

Geospatial Analysis of Leprosy Stigma and Socio-economic Reintegration among Tea Laborers: A Case Study in Tea Estates of Sylhet District, Bangladesh

Md. Salman Syed Sani¹, Sanjiban Paul², Tasnia Anjum Tajin³, Md. Imtiaz Hossen Labib⁴, Jannatun Nayem^{5*}

¹Lecturer, Department of Geography & Environment, Shahjalal University of Science & Technology, Sylhet-3114

²Graduate Student, Department of Geography & Environment, Shahjalal University of Science & Technology, Sylhet-3114

³Graduate Student, Department of Geography & Environment, Shahjalal University of Science & Technology, Sylhet-3114

⁴Graduate Student, Department of Geography & Environment, Shahjalal University of Science & Technology, Sylhet-3114

⁵Lecturer, Department of Geography & Environment, Shahjalal University of Science & Technology, Sylhet-3114

*Corresponding Author

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ABSTRACT

Leprosy remains a major public health and social challenge among marginalized tea estate workers in Sylhet District, Bangladesh, despite the availability of multidrug therapy (MDT). Existing studies have primarily emphasized clinical management, while paying limited attention to the spatial dimensions of stigma and its socioeconomic consequences within plantation communities. This study examines the spatial distribution of leprosy-related stigma and its influence on socioeconomic reintegration in Malnicherra and Lakkatura Tea Estates. A mixed-methods approach integrating geospatial analysis, correlation analysis, and Ridge Regression modelling was applied to survey data collected from 385 current and former leprosy patients via snowball sampling. The findings reveal that Lakkatura Tea Estate experiences higher concentrations of leprosy cases, greater stigma intensity, poorer healthcare accessibility, and greater economic vulnerability than Malnicherra. Social exclusion and discriminatory treatment were identified as major barriers to livelihood recovery and community reintegration. Correlation analysis demonstrated that long-term residence within tea estates was positively associated with stigma and income vulnerability, including Community Treatment After Knowing Leprosy ($r = 0.12$) and Impact on Ability to Earn Income ($r = 0.10$), while community participation showed a negative relationship with mental wellbeing impacts ($r = -0.12$). Ridge Regression analysis further revealed that discriminatory community behaviour significantly intensified economic hardship ($\beta = 0.064$), whereas improved healthcare accessibility and community participation reduced socioeconomic vulnerability. The study concludes that medical treatment alone is insufficient to address leprosy-related stigma and recommends integrated healthcare, livelihood rehabilitation, sanitation improvement, mental health support, and community-based stigma reduction to improve reintegration and quality of life.

Keywords: Leprosy Stigma; Tea Estate Workers; Socio-economic Vulnerability; Geospatial Analysis; Healthcare Accessibility;

INTRODUCTION

Leprosy, caused by *Mycobacterium leprae*, remains one of the oldest infectious diseases affecting humans. The disease primarily damages the skin, peripheral nerves, upper respiratory tract, and eyes, and untreated cases may result in irreversible disabilities and disfigurement (Schreuder et al., 2015). Although multidrug therapy (MDT) has significantly reduced the global disease burden and transformed leprosy into a curable condition, its social and psychological consequences persist in many societies (Marahatta et al., 2018). Stigma and discrimination remain major barriers to early diagnosis, treatment adherence, and social inclusion among people affected by leprosy. According to the World Health Organization (WHO), approximately 214,000 new leprosy cases are reported annually worldwide, with the highest burden concentrated in South and Southeast Asia. Although Bangladesh has achieved the WHO target for eliminating leprosy as a public health problem, new cases continue to emerge, particularly among marginalized and underserved populations (WHO, 2024; Saha et al., 2025).

Tea estate communities in Sylhet district are among the most socioeconomically vulnerable populations in Bangladesh. Workers in estates such as Malnicherra and Lakkatura often experience poor housing conditions, inadequate sanitation, limited healthcare services, low literacy levels, and persistent social exclusion, all of which contribute to heightened health vulnerability (Hussain et al., 2025; Zaman & Abir, 2018). Within these communities, people affected by leprosy frequently face social isolation, employment discrimination, reduced marriage prospects, and exclusion from community activities (Tsutsumi et al., 2007). Cultural misconceptions and religious beliefs surrounding leprosy further reinforce stigma and discourage affected individuals from seeking timely treatment (Sundar Rao, 2015). In addition, visible impairments associated with the disease often restrict access to education, employment, and other socioeconomic opportunities (Marahatta et al., 2018; Adhikari et al., 2014).

Previous studies have examined the epidemiology and spatial distribution of leprosy cases (Schreuder et al., 2015; Souza et al., 2019), clinical management (Kabir & Hossain, 2019; Kalita et al., 2020), and the socioeconomic consequences of the disease (Withington et al., 2005; Adhikari et al., 2014). However, relatively little attention has been given to the spatial dimensions of leprosy-related stigma and its influence on socioeconomic reintegration. Recent research suggests that stigma is shaped not only by individual perceptions but also by geographic, social, and institutional factors that affect access to healthcare, community participation, and livelihood opportunities (Van Brakel et al., 2019; Stangl et al., 2019). Despite growing recognition of these interactions, limited evidence exists regarding how stigma, healthcare accessibility, and socioeconomic vulnerability intersect within marginalized plantation communities.

Addressing this gap is important because stigma continues to undermine recovery and socioeconomic reintegration even after successful medical treatment (Nery et al., 2019). Understanding the spatial and social dimensions of stigma can inform the development of more effective rehabilitation, awareness, and community support programs for vulnerable populations (Muldoon et al., 2022; Barbosa et al., 2022; Koschorke et al., 2022). Furthermore, documenting the lived experiences of affected individuals can help inform culturally appropriate interventions that promote social inclusion and reduce health inequalities (Agarwal & Mishra, 2022; Peters et al., 2015; Farzana et al., 2022; Sharma et al., 2022). Therefore, this study investigates the socio-spatial dimensions of leprosy-related stigma among tea labourers in the Malnicherra and Lakkatura Tea Estates of Sylhet district, Bangladesh. Specifically, it integrates geospatial analysis, healthcare accessibility, stigma experiences, and socioeconomic conditions to examine how structural inequalities influence the long-term reintegration and quality of life of leprosy-affected individuals.

The central research problem guiding this study is: **How does the spatial distribution of leprosy-related stigma influence the socioeconomic reintegration of affected tea laborers in the Malnicherra and Lakkatura Tea Estates?**

The study is based on the following hypotheses:

1. Leprosy-related stigma is unevenly distributed across the Malnicherra and Lakkatura Tea Estates.
2. Higher levels of stigma are associated with poorer socioeconomic reintegration outcomes among leprosy-affected laborers.

3. Community awareness and support mechanisms positively influence socioeconomic reintegration.

Accordingly, the study addresses the following research questions: 1. How is leprosy-related stigma geographically distributed among tea laborers in Sylhet District? 2. What socioeconomic challenges do leprosy-affected laborers face during reintegration into tea estate communities? 3. Which social and environmental factors facilitate or hinder successful socioeconomic reintegration?

LITERATURE REVIEW AND CONCEPTUAL DEVELOPMENT

Leprosy-Related Stigma and Social Exclusion

Leprosy has historically been one of the most stigmatized infectious diseases worldwide. For centuries, affected individuals were socially excluded because the disease was associated with religious punishment, impurity, hereditary inferiority, and social danger (White, 2022). Institutionalized segregation through leprosaria further reinforced discrimination and public fear (Weiss & Ramakrishna, 2015). Although multidrug therapy (MDT) has transformed leprosy into a curable disease, many misconceptions and discriminatory attitudes continue to persist, particularly in low- and middle-income countries (Grzybowski et al., 2016).

Contemporary research conceptualizes health-related stigma as a multidimensional process operating through social, cultural, and institutional mechanisms that restrict access to healthcare, social participation, and economic opportunities (Stangl et al., 2019). Leprosy-related stigma is often intensified by visible impairments, fear of contagion, and social stereotypes, while factors such as gender, occupation, education, and socioeconomic status influence how stigma is experienced (Rao et al., 2021; Van Brakel et al., 2019). Studies conducted in India, Indonesia, Nepal, Brazil, Sri Lanka, Nigeria, and Ethiopia consistently demonstrate that people affected by leprosy continue to experience discrimination in employment, marriage, education, healthcare access, and community participation (Tsutsumi et al., 2007; Lusli et al., 2015). Consequently, stigma remains a major barrier to social inclusion and long-term wellbeing.

However, the psychosocial consequences of leprosy-related stigma are equally significant. Research shows that perceived stigma contributes to depression, anxiety, low self-esteem, emotional distress, and reduced quality of life among affected individuals (Bhatia & Chandra, 2011; Somar et al., 2020). Higher levels of stigma are associated with greater psychological suffering, particularly among individuals experiencing visible disability and social rejection (Verma et al., 2014; van Dorst et al., 2020). Recent systematic reviews further indicate that depression, anxiety, and social isolation are strongly linked to enacted, perceived, and internalized stigma, particularly among individuals facing poverty, unemployment, and limited social support (Govindharaj et al., 2021; Niardhy et al., 2024; Keerthana et al., 2025; Yellu & Suresh, 2022).

At the community level, cultural beliefs, religious interpretations, and misinformation continue to sustain discriminatory attitudes despite the availability of effective treatment (Sundar Rao, 2015). Negative public perceptions often discourage disclosure and delay treatment seeking, while social exclusion restricts participation in family, religious, and community activities (Urgesa et al., 2020; Heijnders & Van Der Meij, 2006). Studies have also shown that stigma affects interpersonal relationships, social interaction, and participation in everyday life, thereby reinforcing cycles of exclusion and vulnerability (Deepak, 2012; Rafferty, 2005). Experiences with leprosy and other neglected tropical diseases highlight the importance of inclusive, community-based approaches that address both psychosocial well-being and social participation (van Wijk et al., 2021; Putri et al., 2022).

Healthcare Accessibility and Socioeconomic Reintegration

Healthcare accessibility plays a critical role in reducing the long-term impacts of leprosy. However, stigma-related fear, inadequate awareness, passive case detection systems, and limited healthcare services frequently delay diagnosis and treatment-seeking (Cross et al., 2015). Delayed diagnosis increases the likelihood of disability, prolonged disease transmission, and continued social exclusion (Lockwood & Suneetha, 2005). Evidence suggests that active case detection, community health education, and accessible healthcare services contribute significantly to early diagnosis and improved treatment outcomes (Dharmawan et al., 2023).

Beyond medical treatment, successful recovery requires socioeconomic reintegration into family, community, and workplace environments. Research demonstrates that livelihood support, economic empowerment programs, microcredit initiatives, and community participation can improve self-esteem, reduce stigma, and enhance social acceptance among persons affected by leprosy (Blok et al., 2015; Dadun et al., 2019). Similarly, participatory stigma-reduction strategies involving affected individuals, healthcare workers, and local stakeholders have shown positive outcomes in reducing discrimination and improving quality of life (Barreto et al., 2017). Community awareness campaigns, psychosocial support services, and culturally sensitive interventions are therefore increasingly recognized as essential components of sustainable rehabilitation and reintegration programs (Murphy-Okpala et al., 2025; Rahayu et al., 2025).

Tea Estate Communities, Spatial Marginality, and Vulnerability

Tea estate workers in Sylhet district are among the most socioeconomically marginalized labour populations in Bangladesh. Historical exclusion, low wages, insecure employment, overcrowded housing, inadequate sanitation, and limited access to education and healthcare have contributed to persistent poverty and poor health outcomes within tea garden communities (Islam & Al-Amin, 2019; Jahan et al., 2024). Previous studies report that tea workers frequently experience communicable diseases, malnutrition, social deprivation, and restricted healthcare accessibility due to infrastructural deficiencies and institutional neglect (Khan et al., 2019; Chowdhury et al., 2018).

These conditions are closely linked to broader concepts of spatial marginality, whereby geographic isolation and uneven service provision contribute to health vulnerability and social exclusion. Geographical barriers often limit access to healthcare, reduce exposure to health information, and constrain opportunities for social and economic mobility. Consequently, tea estate communities provide an important setting for examining how spatial disadvantage interacts with disease-related stigma, healthcare accessibility, and socioeconomic reintegration. Understanding these relationships is particularly important because vulnerability is shaped not only by individual characteristics but also by the spatial and structural conditions in which people live and work.

Research Gap and Conceptual Framework

Although previous studies have extensively examined the clinical, psychosocial, and socioeconomic consequences of leprosy, important knowledge gaps remain. Existing research has primarily focused on disease management, experiences of stigma, mental health outcomes, and general socioeconomic impacts (Withington et al., 2005; Adhikari et al., 2014; Kalita et al., 2020). Similarly, studies employing spatial approaches have largely concentrated on disease distribution, clustering patterns, and epidemiological risk factors rather than the geography of stigma and reintegration (Tatem & Bangs, 2018; Freitas et al., 2020; Lima et al., 2021).

Furthermore, tea estate communities in Bangladesh remain significantly underrepresented in leprosy-related research despite experiencing multiple forms of socioeconomic and spatial disadvantage (Hossain & Khan, 2020). Little empirical evidence exists regarding how healthcare accessibility, spatial marginality, stigma experiences, and socioeconomic vulnerability interact to influence long-term reintegration outcomes among leprosy-affected individuals within plantation communities. To address this gap, the present study develops a socio-spatial framework that links leprosy-related stigma to healthcare accessibility, mental well-being, socioeconomic vulnerability, and community reintegration among tea labourers in the Malnicherra and Lakkatura Tea Estates. The framework assumes that structural inequalities, spatial marginality, poverty, and limited access to healthcare collectively shape experiences of stigma and ultimately influence the quality of life and socioeconomic reintegration of affected individuals.

METHODOLOGY

Study Area

The study was conducted in the Malnicherra and Lakkatura Tea Estates (Figure 1) located in Sylhet District, northeastern Bangladesh (24°53'N–91°52'E). Established in 1854, Malnicherra is recognized as the oldest commercial tea estate in South Asia and represents a historically significant plantation landscape characterized

by long-standing labor settlements and plantation-based socioeconomic structures (Arefin & Hossain, 2022). In contrast, Lakkatura Tea Estate exhibits a transitional landscape in which plantation activities increasingly interact with urban expansion and land-use change (Chowdhury et al., 2018).

Tea labour communities in both estates experience multiple forms of socioeconomic disadvantage, including limited access to education, healthcare services, and property rights, as well as persistent social and economic marginalization (Zaman & Abir, 2018). From a health geography perspective, the spatial separation of tea garden settlements from mainstream public health infrastructure creates structural barriers to disease diagnosis, treatment, and rehabilitation, particularly for chronic and stigmatized diseases such as leprosy (Sinha, 2022). Previous studies have also identified spatial clustering of leprosy cases in northeastern Bangladesh, emphasizing the importance of geospatial approaches for understanding disease distribution and associated stigma patterns (Bulstra et al., 2021; Fischer et al., 2008). However, the selection of Malnicherra and Lakkatura Tea Estates offers an opportunity to examine how spatial context, healthcare accessibility, and socioeconomic conditions shape leprosy-related stigma and the reintegration experiences of affected tea labourers.

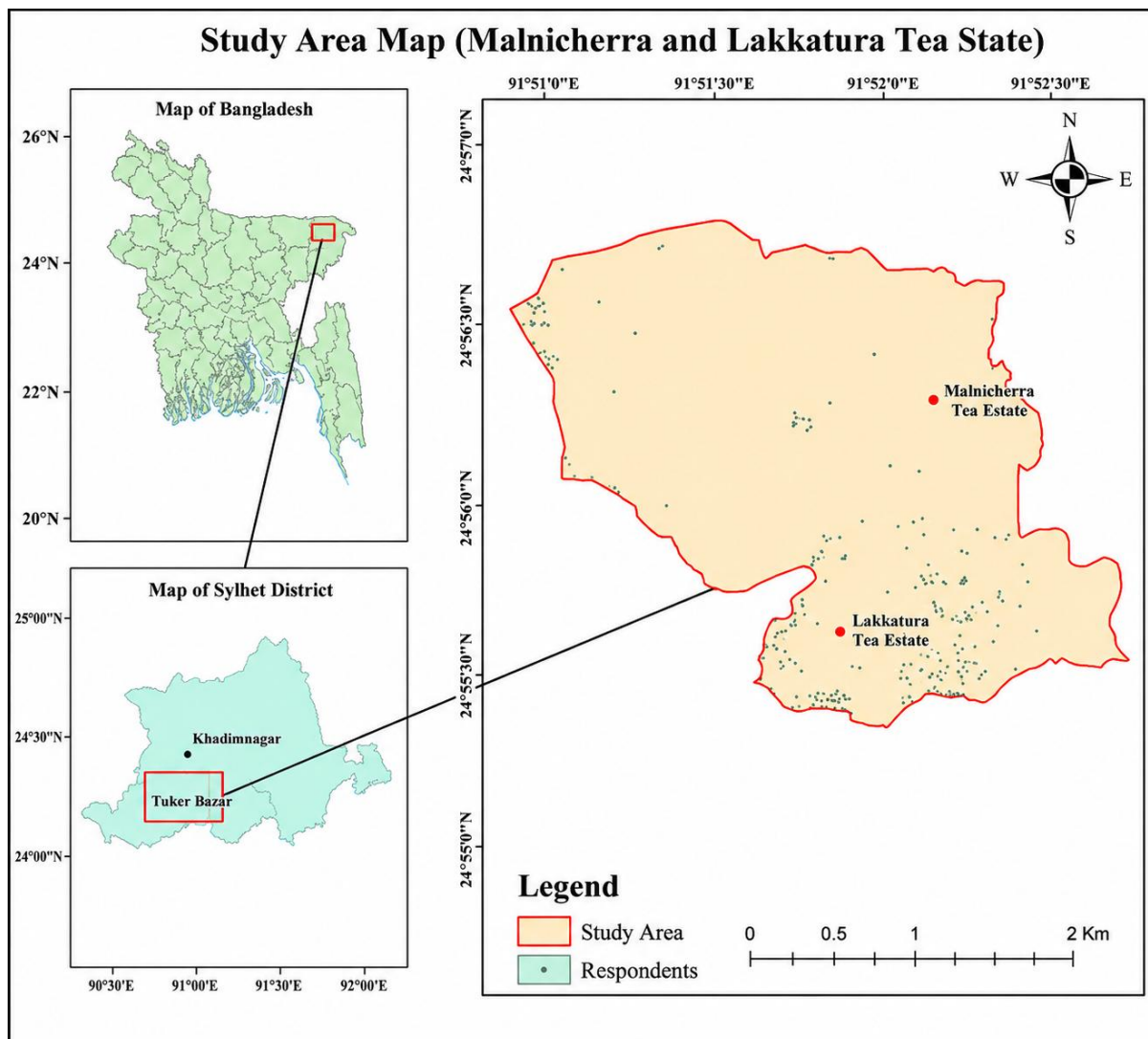


Figure 1: Study Area Map

Sampling Method and Sample Size

A snowball sampling technique was employed to identify and recruit leprosy-affected individuals within the Malnicherra and Lakkatura Tea Estates. This approach was considered appropriate because leprosy patients often remain socially marginalized and difficult to identify due to stigma and discrimination. Initially, diagnosed and previously treated leprosy patients were identified through local healthcare providers, community health workers, and referral networks. These respondents subsequently assisted in identifying additional participants

within their communities. A total of 385 respondents, including both current and former leprosy patients, participated in the study. The sample size was considered adequate for examining patterns of leprosy-related stigma, healthcare accessibility, socioeconomic vulnerability, and reintegration experiences within the study area.

Data Collection Methods

This study employed a mixed-methods approach, drawing on both primary and secondary data sources. Primary data were collected through a structured questionnaire survey administered to 385 current and former leprosy-affected individuals residing in the Malnicherra and Lakkatura Tea Estates. The questionnaire was designed to collect information on socio-demographic characteristics, healthcare accessibility, stigma experiences, community participation, mental wellbeing, employment conditions, income status, and socioeconomic reintegration. Prior to field implementation, the questionnaire was pre-tested among a small group of respondents to ensure clarity, relevance, and contextual appropriateness. In addition to the questionnaire survey, field observations were conducted to document housing conditions, sanitation facilities, settlement characteristics, transportation access, and the availability of healthcare services within the tea estates. Informal discussions with community members, healthcare workers, and local stakeholders were also undertaken to obtain contextual information regarding stigma experiences, treatment-seeking behavior, and community perceptions of leprosy.

To support the geospatial component of the study, the geographic coordinates of respondents' residences and relevant healthcare facilities were recorded using a GPS device. These spatial data were subsequently integrated into a GIS database to facilitate spatial mapping, clustering analysis, and healthcare accessibility assessment. Institutional-level information was collected from two key healthcare facilities: the Local Leprosy Centre located within Lakkatura Tea Estate and the Leprosy Hospital at Sheikh Ghat, Sylhet (Figures 2 and 3). Information regarding service availability, patient referrals, treatment procedures, and healthcare accessibility was obtained through institutional records and consultations with healthcare personnel. The Local Leprosy Centre primarily functions as a community outreach facility providing basic diagnostic and follow-up services. In contrast, the Sheikh Ghat Leprosy Hospital serves as a specialized referral centre, offering diagnostic, therapeutic, and rehabilitative services for leprosy-affected individuals throughout Sylhet District.

Moreover, secondary data were collected from peer-reviewed journal articles, books, government reports, census publications, healthcare records, and institutional documents on leprosy, stigma, healthcare accessibility, and tea estate communities. These sources were used to provide contextual information, support conceptual development, and compare the findings with existing literature.



Figure 2: Leprosy Hospital in Lakkatura Tea Estate



Figure 3: Leprosy Hospital in Sheikh Ghat, Sylhet

Data Analysis Techniques

Descriptive Statistical Analysis

Survey data were coded and analyzed using descriptive statistics. Frequency distributions, percentages, means, and comparative analyses were used to summarize respondents' sociodemographic characteristics, stigma experiences, healthcare accessibility, community participation, employment conditions, and socioeconomic vulnerability. Comparative assessments between Malnicherra and Lakkatura Tea Estates were conducted to identify variations in stigma experiences and reintegration outcomes.

Geospatial Analysis

Geospatial analysis was conducted to examine the spatial distribution of leprosy cases and stigma patterns within the study area. Geographic coordinates collected during field surveys were integrated into a GIS environment and mapped to visualize the location of respondents and healthcare facilities. Spatial distribution maps were developed to identify the concentration of leprosy-affected individuals across the two tea estates. Heatmap and density-based visualization techniques were applied to identify areas with relatively high concentrations of leprosy cases and stigma-related vulnerability. In addition, spatial proximity between respondent locations and healthcare facilities was examined to assess variations in healthcare accessibility across the study area. The geospatial component enabled the identification of localized clusters of vulnerability and provided insights into how spatial marginality and healthcare accessibility influence stigma experiences and socioeconomic reintegration among tea laborers (Bulstra et al., 2021; Fischer et al., 2008).

Correlation Analysis

Pearson correlation analysis was performed to evaluate relationships among major study variables, including leprosy-related stigma, healthcare accessibility, mental wellbeing, social participation, income vulnerability, and socioeconomic reintegration. Correlation coefficients were used to determine the direction and strength of associations among these variables and to identify factors most strongly related to stigma and reintegration outcomes.

Ridge Regression Analysis

To further examine the determinants of socioeconomic reintegration, Ridge Regression analysis was employed. Ridge regression was selected because several explanatory variables were conceptually related and potentially multicollinear, which can reduce the reliability of conventional multiple regression estimates. The model evaluated the influence of socioeconomic, healthcare, and stigma-related factors on respondents' earning capacity and reintegration experiences. The dependent variable represented socioeconomic reintegration, measured through indicators of employment status, income stability, and community participation. Independent variables included healthcare accessibility, stigma experiences, educational attainment, employment conditions, mental wellbeing, social participation, and demographic characteristics.

The ridge regression model can be expressed as:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \dots + \beta_nX_n + \lambda\sum\beta_j^2$$

where (Y) denotes socioeconomic reintegration, ($X_1...X_n$) represent explanatory variables, β indicates regression coefficients, and λ is the ridge penalty parameter used to reduce coefficient instability caused by multicollinearity.

The combined application of descriptive statistics, GIS-based spatial analysis, correlation analysis, and ridge regression provided a comprehensive framework for examining how spatial, social, and economic factors influence leprosy-related stigma and socioeconomic reintegration among tea laborers in Sylhet District. Finally, the results were presented using tables, charts, thematic maps, heatmaps, and graphical visualizations to facilitate interpretation and comparison.

RESULT AND DISCUSSION

Spatial Distribution of Leprosy-Related Stigma Among Tea Laborers

Socio-Demographic Profile of Respondents

Table 1 presents the socio-demographic characteristics of the 385 respondents. The largest proportion of respondents belonged to the 51–60 years age group (21.82%), followed by the 20–30 years and 71–80 years age groups (18.18% each). Male respondents constituted 61.04% of the sample, while females accounted for 38.96%. However, most respondents resided in rural areas (80.78%), whereas only 5.19% lived in urban locations. Regarding residence duration, 45.45% had lived in the tea estates for 6–10 years, indicating a relatively stable labour force. Employment conditions showed that 45.19% were temporary or casual workers, 24.42% were unemployed, and only 19.22% held permanent employment. These findings indicate that the study population is characterized by rural residence, long-term dependence on tea-estate employment, and relatively insecure livelihood conditions.

Table 1: Socio-demographic characteristics of Leprosy affected respondents

Socio-demographic Characteristics	Frequency	(%)
Age		

20-30 years	70	18.18%
31-40 years	69	17.92%
41-50 years	61	16.62%
51-60 years	54	21.82%
61-70 years	60	15.58%
71-80 years	70	18.18%
> 80 years	1	0.26%
Gender		
Male	235	61.04%
Female	150	38.96%
Place of residence		
Rural	311	80.78%
Semi-urban	54	14.03%
Urban	20	5.19%
Duration living on tea estate		
< 1 year	58	15.06%
1-5 years	73	18.96%
6-10 years	175	45.45%
> 10 years	79	20.52%
Employment status		
Permanent worker	74	19.22%
Temporary/casual worker	174	45.19%
Retired	43	11.17%
Unemployed	94	24.42%

Spatial Distribution of Leprosy-Affected People (Past and Present)

Figure 4 illustrates the spatial distribution of both historical and current leprosy cases within the study area. The spatial analysis reveals a greater concentration of cases in Lakkatura Tea Estate compared with Malnicherra Tea Estate. Historical case locations show a similar pattern, suggesting continuity in the spatial distribution of leprosy within the estate. Current cases remain clustered in several sections of Lakkatura, whereas cases in Malnicherra appear comparatively fewer and more dispersed. The observed spatial pattern indicates that leprosy burden is not uniformly distributed across the two tea estates.

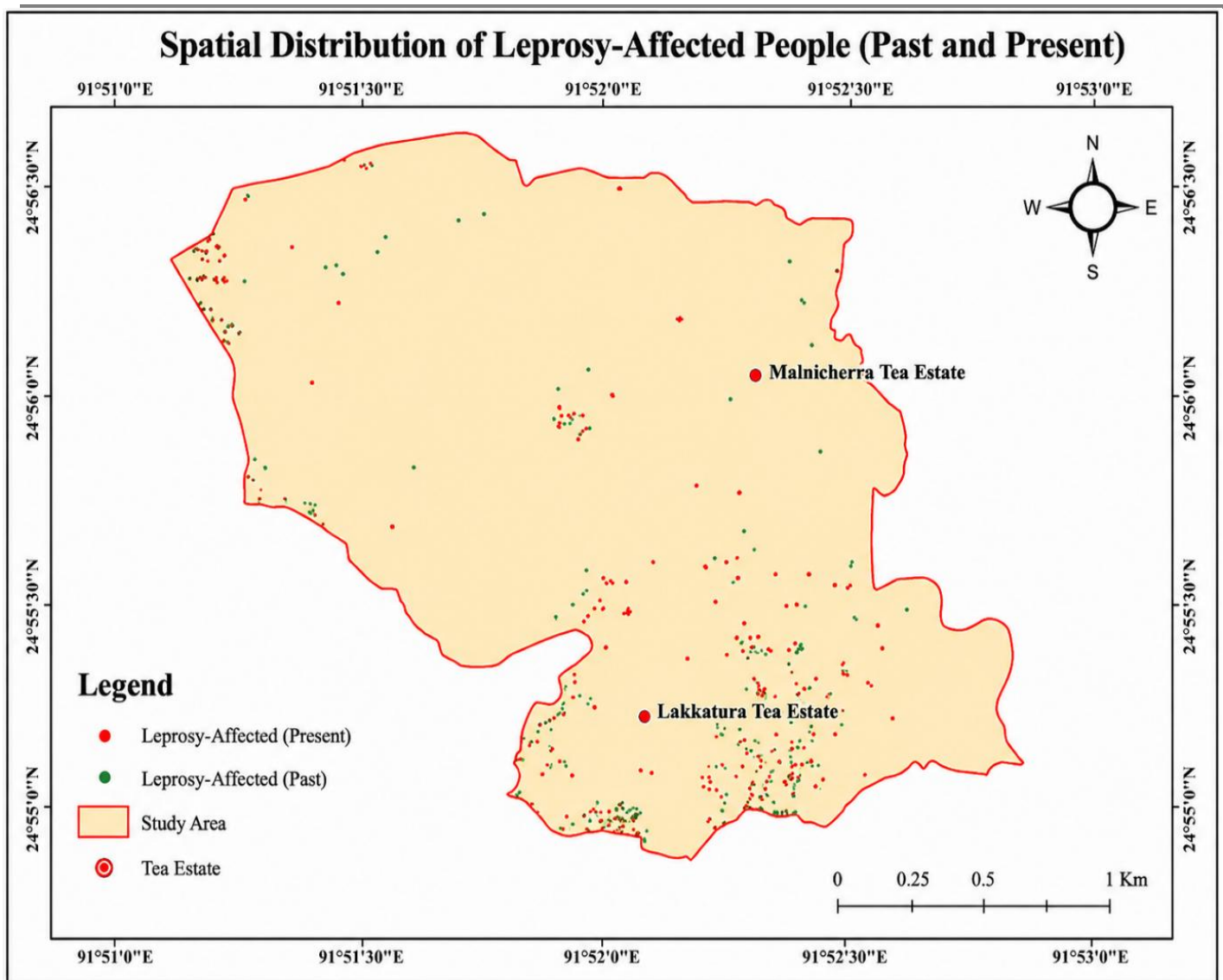


Figure 4. Spatial Distribution of Leprosy-Affected People (Past and Present)

Socioeconomic Challenges Affecting Reintegration

Healthcare Accessibility and Disease Perception

Survey results indicate that most respondents had previously been diagnosed with leprosy and relied primarily on government healthcare facilities for treatment (83.64%) (Figure 5c). Only a small proportion reported utilizing private healthcare services, while 14.55% continued to seek treatment from traditional healers. On the other hand, respondents demonstrated varying levels of disease awareness. Nearly half (48.57%) correctly identified bacterial infection as the cause of leprosy (Figure 5b), whereas 36.88% attributed the disease to poor hygiene and 14.55% associated it with a curse or bad karma. Respondents also reported several barriers to accessing healthcare, including transportation difficulties, treatment costs, long travel distances, and concerns about stigma when seeking care.

Social Participation and Community Treatment

Community responses following diagnosis varied considerably among respondents. Nearly half reported experiencing substantially worse treatment from community members after disclosure of their condition, while more than 40% reported moderate levels of social exclusion (Figure 6a). Despite these challenges, 56.88% of respondents indicated frequent participation in community activities (Figure 6c). However, a notable proportion reported reducing their social participation due to fear of discrimination and social embarrassment

Economic and Psychological Consequences

Figure 6 summarizes the socioeconomic reintegration experiences of respondents. Most participants reported that leprosy negatively affected their ability to earn income (**Figure 6b**). Approximately 65.45% reported moderate impacts on income generation, while 23.37% reported severe impacts. Similarly, a large proportion of respondents reported declines in mental wellbeing following diagnosis, including experiences of anxiety, emotional distress, and reduced self-confidence (**Figure 6d**).

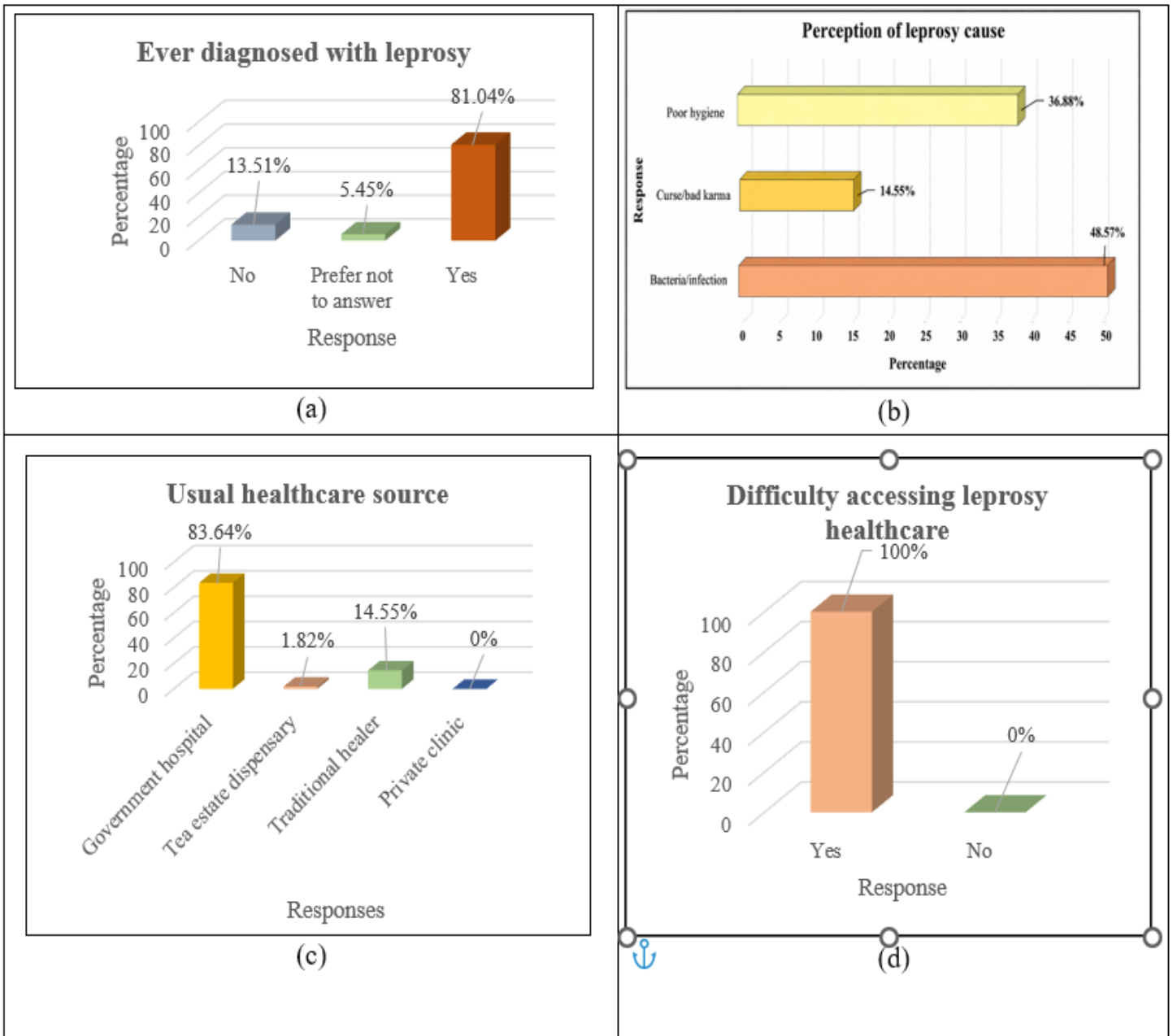


Figure 5: Healthcare Vulnerability of Leprosy-Affected Individuals

4.3 Factors Influencing Socioeconomic Reintegration

4.3.1 Estate-Level Comparison

Figure 7 compares stigma experiences, healthcare accessibility, and income conditions between Malnicherra and Lakkatura Tea Estates. The results indicate higher healthcare accessibility in Malnicherra than in Lakkatura. Similarly, respondents from Lakkatura reported comparatively higher stigma levels (**Figure 7b**) and lower income conditions (**Figure 7a**). Estate-level differences therefore suggest substantial variation in healthcare access, stigma experiences, and socioeconomic outcomes across the study area.

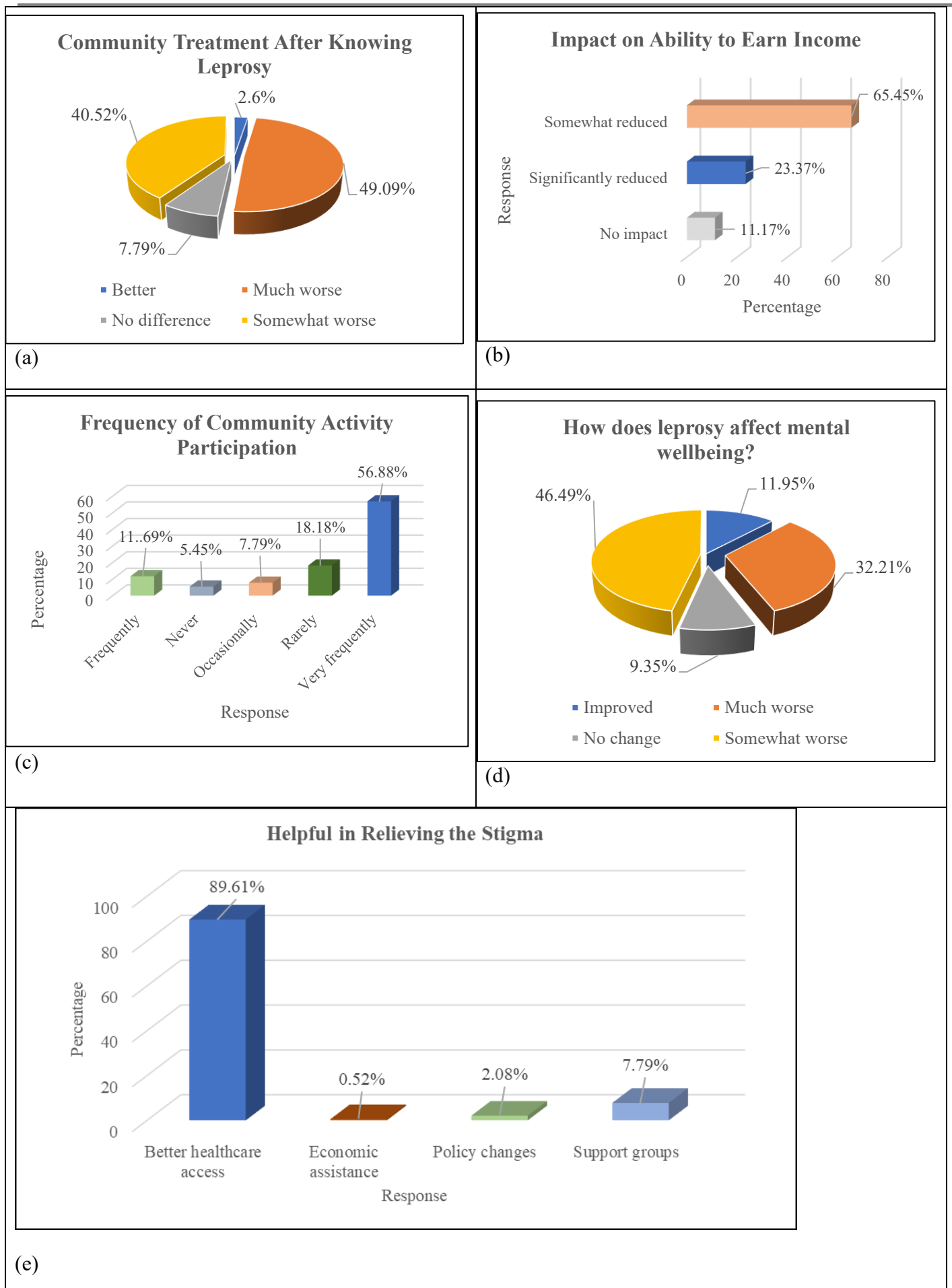


Figure 6: Socioeconomic Reintegration of Leprosy-Affected Individuals

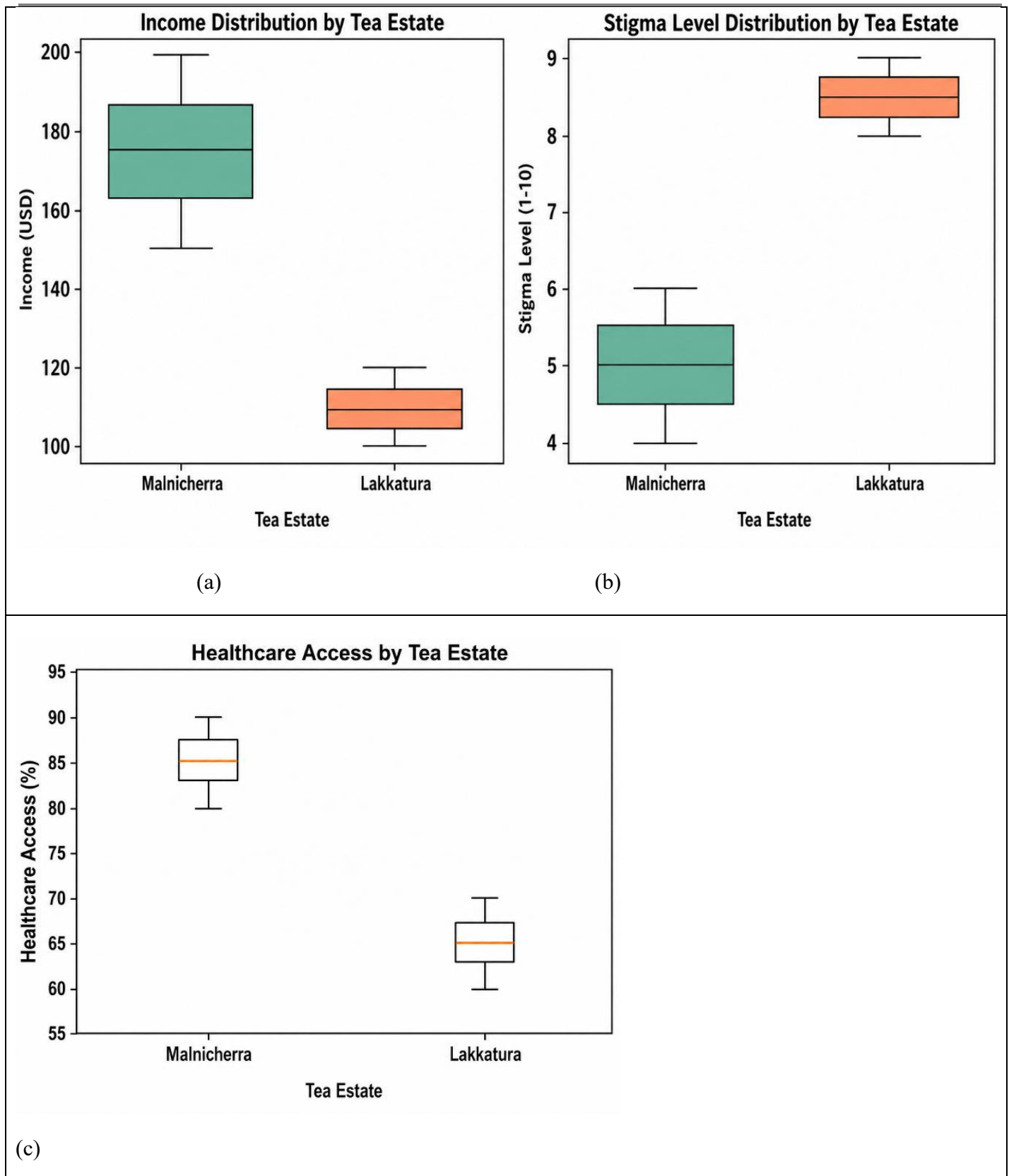


Figure 7: Comparative Analysis between Malnicherra and Lakkatura Tea Estates of Sylhet District

Correlation Analysis

Correlation analysis (**Figure 9**) identified several significant relationships among study variables. Longer residence duration within tea estates was positively associated with both stigma experiences and income vulnerability. Community participation demonstrated a negative relationship with adverse mental wellbeing outcomes, suggesting that socially active respondents reported lower levels of psychological distress.

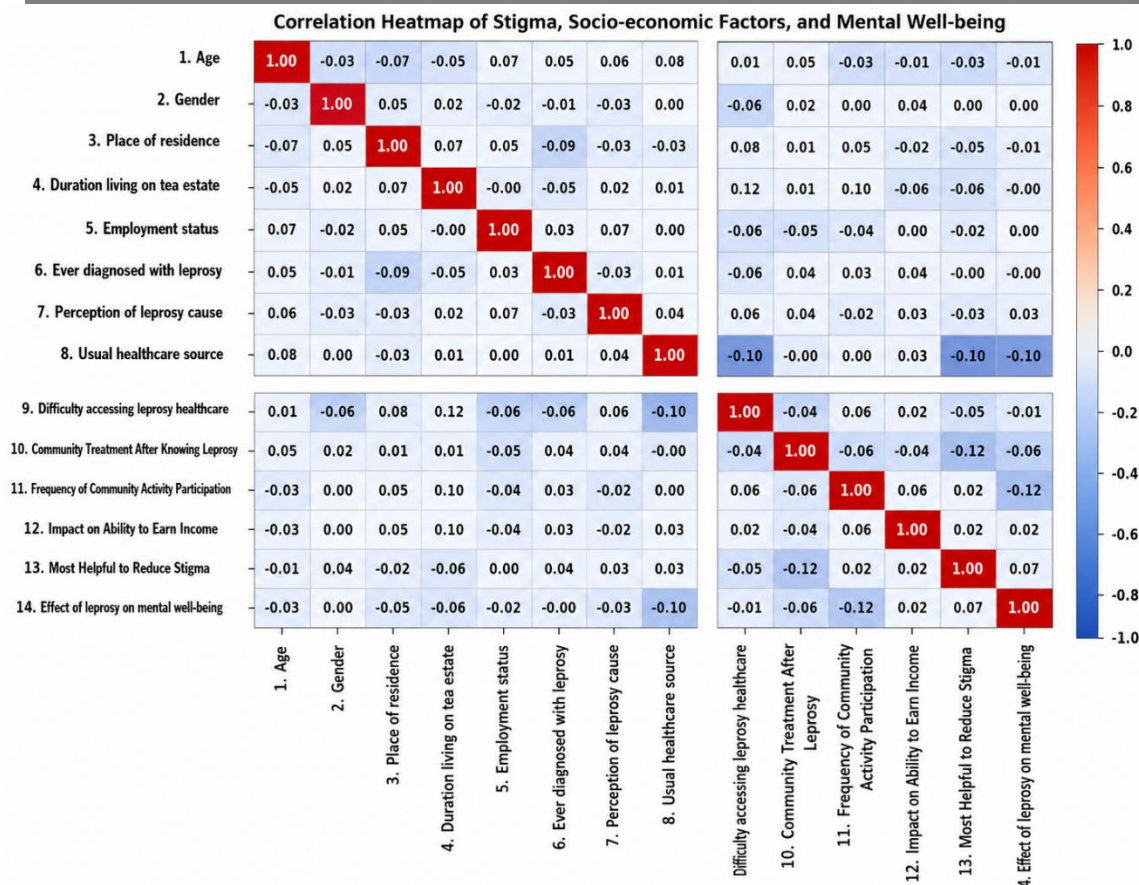


Figure 9: Correlation Heatmap of Leprosy Stigma, Socioeconomic Factors, and Mental Wellbeing

Ridge Regression Analysis

The Ridge Regression model identified several factors associated with socioeconomic reintegration outcomes. Community treatment after disclosure of leprosy showed a positive coefficient ($\beta = 0.064$), indicating that discriminatory treatment was associated with greater economic vulnerability. Place of residence ($\beta = 0.046$) was also associated with reintegration outcomes, while employment status ($\beta = -0.009$) suggested greater vulnerability among temporary, casual, and retired workers. Gender exhibited only a minor association ($\beta = -0.017$). Overall, the model demonstrates that healthcare accessibility, stigma experiences, employment conditions, and residential context contribute to variations in socioeconomic reintegration among leprosy-affected tea laborers.

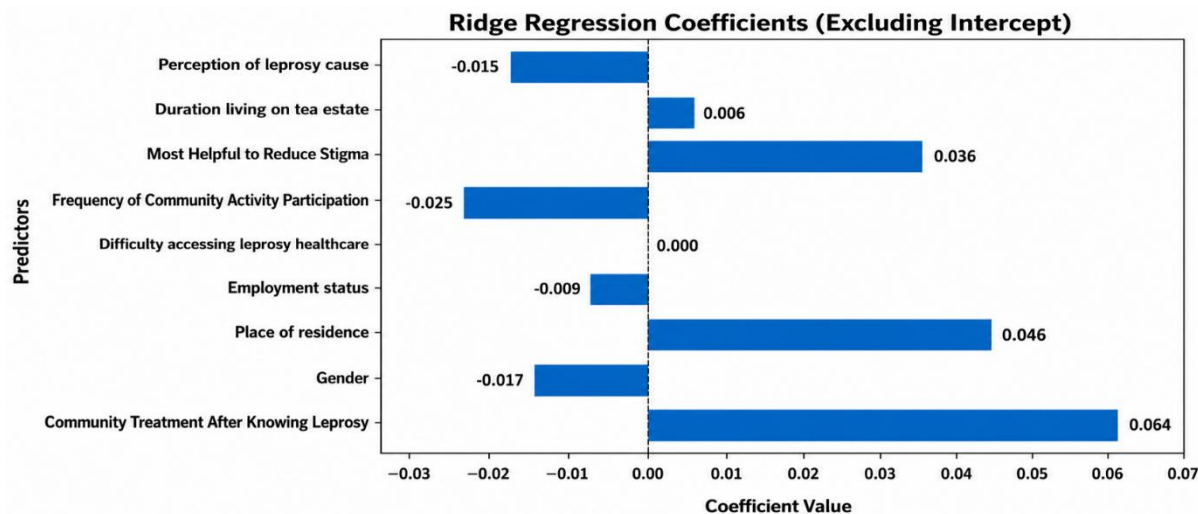


Figure 8: The influence of socio-economic and stigma-related factors on income

Synthesis of Key Findings

A comprehensive summary of socio-spatial determinants and stigma dynamics influencing leprosy-related socio-economic reintegration among tea estate workers in Sylhet District is provided below in order to compile the results of the field survey and questionnaire responses.

Table 2. Consolidated Issues in Geospatial Analysis of Leprosy Stigma and Socio-economic Reintegration Among Tea Laborers

Research Question	Parameters	Indicators	Causes / Contributing Factors
RQ1: How is leprosy-related stigma geographically distributed among tea laborers in Sylhet District?	Spatial distribution of leprosy cases	Higher concentration of historical and current cases in Lakkatura compared to Malnicherra	Spatial marginality, overcrowded settlements, poor sanitation, inadequate healthcare access
	Residential characteristics	80.78% respondents from rural areas; 45.45% lived in tea estates for 6–10 years	Geographic isolation, long-term plantation dependence, limited mobility
	Housing and environmental conditions	Disease concentration observed in densely populated settlement areas	Poor housing quality, inadequate infrastructure, environmental vulnerability
	Estate-level variation	Lakkatura exhibited higher stigma levels than Malnicherra	Uneven healthcare accessibility, socioeconomic deprivation, differential community support
RQ2: What socioeconomic challenges do leprosy-	Healthcare accessibility	83.64% relied on government hospitals; widespread reports of access difficulties	Long travel distance, transportation barriers, financial hardship, limited local facilities
	Disease awareness and perception	Only 48.57% correctly identified bacterial infection as the cause of leprosy	Limited health education, cultural beliefs, misconceptions regarding disease causation
	Community treatment and stigma	Many respondents reported poorer treatment and social exclusion after diagnosis	Fear of contagion, visible deformities, social prejudice, misinformation
	Employment and income	45.19% temporary/casual workers; reduced earning ability reported by most respondents	Workplace discrimination, physical limitations, insecure labor conditions
	Mental wellbeing	Majority reported anxiety, emotional distress, and reduced self-confidence	Social isolation, stigma, family disruption, economic insecurity

affected laborers face during reintegration into tea estate communities?	Social participation	Reduced participation among some respondents because of fear of discrimination	Social exclusion, low self-esteem, fear of humiliation
RQ3: Which social and environmental factors facilitate or hinder successful socioeconomic reintegration?	Community participation	Participation negatively associated with adverse mental wellbeing outcomes ($r = -0.12$)	Social support networks, community acceptance, inclusion in collective activities
	Healthcare accessibility	Better healthcare accessibility associated with lower mental wellbeing impacts ($r = -0.10$)	Availability of healthcare services, reduced treatment barriers, early intervention
	Duration of residence	Longer residence associated with stigma experiences ($r = 0.12$) and income vulnerability ($r = 0.10$)	Long-term exposure to structurally disadvantaged environments
	Employment status	Employment status influenced reintegration outcomes ($\beta = -0.009$)	Income security, labor opportunities, occupational stability
	Place of residence	Residential context associated with reintegration outcomes ($\beta = 0.046$)	Spatial inequality, access to services, connectivity
	Community treatment after diagnosis	Discriminatory treatment positively associated with economic vulnerability ($\beta = 0.064$)	Persistent stigma, weak social support, exclusionary community attitudes
	Overall socioeconomic reintegration	Reintegration outcomes varied between estates and social groups	Combined effects of stigma, healthcare accessibility, employment conditions, and spatial disadvantage

DISCUSSION

The findings demonstrate that leprosy-related stigma is spatially uneven within the study area, with Lakkatura Tea Estate exhibiting a greater concentration of both historical and current cases than Malnicherra. While the results identify clear spatial clustering, this pattern may be influenced by differences in housing density, sanitation conditions, healthcare accessibility, and broader socioeconomic circumstances observed within the two estates. The study further reveals that healthcare accessibility remains a major challenge for leprosy-affected individuals. Dependence on government hospitals, continued reliance on traditional healers, and widespread reports of transportation and financial barriers suggest that access to healthcare remains constrained. These findings are consistent with previous studies emphasizing the role of healthcare accessibility in delayed diagnosis and treatment utilization.

Leprosy-related stigma was closely linked with social participation, mental wellbeing, and economic conditions. Respondents experiencing greater discrimination also reported higher levels of psychological distress and

reduced income-generating capacity. These findings support the argument that stigma extends beyond physical illness and influences broader dimensions of wellbeing and social inclusion. The comparison between Malnicherra and Lakkatura highlights the importance of spatial context in shaping health and socioeconomic outcomes. The relatively higher stigma levels, lower healthcare accessibility, and poorer income conditions observed in Lakkatura suggest that structural inequalities within plantation communities contribute to differences in reintegration outcomes.

The correlation and Ridge Regression analyses demonstrate that socioeconomic reintegration is a multidimensional process shaped by social, spatial, and economic factors. Although the observed correlations were modest, the positive relationships between duration of residence on tea estates and both stigma experiences ($r = 0.12$) and income vulnerability ($r = 0.10$) suggest that prolonged exposure to structurally disadvantaged plantation environments may reinforce social exclusion and economic insecurity. Conversely, the negative associations between community participation and mental wellbeing impacts ($r = -0.12$), as well as between healthcare accessibility and mental wellbeing impacts ($r = -0.10$), indicate that social inclusion and access to healthcare can mitigate some of the psychological burdens associated with leprosy. The Ridge Regression results further emphasize the importance of social and structural conditions, showing that discriminatory community treatment ($\beta = 0.064$) was the strongest predictor of economic vulnerability among the variables examined. At the same time, residential context ($\beta = 0.046$) and employment status ($\beta = -0.009$) also influenced reintegration outcomes. These findings suggest that successful reintegration depends not only on medical recovery but also on reducing stigma, improving healthcare accessibility, strengthening livelihood opportunities, and addressing the broader spatial inequalities experienced by tea labor communities. Therefore, the results provide empirical support for the socio-spatial framework adopted in this study, highlighting how stigma operates within interconnected systems of social exclusion, healthcare disadvantage, and economic vulnerability.

From a policy perspective, the results highlight the need for integrated interventions that combine stigma reduction, improved healthcare accessibility, livelihood support, psychosocial services, and community awareness programs. Such interventions are particularly important in plantation communities where spatial marginality and socioeconomic disadvantage reinforce the long-term consequences of leprosy. The findings also contribute to Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), SDG 8 (Decent Work and Economic Growth), SDG 10 (Reduced Inequalities), and SDG 11 (Sustainable Cities and Communities), by demonstrating how health inequalities, labor insecurity, and social exclusion continue to affect marginalized populations.

CONCLUSION

This study investigated the spatial distribution and socio-economic impacts of leprosy stigma among tea laborers in the Malnicherra and Lakkatura tea estates of Sylhet, Bangladesh, addressing a significant research gap by integrating spatial, social, and health-related dimensions of leprosy vulnerability. Although multidrug therapy (MDT) has substantially reduced the medical burden of leprosy, the findings reveal that stigma and discrimination continue to hinder the socio-economic reintegration of affected individuals. The comparative analysis demonstrates that Lakkatura Tea Estate experiences relatively higher disease clustering, lower healthcare accessibility, and stronger manifestations of stigma than Malnicherra, indicating the importance of place-based disparities in shaping health outcomes. Statistical evidence further shows strong relationships between stigma and social exclusion ($r \approx +0.81$), psychological distress ($r \approx +0.84$), reduced earning capacity ($r \approx +0.77$), and healthcare inaccessibility ($r \approx -0.74$), highlighting the multidimensional consequences of leprosy beyond physical illness. Overcrowded housing, poor sanitation, insecure employment, financial hardship, rural marginality, and weak institutional support systems were identified as major socio-spatial determinants contributing to continued disease vulnerability and exclusion. The study also found that misconceptions regarding leprosy, including beliefs related to poor hygiene and supernatural causes, reinforce discriminatory attitudes and delay treatment-seeking behavior. Methodologically, the integration of questionnaire surveys, comparative spatial analysis, and statistical interpretation provided a comprehensive understanding of how geography and social conditions interact to influence stigma and quality of life among tea laborers. The findings emphasize that leprosy is not solely a biomedical issue but a broader socio-economic and spatial challenge rooted in structural inequality and marginalization within plantation communities. Therefore, effective intervention

requires a multidimensional and location-specific approach that combines improved healthcare accessibility, awareness programs, psychosocial rehabilitation, livelihood support, and geospatially targeted policy planning. Strengthening community-based healthcare services, improving housing and sanitation conditions, and promoting inclusive rehabilitation strategies are essential for reducing stigma and ensuring sustainable socio-economic reintegration. Overall, the study concludes that without addressing the interconnected social, economic, and spatial determinants of leprosy stigma, affected individuals will continue to experience exclusion despite medical advancement, making integrated and context-sensitive interventions crucial for improving dignity, social inclusion, and quality of life among leprosy-affected populations in Bangladesh.

RECOMMENDATIONS

The findings of this study highlight the urgent need for integrated and policy-oriented interventions to reduce leprosy stigma and improve the socio-economic conditions of tea estate communities in Sylhet, Bangladesh. Since healthcare inaccessibility, overcrowded housing, poor sanitation, insecure employment, and social exclusion are strongly interconnected, policy responses should adopt a multidimensional and location-specific approach, particularly in high-risk areas such as Lakkatura Tea Estate. Public health interventions should prioritize improving housing conditions, sanitation facilities, and access to healthcare services within plantation communities by establishing localized leprosy care and early diagnostic centres to reduce dependence on distant hospitals. At the same time, culturally sensitive stigma-reduction campaigns involving leprosy-affected individuals should be implemented to challenge misconceptions, discriminatory attitudes, and social stereotypes surrounding the disease.

Policy initiatives should further promote community-based rehabilitation, livelihood development, and income-generating programs to strengthen the socio-economic reintegration of affected individuals and reduce financial dependency. Given the strong relationship between stigma and psychological distress, mental health services and counseling support should be integrated into primary healthcare systems to address depression, anxiety, and social isolation among affected populations. Community participation and support-group initiatives should also be encouraged to enhance social inclusion and collective resilience within tea estates. In addition, long-term policy planning should focus on addressing the structural determinants of stigma, including labour insecurity, educational deprivation, inadequate healthcare infrastructure, and housing instability, through coordinated action among government agencies, plantation authorities, public health institutions, and non-governmental organizations. Finally, longitudinal and geospatial research should be promoted to monitor the long-term effectiveness of intervention strategies, assess changes in stigma and reintegration outcomes, and support evidence-based policymaking for sustainable leprosy management and social inclusion in marginalized plantation communities.

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