-472

Received: 06-07-2025
Accepted: 09-08-2025

Indexed Journal
Peer Reviewed Journal

Food security in a remote island context: A study of Lakshadweep households

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DOI: https://www.doi.org/10.33545/26180723.2025.v8.i10g.2570

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Abstract

Food security is a dynamic concept that has continuously evolved, incorporating new dimensions and levels of analysis over the years, reflecting the growing recognition of its complexities in research and public policy issues. The study quantifies household food security in the geographically remote and ecologically delicate Lakshadweep Islands, which rely significantly on the mainland for necessities. Data were gathered on the four dimensions of food security as defined by FAO, which include availability, access, utilisation, and stability, using a cross-sectional survey of 200 randomly selected households. To account for discrete variables, twelve indicators were combined using polychoric Principal Component Analysis (PCA) to create a composite Food Security Index (FSI). The FSI revealed that more than 90% of the households fell into the first and second quartile, indicating low and medium food security but ongoing vulnerabilities, while only 0.5% of households were considered food secure. The results suggest the need for integrated and location-specific strategies to strengthen food security in such a fragile island contexts. The findings are particularly relevant for policymakers in India and other countries with similar remote and resource-constrained settings, where building resilience through diversified livelihoods and improved access to essential services is crucial.

Keywords: Small islands, Availability, Access, Utilisation, Stability

Introduction

Globally, one of the most pressing issues of the 21st century is food security, which is closely related to public health, environmental sustainability and economic growth. Food and Agriculture Organisation (FAO) of the United Nations defined food security as a situation "that exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2002). Millions of people remain at risk of food insecurity despite decades of progress in agriculture and global economic growth. In 2024, approximately 2.3 billion people (28 per cent of the world's population) experienced moderate to severe food insecurity, up from 21.4 per cent (1.6 billion) in 2015. Meanwhile, an estimated 8.2 per cent of the global population may have faced hunger in 2024 (FAO, 2025). Five decades after the advent of the Green Revolution, India's food grain production has increased nearly fivefold, making it one of the world's largest producers of rice and wheat (MoAFW 2023). Nevertheless, India's hunger and malnutrition levels still remain high. Despite progress in economic diversification and strides toward food self-sufficiency, the share of agriculture in India's GDP has declined, even as over 190 million people remain undernourished and nearly 30% of the population continues to live in poverty (FAO 2023). According to Sani and Kemaw (2019), Gadiso *et al*. (2024), and Bahiru *et al*. (2023) [5, 6, 7], food remains as one of the basic human needs. It has a major impact on people's general well-being and health. Building a prosperous and healthy society requires ensuring that everyone has access to sufficient nutrition. The Universal Declaration of Human Rights affirms the right to food as a fundamental human right. Every person has the right to adequate, wholesome and nutritious food, both in terms of quality and quantity (United Nations General Assembly, 1948).

However, ensuring that all individuals have consistent access to reasonably priced, wholesome and sustainable food remains a significant and intricate task for many developing nations. As a result, food insecurity has a range of effects on various societal groups. Several developing regions have responded by making increasing food security a top policy goal (Abafita and Kim, 2014; Bitana *et al*., 2023; Matita *et al*., 2021; Aziz *et al*., 2022) [9, 10, 11, 12]. International leaders, policymakers, researchers, development partners, and various NGOs operating at different scales have taken notice of this issue (Bitana *et al*., 2023; Alemayehu and Tesfaye, 2024; Dinesh *et al*., 2021; Mossie *et al*., 2024) [10, 13, 14, 15]. According to Manikas *et al*. (2024) [16], food security will remain a significant global issue, as it is crucial for human well-being. This is particularly critical in emerging countries, where problems such as persistent poverty, rapid population growth, and climate change are prevalent. There is a growing need to integrate value-added processes into food systems to alter them, as current global efforts to eradicate food insecurity are not meeting their goals (Dinesh *et al*., 2021; Nchanji and Lutomia, 2021; Borman *et al*., 2022; Tamru and Minten,

2023) [14, 17, 18, 19]. According to Herens *et al*. (2022) [20], there are still obstacles to the efficient governance of food systems. Geographically remote and ecologically fragile areas, such as the Lakshadweep Islands, exacerbate this problem significantly. Achieving sustainable food security for its people is particularly difficult in Lakshadweep, a remote Union Territory comprising a collection of tiny coral islands in the Arabian Sea.

The people of the Lakshadweep islands rely heavily on the mainland for their needs and are geographically isolated from it, with a maximum distance of more than 400 km. This makes these islands the remotest and the most challenging to live in. Shipping serves as the primary lifeline, with Mangalore acting as the main source of food supplies and Calicut serving as the principal source of fuel. All other provisions are supplied from Kochi. The high cost of transportation for any produce from Lakshadweep to be marketed on the mainland, or possibly to other countries, poses the greatest problem for the islands. Connectivity poses a significant problem, affecting both the quality of life and the marketing of local produce in the islands. The distance from the mainland affects the mobility of people for educational, employment, social, and religious purposes, as well as medical treatment.

In Lakshadweep, there has been a notable absence of research on the food security status of households. The lack of comprehensive information regarding the food security conditions of households hinders the effective formulation of policies and strategies to enhance food security for people in the Lakshadweep Islands. The study aims to quantify the food security status of households in the Lakshadweep Islands. To accomplish this, the following objectives are put forward:

1. To describe the socio-economic characteristics of respondents in the study area.
2. To quantify the food security status of households in Lakshadweep.

Theoretical framework

Food and Agriculture Organisation (FAO) of the United Nations defined food security as a situation "that exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2002). According to FAO (1996), food security is a function of four major dimensions: availability, access, stability and utilisation. The availability of sufficient quantities of food of suitable quality, whether from imports or domestic production, is referred to as food availability. When everyone has the means to purchase the right food for a healthy diet, food access is ensured. Food access is a function of the physical environment, social environment and policy environment, which determine how effectively households can utilise their resources to meet their food security objectives. Food utilisation encompasses a balanced diet, clean water, sanitation, and healthcare to achieve a state of nutritional well-being, underscoring the importance of non-food inputs in food security (Timmer 2000) [22]. Food stability relates to maintaining enough food availability for those households that are at high risk of temporarily or permanently losing access to the resources needed to consume appropriate food owing to economic shocks, lack of enough 'reserves' for adequate consumption, or both (Shah and Dulal 2015) [23].

Materials and Methods

Study Area

The study area is the Lakshadweep islands, an archipelago that spans more than 2,500 kilometres and is situated at the northern tip of the Chagos Maldive-Laccadive undersea mountain ridge. The Lakshadweep Islands, consisting of a group of small coral islands and reef structures in the Arabian Sea positioned between 70°-74°E and 8°-13°N, are one of India's Union Territories (Fig. 1). This region includes 12 atolls housing 36 islands, along with three reefs and six submerged sandbanks. It spans a total geographical area of 32.20 square kilometres, with a coastline measuring 132 kilometres. As a collection of small, isolated coastal territories, Lakshadweep faces heightened vulnerabilities, including isolation and remoteness. The islands may also face additional threats from increased exposure to external shocks and natural disasters, rising sea levels, saltwater intrusion, diminished freshwater availability, coral bleaching and degradation, impaired ecosystem functionality, a shrinking base for livelihoods, and an overwhelming reliance on external support and resources (LAPCC 2012).

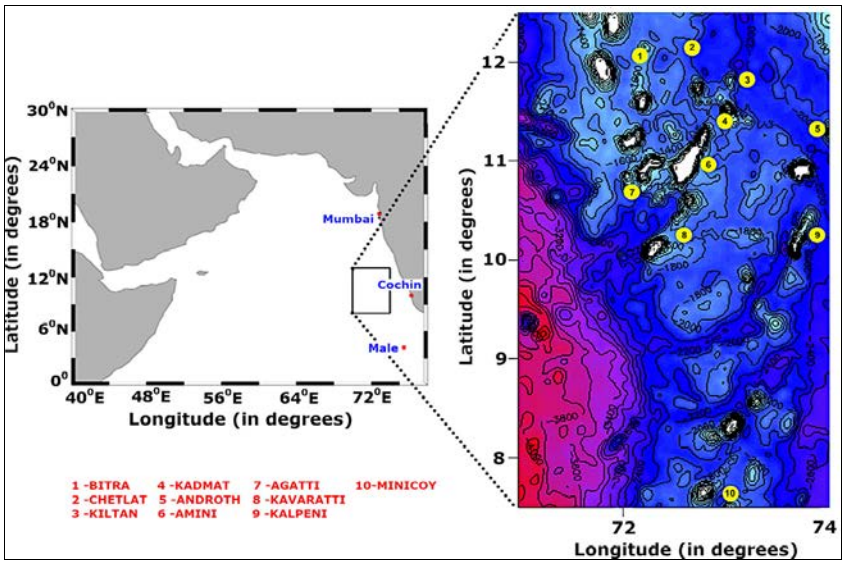

Fig 1: Map of Lakshadweep (Jennath *et al*. 2021)

Data and sampling techniques

A total of 200 households were sampled from the Lakshadweep using simple random sampling. This approach ensured that every household in the population had an equal chance of being selected, thereby enhancing the representativeness and reliability of the study findings. The primary tool used to collect data from individuals residing in Lakshadweep for this study was an interview schedule. To ensure the interview schedule was both valid and reliable, we conducted a pilot study with a small group of individuals who weren't part of the primary research. We made necessary modifications in the interview schedule based on their feedback to enhance its effectiveness. Additionally, trained enumerators were available to assist with administering the interview schedule, ensuring that respondents clearly understood each question. This approach helped promote accuracy and consistency in collecting data to analyse the food security situation of households in Lakshadweep. The interview schedule was administered to a representative sample of 200 households. Each session took approximately 45 minutes, allowing respondents ample time to consider their responses.

Methods

The data collected in this study were analysed using a combination of descriptive and inferential statistical techniques to address the study's objectives. Descriptive statistics, including percentage analysis, tabular analysis and frequency counts, were utilised to address objective (i), which seeks to profile the socio-economic characteristics of respondents.

We developed a Food Security Index (FSI) to evaluate the food security status of households. The construction of this FSI was based on a systematic methodology aimed at generating composite indices (Antony and Rao 2007; Mutabazi *et al*. 2015) [25, 26]. The FSI was formulated as a weighted index that integrates various indicators across different dimensions of food security into a unified composite measure. A set of 12 key indicators representing the four dimensions of food security was used to construct the FSI. The indicators and their explanations are elucidated in Table 1. The indicators of food availability include household-level food production and distance to public distribution system outlets. Access to school, distance to schools and awareness of institutional credit access are incorporated into the food access dimension. The food utilisation dimension encompasses access to safe drinking water, sanitation facilities, distance to healthcare services, and access to health insurance services. To represent the food stability dimension, the indicators used is involvement in a government employment scheme, total annual average household income and average monthly household food expenditure

Table 1: Indicators used for constructing the Food Security Index (FSI)

Dimensions of food security (FAO)	Indicators	Explanations	Sources
Food availability	Household-level food production	Indicates whether households produce food items for their own consumption, reflecting self-sufficiency and contribution to household food security.	Ngongi and Urassa (2014) [27]
	Distance to Public Distribution System (PDS)	Physical proximity or travel distance between a household and the nearest PDS.	Zhong *et al*. (2023) [28]
Food access	Access to school	Access to nearby schools reflects both the ease of children's education and the role of schools as platforms for food distribution programmes, thereby linking educational opportunities with household food security.	Gupta *et al*. (2025) [29]
	Distance to school	Distance to nearby school indicates the physical accessibility of education, where shorter distances increase the likelihood of school attendance. Since schools also serve as platforms for food distribution programs, closer proximity enhances both educational access and household food security.	Sam *et al*. (2018) [30]
	Awareness of formal credit access	Households' awareness of how and where to access credit facilities to improve their livelihood activities.	Mole and Namusonge (2016) [31]
Food utilization	Access to safe drinking water	Access to safe drinking water is essential for food security, as it supports safe food preparation, consumption, and overall health, thereby enhancing the effective utilisation of available food..	Linderhof *et al*. (2021) [32]
	Sanitation facilities	Access to improved sanitation facilities influences food security by reducing the risk of water- and foodborne diseases, promoting better health, and ensuring that households can effectively utilise the food they consume.	Abubakar (2017) [33]
	Distance to healthcare services	Distance to healthcare services reflects access to health facilities, where closer proximity supports household health and nutrition, enhancing food security.	Kelly *et al*. (2016) [34]
	Household with health insurance	Households with health insurance are better protected against medical expenses, which reduces the risk of selling food or assets to cover healthcare costs and thereby supports food security.	Sonik (2019) [35]
Food stability	Involvement in a government employment scheme	Household involvement in government employment schemes provides regular income or work opportunities, which enhances their ability to access and afford food, thereby strengthening food security.	OECD (2013)
	Total annual average household income	The total annual average household income reflects the economic capacity of a household to access sufficient and nutritious food, directly influencing its food security.	OECD (2013)
	Average monthly household food expenditure	The average monthly household food expenditure indicates the typical resources a household allocates for food, reflecting its access to sufficient and nutritious food and overall food security.	Rashid *et al*. (2024) [37]

A Principal Component Analysis (PCA) was conducted to establish an objective-weighting method for estimating food security indicators. Several indicators utilised in the calculation of the Food Security Index (FSI) were discrete. The use of these discrete variables resulted in a violation of the Gaussian distribution assumption of PCA, leading to biased results. To prevent this violation, we opted for polychoric PCA. After performing the polychoric PCA, the Food Security Score (FSS) was calculated using equations (1) and (2).

$$PC_{hk} = \sum a^{l}_{k} (x^{l}_{h}) \quad (1)$$

Where, PC_{hk} is the kth component for h^{th} respondent household.
a^{l}_{k} is the factor loading of the kth component for the lth indicator.
x^{l}_{h} are factors of h^{th} respondent household

$$FSS_h = \sum V_k (PC_{hk}) \quad (2)$$

FSS_h is the composite food security score of h^{th} household.
V_k is the variance accorded by the kth principal component.
FSS is used to construct the FSI (equation (3)), with a scale ranging from 0 to 1.

$$FSI_h = \frac{FSS_h - FSS_{min}}{FSS_{max} - FSS_{min}} \quad (3)$$

Where, FSI_h is the food security index of h^{th} household.
FSS_h is the food security score of h^{th} household.
FSS_{min} is the minimum value of the food security score in the sample.
FSS_{max} is the maximum value of the food security score in the sample.

Results and Discussion

Socio-Economic Characteristics of Respondents

Table 2 depicts the Socio-economic characteristics of the respondents. The average age of household heads in the study area was 56 years, with 66% aged 41-60. This indicates a predominantly mature population managing household resources. This age range represents a financially active and economically involved female population, many of whom are the decision-makers for household budgeting, business investment and informal savings (Malombe, 2025) [38]. In contrast, only 7.5% of household heads were aged 20-40, highlighting low youth participation in key livelihood activities such as fishing and coconut farming.

Table 2: Socio-economic characteristics of respondents

Age of household head	**Frequency (n=200)**	**Percent**
20-40	15	7.5
41-60	132	66.0
61-90	53	26.5
Gender	**Frequency (n=200)**	**Percent**
Male	176	88.0
Female	24	12.0
Educational level	**Frequency (n=200)**	**Percent**
No formal education	3	1.5
Primary education	177	88.5
Secondary education	18	9.0
Tertiary education	2	1.0
Family type	**Frequency (n=200)**	**Percent**
Joint family	155	77.5
Nuclear family	45	22.5
Access to school	**Frequency (n=200)**	**Percent**
Households having access	179	89.5
Households without access	21	10.5
Awareness of credit facilities	**Frequency (n=200)**	**Percent**
Households aware of CF	48	24.0
Households are not aware of CF	152	76.0

The study revealed that 88% of the respondents were male, which may influence women's decision-making power and participation in economic activities. This finding is consistent with that of Alemu *et al*. (2022), which reported that 12% of households were female-headed, indicating a predominance of male-headed households across the surveyed islands. This pattern reflects the traditional socio-cultural structure of Lakshadweep, where men are primarily engaged in income-generating activities, such as fishing and coconut farming. At the same time, women often manage household responsibilities and play a supporting role in small-scale livelihood activities. Almost all household heads had some level of formal education, with 88.5% holding primary education, followed by 9.0% holding secondary education, and 1.0% holding tertiary education. Only 1.5% of respondents reported having no formal schooling. The

predominance of primary education indicates a basic level of literacy across households, which plays a crucial role in shaping food-related decisions, livelihood strategies and the ability to access government support programs. It makes sense because, according to the FAO, one of the most effective strategies for reducing hunger is education (FAO 2005).

The majority of respondent households belonged to joint families, accounting for 77.5%, while 22.5% were nuclear families. This indicates a predominance of joint family structure in the study area. This reflects the traditional social setup of Lakshadweep, where extended families live together, sharing resources and responsibilities. Because joint families frequently provide a safety net during times of income volatility, particularly in communities that depend on seasonal fishing and coconut-based incomes, their frequency has a substantial impact on food security. Dependency on other family members for living and decision-making in the home is encouraged in joint families. Furthermore, compared to nuclear family homes, this structure has a higher number of wage earners and frequently makes a significant contribution to the overall household income (Griffiths *et al*. 2002) [41]. The joint family is a style of combining smaller families into larger family units through the extension of three or more generations (Mukarram *et al*. 2012) [42].

In this study, 89.5% of households had access to a school, while 10.5% did not, indicating that educational facilities are generally well-distributed across the islands under investigation. To improve awareness and knowledge about nutrition, health, and food management, all of which can indirectly enhance household food security, access to schools is essential. Furthermore, providing midday meals in schools helps children eat more healthily, reduces family food insecurity, and ensures that children from low-income families have at least one balanced meal per day. School feeding programs are the "world's most extensive safety net", providing food to 418 million children each school day (WFP, 2022).

According to the study, only 24% of respondents were aware of the credit facilities offered, while 76% were not. This lack of awareness is a result of the isolated islands of Lakshadweep having little access to official banking services and financial information. Households may be more vulnerable to food insecurity if they are unable to invest in livelihood or food-related activities and manage income changes due to a lack of information about financing choices. Financial awareness can play a crucial role in advancing the cause of financial inclusion, particularly in areas where literacy, higher education, and general awareness are limited. Iqbal and Sami (2017) [44] discussed that a low level of financial education and literacy is associated with financial exclusion.

Household food security: FSI

We constructed the Food Security Index (FSI), which represents the range of aspects related to food security. Polychoric PCA was performed on the data set of twelve indicators as the first step in the FSI construction process. The number of factors selected was based on the eigenvalue criterion, i.e., factors with eigenvalues greater than one were selected (table 3). In accordance with this criterion, a total of six factors were chosen, which explained 70.88% of the total variance. The first factor (F1) had an eigenvalue of 2.081, explaining 17.34% of the variance. The second factor (F2) had an eigenvalue of 1.894, explaining 15.78% of the variance. The third (F3), fourth (F4), and fifth (F5) factors had eigenvalues of 1.289, 1.151 and 1.089, respectively. F3 explained 10.74% of the variance, F4 explained 9.59% of the variance, and F5 explained 9.08% of the variance. A total of 8.35% of the variance was explained by the sixth factor (F6), which had an eigenvalue of 1.003.

Table 3: Eigen values and variability

Factors	Eigen value	Variability (%)	Cumulative variance (%)
F1	2.081	17.34	17.34
F2	1.894	15.78	33.12
F3	1.289	10.74	43.86
F4	1.151	9.59	53.45
F5	1.089	9.08	62.53
F6	1.003	8.35	70.88

Table 4 shows the results of polychoric PCA. The correlation between a factor and the indicators in a PCA framework is known as factor loading, which reveals the information shared by the indicators and factors (Mutabazi *et al*., 2015) [26]. The Food Security Score (FSS) was constructed using the highest factor loading of each indicator, as shown in equation (2). Indicators such as distance to public distribution system outlets, distance to school and distance to healthcare services had the highest loadings in the first factor (F1). In the second factor (F2), household food expenditure per month, household-level food production, and total annual average household income had the highest factor loadings. Awareness of institutional credit access and access to health insurance services had their maximum loadings in the third factor (F3). Regarding the fourth factor (F4), the maximum loading was found with the sanitation facilities indicator. In the fifth factor (F5), involvement in a government employment scheme had the highest factor loadings. At last, in the sixth factor (F6), both the access to school and access to safe drinking water had their maximum loadings. The primary goal of PCA in this study was to derive weights for constructing the FSI, while also revealing the hidden correlations between different variables (Sam *et al*., 2018) [30].

Table 4: Factor loadings of PCA used for the construction of FSI

Food security dimensions	Indicators	Factors loadings					
		F1	F2	F3	F4	F5	F6
Food availability	Household-level food production	-0.157	0.506	0.341	-0.020	-0.257	-0.247
	Distance to Public Distribution System (PDS)	0.699	0.288	-0.388	0.098	0.161	0.083
Food access	Access to school	0.250	-0.438	0.123	-0.385	0.227	-0.511
	Distance to school	0.817	-0.307	0.112	-0.158	0.001	-0.053
	Awareness of formal credit access	0.096	0.434	0.492	-0.230	-0.041	0.287
Food utilization	Access to safe drinking water	-0.088	0.269	-0.190	-0.499	-0.040	0.543
	Sanitation facilities	0.175	0.160	0.306	0.705	-0.199	-0.035
	Distance to healthcare services	0.834	0.054	-0.054	0.040	-0.311	0.132
	Household with health insurance	0.252	0.097	0.709	-0.169	0.152	0.071
Food stability	Involvement in a government employment scheme	0.027	0.079	0.138	0.275	0.867	0.203
	Total annual average household income	-0.006	0.657	-0.052	-0.244	0.122	-0.431
	Average monthly household food expenditure	0.172	0.730	-0.310	0.053	0.133	-0.207

Values in bold indicate the highest factor loading; Bartlett's sphericity test: Chi-square (Critical value): 85.96 (P<0.0001), df: 66

The adjusted FSI ranges from 0 (indicating food insecurity) to 1 (indicating food security). Based on this, the households were divided into four quartiles as follows:

- **First quartile:** 0-0.25 (Low food security)
- **Second quartile:** 0.251-0.50 (Medium food security)
- **Third quartile:** 0.501-0.750 (High food security)
- **Fourth quartile:** 0.751-1 (Very high food security)

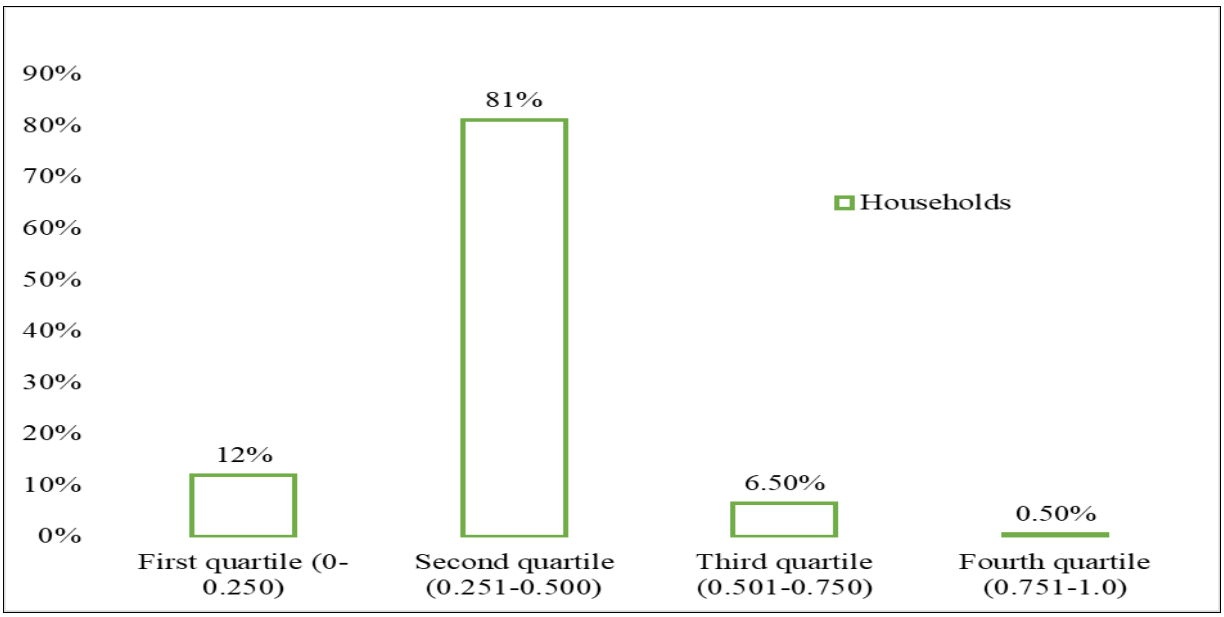

Fig 2: Distribution of respondents according to FSI scores

Figure 2 depicts the percentage of households falling under each quartile. More than 90% of the households fell within the first and second quartile, indicates low and medium food security. Only about 7% of households fell within the third and fourth quartile, showing relatively higher food security. This distribution highlights the fragile nature of household food systems in the islands. The major reasons for such low food security are the geographic isolation of Lakshadweep islands, which creates heavy dependence on the mainland for essential food supplies, and the high transportation costs that inflate food prices and reduce affordability (Purvaja *et al*. 2019) [45]. Moreover, the limited livelihood diversification, largely confined to fishing and coconut farming makes households vulnerable to seasonal fluctuations, market uncertainties, and climatic risks. Collectively, these constraints prevent most households from moving beyond medium food security and underscore the structural challenges of ensuring stable and reliable access to food in a remote island context.

Conclusion

The present study quantified household food security in the geographically isolated and ecologically fragile Lakshadweep islands, where dependence on the mainland, high transportation costs, and limited livelihood opportunities trap households in persistent vulnerability. This study constructed a composite FSI considering various dimensions of food security suggested by FAO, which are intended to create household food security. The study revealed that the majority of households experience medium food security, with a tiny proportion being food secure. The findings highlight how socio-economic factors, such as household income, education, access to schools, and healthcare services, strongly shape household resilience. Similar to other marginalised areas, the adaptive capacity of households plays a pivotal role in shaping food security outcomes, suggesting that interventions such as livelihood diversification beyond fishing and coconut farming, greater awareness of credit facilities, improved connectivity, and strengthened social safety nets are crucial.

Acknowledgement
We would like to express sincere gratitude to all the respondents who participated in this study and generously shared their valuable insights and experiences on food security. Their cooperation and willingness to provide detailed feedback were instrumental in making this research possible.

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