Climate Change Vulnerability and Its Impact on A Small and Medium-Scale Agricultural Community in Rural Sri Lanka; with Special Reference to Galle District

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Abstract

Climate change is a global concern caused by human activities, impacting ecosystems and socio-economic ecology and systems in small cities and rural communities. In particular, communities that rely on the environment and natural resources for livelihood have become more vulnerable to the impact of climate change. In rural Sri Lanka, climate change poses challenges for the agricultural community in various manner. This study explores the vulnerability and impact of climate change on small and medium-scale rural agricultural communities in the Galle District of Sri Lanka. The study involved interviews with key informants and semi-structured interviews with impacted villagers, revealing findings such as; a decline in livelihood productivity, food insecurity, livelihood changes, migration and labour shortages, changes in employment patterns in the agriculture sector to other informal patterns, increased cost of adaptation to climate change incidents, threat to traditional knowledge, and loss of agricultural-friendly biodiversity. Addressing these impacts requires a holistic approach that integrates social and technological aspects, emphasising the importance of collaboration and local knowledge in enhancing resilience in the agricultural sector.

Keywords: Agriculture, Climate Change, Rural Community, Social Impact, Vulnerability

INTRODUCTION

Climate change refers to long-term shifts in temperatures and weather patterns, which can be natural or human-induced. Climate scientists have demonstrated that human activities, such as the emission of greenhouse gases, are primarily responsible for the significant global warming observed over the past two centuries. This rapid warming poses a threat to various aspects of our lives, including health, food security, housing, safety, and employment. Vulnerable populations, such as those residing in small island nations and developing countries, are particularly at risk from the impacts of climate change. From a Sociological perspective, investigating the social impact of climate change in largely overlooked rural communities would provide certain implications for social policy interventions in the country regarding climate change. Therefore, in this study, the researchers aimed to explore climate change vulnerability and its social impact on small and medium-scale rural agricultural communities, particularly in rural areas of the Galle District of Sri Lanka.

LITERATURE REVIEW

Climate change is the result of long-term shifts in temperatures and weather patterns, primarily caused by human activities, especially the burning of fossil fuels (Berrang-Ford et al., 2010). Burning fossil fuels releases greenhouse gases that trap heat in the atmosphere, leading to a rise in the global temperature. This has various negative impacts on Earth, including changes in temperature, precipitation patterns, and other climate variables. Since the late 1800s, the Earth's surface temperature has increased by approximately 1.2 degrees Celsius, making recent decades the warmest on record (Dietz et al., 2020).

Climate change is a major global concern due to rising temperatures, changing precipitation patterns, sea level rise, and natural hazards. Locally, the effects of climate change vary by region, with communities experiencing these impacts to varying degrees (United Nations. n.d.). Ecosystems, human health, food and water security, economies, and communities are highly vulnerable to the

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climate change emergency, making it one of the most critical environmental issues (ibid). The impact of climate change on human systems is influenced not only by the amounts of emissions but also by the vulnerability of these systems to changing climate conditions. Agriculture, water resources, and human health in the region have faced challenges and negative consequences due to these changes (UNEP, 2003). These issues bring uncertainty to the future world. Evaluating the effects of climate change is challenging due to considerable uncertainty regarding future societal and economic development (Hallegatte et al., 2011).

Climate change significantly impacts small and medium-scale agricultural communities, particularly smallholder farmers, who face heightened vulnerabilities due to environmental shifts. Empirical studies reveal that these vulnerabilities vary across different agroecological zones, necessitating tailored adaptation strategies to mitigate adverse effects. Berhanu et al. (2024) highlight smallholder farmers' vulnerabilities to climate change across three agroecologies in Ethiopia, revealing highland areas as the most sensitive and lowland households as the most vulnerable, emphasising the need for sustainable land-use practices and climate-smart agriculture interventions. A study focused on assessing agricultural vulnerability to climate change in Odisha, emphasising exposure, sensitivity, and adaptive capacity proposes tailored adaptation strategies for districts, highlighting the need for localised approaches to mitigate climate change impacts on agriculture (Sahoo & Moharaj, 2024). A study by Abelieneh et al. (2023), assesses smallholder farmers' vulnerability to climate change in Ethiopia, revealing significant agricultural losses and hardships. It highlights the susceptibility of different agroecological zones, with lowland households being the most vulnerable, emphasising the need for sustainable land use practices. Further, smallholder farmers in Nandom District, Ghana are vulnerable to climate change impacts across communities, influenced by agroecosystem services and climate information, which are crucial for effective adaptation practices in agricultural livelihoods (Lente et al., 2024).

Climate change has diverse impacts in the Global South, affecting ecosystems and socio-economic systems in small cities and rural communities (Mirza, 2010). Examples include melting glaciers in the Himalayas, rising sea levels impacting the social ecology of coastal areas and communities, and altered monsoon patterns leading to floods and droughts creating severe negative impacts (Cai et al., 2015). Agriculture is particularly vulnerable to climate change due to its reliance on natural resources like land and water, which are highly impacted by climatic conditions (Gowda et al., 2018). Changes in temperature, precipitation, and frost timing can affect the growing season and crop cultivation. While some regions may benefit from extended growing seasons or new crop opportunities, others may face challenges in agricultural practices.

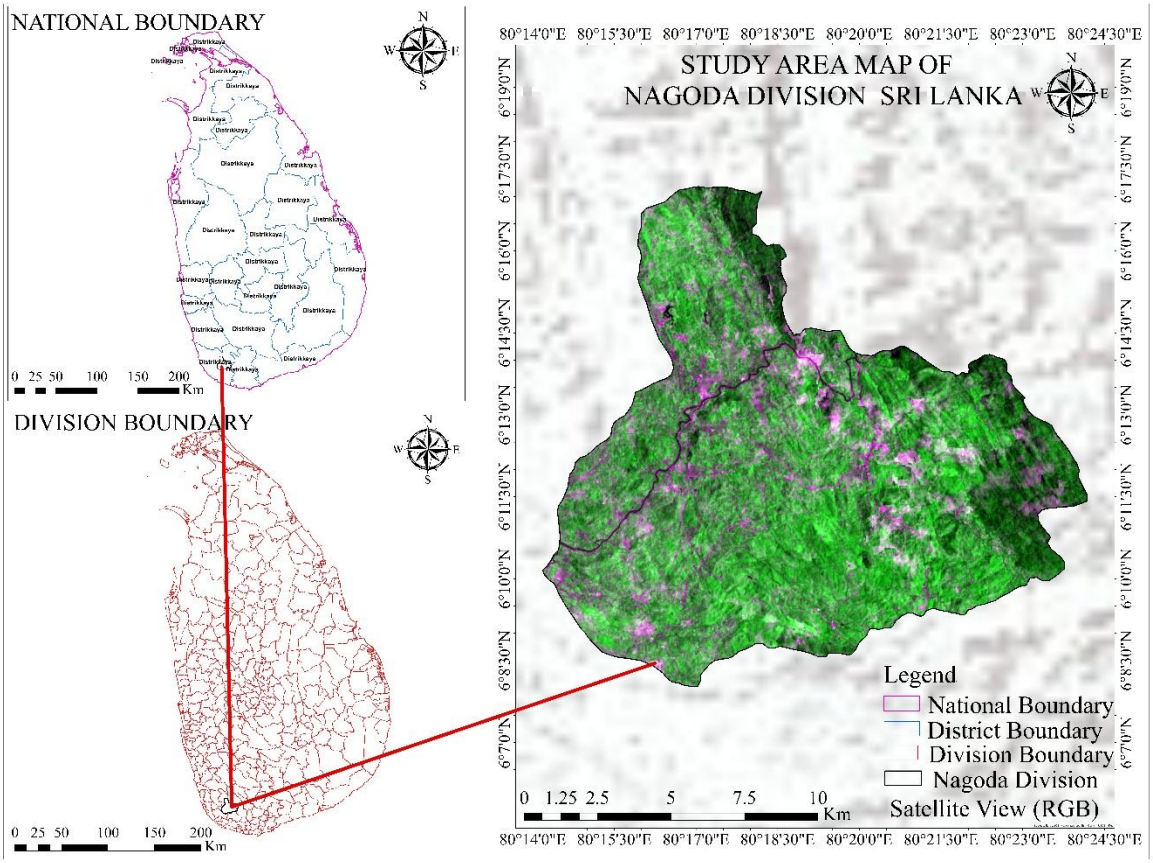
Historical climate data for Sri Lanka show more pronounced warming trends compared to other regions in South Asia (Sheikh et al., 2015). As a result, Sri Lanka is experiencing a rise in the frequency of extreme weather events, including major floods and droughts (Perera, 2015), which have significant implications for food production and rural agricultural livelihoods. The agriculture sector remains a key contributor to Sri Lanka's economy, accounting for 8.57% of the GDP (Central Bank of Sri Lanka, 2023). Approximately 41% of the economically active population is involved in primary agricultural production (FAOSTAT, 2014). Sri Lanka meets about 80% of its annual food requirements domestically (DCS, 2014), with 80% of this food being produced by smallholder farmers who typically cultivate an average landholding size of 0.87 hectares (World Food Programme CDN, n.d.).

Sri Lanka is projected to suffer an economic loss of 1.2% of its GDP by 2050 as a result of climate change (Ahmed and Suphachalasai, 2014). There is a strong consensus that agricultural productivity in the country will decline due to climate change, which will have a negative impact on people who rely on agriculture as their primary livelihood. This may create social economic determinants and drawbacks for the agricultural community living in rural Sri Lanka.

MATERIALS AND METHODS

The research conducted a qualitative study in five selected Grama Niladhari (GN) divisions in the Nagoda Divisional Secretariat office in the Galle District, Sri Lanka, (Figure 01) which experienced the highest instances of floods, unexpected weather events, and droughts from 2020 to 2023. The selected GN Divisions were, Nagoda, Gammaddegoda North, Gammaddegoda South, Kurupanawa and Gonalagoda. Figure 01 shows the location of the study area. The Galle District has an estimated population of 1,139,000, with 87.8% considered rural dwellers engaged in agriculture (Department of Census and Statistics, 2014), making them highly vulnerable to the impacts of climate change. A total of 10 key informant interviews were conducted with officials responsible for agricultural activities, climate change, and disaster management in selected GN divisions and Divisional secretariat areas. Additionally, 30 semi-structured interviews were carried out with individuals affected by climate change-related incidents. The demographic profiles of the respondents are presented in Table 1, with a mix of male (n = 22) and female (n = 8) participants from diverse socio-demographic backgrounds. Initially, key informant interviews were conducted with 8 government officials, including the Village Officer (Grama Niladhari), Economic Development Officer, Disaster Management Officer, Social Service Officer, Agricultural Officer, and Samurdhi Development Officer, as well as two community leaders in the agricultural sector, a doctor from the MOH, and a Physical Health Inspector (PHI) in the area. These interviews aimed to gather insights into the impact of climate change and the vulnerable conditions of the rural community. Subsequently, 30 community members were selected using purposive sampling criteria, based on their experience of being impacted by climate change events and incidents and owning at least 1 acre of agricultural land or 1 acre of tea plantation land affected by climate change between 2022 and 2023. The climate change impact reports of the GN divisions were utilised to identify potential respondents within a specific GN division. Table 3 presents the themes resulting from the analysis, along with their thematic descriptors. In the narratives provided, "KI" refers to key informant interviews, and "SI" refers to semi-structured interviews with community members.

Figure 1: Location map of the Nagoda Divisional Secretariat area



Source: Developed by author, 2024

The sample included both men and women aged 25 to 70 years. A separate interview guide was used for those respondents to explore individual-level experiences regarding the social and environmental impacts of climate change. The demographic information of the respondents is presented in Table 1. Data collection was carried out using a semi-structured interview guide.

Table 1: Demographic information of the respondents in selected GN divisions

Index	Sex	Occupation	Age	GN Division
		Key Informants		
1	F	Grama Niladhari	52	Gammaddegoda North
2	F	Economic Development Officer	42	Kurupanawa
3	F	Samurdhi Officer	45	Gonalagoda
4	M	Disaster Management Officer	37	Nagoda DS Division
5	M	Social Service Officer	58	Nagoda DS Division
6	F	Agricultural Officer	53	Nagoda DS Division
7	M	Chairman of Farmers' Association	62	Gamaddegoda South
8	M	Chairman of Tea Association	69	Nagoda
9	M	Doctor from the MOH, and a	47	Udugama MOH Office
10	M	Physical Health Inspector (PHI)	32	Udugama MOH Office
		Respondents for Semi Structured Interviews		
1	M	Farmer	32	Nagoda
2	M	Tea Palter	37	Nagoda
3	M	Farmer/ Tea planter	42	Nagoda
4	M	Tea Planter	48	Nagoda
5	F	Tea Planter	43	Nagoda
6	M	Farmer	55	Nagoda
7	M	Tea Planter	52	Gammaddegoda South
8	F	Farmer/ Tea planter	67	Gammaddegoda South
9	M	Tea Planter	70	Gammaddegoda South
10	M	Farmer	49	Gammaddegoda South
11	M	Farmer/ Tea planter	51	Gammaddegoda South
12	M	Farmer/ Tea planter	45	Gammaddegoda South
13	F	Tea Planter	68	Gammaddegoda North
14	F	Farmer/ Tea planter	54	Gammaddegoda North
15	M	Farmer/ Tea planter	47	Gammaddegoda North
16	M	Farmer	56	Gammaddegoda North
17	M	Tea Planter	39	Gammaddegoda North

18	F	Farmer/ Tea planter	53	Gammaddegoda North
19	M	Farmer	61	Kurupanawa
20	M	Farmer/ Tea planter	70	Kurupanawa
21	M	Farmer	36	Kurupanawa
22	M	Farmer	41	Kurupanawa
23	M	Farmer/ Tea planter	40	Kurupanawa
24	M	Farmer	57	Kurupanawa
25	M	Farmer/ Tea planter	44	Gonalagoda
26	F	Farmer/ Tea planter	57	Gonalagoda
27	M	Farmer	64	Gonalagoda
28	F	Farmer/ Tea planter	69	Gonalagoda
29	M	Farmer	56	Gonalagoda
30	F	Farmer/ Tea planter	53	Gonalagoda

Source: Field data, 2023

Before the interviews, the research objectives and data protection/access procedures were explained to the respondents, and their participation was voluntary. They were informed that they could withdraw from the interview at any time following the Helsinki guidelines. The interviews were conducted in Sinhalese, the local language, and recorded with their consent. Semi-structured interviews lasted around 40 to 45 minutes, and data collection stopped when saturation was reached.

Recorded narratives were transcribed verbatim and analysed using hand coding. The analysis was inductive and followed a thematic analysis approach (Tong et al., 2007). Interviews were read, codes were identified, and subthemes and main themes were determined by the researcher. Data segments related to themes were translated into English. After the analysis, the findings were shared with key informants and six community members, who confirmed that the findings were coherent and they understood the connection between climate change impacts and societal vulnerability. The researcher ensured the credibility, transferability, dependability, and conformability of the research findings (Lincoln, et al., 1985). The study also followed the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines (Tong et al., 2007). Confidentiality guidelines for data and respondent privacy were strictly adhered to, and data were securely stored. This article does not contain any potentially identifiable information. The study design posed no risks to the respondents during the interviews.

RESULTS AND DISCUSSION

Table 2: Themes and descriptors

No.	Themes	Descriptors
1	Decline in livelihood Productivity	Lack of proper income from tea garden
		Lack of sufficient harvest from the paddy field
		Lack of benefit from farming is less than in prior years
		Soil degradation and no natural organic fertiliser and the magnitude of soil stress in flood and drought
		Water scarcity and natural over-sufficiency
		Dryness of Soil during drought
2	Food Insecurity	Flooding and crop damage
		Flooding and cultivation damage
		Moisture stress during droughts and unexpected temperature
		Challenges in Post-Harvest Storage and Processing
		Pest and Disease Outbreaks
3	Livelihood Changes, Migration and Labour Shortage	Less harvesting areas, fewer tea plantation areas and an Agricultural Workforce
		Lack of working conditions due to extreme weather conditions, and difficulty in economic recovery and finding another source of income generation
		Vulnerability and Inequalities in the agriculture sector and Transformation of Climate resilience and changes in livelihood
4	Changes in Employment Patterns	Health risks to workers
		Increased heat stress and rainfall and loss of labour hours
		Deviation of the young generation from the agriculture sector
		Job Loss in Climate-Sensitive Sectors
		Gender Disparities in Employment
5	Increased Cost of Adaptation	High cost of fertilisers
		Increasing cost of maintenance
		Drought-Resistant Seeds and Crops
		Advanced Irrigation Systems
		The increasing cost of pesticides and pest control
6	Threat to Traditional Knowledge	Disruption of Environmental Cycles and Ecosystems
		Erosion of Agricultural Practices
		Loss of Traditional Crops and Water Resources Management
		Undermining of Traditional Knowledge Transmission
		Introduction of New Environmental Challenges
7	Loss of Biodiversity	Shifts in Habitat and Migration Patterns
		Altered Growing Seasons of plants and species
		Increased Spread of Invasive Species and Pests
		Loss of Culturally and traditionally Important Species

Source: Field data, 2023

According to the respondents, four main types of drastic climate change incidents that they have faced for the last three years were identified. The frequency of response that they have faced these disasters is detailed in Table 3.

Table 3: The frequency of responses to facing climate change incidents

The Nature of the Climate Change Incident	Frequency of the Response
Unpredictable Rainfall	24/30
Unpredictable Drought	27/30
Continuous Flood	32/30
Temperature Changes	21/30

Source: Field data, 2023

According to the table, the most prevalent climate change impact in the area is the continuation of floods. The study area is located near the Gin River, one of the largest rivers in the country which has many low-lying areas. Due to development projects like the Southern Expressway, these low-lying areas have been blocked, exacerbating the flood situation in the area. The second major issue faced by the residents is unexpected drought conditions. Although the droughts are short-term, they are intense in the area, leading to rapid evaporation of groundwater and negatively affecting paddy farming and tea plantations. Unpredictable rainfall is the third major concern, with respondents noting that once it starts, it can last for at least two weeks, often in the form of heavy and prolonged rain. This type of rainfall is detrimental to crops, especially in tea plantations where the growth of baby tea leaves is delayed. The final climate change impact reported by the residents is temperature changes, which have been occurring in an unprecedented manner. These rapid and extreme temperature fluctuations are challenging for plantations and threaten the sustainability of harvests.

Theme 01: Decline of Livelihood Productivity

Climate change has significantly diminished the livelihoods and production of the respondents, leading to a direct negative impact on small and medium-sized agricultural communities in the rural sector. The majority of people depend heavily on agricultural activities, such as paddy fields and tea plantations. The selected GNDs are located in a wet zone characterised by tropical weather conditions, making the community reliant on natural rainfall for their agricultural livelihoods.

"For centuries, we have relied solely on natural rainfall for agriculture. This method has sustained our tea plantations and paddy fields for generations." (Male, 70 years old, SI-GS)

The livelihoods of these people are primarily dependent on agriculture, particularly tea plantations and mud farming. However, their productivity has declined significantly due to insufficient income from the tea gardens. This decrease in income has been attributed to factors such as heavy rainfall and unexpected droughts. The previously stable weather conditions in the region supported the tea plantation sector, but the recent changes in weather patterns have posed challenges to its sustainability.

"We used to generate a steady income from our tea plantation, but due to unforeseen heavy rain, the growth patterns of the tea leaves have been disrupted. Instead of our usual schedule of plucking tea once a week or every five days, we now find ourselves plucking tea only once every two weeks in some months. As a result, our income has significantly decreased." (Male, 56 years old, SI - GN)

Insufficient harvest from the paddy fields has also led to lower productivity in the livelihoods of the area. The crops in this region are vulnerable to climate variability and extremes. Sudden floods and drought conditions during the early stages of cultivation negatively impact plant growth and final production.

"Paddy plants absorb nutrients naturally from the soil, and they require a balanced climate for proper growth. When plants are exposed to extreme conditions, it can negatively affect their growth and ultimately impact the harvest. It is crucial to maintain optimal growing conditions for paddy plants to ensure a successful yield." (Male, 64 years old, SI-Gonalagoda)

The lack of benefits from farming is evident in the decreasing income reported by respondents compared to previous years, indicating a decline in livelihood productivity. Respondents attribute this trend to ongoing unexpected climatic changes in the area.

"The weather patterns have been fluctuating significantly, with prolonged periods of heavy rain lasting up to five days and extended dry spells lasting a week or more. These extreme weather conditions are detrimental to agricultural lands and crops. The tea harvest has decreased, leading to a decline in income." (Male, 55 years old, SI- Nagoda)

The agriculture officer further extends this;

"The weather patterns in the area have unexpectedly changed, posing challenges to the favourable conditions needed for agricultural progress. Specifically, heavy rain is detrimental to tea plantations as it can reduce the quality of the lacquer tea leaves and subsequently lower their market price. Additionally, strong winds have also led to a decrease in tea plantation yields." (Male, 70 years old, SI – Nagoda DS office)

Soil degradation, the absence of natural organic fertilisers, and the intensity of soil stress during floods and droughts have significantly reduced the productivity of lands in the area. Adequate nourishment of topsoil is essential for plant growth. Intense rainfall can erode topsoil, leading to decreased fertility and agricultural yields. Additionally, rising temperatures can disrupt plant growth cycles, resulting in poor harvests or crop failures.

"For the past few years, our land's productivity has been declining significantly. Previously, we could grow a variety of crops easily, but now it has become challenging. Our land is now filled with gravel and pebbles due to soil erosion. Previously, the rain was light and lasted for only a few days, but now it is excessive, causing the topsoil to erode and damaging the soil's fertility." (Male, 62 years old, KI- GS)

Uncertainties in the area include the availability of water in rivers during the dry season, soil stress levels, extreme floods, irrigation efficiency, and upstream water usage. While serious droughts were not common in the past, they have now become a regular occurrence. Additionally, heavy rainfall has led to water overflow, posing a threat to agriculture and reducing crop yields.

"We cannot control the weather patterns. Both excessive rainfall and drought can affect the land and crop production simultaneously." (Female, 68 years old, SI- GN)

Theme 02: Food Insecurity

In recent years, the area has experienced increased rainfall variability and delayed onset of monsoon rains, leading to fluctuations in the food harvesting season and production. Climate variability, including temperature and rainfall changes, has negatively affected crop output, with excessive rainfall and higher temperatures damaging plants and reducing production. These factors have resulted in crop and agricultural losses at different stages.

"Excessive rainfall has a detrimental impact on the harvest, particularly during the blooming season of the crop. Heavy rain can destroy flowers, leading to a decrease in the final production. Additionally, high temperatures can cause flowers to dry out. Therefore, moderate rainfall is crucial during this stage to ensure optimal crop growth and yield." (Male, 64 years old, SI - Gonalagoda)

Post-harvest losses throughout the food chain have significant implications for food security as they diminish the available food supply and decrease the income of smallholder farmers. Issues related to post-harvest storage and processing have further exacerbated food security challenges within the community. These respondents reside in the Gin River basin, known as one of the largest and most flood-prone rivers in the country. The region experiences frequent river overflow and flooding due to high rainfall. Low-lying homes are particularly susceptible to flooding, and residents lack adequate methods to safeguard their harvests. A KI has explained the condition;

"The Majority of people living in the river basin are at high risk of flooding, making them particularly vulnerable to post-harvest losses. While they can manage small floods by storing their harvest in the highest parts of their homes, more severe floods leave them with no choice but to lose their crops, increasing their vulnerability to food insecurity." (Female, 45 years old, KI- Goalagoda)

Pests and disease outbreaks are also contributing to the community's food insecurity. Warmer temperatures can lead to an increase in pests and diseases affecting crops, reducing productivity. The rise in temperatures and humidity fluctuations create favourable conditions for pests and plant diseases, posing a threat to agricultural productivity. Farmers may incur higher pesticide costs or suffer complete crop losses, leading to livelihood and food insecurity.

"Pests and insects have spread, causing damage to the harvest. In certain areas of the paddy fields, the rice plants are unable to compete with these pests, resulting in the destruction of a large portion of the field. Last time, we lost our harvest, and it was not enough to sustain us until the next season." (Male, 70 years old, SI-Kurupanawa)

One of the KI further expressed;

"Some tea plantations have been damaged by a peculiar type of insect. These insects bite the young tea leaves and excrete a harmful liquid, leading to damage to the tea leaves and a decrease in tea production. These insects were not previously present in the area but have emerged due to the increasing heat in the region." (Female, 54 years old, KI- Nagoda DS Division)

Theme 03: Livelihood Changes, Migration and Labour Shortage

The researcher found that climate change has led to changes in livelihoods in the area, resulting in labour migration to other locations due to reduced harvesting areas, tea plantation acreage, and agricultural workforce.

"Due to the flood, my tea plantation was destroyed, leaving me with no work. I am planning to go to Colombo, the capital city, to find a job." (Male, 32 years old, SI - Nagoda)

Climate change has led to changes in people's livelihoods, with the younger generation in the area now pursuing career opportunities abroad or migrating to other cities within the country for temporary work to sustain themselves economically. This shift has resulted in a decline in agricultural labour in the region. Younger generations often migrate to cities in search of better opportunities, leaving behind an ageing population. This demographic shift reduces the rural workforce, leading to labour shortages in agriculture. According to a key informant, the situation is as follows;

"The younger generation lacks interest in agriculture due to the uncertainty of livelihood. Instead, they tend to seek employment opportunities abroad or in the capital city." (Male, 64 years old, SI - Gonalagoda)

Due to vulnerabilities and inequalities in the agriculture sector, there has been a shift in livelihoods in the region. Communities are moving away from agriculture towards more climate-resilient livelihoods. Climate change disproportionately affects women, children, the elderly, and marginalised populations, who often lack the resources to adapt or recover from shocks. This worsens existing inequities, making already fragile livelihoods even more vulnerable. A key informant emphasised this issue;

"Climate change has had a significant impact on women, children, and the elderly population. Last year, we provided compensation to vulnerable victims, with priority given to women and the elderly who have lost their homes. Female-headed households were particularly affected by the damages caused." (Male, 58 years old, KI - Nagoda DS Division)

The lack of working hours due to extreme weather conditions, as well as the challenge of economic sustainability and recovery, are additional impacts of climate change that should be taken into consideration. Finding alternative sources of income generation is crucial in addressing these challenges.

"In the morning, there is intense sunshine, followed by evening thunderstorms with heavy rainfall. The extreme weather conditions of scorching sun and heavy rain are unbearable. Due to this, people can only work for 4 hours in their agricultural fields, leading to economic hardships. This

situation is particularly challenging for wage labourers." (Male, 37 years old, KI- Nagoda DS Division)

Theme 04: Changes in Employment Patterns

Climate change has made agriculture less sustainable as a source of income for farmers and agricultural workers. Unpredictable rainfall, rising temperatures, droughts, and floods have disrupted crop cycles, leading to decreased yields and productivity. Agriculture, being a seasonal livelihood in the region, is particularly vulnerable to these climate-related challenges, especially in areas with paddy farms and tea plantations.

"Although we are involved in tea plantation, our children have no desire to continue in this industry. They believe that it is not sustainable due to past experiences of our plantations being ruined by floods and droughts, which are beyond our control. They are seeking alternative options." (Male, 61 years old, SI - Kurupanawa)

Climate change has resulted in health risks such as leptospirosis, fever, and bacterial infections due to higher levels of rainfall. These risks have also impacted employment patterns, especially in the agriculture sector.

"During the heavy rainy season, paddy fields become saturated with water, leaving no room for excess water to drain. The waterlogged conditions create a breeding ground for leptospirosis, a common disease during this time. Seven cases of leptospirosis were reported during the harvesting period, resulting in one fatality." (Male, 32 years old, KI - Udugama MOH Office)

People often seek casual labour opportunities, such as working on nearby farms, construction sites, or in local markets. These jobs are typically short-term and unstable, making workers susceptible to economic shocks and disruptions caused by climate change.

"I am currently working at a construction site, which provides a steady income, although I am unable to be at home every day." (Male, 37 years old, SI - Nagoda)

The gender dynamics of agricultural livelihoods have been altered by the impacts of climate change in the region. This shift has led to changes in employment patterns, with climate-induced migration causing men to leave rural areas in search of work. This leaves women to manage households and farms with limited resources and support. In some cases, women themselves migrate for employment, often facing unsafe working conditions in the informal sector. In many families, male members have left their villages to seek alternative sources of income, sometimes leaving agricultural tasks to their wives or mothers. Due to repeated exposure to the negative effects of climate change, they are unable to see the sustainability of their tea plantations or agricultural lands.

"My husband used to be fully engaged with the tea plantation, but he has left the tea plantation. Now, I am the one responsible for managing our tea plantation." (Female, 43 years old, SI- Nagoda)

Theme 05: Increased Cost of Adaptation

The increasing costs of climate change adaptation in agricultural communities are driven by factors like adopting new technologies, changing farming practices, and investing in infrastructure to mitigate climate impacts. This financial burden disproportionately affects these small-scale farmers who struggle to access funding, education, and government assistance.

Due to climate change in the area, irrigation systems need to be designed to withstand extreme weather conditions, such as excessive rainfall. With more variable rainfall patterns and longer droughts, farmers need to adopt water-saving and management irrigation methods and systems. However, these systems can be costly, especially for small-scale farmers, and require ongoing maintenance and technical expertise. This poses a challenge for this community.

"During heavy rainfall, it is crucial to keep the irrigation channels and spillways clear to prevent overflow and protect agricultural crop yields. As the system expands, the technology costs will increase." (Male, 62 years old, KI - Gamaddegoda South)

Due to unexpected droughts, traditional seeds and crops have become less productive, requiring the use of drought-resistant seeds and crops. To adapt to dry conditions or extreme weather, farmers need to invest in drought-resistant seeds, which are usually more expensive than conventional seeds. Developing or acquiring climate-resilient crops through biotechnology or selective breeding also adds to the overall cost.

"The agricultural department provides seeds at a low price that are suitable for the local climate. However, during heavy drought seasons, the seeds and young plants are often destroyed. To address this issue, we need to purchase drought-resistant seeds from the private sector, which may require a higher investment." (Male, 32 years old, SI- Nagoda)

Climate adaptation measures should be improved, including the use of fertilisers and soil amendments to enhance agricultural land productivity. Heavy rainfall can lead to soil erosion at various times, affecting soil fertility. To maintain consistent crop yields, farmers need to use fertilisers or soil amendments to counter the impact of changing weather conditions. Soil health may deteriorate due to climate-induced erosion or salinity, leading to increased costs for farmers to restore or enhance soil productivity.

"Normally, we apply fertiliser to the tea plantation every four months to ensure a proper tea harvest. However, heavy rainfall has led to significant soil erosion and damage. As a result, we need to increase the frequency of fertiliser application. This has resulted in higher maintenance costs." (Male, 56 years old, SI- Gonalagoda)

The growing patterns and rapid growth of weeds in tea plantations, exacerbated by heavy rain, have necessitated increased use of weedicides due to the high cost of manual labour and challenging weather conditions as it extreme.

This frequent application of weedicides has led to higher costs for tea plantation owners. Changing climate conditions, including shifting humidity patterns and warmer temperatures, have created favourable conditions for pests and diseases to thrive. Consequently, farmers are compelled to invest in more pesticides or integrated pest management (IPM) systems to protect their crops and control weeds, adding to the overall expenses of farming in the tea plantation sector.

"The high labour costs and time-consuming process of manual weed removal in the tea plantation have led us to use herbicides instead. Herbicide application only takes two days to eliminate the weeds. However, heavy rainfall can cause weed seeds to spread and regrow quickly, requiring more frequent herbicide applications." (Male, 45 years old, SI- GS)

Theme 06: Threat to Indigenous/ Traditional Knowledge

Rural communities rely heavily on the local environment and predictable natural cycles. However, climate change is now threatening these traditional practices and knowledge based on the local environment. The disruption of environmental cycles and ecosystems poses a significant danger to the transmission and effectiveness of traditional knowledge within rural communities. This has created challenges for communities that have historically depended on these practices for survival, agriculture, and resource management. This knowledge, based on centuries of observation and experience with local weather patterns, seasons, and ecosystems, is becoming less reliable as the climate changes. Unpredictable temperatures, rainfall, and seasonal cycles make it challenging for rural communities to cultivate and harvest crops using traditional methods.

"All farming activities were previously based on the climate. Decisions were made according to the weather conditions. However, with unpredictable climate changes, decisions made based on past climate patterns have proven to be unreliable." (Male, 69 years old, SI - Gonalagoda)

Due to climate change, rural areas are now experiencing a shift in their harvesting seasons. They used to harvest two seasons, Yala (from March to August) and Maha (from September to March of the following year). However, they have now lost the Yala season, which typically occurs between March and August. They are now only able to harvest the Maha season, which takes place from November to April of the following year due to unpredictable conditions. The changing seasons have had a significant impact on agricultural practices in these areas.

"We used to cultivate two seasons annually, but for the past five years, we have only been cultivating the Maha season. This season starts late in November due to flood conditions in September and October. To overcome the floods, we delay cultivating until the end of November. However, we also face a threat of drought from February to March." (Male, 56 years old, SI - GN)

Traditional knowledge is often tailored to specific environments, but climate change is undermining and devaluing these knowledge systems. This puts rural communities at risk as they struggle to adapt to new and unfamiliar conditions. Climate-related activities that were once used to plan agricultural methods are no longer effective, leading to confusion and uncertainty. The interaction between animal practices and climate activities also impacts the timing and duration of production, but these dynamics have shifted, leaving communities ill-equipped to make informed decisions.

"During the fallow period, the fields are frequented by various types of cranes during the day, and in the evening, heavy rain accompanied by thunderstorms occurs. This rain lasts for four to five hours, filling the entire paddy fields with water by the following morning. This phenomenon is known as "Kunu Pidhuru Watarama." This small flood helps clear the agricultural lands, signalling to farmers that it is time to start cultivation. However, due to the ongoing continuous flooding, it has become difficult to identify the traditional "Kunu Pidhuru Watarama." (Male, 70 years old, SI - Kurupanawa)

Climate change has disrupted traditional agricultural practices. Methods such as crop rotation and seed selection, which are typically based on long-term environmental cycles, are no longer as effective due to the unpredictability caused by climate change. The village has historically depended on rain-fed agriculture, but with increasingly frequent and severe droughts, these traditional techniques are no longer sustainable.

The loss of traditional crops and water resources management is another impact of climate. The farming systems of the community depended on cultivating native or traditional crop varieties adapted to local climates and soils. The cultivation and exiting of traditional crops and seeds is becoming increasingly challenging due to rising temperatures, fluctuating rainfall patterns, and the emergence of new pests and diseases in the region.

"We used to grow tea and rubber in this area due to the favourable climate conditions. However, it has become increasingly difficult to match the crop suitability with the extreme weather conditions. Despite our efforts to continue growing these crops, we are facing challenges in achieving proper harvests and reaping benefits from them. As a result, some people have abandoned these crops." (Male, 61 years old,SI - Kurupanawa)

Climate change has posed a significant challenge to traditional water management systems that depend on local knowledge. The community has historically relied on traditional irrigation systems and flood cycle management, which have been effective in prevailing weather conditions. However, these systems are now being rendered ineffective by the increasing variability in water availability caused by climate change. As traditional water sources dry up or become filled up, the community is struggling to manage water resources sustainably.

"We rely solely on rainwater for our agricultural lands and adhere to traditional practices for management. However, excessive rainfall or droughts in the area have made it challenging to sustain these traditional methods and systems." (Male, 61 years old, SI - Kurupanawa).

In this rural community, traditional knowledge is transmitted orally from generation to generation through storytelling, practical experience, and observation. Elders have relied on reliable weather patterns for farming, but climate change is now disrupting these knowledge systems by introducing unfamiliar conditions. This may lead to a knowledge gap as younger generations may not be able to learn the same practices from the elders.

"Recently, I taught my son how to plough the fields, and he followed my instructions diligently. I advised him to plough in preparation for light rain in the evening, which would help the seeds settle in the soil for protection and nutrition. Unfortunately, there was no rain for two weeks after ploughing, leaving our paddy field vulnerable to bird attacks. Hundreds and thousands of birds descended on the land and devoured the seeds." (Male, 64 years old, SI - Gonalagoda)

Theme 07: Loss of Agricultural Sensitive Biodiversity

Climate change-induced biodiversity loss has far-reaching consequences for ecosystems, agriculture, and human lives, particularly for rural communities that depend on local biodiversity for food, medicine, livelihoods, and cultural practices. Climate change disrupts ecosystems, leading to species extinction, habitat destruction, and a decline in ecosystem functioning. These changes have significant impacts on communities that heavily rely on biodiversity for their survival.

Climate change-related incidents are altering habitat and migration patterns, making some ecosystems more vulnerable to invasive species that outcompete native ones. Warmer temperatures may also encourage pests and diseases to thrive, harming plants, animals, and humans. These changes decrease biodiversity by displacing or eradicating native species.

"The bee population has decreased significantly in this area. In the past, we used to see bees commonly in the morning, especially during the blossoming season. However, due to heavy rain, there has been a lack of blossoms, which has directly affected our farming, particularly vegetable farming." (Male, 57 years old, SI - Kurupanawa)

The agricultural officer extended this;

"The bee population in the area is declining due to extreme weather conditions, which has had a negative impact on pollination. This has led to grievances among people regarding the yield and productivity of agricultural work. The heavy rainfall has caused the loss of flower buds at a very young age, and the remaining buds are not being pollinated properly." (Male, 53 years old, KI – Nagoda DS Division)

Climate change has negatively impacted the area by disrupting growing seasons and facilitating the spread of invasive species and pests. The altered seasonal patterns have caused a mismatch in the life cycles of plants and animals. Additionally, invasive plant species and pests have proliferated in the region, posing a significant threat to agricultural practices.

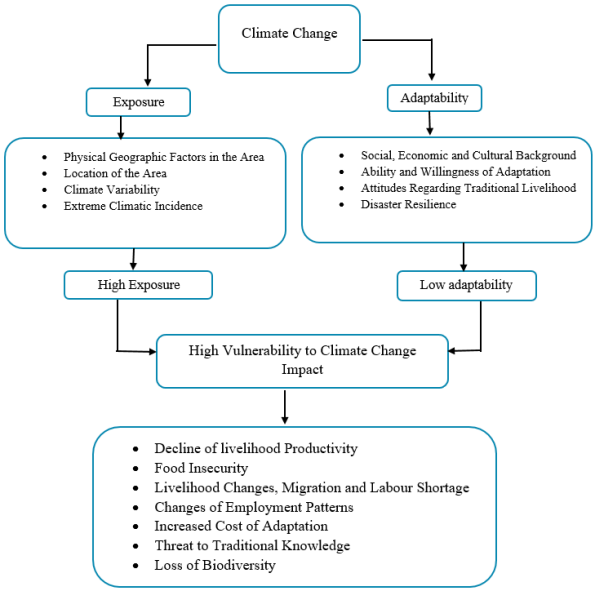
"We have noticed several unfamiliar species of pests in the ground that we have never encountered before. When we asked officers about them, they also did not have information. Nowadays, there is a variety of insects that are feeding on baby tea leaves, posing a threat to the tea plantation." (Male, 61 years old, SI - Kurupanawa)

Another respondent extends this;

"We cannot go to the garden because a plant species has spread throughout it, causing severe itching when touched. I have observed that these plants have proliferated in our area following the recent floods. Despite our efforts to remove them, they continue to spread rapidly." (Female, 53 years old, SI- GN)

The seven domains of climate change impact collectively affect the community's quality of life and increase its vulnerability. This impact is illustrated in Figure 2 below.

Figure 2: Climate change impact domains of small and medium-scale rural farmers in the selected GN Division



Source: Developed by author, 2024

Discussion

This study highlights the significant impact of climate change on rural areas, which are often overlooked, climate change vulnerable sectors, including rural areas with a large number of people depending on agriculture. The findings offer novel standpoints on the climate change discussion in rural areas of South Asia, where the socioeconomic aspect has been underrepresented in previous empirical research on climate change.

A significant amount of research on the impact of climate change in Sri Lanka and the South Asian region has primarily focused on environmental impacts, particularly on food insecurity and poverty (Bandara & Cai, 2014; Chakraborty & Newton, 2011). This research uniquely focuses on the social determinants of climate change in rural communities that rely on agriculture as their main livelihood. Through the findings of the study, the negative impacts and challenges of climate change in rural areas have been discussed in detail. The social impact of climate change had not been fully explored, and our research aimed to fill this gap through our

findings (Chithranayana & Punyawardena, 2014; Cruz, et al. 2007).

The research identified four main types of climate change incidents that occur frequently in the area: Unpredictable rainfall and droughts, continuous flooding, and temperature changes. The research has identified four common types of climate change events that occur frequently in the study area and their impact on the community.

Numerous studies have highlighted food insecurity as a major issue exacerbated by the impact of climate change (Dietz et al., 2020; Esham & Garforth, 2013). However, this study reveals that the primary concern resulting from climate change is the economic impact, leading to various related issues. In Sri Lanka, where the dimension of livelihoods is highly diversified, the majority of people residing in rural and remote areas of the country rely on agricultural livelihoods, estimated to be more than 80% of the rural community (Statistics Department, 2022). Agricultural livelihoods face challenges that have a negative impact on these communities, particularly due to heavy reliance on agriculture and related industries, which are greatly influenced by agro-climatic and topographic factors (He et al., 2021). The study found that the impact of climate change on livelihoods is primarily economic, leading to challenges such as loss of income and economic instability. Shifts in gender roles in agriculture, changes in livelihood patterns, and labour shortages due to migration have emerged as related issues alongside economic instability and income losses.

The gender dynamics in the agricultural sector are diverse, with distinct roles for men and women. Research indicates that climate change has significantly altered the gender dynamics of rural agricultural livelihoods, resulting in changes in livelihood patterns. These changes have made women in the community more vulnerable. (Panabokke & Punyawardena (2010) revealed that women are more vulnerable overall, regardless of age, educational attainment, or location. This vulnerability stems from women's limited access to productive resources, low participation in adaptation decision-making, and heavy domestic responsibilities. Although women face similar levels of exposure to climate change impacts as men, they encounter greater challenges in adapting to these changes (Owusu et al., 2018).

As more individuals in the area move away from agricultural livelihoods, there is a decreasing number of workers available for essential tasks such as planting, harvesting, and livestock management. This labour shortage is negatively impacting food production and food security in the community. Agriculture is most affected by climate change. Farming become more viable due to climate shocks including droughts, floods, and soil erosion (Thomas, 2010). This has resulted in a significant number of rural workers moving to cities, leading to a shortage of labour in the agricultural sector in rural areas and the decline of traditional livelihoods. The lack of workers in agriculture results in lower agricultural output, worsening food insecurity and poverty (Tol, 2009).

The research revealed that food security and productivity in the area are directly threatened by the incidence of climate change. Climate-driven declines in agricultural productivity are reducing the viability of farming as a livelihood (Ingram et al., 2012). The reliance on self-farming for food supply increases the risk of food shortages and insecurity due to damage to agricultural land and post-harvest losses from floods in the area. The increasing temperatures and extreme weather events will worsen storage losses unless storage facilities are enhanced to withstand the impacts of climate change (Koralegedara et al., 2015). Increases in flooding during the monsoon season and the continuation of floods could lead to significant damage to rice crops, impacting food security, particularly in rural areas. The most vulnerable communities, including poor women and children, are at risk (Mirza, 2010)

Agricultural workers confront a number of climate-related health concerns. These include exposure to heat and other extreme weather, increased chemical exposure due to greater pest presence, disease-carrying pests such as mosquitos and ticks, and deteriorated air quality (Gamble, et al., 2016). Climate change has had a detrimental impact on the health of people in the area, leading to an increase in cases of leptospirosis and skin diseases during cultivation and harvesting seasons due to extreme weather patterns. Although the weather conditions are harsh, they cannot stop the livelihood activities in the area hence the main livelihood is agriculture-related. Leptospirosis among paddy workers is linked to environmental factors such as water contamination, wet conditions, and working in abandoned paddy fields due to heavy rain conditions. Working in abandoned paddy fields increases the risk of contracting the disease (Udayanga et al., 2024). The lack of awareness about health issues related to climate change is a significant factor contributing to the spread of diseases during climate events. It is crucial to educate people about the diseases that can arise due to climate variations, such as floods and extreme temperatures. Public authorities should collaborate with community organisations to provide support during the post-disaster period and empower local populations to take proactive prevention measures (ibid).

Several studies have explored the use of traditional and indigenous knowledge for climate change adaptation (Indigenous Knowledge Is Crucial in the Fight against Climate Change – Here's Why, n.d.; Makondo & Thomas, 2018), However, very little attention has been given to the impact of climate change on traditional and local knowledge. Traditional and local knowledge, influenced by human-environment interactions, is deeply embedded in cultural contexts. It can be instrumental in assisting communities to adapt to global challenges such as climate change (Adams & Cuecuecha, 2013). This research has shown that climate change is devaluing traditional knowledge and posing a threat to its preservation. The utilisation of traditional climate-based knowledge for agricultural practices has proven to be ineffective. Climate change has altered the agricultural calendar that a community has followed for centuries. To adapt to these changes, the community is modifying its traditional agricultural calendar, diversifying crops, adopting more sustainable farming practices, and exploring alternative sources of income.

Some researchers have highlighted the impact of climate change on biodiversity loss in various studies (Lai et al., 2022; Audusseau et al., 2024; Wilson & Piper, 2008; Nhapi, 2021). Studies have shown that the decline in biodiversity caused by climate change has adverse effects on agricultural practices, particularly concerning seasonal variations and pollination (Johnson et al., 2022). The recent changes in weather patterns have caused shifts in the rhythm of the weather, leading to disruptions in ecosystems. These changes have drastically altered animal habitats, migration patterns, and plant extinction in the affected areas. The alterations in biodiversity resulting from climate change have intensified the competition between agricultural-friendly plants and species and invasive species and pests for survival. Moreover, the shifting breeding patterns and behaviours of agricultural-friendly birds, worms, and crucial species like bees have heightened the risk to insect populations and the pollination process (Nhapi, 2021).

CONCLUSION

Climate change poses significant challenges to small and medium-scale agricultural communities in Sri Lanka, jeopardizing food security, livelihoods, and the rural economy. Droughts, floods, and erratic weather patterns are reducing agricultural productivity and worsening existing issues. Traditional agricultural practices and methods, which have historically provided resilience, are now under pressure from climate change. Limited access to resources and technology is hindering communities' ability to adapt effectively. To address these risks, a comprehensive approach that combines social and technological solutions is needed. Collaboration between scientific experts and local knowledge is crucial at the policy level to enhance resilience in the agricultural sector and safeguard the livelihoods of rural communities in Sri Lanka from the impacts of climate change.

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