A Study on

"Rubber Cultivation and Land Use Patterns in Lakhimpur: Environmental and Socio-Economic Implications."

A dissertation submitted to the Department of Social Work for the partial fulfilment of the requirement for the award of the Degree of Master of Social Work



SUBMITTED TO

Department of Social Work

MSSV, Guwahati Unit

SUBMITTED BY

Deep Jyoti Saikia

MSW 4th Semester

Registration No: -MSSV-0023-008-001416

Roll No: - MSW 15/23

Session: 2023-2025

MAHAPURUSHA SRIMANTA SANKARADEVA VISWAVIDYALAYA GUWAHATI UNIT, RUPNAGAR 781032, ASSAM

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মহাপুৰুষ শ্ৰীমন্ত শঙ্কৰদেৱ বিশ্ববিদ্যালয় MAHAPURUSHA SRIMANTA SANKARADEVA VISWAVIDYALAYA

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GUWAHATI CONSTITUENT UNIT
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CERTIFICATE

I have the pleasure to certify that Sri Deep Jyoti Saikia, MSW 4th Semester student bearing Roll No: MSW-15/23 with Registration No: MSSV-0023-008-001416 of 2023, MSSV has successfully completed the dissertation entitled "A Study on Rubber Cultivation and Land Use Patterns in Lakhimpur: Environmental and Socio-Economic Implications."

He has made a successful completion of this research by his own.

I wish him bright future.

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মহাপুৰুষ শ্ৰীমন্ত শঙ্কৰদেৱ বিশ্ববিদ্যালয় MAHAPURUSHA SRIMANTA SANKARADEVA VISWAVIDYALAYA

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CERTIFICATE FROM SUPERVISOR

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The work reported in this research has not been submitted elsewhere and the facts presented here are true to the best of my knowledge.

I wish him all the very best for his future endeavour.

Place: MSSV, Guwahati unit

Date: 09/06/25

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DECLARATION OF ORIGINALITY

I, Sri Deep Jyoti Saikia, student of 4th Semester, Department of Social Work, (Roll No. MSW 15/23 and Registration No: MSSV-0023-008-001416 of 2023), Mahapurusha Srimanta Sankaradeva Viswavidyalaya, Guwahati Unit, hereby declare that the research study titled "A Study on Rubber Cultivation and Land Use Patterns in Lakhimpur: Environmental and Socio-Economic Implications" is my original work under the guidance of Dr. Deepshikha Carpenter, HOD(i/c), Assistant Professor, Department of Social Work, MSSV, Guwahati Unit., and that all sources used in the study have been properly cited and acknowledged.

I affirm that this research study has not been previously submitted for academic credit or publication, nor has it been copied or plagiarized in whole or in part from any other source.

I confirm that all data collected for the research study has been obtained through ethical means, and that all participants involved in the study were informed about the purpose and nature of the research, and gave their informed consent to participate.

Deep Jyoti Saikia.

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ABSTRACT

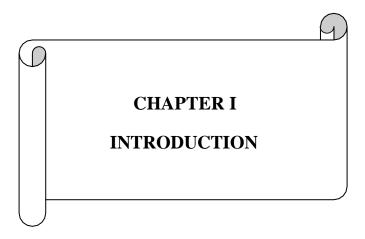
Rubber cultivation is becoming a major agricultural activity in the Lakhimpur district of Assam, driven by growing global demand and government support. This study examines how rubber plantations influence land use patterns, affect the environment, and shape the socio-economic conditions of local laborers. While rubber farming has created employment opportunities and improved income for many, it has also led to serious concerns such as deforestation, loss of biodiversity, water scarcity, and soil degradation. Traditional agricultural practices and forest areas are being replaced by rubber plantations, which offer long-term economic benefits but also cause environmental harm. Labourers working in these plantations face various challenges, including delayed payments, job insecurity, low wages, and lack of awareness about government welfare schemes. Some plantations provide housing and basic support, but overall working conditions remain unstable, especially for temporary and migrant workers. Environmental issues like reduced rainfall, declining groundwater levels, and loss of native flora and fauna have also been observed. This research uses a qualitative approach, including field visits and interviews with plantation workers and local residents. It highlights both short-term economic gains and long-term ecological and social consequences. The study concludes that while rubber cultivation contributes to rural development, it must be practiced sustainably to protect natural resources and ensure fair treatment ofworkers. Suggestions include adopting agroforestry practices, enforcing labour rights, and implementing supportive government policies. Balancing economic growth with environmental and social responsibility is crucial for making rubber cultivation a sustainable and inclusive development strategy in Lakhimpur and similar regions.

Key words:-Rubber Cultivation, Land Use Patterns, Labourers, Deforestation, Climate Change, Traditional Farming.

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INTRODUCTION

Rubber farming, particularly of the species Hevea brasiliensis tree commonly known as Brazilian rubber tree, has become a major agricultural activity in tropical regions like Lakhimpur, Assam, after being introduced from South America. This crop is highly valuable, used in over 5,000 products, from tires to medical supplies, and supports millions of Indian workers, especially labourerswho rely on employment in plantations, tapping, processing, and related industries. The global demand for natural rubber keeps growing, though prices fluctuate due to oil prices, economic conditions, and competition from synthetic rubber. In India, rubber farming has boosted rural employment and economic growth, making it a key crop for development. However, its rapid expansion has also caused serious environmental and social concerns. Large areas of forests, grasslands, and traditional farmlands are often cleared for rubber plantations, leading to deforestation, loss of wildlife, and damage to soil and water systems. Unlike natural forests, rubber plantations do not support much biodiversity, and their monoculture nature makes them prone to diseases, pests, and climate-related risks like droughts or heavy rains. In Lakhimpur, rubber farming has brought both benefits and challenges while it has provided employment opportunities and income for many labourers in tapping, transport, and processing, it has also disrupted traditional community-based livelihoods and increased dependence on seasonal or insecure plantation work, raising concerns about long-term social and economic stability.

One of the biggest environmental problems is deforestation, as rubber plantations often replace natural forests, reducing habitats for animals and plants and weakening ecosystems. Studies show that rubber farms have far fewer species than forests and do not provide the same benefits, such as storing carbon or regulating water flow. Soil health is also affected, as land clearing leads to erosion, loss of fertile topsoil, and pollution from fertilizers and pesticides washing into rivers. Rubber trees consume a lot of water, which

can lower groundwater levels and affect nearby crops, especially in dry seasons. Climate change adds to these challenges, as unpredictable weatherlike longer droughts or stronger stormscan damage rubber trees and reduce latex production. To cope, researchers are working on developing climate-resistant rubber varieties and better farming techniques.

On the economic side, rubber has helped many labourers in Lakhimpur gain employment in tapping, collection, processing, and transport. These jobs have become a source of income for families that previously depended on other forms of agriculture or forest-based work. Some plantations also offer training and housing, which can support labourers living conditions. However, the income and working conditions of these labourers are often unstable and vary depending on plantation size and ownership. Global market fluctuations in rubber prices affect not only owners but also workers, who may face reduced wages, job cuts, or delays in payment. Large rubber estates sometimes occupy lands that were previously used by local communities, leading to social conflicts, displacement, and exploitation. Laborers often face issues like low wages, lack of job security, poor living conditions, and limited access to healthcare or social support. Ensuring fair wages, labour rights, and improved working conditions is essential to making rubber cultivation socially just and economically viable for those who depend on it for their livelihood.

For Lakhimpur, a region rich in biodiversity and traditional farming systems, balancing the economic benefits of rubber with the need to protect the environment and labourers rights is crucial. Sustainable approaches like agroforestry (growing rubber alongside other trees and crops), soil conservation, and water management can reduce harm. Policies that protect forests, ensure labourers rights, and promote eco-friendly rubber production are needed to ensure long-term benefits. This study aims to explore how rubber farming is changing land use in Lakhimpur, its environmental and social impacts especially from the perspective of laborers and ways to make it more sustainable and inclusive. By combining

academic research, local knowledge, and government support, it is possible to build a system where rubber farming supports employment without harming ecosystems or livelihoods. The findings from this research will be beneficial for policy-makers, plantation managers, environmentalists, and labour organizations, helping them to make informed decisions that balance development with equity and sustainability in Lakhimpur and similar regions.

1.1 Operational definitions

Rubber Cultivation-

Rubber cultivation means growing rubber trees to collect latex, which is used to make rubber products. This includes planting, taking care of the trees, and harvesting latex for sale. It also involves looking at how labourers manage their plantations and how profitable rubber farming is.Rubber comes in various forms, including natural rubber, synthetic rubbers, and specialized types such as neoprene and butyl rubber.

Land Use Patterns-

Land use patterns refers to people, how they use land for various purposes like farming or building houses. This research sheds light on how the land that was used earlier for other cultivation or forests is now being used for rubber plantations and what are the changes this brings.

EnvironmentalImplications-

Environmental implications are the effects of rubber farming on nature. This includes things like cutting down forests, changes in soil quality, water availability, and the loss of plants and animals that lived in those areas before.

Socio-Economic Implications-

Socio-economic implications mean how rubber farming affects people's lives, jobs, and income. It looks at whether labourers earn more money, how job opportunities change, and what challenges they face, such as market price changes or land ownership issues.

Labourer-

A rubber plantation labourer is a worker involved in manual tasks like tapping trees, collecting latex, applying fertilizers, and maintaining the plantation. They often work long hours for low wages and play a vital role in the rubber production process, usually with limited job security and welfare support.

1.2 Statement of the problem

The growing shift toward rubber cultivation in Lakhimpur district, driven by its income potential and government support, presents both opportunities and serious challenges that need careful attention. While rubber farming offers economic benefits by creating jobs and boosting earnings, it also leads to deforestation as forests are cleared for plantations, resulting in biodiversity loss, soil degradation, and disrupted water cycles, which can make land less fertile over time. Labourers face financial risks because they must wait years before rubber trees yield latex, leaving them without income during this period, and fluctuating market prices can further threaten their livelihoods. Additionally, land disputes arise as rubber expands, sometimes displacing traditional farming and causing conflicts over land use. Despite its growing popularity, there is insufficient research on the longterm environmental and socio-economic impacts of rubber farming in the region. This study aims to examine how rubber cultivation is transforming land use, affecting ecosystems, and influencing local communities, with the goal of finding sustainable solutions such as agroforestry, soil conservation, and fair pricing policies that balance economic growth with environmental protection and community well-being, ensuring that rubber farming benefits labourers without harming the natural resources they depend on.

1.3 Significance of the Study

Rubber cultivation is becoming increasingly important in Lakhimpur's agricultural landscape, and this study explores how the expansion of rubber plantations is affecting both the natural environment and the lives of local people. As morelabourers and landowners convert forests and traditional farmlands into rubber plantations, they are often motivated by the promise of stable income, better profits, and improved livelihoods due to the high demand for rubber in national and international markets. This shift in land use can bring economic growth by creating jobs and supporting the local economy, which is why many are turning to rubber as a preferred crop over traditional farming options. However, while there are financial benefits, there are also environmental and economic risks. The clearing of forests for rubber cultivation can lead to significant deforestation, loss of biodiversity, and negative impacts on soil fertility and water availability. The natural ecosystems, which support wildlife and provide important services like clean water and healthy soil, are under threat when large areas are transformed into single-crop plantations. Moreover, the long-term sustainability of rubber farming is uncertain, especially in the face of price fluctuations in the rubber market that can make income unpredictable for labourers. These financial instabilities, combined with environmental degradation, raise important questions about the future of land use in the region. By examining how land is changing, what economic advantages rubber offers, and what environmental consequences it brings, this study seeks to offer a balanced view of rubber cultivation in Lakhimpur. It will help us understand whether the current trend toward rubber farming can be sustained over time without harming nature or increasing the vulnerability of local communities.

Rubber cultivation is becoming a major part of agriculture in Lakhimpur, as many labourers are turning to it in search of better income and improved livelihoods. The global demand for natural rubber is high because it is used in many industries such as automobile

manufacturing, healthcare, and consumer goods. This demand has encouraged labourers to replace traditional crops like rice, pulses, and vegetables, as well as forested areas, with rubber plantations. Rubber trees take a few years to mature, but once they do, they can provide latex for many years, offering a stable and long-term income. As a result, many labourers see rubber as a more profitable and dependable option than traditional farming, which is often affected by weather conditions, pests, and market challenges.

This study is being conducted to understand all these impactsboth positive and negative of rubber cultivation in Lakhimpur. It looks at how land use is changing by mapping areas where rubber plantations have replaced forests and farms. It also studies how much money labourers earn, how rubber farming affects their daily lives, and how they manage the risks they face. The research involves testing soil and water quality in rubber plantation areas, examining changes in biodiversity, and engaging with labourers and local leaders through interviews.

1.4 Objectives of the study

Three objectives were formulated to conduct the study. These are-

- 1. To evaluate the socio-economic benefits of rubber cultivation for local communities.
- 2. To assess the environmental impacts of rubber cultivation in Assam.
- 3. To examine the challenges faced by labourers in rubber cultivation.

1.5 Research questions

To achieve the objectives of the study, two research questions were developed. These are-

1. What are the major environmental changes (such as deforestation, soil degradation, or biodiversity loss) associated with rubber plantations?

2. How has rubber cultivation contributed to the income and livelihood oflabourers in Assam?

CHAPTER II REVIEW OF LITERATURE

- Dove (1993) examined in the article "SMALLHOLDER RUBBER AND SWIDDEN AGRICULTURE IN BORNEO: A SUSTAINABLE ADAPTATION TO THE ECOLOGY AND ECONOMY OF THE TROPICAL FOREST". The study highlighted how rubber, as a cash crop, complements subsistence farming by providing financial stability while maintaining ecological balance. Unlike large-scale plantations, smallholder rubber farming integrates traditional swidden techniques, allowing farmers to diversify their income sources and reduce economic risks. The historical adoption of rubber in Kalimantan, beginning in the early 20th century, demonstrates its adaptability within indigenous farming practices. Dove contends that the success of this system stems not from avoiding disruption to swidden cycles, but from effectively complementing and enhancing them. This study challenges conventional views on cash crop integration in traditional farming, emphasizing the need for policies that recognize the benefits of mixed agricultural strategies. The findings suggest that combining rubber cultivation with swidden farming can be a sustainable and economically viable practice for rural communities.
- Choudhury. et al (2001) examined in the article "AVAILABLE NUTRIENT STATUS OF THE RUBBER (Hevea brasiliensis) GROWING SOILS OF MEGHALAYA, MIZORAM, MANIPUR AND SOUTHERN PARTS OF ASSAM". Soil nutrient levels in rubber-growing areas of Meghalaya, Mizoram, Manipur, and southern Assam were assessed through samples collected at two different depths, which were analyzed for pH, organic carbon, phosphorus, and potassium content. The study found that soil in these regions is acidic, with pH levels ranging from very strong to medium. Organic carbon was low in Cachar and Churachandpur but medium to high in other areas. Available phosphorus was low across all sites, while potassium showed wide variations, mostly in the medium range. The study emphasizes the need for proper soil fertility management, including maintaining leguminous ground cover to improve soil health and prevent erosion.

- Lekshmi& George (2003) examined in the article "Expansion of natural rubber (NR) cultivation in Kerala." The study highlights that Kerala's agriculture has shifted towards perennial crops, particularly NR, due to relative profitability, institutional support, and price stability. The authors argue that protected price policies played a crucial role in NR's growth, making it a preferred crop over others. However, they note that since the late 1980s, agro-climatic limitations and policy changes have slowed expansion. The research also underscores the dominance of smallholder farmers in NR cultivation, raising concerns about sustainability amid economic reforms and declining policy protections. The authors suggest that future policy measures should focus on ensuring economic viability and sustainability for smallholders. This study holds significance in the context of Kerala's evolving agricultural landscape and its increasing integration into the global market.
- Meti. et al (2005) examined in the article "DISTRIBUTION OF NATURAL RUBBER CULTIVATION IN RELATION TO SOIL AND LANDSCAPE ATTRIBUTES IN INDIA". The use of remote sensing and GIS in mapping rubber plantations in Kottayam, Kerala. The study used satellite imagery, supervised classification, and GIS overlay analysis to examine the distribution of rubber cultivation in relation to soil suitability and landscape features. Findings revealed that rubber plantations were mainly concentrated in midland regions, with about 49% located on slopes ideal for cultivation (5-15%). The study highlighted the need for soil conservation in areas with erosion risks and waterlogging issues. It also emphasized that GIS-based mapping offers a cost-effective and accurate alternative to traditional survey methods, enabling better decision-making for rubber cultivation expansion.
- Rodrigo. et al (2005) examined in the article "The growth and yield of rubber at maturity is improved by intercropping with banana during the early stage of rubber cultivation." The long-term advantages of intercropping rubber with banana, with particular emphasis on plant growth and latex yield. Traditionally, rubber has a long immature phase with no income, causing financial strain on smallholders. This study

confirmed that intercropping not only provides early income but also improves rubber growth. The researchers found that rubber trees intercropped with banana reached tapping size about four months earlier than sole-cropped rubber. Additionally, although individual latex yield remained the same, the overall yield per hectare was higher due to more tappable trees. Improved growth was attributed to better resource use and reduced light stress, supporting smallholder farmers by ensuring higher productivity. The findings suggest that intercropping is a viable strategy to enhance rubber cultivation without adverse effects, benefiting both smallholders and plantation owners.

- Liu. et al (2006) examined in the article "Environmental and socioeconomic impacts of expanding rubber plantations in Menglun Township, Southwest China." Their study underscores the swift transformation of land use from traditional agriculture to cash government policies crop plantations, propelled by and market-driven incentives. Using remote sensing and GIS analysis, the authors found significant forest loss, biodiversity decline, and reduced agrobiodiversity. While rubber cultivation has boosted local income and economic development, it has also led to cultural shifts and increased dependence on a single crop, posing risks in a free-market economy. The study emphasizes the need for sustainable land management strategies to balance economic benefits with environmental conservation. These findings are relevant beyond China, as rubber plantations continue expanding into neighboring countries, raising concerns about long-term ecological and economic sustainability. This research contributes to understanding the trade-offs between agricultural modernization and environmental sustainability in tropical regions.
- Wijesuriya et al (2007) examined in the article "Some issues related to sustainability in the smallholder rubber sector: a case study of three major rubber growing districts." The study investigates sustainability challenges in Sri Lanka's smallholder rubber sector, with a focus on the key rubber-growing districts of Kegalle, Kalutara, and Ratnapura. It identifies several critical issues, including poor growth in immature rubber

plantations, low productivity in mature areas, and a decline in the quality of rubber produced. The researchers found that limited adoption of recommended practices, inefficient marketing systems, and weak societal involvement contributed to reduced income and interest in rubber cultivation. The study also observed a troubling trend of rubber plantations being converted to alternative land uses. Using participatory methods and surveys, the research emphasized the need for better institutional support, improved extension services, and increased farmer awareness. The findings emphasize the need to address socio-economic, environmental, and technological challenges to ensure the long-term sustainability of Sri Lanka's smallholder rubber sector.

- Rodrigo. et al (2009) examined in the article "Rural livelihood and rubber cultivation in Eastern province of Sri Lanka". The study highlighted the region's unimodal rainfall pattern, which, despite distinct dry periods, was deemed suitable for rubber under rain-fed conditions. Farmers traditionally relied on subsistence farming with seasonal crops such as maize, cowpea, and green gram. A SWOT analysis revealed strong farmer interest in rubber, given its potential for long-term income stability. However, socio-economic factors influenced adoption, with rural households operating on low annual incomes of approximately Rs. 55,000. Labourers demand for rubber was year-round but manageable alongside seasonal crops. The study concluded that rubber cultivation could enhance rural livelihoods while increasing tree cover, but careful planning was necessary to balance labourers requirements and traditional agricultural activities.
- Rodrigo. et al (2011) examined in the article "Potential for rubber (Hevea brasiliensis Muell. Arg.) cultivation in the Eastern Province of Sri Lanka." The study highlighted the potential of the Intermediate Zone, where soil and climatic conditions were found to be suitable for rubber growth. Farmers showed interest in rubber cultivation, but challenges such as a lack of knowledge, poor infrastructure, and

limited financial support were identified. Initial trials demonstrated a 75% survival rate and positive growth trends. Intercropping with crops like maize and banana was recommended to provide farmers with short-term income while rubber trees matured. The authors emphasized the importance of extension programs and timely distribution of resources to ensure successful plantation establishment. Overall, the study suggested that rubber cultivation could improve the region's economy, increase forest cover, and provide a sustainable livelihood for smallholder farmers.

- Umar. et al (2011) examined in the article "An Overview of World Natural Rubber Production and Consumption: An Implication for Economic Empowerment and Poverty Alleviation in Nigeria". The study highlights the historical background of NR, tracing it back to its discovery in 1493 and its spread across the world by 1913. Although NR is widely used in industries today, Africa's contribution remains low, with only about 5% of global supply. Nigeria, once a major producer, has seen a decline in output due to inconsistent government policies, civil conflicts, and socioeconomic challenges. Despite this, recent efforts like high-yielding rubber clones and intercropping practices show some progress in revitalizing rubber farming. The authors emphasize that boosting NR production in Nigeria could enhance rural livelihoods and reduce poverty. However, strong policies, better support for farmers, and solutions to environmental challenges are essential for sustainable growth in this sector.
- Mohanakumar (2013) examined in the article "Expansion of Natural Rubber Cultivation in Tripura: Impact on Landholding, Employment and Income." The study shows that the shift from traditional food crops like rice to NR was driven by higher profits and government support. Tripura, a non-traditional rubber-growing area, saw large areas of tribal land being converted to rubber plantations, which created income for some but also led to land loss and fewer jobs for tribal and poor communities. The research highlights that NR farming is less labourersintensive than food crops, which resulted in reduced employment for many agricultural workers, especially women and

- tribal people. The author warns that this trend might increase inequality and food insecurity in the state. The study calls for balanced agricultural policies that protect food crops and employment while still supporting NR farming.
- Fox. et al (2014) examined in the article "Rubber Plantations Expand in Mountainous Southeast Asia: What Are the Consequences for the Environment?" Traditionally, shifting cultivation maintained soil and biodiversity, but over one million hectares have now been converted to rubber, with projections of a fourfold increase by 2050. This shift has led to concerns about soil erosion, water shortages, and increased carbon emissions when forests are replaced by rubber. While rubber plantations are economically profitable, their long-term environmental impacts remain uncertain. The authors suggest that agroforestry systems, such as tea-rubber intercropping or using leguminous cover crops, could improve carbon sequestration and soil health. However, challenges like rubber tree disease, price fluctuations, and policy constraints complicate sustainable land-use strategies. They emphasize the need for further research, improved mapping techniques, and inclusive policymaking to balance economic development with environmental protection in the region.
- Villamor. et al (2014) examined in the article "Biodiversity in rubber agroforests, carbon emissions, and rural livelihoods: An agent-based model of land-use dynamics in lowland Sumatra." The study explores the potential of Payment for Ecosystem Services (PES) to conserve biodiversity-rich rubber agroforests in Sumatra, Indonesia. Using the agent-based model (LB-LUDAS), the authors simulated land-use changes to assess the impact of PES schemes. The results showed that PES scenarios, particularly eco-certification, helped reduce carbon emissions and species loss more effectively than business-as-usual and subsidized land-use change scenarios. However, the financial incentives offered were insufficient to compete with monoculture rubber or oil palm plantations. The study highlights the importance of understanding household decision-making and designing appropriate conservation policies. While PES schemes can support ecosystem services (ES) and local livelihoods, the study suggests that

refining PES modalities and including other ecosystem services like water management can improve adoption and long-term sustainability. The research underscores the need for balancing economic incentives with biodiversity conservation goals.

- **Xiao.** et al (2014) examined in the article "Intensive rubber cultivation degrades soil nematode communities in Xishuangbanna, southwest China" They compared four types: rubber-only farms, rubber mixed with tea, rubber grown with other crops, and natural forests. The results showed that rubber-only farms had the least variety of nematodes and lower soil nutrients like carbon and nitrogen, while natural forests had the highest. Over time, planting only rubber reduced the number of nematode types by 33%, which harmed soil health. The study suggests that mixing rubber with crops like tea or cocoa and using less intense farming methods can improve soil health and keep the environment balanced while still benefiting farmers.
- Zomer. et al (2014) examined in the article "Environmental stratification to model climate change impacts on biodiversity and rubber production in Xishuangbanna, Yunnan, China." Using a Global Environmental Stratification (GEnS) model with climate projections for 2050, the study identifies major shifts in bioclimatic zones and ecosystem changes. The rapid expansion of rubber plantations has replaced forests and traditional farming systems, contributing to biodiversity loss and ecosystem degradation. Climate change is expected to increase temperatures by 1.6°C to 2.4°C, shifting bioclimatic zones upward by 309 meters and expanding suitable areas for rubber plantations to nearly 75% of the region. These changes pose significant challenges for conservation efforts and protected areas. The study highlights the need to integrate climate change data with land use management to safeguard biodiversity and ensure sustainable development in Xishuangbanna.
- Ahrends. et al (2015) examined in the article "Current trends of rubber plantation expansion may threaten biodiversity and livelihoods". The rapid expansion of rubber plantations in Southeast Asia, highlighting both environmental and socio-economic

risks. Rising rubber prices in the early 2000s led to large-scale land conversion, with plantations spreading into marginal environments. These areas face challenges such as drought, erosion, and vulnerability to storms, which threaten long-term sustainability. The study found that over 70% of plantations exist in unsuitable regions, leading to reduced yields and potential economic losses. Additionally, rubber expansion contributes to deforestation, biodiversity loss, and hydrological disruptions. The authors stress the need for policy interventions, sustainable land-use planning, and awareness programs to mitigate environmental and livelihood risks associated with rubber cultivation.

- George. et al (2015) examined in the article "Polypropylene woven fabric: A good mulch material for young rubber plants". A comparative study on the effectiveness of various mulch materials dry leaves, coconut tree mats, coir pith, and polypropylene woven fabric on the growth of young rubber plants in a drought-prone region of Kerala. The study found that while traditional organic mulches like coir pith and dry leaves initially helped retain soil moisture, they decomposed quickly and were less effective during the rainy season. In contrast, polypropylene woven fabric stood out for its durability, better soil moisture retention, and weed suppression. Unlike plastic mulch, it is breathable and allows water and air to pass through, making it more sustainable. Coco tree mats also performed well but decomposed within a year. The study suggests that polypropylene woven fabric is a promising mulch material for rubber plantations, especially in drought-prone regions, as it helps conserve moisture and manage weeds effectively. However, further research is needed on its long-term effects on soil health and plant growth.
- Hauser. et al (2015) examined in the article "Environmental and socio-economic impacts of rubber cultivation in the Mekong region: challenges for sustainable land use." The environmental and socio-economic impacts of expanding rubber cultivation in the Greater Mekong Subregion (GMS). The study highlighted that over 90% of the world's natural rubber comes from tropical Asia, with GMS countries seeing rapid

expansion of rubber plantations. This growth, often at the cost of natural forests, has led to changes in carbon balance, water availability, and soil conditions. Farmers reliant on rubber monoculture experience economic instability caused by fluctuating market prices. The study suggests alternative land-use strategies such as crop diversification and improved plantation management to balance economic needs with environmental sustainability. Additionally, a socio-economic framework involving farmers and policymakers is essential to address trade-offs between ecological and financial concerns. This research underscores the need for sustainable rubber cultivation to protect ecosystems while ensuring farmer livelihoods.

- Rasutis. et al (2015) examined in the article "A sustainability review of domestic rubber from the guayule plant". Guayule (Parthenium argentatum Gray) has gained attention as a sustainable alternative to Hevea rubber (Hevea brasiliensis) and petroleum-based synthetic rubber. The plant is well-suited for cultivation in arid regions of the southwestern U.S., requiring fewer inputs such as fertilizers and pesticides. Guayule rubber matches Hevea rubber in quality and holds promise for reducing U.S. reliance on imported rubber, while also minimizing environmental impacts (Rasutis et al., 2015). Additionally, guayule's residual biomass can be used for biofuels and other valuable co-products, enhancing its economic feasibility. However, large-scale commercialization is still a challenge due to economic and processing barriers. Further research is needed to improve agricultural efficiency, optimize processing methods, and establish a stable guayule rubber supply (Rasutis et al., 2015). Conducting life cycle assessments could provide insights into reducing its environmental footprint and expediting commercialization.
- Blagodatskya. et al (2016) examined in the article "Carbon balance of rubber (Hevea brasiliensis) plantations: A review of uncertainties at plot, landscape and production level". The rapid expansion of rubber plantations in Southeast Asia has significantly altered ecosystem carbon stocks, influencing climate change mitigation and carbon trading opportunities. Their study found that while converting arable land

to rubber increased carbon sequestration, replacing forests with rubber led to net carbon losses. Factors such as climate, soil conditions, elevation, and plantation management practices (e.g., tapping frequency and planting density) affected carbon stock dynamics. Additionally, rubber plantations in subtropical areas with drier climates showed reduced carbon sequestration potential. The review emphasized the need for improved carbon estimation methods, including remote sensing and time-averaged carbon stock calculations, to enhance regional assessments. The authors concluded that understanding carbon balance uncertainties is crucial for better land-use planning and climate policy development.

Martin K & He P (2016) examined in the article "Effects of Rubber Cultivation on Biodiversity in the Mekong Region," analyze the impact of expanding rubber plantations on biodiversity. The study highlights that large-scale rubber monoculture has significantly reduced natural forest cover, leading to habitat loss and fragmentation in the Greater Mekong Subregion (GMS), which is a global biodiversity hotspot. Between 2002 and 2010, rubber cultivation in Xishuangbanna, Southern Yunnan, increased by 175%, contributing to the decline of natural forests from 49% to 28% of the land area. The researchers found that species richness in rubber plantations is less than half compared to natural forests. The study emphasizes that preserving remaining forest patches is crucial for sustaining biodiversity. While concepts like forest restoration and plantation diversification have been proposed, their effectiveness remains uncertain due to socio-economic challenges. The authors suggest promoting natural undergrowth vegetation in rubber plantations as a practical and economically viable method to enhance biodiversity. Reducing weeding and herbicide use can help create better habitats for native species. The study underscores the urgent need for sustainable land-use strategies that balance rubber production with conservation. Without effective interventions, continued rubber expansion could lead to severe biodiversity loss in the GMS.

- Impact Analysis of Rubber Cultivation in Southeast Asia". Rubber cultivation has been widely promoted as a means of poverty alleviation and rural development in Southeast Asia. However, the rapid expansion of rubber cultivation has significant environmental implications, including deforestation, biodiversity loss, and watershed degradation. Studies indicate that the increasing demand for natural rubber, particularly in China and India, has driven large-scale land conversion, often at the expense of ecologically valuable forests. While rubber plantations offer carbon sequestration benefits, concerns remain regarding their long-term sustainability and socio-economic impact. Researchers advocate for improved land-use planning, certification schemes for sustainable rubber, and greater community involvement in decision-making to mitigate negative effects. Future research should explore the ecological consequences and socio-economic conflicts arising from rubber expansion.
- Ahmed. et al (2017) examined in the article "GIS-Based Land Suitability Mapping for Rubber Cultivation in Seremban, Malaysia". The study integrated biophysical, ecological, and socio-economic factors to assess land suitability. The Analytical Hierarchy Process (AHP) was applied to weight different land attributes, with soil productivity identified as the most influential factor. Results classified 45% of the area as highly suitable, 43% as moderately suitable, and 12% as marginally suitable for rubber cultivation. The study found that many existing rubber plantations were located on less suitable land, which could affect productivity. The model demonstrated an 80% accuracy rate, proving its reliability for land-use planning. This research highlights the potential of GIS-based models in agricultural decision-making and suggests that such techniques could be applied to other regions for better land-use planning and resource management.
- Chen. et al (2017) examined in the article "Effects of rubber-based agroforestry systems on soil aggregation and associated soil organic carbon: Implications for land

- use". The impact of rubber-based agroforestry systems on soil aggregation and organic carbon storage in Xishuangbanna, China. The research compared rubber monoculture with four agroforestry systems, finding that agroforestry significantly improved soil quality. Except for coffee (C. arabica), intercropping with species like cacao, F. macrophylla, and D. cochinchinensis enhanced soil organic carbon and nitrogen, promoted macroaggregate formation, and reduced soil erosion. These improvements helped prevent carbon and nitrogen loss, making agroforestry a more sustainable alternative to monoculture. The study suggests that farmers and policymakers should adopt these intercropping systems to maintain soil fertility and long-term sustainability in rubber plantations.
- Pradeep. et al (2017) examined in the article "Identification and Mapping of Natural Rubber Plantations and Potential Areas for Its Cultivation in Assam Using Remote Sensing Technology." The research utilized satellite remote sensing technology to map natural rubber (NR) plantations and identify suitable wastelands for rubber cultivation in Assam. The study estimated 16,872 hectares of existing Natural Rubber plantations and identified 24,783 hectares of wasteland as suitable for expansion. The researchers emphasized the need for further analysis, incorporating pedo-climatic variables, to better assess land suitability. Their findings highlighted the importance of geo-spatial data for sustainable land-use decisions, ensuring that rubber cultivation does not adversely impact food crops or forests. The study provides valuable insights for policymakers and land planners in Assam and has broader implications for expanding rubber cultivation in non-traditional areas of India. It demonstrates the effective use of remote sensing for land suitability mapping, offering a foundation for sustainable agricultural expansion.
- **Pradeep. et al (2017)** examined in the article "INVENTORY OF RUBBER PLANTATIONS AND IDENTIFICATION OF POTENTIAL AREAS FOR ITS CULTIVATION IN ASSAM USING HIGH RESOLUTION IRS DATA". High-resolution satellite imagery and remote sensing techniques used to map existing rubber plantations and identify wastelands suitable

for cultivation in Assam. The study employed data from IRS satellites, including Resourcesat I & II and Cartosat PAN, along with GIS analysis and ground truth verification. Findings revealed that Assam has 16,872 hectares under rubber cultivation and an additional 24,783 hectares of wastelands suitable for expansion. The study emphasized the importance of remote sensing in land-use planning, ensuring sustainable rubber expansion without affecting forests or food crops. It also highlighted the potential socio-economic benefits of promoting rubber cultivation in Northeast India. The research contributes to geospatial decision-making, aiding policymakers in sustainable agricultural development.

- Wigboldus. et al (2017) examined in the article "Scaling green rubber cultivation in Southwest China—An integrative analysis of stakeholder perspectives". The study highlights the negative environmental and socio-economic impacts of monoculture rubber plantations, such as biodiversity loss, soil degradation, and economic vulnerability due to fluctuating rubber prices. While technical solutions have been proposed, the authors emphasize that social factors—such as weak communication among stakeholders and fragmented visions for land use—are major barriers to sustainability. They argue that a more integrated approach is needed, involving policy support, stakeholder collaboration, and a broader landscape perspective to avoid the cycle of boom-and-bust seen with other cash crops. The study suggests that fostering knowledge exchange and addressing power dynamics between smallholder farmers, researchers, and government officials are key to promoting green rubber cultivation. The findings have implications beyond China, as similar issues exist in other rubber-producing regions of Southeast Asia.
- Golbon. et al (2018) examined in the article "Climate change on potential rubber cultivation areas in the Greater Mekong Subregion." which includes China, Vietnam, Thailand, Laos, Myanmar, and Cambodia. Using climate models and classification techniques, the study projects changes in rubber-suitable areas under two climate scenarios (RCP 4.5 and RCP 8.5) for 2030, 2050, and 2070. Results indicate that

although climate change will increase suitable areas for rubber cultivation, excessive heat (above 28°C) may reduce climatically optimal zones in the future. By 2030, over 50% of the GMS region may become suitable for rubber cultivation, but nearly half of these new areas are ecologically pristine, raising concerns about biodiversity loss. The study emphasizes the need for careful land use planning and sustainable policies to mitigate the potential negative environmental impacts of rubber expansion due to climate change.

- ecologies of plantation sustainability in Laos and Myanmar". The rapid expansion of rubber cultivation in non-traditional areas like Laos and Myanmar, highlighting both the economic opportunities and the environmental and social risks involved. The authors explain how rising rubber prices and strong government support led to increased investment in rubber farming. However, the decline in prices since 2011 has hurt small-scale farmers, and large-scale plantations have caused land loss, environmental degradation, and social problems. The study argues that the idea of "sustainable rubber" is complex and often used in ways that benefit powerful groups, without solving deeper problems. The authors suggest that true sustainability would need strong rules, support for small farmers, and better environmental practices. However, they point out that political and economic challenges in both countries make this very difficult. The study calls for using the idea of sustainability to spark political debate and reduce the most harmful practices in rubber farming.
- **Peerawat. et al (2018)** examined in the article "Rubber plantation ageing controls soil biodiversity after land conversion from cassava." Using a chronosequence (1–25 years) to assess changes, the study found that conversion from cassava to RP increased soil organic matter and biological activity over time. Young RP (1–3 years) impacted microbial biomass and fungal composition, while older RP (23–25 years) showed higher microbial and macrofaunal biomass but reduced bacterial richness. Canopy closure after 7 years significantly altered soil biota. Although macrofauna composition

remained resilient to land use changes, microbial diversity and activities were sensitive but recovered over 20 years. The findings highlight that RP ageing influences soil biota more than land use conversion, stressing the need for sustainable land management.

- Phukan (2018) examined in the article "Ecological impact of rubber plantations in Karbi Anglong, Assam." The study notes that rubber cultivation has provided economic benefits, reducing unemployment and shifting farmers away from traditional Jhum cultivation. However, the expansion of rubber plantations has raised environmental concerns, including biodiversity loss, soil fertility changes, and microclimate alterations. The monoculture nature of these plantations impacts local flora and fauna, leading to reduced ecological diversity. The study also explores carbon sequestration, suggesting that while rubber trees absorb CO₂, young plantations may initially contribute to emissions. Additionally, changes in soil microbes and pH levels affect soil health over time. Phukan recommends promoting mixed plantations instead of monoculture to maintain ecological balance while ensuring economic benefits. The findings emphasize the need for sustainable rubber cultivation practices to mitigate environmental risks in the region.
- Karunakaran (2019) examined in the article "TREND AND OVERALL GROWTH ANALYSIS OF RUBBER CULTIVATION IN KERALA". The shift in Kerala's agricultural pattern, showing a strong move from food crops like rice and tapioca to non-food cash crops, especially rubber. Between 1960-61 and 2013-14, the area under rubber cultivation grew by 328%, making it the second most cultivated crop after coconut. The study found that this shift was driven by farmers' decisions based on expected prices, available land, rainfall, and other economic and environmental factors. Using area and yield response models, the study showed that rubber cultivation was highly responsive to price expectations. Importantly, the growth in rubber output over the decades was mostly due to monetary factors (such as price) rather than actual increases in production (real growth). This trend reflects the

economic motivations behind Kerala's crop diversification, with rubber emerging as a dominant crop. The findings suggest that profitability remains the key driver for land use change in the state's agriculture.

- Ma. et al (2019) examined in the article "Expanding Rubber Plantations in Southern China: Evidence for Hydrological Impacts." The large areas of forest and farmland have been converted into rubber plantations. Rubber trees, with their deep root systems and high water consumption, significantly alter local water balances, leading to reduced streamflow, especially during the dry season. Between 1992 and 2010, rubber plantations increased from 10% to 44% of the studied watershed, causing a 30% decline in water yield between 1993 and 2002. The increased evapotranspiration (ET) due to rubber plantations reduced the availability of groundwater and streamflow. Rubber trees on steep slopes led to increased runoff and soil erosion, further impacting water infiltration. To mitigate these effects, the study suggests promoting sustainable practices such as intercropping and improving rainwater infiltration to protect biodiversity and maintain dry season water resources.
- Vrignon-Brenas. et al (2019) examined in the article "Nutrient management of immature rubber plantations." Rubber tree plantations are a major source of natural rubber, crucial for industries like tire manufacturing. The expansion of rubber cultivation, driven by rising demand, has led to significant environmental impacts, including biodiversity loss and soil degradation. Nutrient management during the immature phase is critical for sustaining productivity, yet fertilization practices remain inconsistent and often lead to soil imbalances. Studies indicate that integrating agroecological practices, such as intercropping and crop residue management, can reduce the reliance on chemical fertilizers (Pradeep &Manjappa, 2015). However, knowledge gaps persist regarding nutrient uptake dynamics and optimal fertilization timing (Chen et al., 2011). A nutrient budget approach could enhance sustainability by aligning nutrient supply with tree demand, but further research is needed for its effective implementation.

- Zulekipli&Pebrian.(2019) examined in the article "Analysis of Energy Consumption in Rubber Cultivation in Malaysia: A Case Study." They looked at different farming steps like preparing the land, planting, weeding, fertilizing, pruning, tapping, and collecting latex. The study found that fertilizing used the most energy, about 65.93% of the total. The energy efficiency was low, with an output/input ratio of 0.83, meaning more energy was used than produced. The authors suggested using better technology to save energy and make farming more effective. Earlier studies mainly focused on rubber processing and its economic impact, but they did not look at energy use in farming. This study fills that gap by showing where energy is used the most and how it can be managed better. The findings help create a useful database on energy use in Malaysian agriculture and suggest ways to make rubber farming more sustainable.
- Junquera. et al (2020) examined in the article "From global drivers to local land-use change: understanding the northern Laos rubber boom." The study analyzed two case study areas (CSAs) using Bayesian network models and regression analysis to identify the drivers of rubber expansion between 2000 and 2017. Results showed that market factors like rubber prices, local price knowledge, and imitation behavior influenced land conversion. Protected areas effectively reduced deforestation, but only in strictly enforced zones. The study highlighted that imitation and social learning played a significant role in the adoption of rubber plantations, particularly during the middle and later stages of the boom. Despite falling rubber prices, expansion continued due to increased cash availability and secure land tenure. The findings emphasized the importance of understanding local decision-making processes and policy interventions in managing crop booms and their socio-ecological impacts.
- Panda &Sarkar.(2020) examined in the article "The growth and challenges of rubber plantations in Tripura". Their study, based on both primary and secondary data, highlighted that Tripura has emerged as the second-largest rubber-producing state in India after Kerala. Rubber cultivation has expanded significantly due to favorable

agro-climatic conditions and government initiatives. However, several challenges hinder its growth, including insurgency, poor infrastructure, lack of credit facilities, and limited technical knowledge among farmers. Issues such as delayed seedling availability, pest attacks, and fluctuating rubber prices also affect production. Despite these obstacles, the study emphasized that rubber plantations contribute to the socioeconomic development of tribal communities. The research suggests that with better support, Tripura has strong potential for further expansion of rubber cultivation.

- Pradeep. et al (2020) examined in the article "Current status and future prospects of mapping rubber plantations in India". Their study used satellite-based mapping to estimate the total area of natural rubber (NR) plantations, identifying approximately 7.22 lakh hectares of NR cultivation across the country. The research highlighted that 77% of Natural Rubber plantations are in Kerala and Kanyakumari, while the North-East, Konkan region, and eastern states contribute the rest. The study emphasized the importance of remote sensing technology in monitoring NR plantations and providing accurate spatial data for policymakers. It suggested that updating NR maps regularly would help track changes in plantation areas. The authors also discussed the potential of advanced technologies like UAVs and multi-sensor satellite data for better management of NR cultivation. The findings indicate that satellite mapping can be a valuable tool for sustainable rubber plantation planning in India.
- Wei& Razak (2020) examined in the article "Rubber Tree Cultivation and Improvement: Biological Aspects and the Risk of Inbreeding Depression". Rubber tree cultivation has significantly contributed to Malaysia's economy, with latex being an essential raw material for various industries. Over the years, breeding programs have focused on improving latex yield, disease resistance, and tolerance to environmental stress. Since the 1950s, bud grafting has been widely used to develop high-yielding clones, such as RRIM 600 and PB 260, replacing unselected seedlings (Wei& Razak, 2020). However, inbreeding depression remains a major challenge, leading to reduced vigor, lower latex production, and increased susceptibility to diseases and wind

damage. To address this, researchers emphasize the importance of expanding the genetic base through hybridization and selecting superior rootstocks (Ong & Razak, 2020). Future breeding efforts aim to develop an "Ideotype" rubber tree that combines desirable traits while minimizing genetic limitations, ensuring long-term sustainability and productivity.

- Kouadio. et al (2021) examined in the article "Dynamics of rubber cultivation in production systems in mountain zone of Côte d'Ivoire". Rubber cultivation in Côte d'Ivoire has expanded significantly, particularly in the western semi-mountainous regions, due to land saturation in traditional growing areas. Initially promoted as a large-scale farming crop, rubber is now predominantly grown by smallholder farmers. The study found that 76.87% of farmers practice perennial polyculture, integrating rubber with other crops, such as coffee and food crops. Rubber plantations cover 46% of cultivated land, with an average farm size of 6.85 hectares per farmer. Most rubber fields were established between 2007 and 2015, and the average plantation age was eight years in 2019. The findings suggest that rubber is increasingly replacing older crops like coffee while being grown alongside food crops. Future research should explore optimal crop associations to enhance sustainable agriculture in the region.
- Singh Kumar Ashutosh. et al (2021) examined in the article" A Global Review of Rubber Plantations: Impacts on Ecosystem Functions, Mitigations, Future Directions, and Policies for Sustainable Cultivation," examine how rubber plantations affect ecosystem functions (EF) compared to natural forests. Using data from the Food and Agriculture Organization (FAO) and studies from various regions, the authors assess key EF, including biomass (aboveground and belowground), soil carbon storage, litter decomposition, soil respiration, and biodiversity. The study finds that rubber plantations generally have lower EF than forests. For example, biomass and plant diversity in rubber plantations are reduced by more than 55%. These effects remain negative regardless of the plantation's age. While rubber cultivation has boosted farmers' incomes, it has also led to large-scale deforestation, soil degradation, and

biodiversity loss. To improve EF in rubber plantations, the authors suggest sustainable practices such as agroforestry, cover cropping, mulching, and composting. However, more research is needed to understand how climate, plantation age, and management techniques affect EF. The study calls for better policies and management strategies to balance rubber production with environmental sustainability.

- Gitz. et al (2022) examined in the article "Sustainable development of rubber plantations: challenges and opportunities." The study emphasized that rubber cultivation sustains around 40 million people globally and is essential for over 5,000 products. However, its rapid expansion raises environmental and social concerns, especially when forests are converted into monoculture plantations. Key environmental issues include loss of biodiversity, soil degradation, and water resource depletion. The authors also highlighted how climate change can affect rubber-growing regions, with risks such as droughts, floods, and pest outbreaks. Economically, smallholders benefit from NR, but both small and large producers face price fluctuations, often leading to income instability. Social issues such as poor working conditions in large estates were also discussed. The study concluded that sustainable rubber production requires coordinated efforts among governments, researchers, and industries. With proper support, rubber cultivation can contribute to a circular bioeconomy and sustainable development. Sustainable management practices and diversification are key to long-term viability.
- Joseph. et al (2022) examined in the article "IMPACTS OF NATURAL RUBBER CULTIVATION INTRIPURA: AN INTER-TEMPORAL SOCIO-ECONOMICANALYSIS OF TRIBAL AND NON-TRIBALRUBBER FARMERS." An inter-temporal socio-economic analysis of tribal and non-tribal rubber farmers in Tripura, focusing on the impacts of natural rubber (NR) cultivation under Block Planting Units (BPUs) and Group Processing Units (GPUs). Initially, rubber farming helped tribal communities shift from shifting to settled cultivation, providing stable income. However, limited human capital and infrastructural constraints reduced

income diversification. A comparative study between 2008 and 2019 showed increased household income, more access to credit, and a shift towards part-time rubber farming due to diversified income sources. The study highlighted a decline in the area under rubber cultivation and a reduced share of income from rubber. It also observed land fragmentation and concerns about the long-term sustainability of rubber farming, especially in tribal areas. The findings emphasized the need for ongoing monitoring and policy support to ensure the socio-economic stability of rubber-based livelihoods in Tripura.

- Nithin &Mahajanashetti (2022) examined in the article "Economic Feasibility of Natural Rubber Cultivation A Farmer Level Approach". The financial viability of natural rubber cultivation in Kerala and Karnataka using capital budgeting tools like Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR). Their study showed that rubber farming is economically feasible in both states, although returns are slightly higher in Karnataka due to lower labor costs and rising yields. While Kerala had a BCR of 2.55 and NPV of ₹9.19 lakhs, Karnataka recorded a BCR of 3.02 and NPV of ₹10.17 lakhs. However, the payback period was longer in Karnataka due to slower tree growth. A sensitivity analysis found that rubber farming remained profitable even under unfavorable conditions such as increased labor and fertilizer costs or reduced rubber prices. The findings suggest that rubber farming is a stable and profitable investment, and the authors recommend encouraging farmers to adopt rubber cultivation, especially in non-traditional areas like Karnataka.
- Chen. et al (2023) examined in the article "Diversified land conversion deepens understanding of impacts of rapid rubber plantation expansion on plant diversity in the tropics". The study investigates the impact of rapid rubber plantation expansion on plant diversity in the Great Mekong Subregion (GMS), where nearly half of the world's rubber plantations are located. Using data from 240 rubber plantations and satellite imagery, the study analyzed how plant diversity changes with land conversion and stand age. Results showed that rubber plantations established on tropical forests

had higher species richness compared to those converted from cropland or old rubber plantations. Although plant diversity in rubber plantations is lower than in tropical forests, it is significantly higher than in croplands. Species richness remains stable over the 30-year plantation cycle, and invasive species decline over time. This highlights the importance of maintaining species diversity during early cultivation stages.

- Jayathilake. et al (2023) examined in the article "The conversion of rubber to oil palm and other landcover types in Southeast Asia." Using time-series data and tree plantation maps, the study identifies land-use changes between 2005 and 2020. Results show that 1.9% of rubber plantations in Indonesia and 2.6% in Malaysia were converted to oil palm between 2014 and 2020. This slow conversion rate suggests a gradual shift influenced by profitability differences between the crops. While conversion from rubber to oil palm has less impact on biodiversity compared to forest conversion, it may lead to indirect deforestation as displaced rubber plantations move to other regions. The study highlights the need for sustainable management of both oil palm and rubber to prevent further threats to natural habitats and biodiversity.
- Panja et al. (2023) examined in the article "Impact of Rubber Plantation Growth on LULC Changes in Eastern Himalayan Region of West Tripura District Using Geospatial Approach". The study analyzed satellite images from 2000, 2010, and 2020, identifying shifts in land use patterns. The results showed a significant increase in rubber plantations and settlement areas, replacing natural vegetation, shrubland, and water bodies. Farmers transitioned from traditional jhum cultivation to rubber plantations for economic stability, encouraged by government policies. Urbanization around Agartala also contributed to agricultural land conversion into built-up areas. The study employed Maximum Likelihood Classification (MLC) and accuracy assessments, revealing over 80% accuracy in LULC classification. The findings highlight the environmental concerns associated with rapid land transformation, emphasizing the need for sustainable resource management. This research provides

- valuable insights for policymakers and planners to balance economic development with environmental conservation in the region.
- Qi et al. (2024) examined in the article "Integrative cultivation pattern, distribution, yield and potential benefit of rubber based agroforestry system in China". Rubber agroforestry systems have gained attention as a sustainable alternative to monoculture rubber plantations, which often face issues like soil degradation and vulnerability to environmental factors (Qi et al., 2024). Research highlights that integrating crops such as banana, pineapple, cassava, and passionfruit in young plantations, and Amorphophallus, Alpinia oxyphylla, and edible fungi in mature plantations, can improve soil health and economic benefits (Qi et al., 2024). Studies have shown that rubber agroforestry systems enhance structural stability, increase farmer income, and mitigate risks from market fluctuations (Penot et al., 2017; Willmott et al., 2023). Government initiatives in China have further supported their expansion, particularly in Hainan and Yunnan provinces (National Forestry and Grassland Administration, 2021). The economic output of these systems exceeds 834 million USD annually, demonstrating their viability for sustainable land use and poverty alleviation
- Plantation in the Northeastern States of India" examines the expansion and obstacles of rubber cultivation in the region using secondary data from government reports, journal articles, and books. The study highlights that rubber plantations have grown significantly, with Tripura emerging as the leading producer in Northeast India. Assam, Meghalaya, Nagaland, Mizoram, and Arunachal Pradesh also have substantial potential for expansion. The research identifies key challenges, including a shortage of modern technology, financial constraints, low-quality rubber sheets, inadequate government support, and fluctuating market prices. The study underscores the role of the Rubber Board in promoting cultivation and the impact of rubber plantations on tribal livelihoods. It concludes that while there is significant scope for rubber

- expansion, addressing these challenges is essential for sustainable growth and economic benefits in the region.
- Vijayan et al. (2024) examined in the article "The large-scale expansion of rubber plantations in southern India: major impacts and the changing nature of drivers."

 Using geospatial techniques and socio-economic methods, the study showed that the area under rubber plantations increased from 30% to 74% over five decades. While rubber plantations improved household income and living standards, they caused environmental problems such as water scarcity, soil erosion, and biodiversity loss. Farmers also experienced reduced socialization due to the shift from group farming to individual rubber cultivation. Additionally, rubber monocultures increased economic vulnerability to market and climate shocks. The study highlighted the changing nature of drivers for land use change, including economic incentives, institutional support, and policy changes. The authors emphasized the need for sustainable agricultural practices and government policies to balance economic benefits with environmental protection.

The study clearly shows that rubber cultivation mainly focuses on economic aspects like cost, profit, and investment returns. However, these studies do not fully explore the environmental impacts, land use changes, or social consequences —like effects on food crop production, biodiversity, or the livelihoods of small and tribal farmers. Also, there is limited research on the long-term sustainability of rubber cultivation, especially in newer regions like Northeast India. The study is based on fixed assumptions, and more research is needed to understand how changing market conditions, climate change, or land-use conflicts might affect the future of rubber cultivation.

CHAPTER III RESEARCH METHODOLOGY

In this research, the qualitative approach was adopted to explore the lived experiences and perceptions of individuals involved in rubber cultivation in Lakhimpur. The researcher conducted in-depth interviews with labourers, local community members, and officials to gather detailed insights into the environmental changes and socio-economic consequences resulting from rubber plantations. Field visits were undertaken to observe land use changes, biodiversity impact, and farming practices.

3.1 Theoretical framework

TheSustainable Livelihood Framework (Chambers & Conway, 1992)explains how people use different resources to support their lives. These resources encompass natural assets like land and water, financial resources such as income and savings, social connections, human skills, and physical infrastructure. In Lakhimpur, rubber cultivation plays an important role in shaping rural livelihoods. Many labourers grow rubber as a source of income, helping them meet their daily needs and improve their living standards. Rubber farming also creates jobs, as workers are needed for planting, tapping, and processing latex. This employment benefits both small labourers who rely on agriculture for their earnings. Additionally, land ownership patterns may change as more land is used for rubber plantations, affecting traditional farming practices. Labourers success depends on factors such as market demand for rubber, access to fertilizers and equipment, and government policies that support or regulate cultivation.

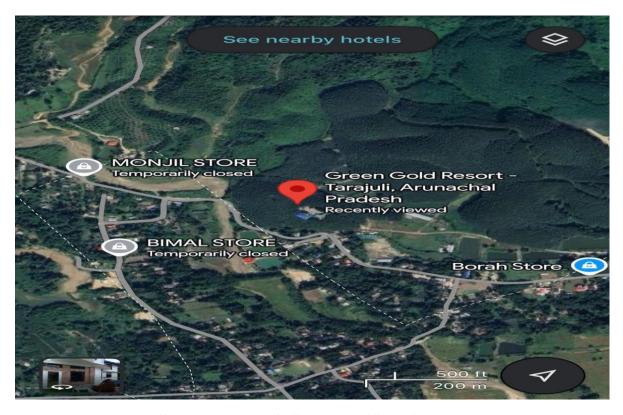
3.2 Research Design

This study uses a descriptive research design to examine how rubber cultivation is expanding and influencing land use in Lakhimpur District. The research aims to capture the current state of rubber farming and its related effects by using qualitative tools such as field observations and interviews. It focuses on documenting changes in the environment, such as loss of forest cover, biodiversity decline, and soil condition alterations. At the same time, the study explores how rubber farming impacts people's lives, including

changes in employment opportunities, income levels, and shifts in the local economy. By describing these developments in detail, the research helps to provide a clear picture of the environmental and socio-economic implications of rubber cultivation in the region.

3.3 Universe of the Study

The study focuses on Lakhimpur District, a region in Assam where rubber cultivation has seen a steady rise in recent years.



https://maps.app.goo.gl/HSn7TkRN2jSYiHCL6

Photo Source : Google Map

(accessed on 19/05/2024)

3.4 Sampling technique

Purposive sampling is adopted in this study to identify and select individuals or groups who are most relevant to the research objectives. Participants are chosen based on specific characteristics, such as involvement in rubber cultivation, recent transition from other crops to rubber, or residence in areas experiencing significant land-use changes. This method enables the collection of detailed and context-specific data by focusing on individuals who are directly associated with or affected by rubber cultivation practices in Lakhimpur District.

3.5 Sample Size

The study includes a sample of 20 respondents selected from the Lakhimpur district. These participants represent individuals directly involved or affected by rubber cultivation, including agricultural labourers, and local community members. The sample size was determined based on the qualitative nature of the study, aiming to capture diverse perspectives related to environmental and socio-economic changes associated with rubber farming. This number is considered adequate for generating in-depth insights through interviews and field observations without compromising the depth and richness of the data.

3.6 Methods of Data Collection

To explore the environmental and socio-economic impacts of rubber cultivation in Lakhimpur district, and unstructured interview schedule was used as a tool.

Unstructured Interviews

Unstructured interviews were conducted with a variety of stakeholders including rubber labourers and local residents. These interviews allowed respondents to freely express their experiences, opinions, and perceptions regarding the changes brought about by rubber cultivation. The flexible nature of this method enabled the researcher to explore

unexpected themes and follow up on relevant issues raised during the discussions. This approach was particularly useful in capturing personal narratives, local knowledge, and context-specific insights that may not emerge through structured formats.

3.7 Ethical Consideration

This study followed ethical guidelines to make sure everything was done fairly and respectfully. All participants were asked for their permission before taking part in the research, and they were told about the purpose of the study and how the information would be used. They were also informed that they could stop participating at any time if they wanted to. The names and personal details of the people who took part were kept private to protect their identity. During visits to the villages and rubber plantations, the researcher was careful to respect local customs and traditions. The study was done in a way that did not harm or take advantage of anyone, and the goal was to help understand and improve the situation for the local people and environment.

3.8 Limitation

• Limited Timeframe:

The study was conducted with in a restricted period, which constrained the depth of data collection and analysis.

Small Sample Size:

Only 20 respondents (rubber labourers) were included in the study, which may limit the comprehensiveness of the findings.

Geographical Constraints:

The research focused exclusively on the Lakhimpur district of Assam. Therefore, the findings may not be applicable or generalizable to other rubber-producing regions in India.

• Labour-Centric Focus:

The study primarily focused on the perspectives of rubber labourers, without incorporating a broader range of stakeholders such as landowners, local authorities, or market intermediaries.

• Language and Communication Barriers:

In some cases, language differences and limited literacy levels among participants may have affected the clarity and completeness of responses.

3.9 Tool for data analysis: The researcher efficiently organised and coded the interview data using QDA Miner Lite v3.0.5, a qualitative data analysis program, to make this procedure easier.

3.10 Inclusion Criteria:

- Labourerscurrently engaged in rubber cultivation in Lakhimpur district.
- Local residents who have experienced changes in land use due to rubber plantations.
- Individuals residing in the area for more than five years.
- Individuals aged 18 years and above.
- Experts or officials knowledgeable about rubber cultivation or land use practices.

3.11 Exclusion Criteria:

- Individuals not involved in or affected by rubber cultivation.
- Individuals residing in the area for more than five years.
- Individuals who are unwilling to participate or unable to provide informed consent.
- Minors (below 18 years of age).

CHAPTER IV DATA ANALYSIS & INTERPRETATION

TRANSCRIPTION-

RESPONDENT 1-

He is 43 years old and is a member of the local community. He has been working as a permanent employee in a rubber plantation for the last 10 years. He earns around ₹17,000 per month. He works as an employee in a rubber plantation. The income from rubber cultivation supports his family's livelihood. Outside the boundary of the main plantation, he also owns a small plot where he grows rubber himself. Many workers in the plantation are hired from the state of Tripura because the local people are not skilled in properly tapping rubber trees. He has not faced any major problems in cultivating rubber. He is not aware of financial issues or any government or private schemes only the plantation manager, who is from Tripura, handles such matters. He believes that if a company invests in the plantation, it could grow and develop further. Currently, the plantation only supplies raw rubber and does not produce any finished rubber products. The plantation started in 2012. Before that, the area was very backward. After the plantation began, some local people got employment there as workers. He also works as a labourer in the same plantation. Since the plantation started, road connectivity in the area has improved. Rubber cultivation has not harmed the land. Stearic and Formic acid is used to produce rubber from latex. From 2012 till now, he has not noticed any major health problems among the local people. Pests and diseases have not caused any serious damage to the rubber trees. However, if the trees are not tapped properly during seed collection, they may die after a few days. Many labourers come from Tripura, if their payments are delayed by the manager, some of them stop working and return to their homes. The rubber produced in the plantation is sold in Guwahati at a fair price.

RESPONDENT 2-

He is 33 years old and he is a permanent worker in the rubber plantation and has been working there regularly for three (3) years. The workers are paid between ₹15,000 to ₹20,000 depending on their work. Everyone receives their payments at different times. Through this work, the family of the worker is able to sustain itself. At present, the workers are not facing any major challenges because the owner pays them on time. They also do not face any financial problems. In that area, due to the presence of rubber plantations, job opportunities have increased, and people are finding it easier to get work. The manager of the plantation lives in Tripura. He has rubber plantations in other places as well, but he does not know exactly where all of them are located. The workers are getting benefits from both private and government sources, but they are not fully aware of what kind of benefits they receive. The owner believes that if the government gives more support for rubber cultivation, then rubber farming will grow and become more successful. Stearic and Formic acid is used in rubber processing, but it has not affected anyone's health badly. No major problems have been seen in rubber cultivation until now. Trucks arrive from outside on time to collect the rubber and transport it to Guwahati for sale.

RESPONDENT 3-

He is 29 years old and comes from Tripura. He has been working in the rubber plantation as a temporary worker for the last two (2) years and earns about ₹15,000 per month. The money is just okay for daily needs, but it becomes difficult if there are extra expenses or if he has to send money home. He says he only does his work and does not know much about schemes or any government help. He has heard that the government helps the plantation sometimes, maybe by giving money, but he does not know the names of any schemes or how they work. Nobody tells them about these things. He feels that the

situation of the workers has not improved much. There are no benefits for them, and even if the work increases, the salary stays the same. If workers ask questions or raise issues, they do not get clear answers. Sometimes when payment is delayed, workers face problems and some even leave and go back home. From what he has seen, the rubber plantation has affected the environment badly. Before, there were many big trees and different types of birds in the area. After starting the plantation, all those trees were cut down. Many birds that lived there have now disappeared. He also noticed that the water level in the area has gone down, especially during the dry season. People in nearby places find it hard to get water. He shared that rubber plantations are mostly done in hilly areas because rubber trees do not grow well in plain land. He said rubber trees do not absorb much water, and they do not disturb the land much either. But even with that, the cutting of natural trees for rubber farming has changed the balance of nature. He does not know where the rubber is sold or how much money it brings. Trucks from outside arrive on schedule to pick up the rubber and transport it to Guwahati for selling. He feels that workers are just used for labourers, and they have no say or knowledge about anything else. According to him, the way things are going, nature and people both are slowly getting affected, and nobody is doing anything about it.

RESPONDENT 4-

He is 35 years old and is a member of the local community. He has been working as a permanent employee in a rubber plantation for the last 10 years. He is employed full-time at the rubber plantation and carries out his duties on a daily basis. From this job, he earns approximately ₹20,000 each month, which helps him support his family. According to him, there have been no major problems in the plantation till now. However, he did mention that rubber cultivation may sometimes cause a drop in the groundwater level, which could lead to issues in the future. Despite this, he has not experienced any direct

difficulties related to his work. Over the years, he has noticed that the area around the plantation has developed a lot. Since the plantation started, many new shops have opened, and transportation facilities have improved. Roads are better now, and people can travel more easily. He also observed that many local people, like himself, have been employed in the rubber plantation. This has allowed them to earn money, manage their households, and take care of their families. In his experience, all the workers in the plantation do their work sincerely and on time. He has not faced any serious challenges in his job so far. Occasionally, the government provides financial support, although he is not always aware of the specific schemes or benefits. He believes that if the government or private sector offers more assistance, rubber plantations in the area can grow and become even more successful. Every day, labourers collect rubber latex from the trees. The rubber that is gathered is then weighed carefully. After weighing, the rubber is loaded into trucks and transported to Guwahati, where it is sold in the market.

RESPONDENT 5-

He is 29 years old and he is a permanent worker in the rubber plantation and has been working there regularly for three (3) years. His monthly income amounts to ₹15,000. He is a hardworking employee who handles various responsibilities in the plantation. However, he does not have any knowledge about government schemes or financial support related to rubber cultivation. According to him, no one has explained these things to the workers, and only the plantation owner or manager may be aware of such benefits. He also mentioned that while rubber cultivation has provided employment, it has caused some negative environmental effects. To make space for the plantation, many small and important trees were cut down, which has harmed the local environment. In terms of labourers issues, he said that sometimes the owner does not provide salaries on time. When this happens, some labourers return to their homes, and the plantation has to

manage with fewer workers. During such times, the remaining workers have to handle more tasks in a short period, which makes their job stressful and difficult. Despite these issues, he confirmed that rubber cultivation has not caused any harm to the land or the people living nearby. No health problems or land damage have been observed in the area so far. The plantation area remains safe for both nature and the community. He also shared that he does not know where the collected rubber is sold or what price it is sold for. The only thing he sees is that trucks come to pick up the rubber, but the workers are not informed about the sale process or pricing.

RESPONDENT 6-

He is 37 years old and belongs to the local community. He has been working in a rubber plantation for seven (7) years and currently earns around ₹17,000 per month. This income helps him support his family and manage household expenses. He works as a regular employee in the plantation and has not faced any serious problems in his work so far. He believes that the rubber plantation has played an important role in improving the overall development of the area. In the past, the place was underdeveloped, but since the plantation started, the area has seen good development. New shops and markets have opened, transportation facilities have improved, and more job opportunities have been created for the local people. Many others like him have also found employment in the plantation, which has made their lives more stable. He shared that most of the labourers in the plantation do their work on time and sincerely. Everyone has different responsibilities, and the tasks are managed well. He mentioned that the groundwater level has slightly decreased in some seasons, possibly due to rubber cultivation, but no serious environmental damage has been noticed. No harmful chemicals are used in the rubber farming process, and the land has not been affected in a negative way. Every day, the labourers collect rubber latex from the trees. It is important to cut the trees properly

during latex collection so that the trees are not damaged. Once the rubber is weighed, it is carefully loaded onto trucks and sent to Guwahati for selling. He does not know the exact price at which the rubber is sold, as only the trucks come and take the rubber away.

RESPONDENT 7-

He is 35 years old and belongs to the local area. He works as a permanent worker in a rubber plantation and earns around ₹17,000 per month. This money is enough for his own basic needs, but it is not enough to fully support his family or send money home. He is poor, and this job is the only way he manages his life. He has seen that rubber plantations are mostly done in hilly areas because rubber trees do not grow well in plain land. These trees do not need much water and do not damage the soil directly, but cutting down the old trees for plantations has affected the local environment. Many birds that used to live in those trees are no longer seen, and over time, the amount of rainfall also seems to have reduced. Rubber trees do not hold the soil tightly like other trees, which may be bad for land in the long term. He also said that many labourers have left the job because they were not getting paid properly or on time. The owner sometimes delays the payment, and this makes it hard for the workers to manage their homes. Because of that, there are fewer workers now, and one person has to do more work than before, which becomes difficult. He does not know anything about government or private schemes that support rubber plantations, even though he has heard that sometimes the plantation gets financial help. He does not know the names or details. When people in the village face water problems, they have to buy water from tankers, which is costly for them. He has been working here for a few years and noticed that the roads have improved and become wider, but at the same time, nature has changed.

RESPONDENT 8-

He is 32 years old and a permanent worker in the rubber plantation, living in the same local area where the plantation is based. He has been working here for the last six (6) years and earns around ₹18,000 per month. According to him, the money he earns from rubber work is useful for his daily life and household needs. It helps manage things at home, though he wouldn't say it completely changes his family's lifestyle. From what he sees, the job is steady, but there are always small issues. Sometimes the work gets heavy, especially when there are fewer labourers available. Not everyone stays in the job longterm, mainly because payments do not always come on time or match the amount of work done. He said rubber farming has brought jobs to the area, which has helped many locals, but at the same time, not everyone benefits equally. He is seen small shops and tea stalls open around the plantation area, which he feels is part of the development, but those things mostly help people who already have some money to invest. He heard from others that the government helps in some way with rubber farming, maybe through money or support, but he does not know the names of any schemes and has never received any support himself. Talking about the environment, he said a lot of trees were cut to make way for the plantation. He noticed that after those trees were gone, directly impact on rainfall Compared to earlier times, the amount of rainfall has decreased, but he is not sure if it is fully related. He feels that for rubber farming to be more helpful for people like him, there should be more proper support, and the payment system should be more clear and timely.

RESPONDENT 9-

He is 32 years old and belongs to the local community. For the past five (5) years, he has been working as a permanent employee in a rubber plantation, earning a monthly salary of around ₹17,000. He shared that rubber cultivation plays an important role in supporting

his household income, as the monthly earnings he receives from working in the plantation help him manage his daily needs. Although the income is enough for personal expenses, it is not always sufficient to fully support his family or send money home, especially during difficult times. He said that rubber farming has improved his family's standard of living to some extent, especially by providing regular work and income. However, he also mentioned some challenges in this sector. Sometimes, labourers availability becomes an issue, especially when the owner cannot pay workers on time. In such cases, some workers leave and return to their home states, making it difficult to complete work on time. Multiple tasks are often handled by the same labourers, which creates pressure during peak work periods. Financially, he does not receive any government or private scheme benefits, and he is not aware of any such programs. He feels that if proper support from the government or private organizations is made available, such as timely payments, access to schemes, and training programs, rubber farming could become more beneficial for local workers. Regarding the local economy, he observed that rubber cultivation has brought some development to the area, including improved transportation and increased job opportunities for both locals and migrant labourers. However, he also pointed out that rubber plantations have impacted the environment negatively. In the initial stages, many trees and local vegetation were cleared, which affected the biodiversity of the area. He also mentioned that the groundwater level has gone down, and sometimes water sources dry up, causing inconvenience to local people. As for soil quality and fertility, he said that there has not been any major visible damage, and no harmful chemicals are used in the cultivation process. Thus, there have been no significant health issues reported among workers or the nearby community. When it comes to selling the rubber, he is not involved in that process. He does not know where or how the rubber is sold, or whether a fair price is received. Only trucks from outside the district come and collect the rubber, and the workers are not informed about market prices or profits.

RESPONDENT 10-

He is 28 years old and comes from a very poor background. He works as a temporary labourers in a rubber plantation and earns ₹18,000 per month. This income is very important for him because it helps him manage his daily expenses and support his family's basic needs. Without this job, it would be very difficult for him to survive. He says that many people like him, both from local areas and from Tripura, have found work in the rubber plantation. It has created good job opportunities and has helped reduce unemployment in the area. He has seen that, because of the plantation, some people have started small shops nearby, and transportation has also improved. This has helped the local economy grow slowly. However, he believes that the plantation needs more help and support from outside, like from the government or private companies. He has noticed that workers often face problems when they are not paid on time or when they are not given their full wages. This causes some labourers to leave the job, and with fewer workers, it becomes difficult to complete all the work on time. Also, when there is a shortage of water in the area, many local people are forced to buy water from tanks, which is an extra burden for them. He feels that even though rubber plantations have brought some positive changes, there are also negative effects. Many trees were cut down to make space for plantations, and this has affected the environment. Birds have lost their homes, and the area has seen less rainfall than before. He thinks that rubber trees, unlike other trees, do not hold the soil well and do not improve the land's fertility. Still, he continues to work because this job is all he has for now, but he hopes for better support and improvements in the future.

RESPONDENT 11-

He is 32 years old and belongs to the local area. For the past four (4) years, he has been working as a gatekeeper at a rubber plantation. He works as a temporary worker. Every

month, he earns around ₹10,000. The income is not much, but it helps him cover his personal expenses. Supporting the entire family with this amount is sometimes difficult. He does not know much about the government or private schemes that might support rubber cultivation. No one has ever informed him about such benefits, and he has not received any help personally. His main focus is on his duty at the gate, and he does not interfere in other plantation activities. However, over time, he has observed some changes around him. According to him, the plantation has brought some development to the area. One of the noticeable changes is the improvement of the road—now it is broader and better than before, which makes transport easier. He is not involved in collecting or processing rubber, so he has limited knowledge about where the rubber is sold or how much it earns. He does feel that rubber farming has provided job opportunities to many people in the area, but he also knows that when payments are delayed, some workers face trouble. He has not personally seen any major environmental issues, but he has heard people say that many trees and plants were removed for the plantation, and that the water level sometimes goes down. Though he feels that development is happening, he also thinks that more awareness and support for workers would help improve their lives further.

RESPONDENT 12-

He is 29 years old and comes from Tripura. He has been working in the rubber plantation for the last two (2) years as a temporary worker. His monthly income is around ₹12,000. It is not a big amount, but he manages somehow. Most of the time, he receives his salary on time, though there can be some delay once in a while. He only does the work assigned to him and does not know much about the full process of rubber farming. He has heard that the government helps the plantation sometimes by giving financial support, but he does not know the names of any specific schemes. No one has explained it to him clearly.

Still, he thinks that kind of help must be useful for the plantation to keep going. He said that having this job has given him a fixed income, which is better than doing nothing. He has noticed some development in the area after the plantation came like better roads and a few new shops. More people have started coming here for work too. He does not know how the rubber is sold or at what price; only trucks come regularly to take the product. He said that when there are fewer workers, it becomes tough because one person has to do many things in less time. That is one problem they face sometimes. As far as he knows, no dangerous chemicals are used, and he has not seen anyone get sick from working here. He just comes, does his work, and leaves. If someone explained things better or supported the workers more directly, it might be helpful. But till now, no one has done that for him.

RESPONDENT 13-

He is 37 years old and originally comes from the state of Tripura. He works as a temporary worker. The income from rubber cultivation helps him to support his family and take good care of them. He earns approximately ₹12,000 per month from this job. The owner pays the workers on a fixed date every month, though sometimes the payment is delayed. He has not encountered any significant challenges otherwise. He is not aware of any government or private schemes related to rubber cultivation. In his area, no significant environmental changes or diseases have been observed because of rubber cultivation. No chemicals or special substances are used during the rubber cultivation process. The land has not been affected in any way. Rubber latex are collected daily, and no pests or diseases affect the rubber trees. The trees need to be cut properly while collecting seeds to ensure they do not get damaged. Many labourers work in the rubber plantation, each assigned to different tasks based on their roles and responsibilities. He does not know where the rubber is sold or how much it is sold for; only vehicles come to collect the rubber.

RESPONDENT 14-

He is 35 years old and belongs to the local area. He is employed as a permanent worker. He has been working in the rubber plantation for five (5) years and earns around ₹17,000 per month. The amount he earns is enough to take care of his own basic needs, but it is not enough for him to regularly send money back home or fully support his family. From his experience, he shared that rubber plantations are usually set up in hilly regions. He explained that rubber trees cannot survive well in flat or plain land because they do not take in much water and need specific soil conditions found in hill areas. According to him, these trees do not cause direct damage to the soil as they do not require heavy watering or chemical use, so the land itself does not get disturbed much. But at the same time, he pointed out some serious environmental issues. A large number of trees had to be removed to start the plantation, and that has badly affected the balance of nature in the area. Many birds that used to live in the old trees have disappeared because their habitats were destroyed. He also observed that rainfall has gone down in recent years, and he believes the clearing of trees may be one of the reasons. Unlike native forest trees, rubber trees do not have strong roots that hold the soil tightly. So, during heavy rains or wind, the soil can loosen, which may lead to problems like erosion. He thinks that while the plantation helps people get jobs and earn money, the long-term effect on nature should not be ignored. He does not know where or how the rubber is sold, or whether a fair price is received. Only trucks from outside the district come and collect the rubber, and the workers are not informed about market prices or profits.

RESPONDENT 15-

He is 27 years old and his home is in Tripura. He has been working in the rubber plantation as a temporary worker for the past two (2) years. He earns around ₹15,000 per month from his job in the plantation. According to him, he has not faced any kind of

problem while working there. The owner pays him the full salary every month on time. The money he earns is enough for him to manage his personal expenses. However, he faces some difficulty when he needs to send money back home to support his family. Still, he continues his work without complaint. He mentioned that no harmful substances or chemicals are used in the plantation that could affect people's health or spread disease. So far, he has not seen any negative impact of rubber cultivation on the environment. The area seems to remain safe and unchanged. He is not aware if the government or private sector has provided any help or support for the plantation. He also does not know much about the development activities that might have taken place because of the rubber plantation. His knowledge is mostly limited to the daily work he performs. He said that he has no idea how the rubber is sold, at what price, or whether it gets a fair market rate. His focus is only on his assigned tasks in the plantation, and he does not have much awareness about the business side or management-related matters.

RESPONDENT 16-

He is 37 years old and belongs to Tripura. He is employed as a temporary worker. He came here a few years ago in search of work and has been working in the rubber plantation ever since. Every month, he earns about ₹15,000. The money is enough for his daily needs, but sometimes, when prices rise or there's a family emergency, it becomes a little difficult to manage. He tries to send money back home, but it's not always possible. He feels that rubber cultivation has given him a stable job. Before this, finding regular work was not easy. The owner usually gives the salary on time, and that helps him plan things. But once in a while, the payment gets delayed, and that creates stress for some workers who depend on it to send money to their families. He does not know much about government or private help for rubber workers. No one explained those things to him. He has only heard that some people get benefits, but he is not sure how it works. He focuses

on doing his job cutting, collecting, and other tasks whatever is given. He said that before the plantation started, the land was full of different kinds of trees and local plants. People used to collect vegetables and fruits easily. Now, those are mostly gone. The rubber trees have replaced many of the old ones. Some locals say it has affected the environment, and even water is not as easily available as before. Sometimes, the wells dry up faster told more clearly about selling prices and where the rubber goes, that would help. He believes the plantation has helped people earn, but it also changed the land a lot.

RESPONDENT 17-

He is 28 years old and comes from Tripura. He has been working in the rubber plantation for the past three (3) years. He is employed as a permanent worker. His monthly income from this job is ₹13,000. However, the amount he earns is not enough to cover all his personal expenses, and he finds it difficult to send money back home. He mentioned that one of the main problems faced by labourers in the plantation is that despite working very hard, they do not receive fair payment from the owner. Many of his friends from Tripura, who had also come to work in the plantation, have already returned home because they were not paid properly. Due to the shortage of workers, it becomes difficult to manage all the work in the plantation smoothly. He said that he is involved only in the task of collecting latex from the trees, so he is not aware whether any chemicals are used in the plantation. He also does not know whether the government or any private sector are providing any kind of support to the plantation or the workers. In terms of environmental impact, he has not noticed any changes in the last three years neither positive nor negative. He feels that the surrounding area has not seen any particular kind of development either during this time. He shared that after the rubber is properly processed and weighed, it is loaded onto trucks and sent out for sale. From that sale, the plantation earns a good amount of income.

RESPONDENT 18-

He is 40 years old and belongs to the local community. For the past several years, he has been working as a permanent worker in the rubber plantation and currently earns a monthly income of ₹18,000. This income plays a crucial role in supporting his day to day life and meeting the basic needs of his family, though it is still not enough for any major savings or financial security. He manages his living with what he earns. Over the years, he has observed that rubber cultivation has provided employment to many people in the area, including locals and workers from Tripura. As job opportunities increased, many people opened small businesses like tea stalls and grocery shops near the plantation area, which has slightly improved the local economy. According to him, this kind of economic activity has brought some positive change, even though not everyone has benefited equally. He mentioned that rubber plantations are mostly done on hilly land because rubber trees do not grow well in plain areas. They do not absorb much water and, unlike other trees, rubber trees do not hold the soil strongly, which sometimes affects land stability. In his view, the plantation work led to the cutting down of many old trees, which earlier provided shelter to different birds and animals. After the trees were removed, many birds have disappeared, and even rainfall seems to have reduced. He cannot say for sure if it is all because of rubber cultivation, but he believes the local environment has been affected. Regarding his work, he says that while he has a regular job, many temporary labourers face issues like late or incomplete payment. This results in workers leaving, which creates a shortage of labourers. As a result, those who remain have to do more work under pressure. He feels that more timely and fair payment could help reduce these problems. He also noted that when water problems occur in the area, many local families are forced to buy water from tankers. He believes that this issue has become more frequent in recent years, possibly linked to the environmental impact of the plantation. In his opinion, while rubber cultivation has brought some economic benefits and job

opportunities, there are still many areas that need improvement especially more consistent worker support, available schemes, and steps to protect the local environment.

RESPONDENT 19-

He is 30 years old and has been working as a temporary worker in the rubber plantation for the past seven (7) years. Earlier, he used to earn a monthly salary of ₹10,000, but now the owner gives him ₹15,000 per month. This amount is enough to meet his basic personal needs, but it is not sufficient for him to send money home or support his family fully. The rubber plantation in that area started around 13 years ago, and it is owned by a man from Tripura. Most of the labourers working there are also hired from Tripura, rather than from the local area. He has not faced any major problems in rubber cultivation. However, he believes that the plantation has had a negative impact on the local environment. Before the plantation started, the area was full of trees and local people used to grow and collect different kinds of traditional medicine, vegetables which were easily available nearby. But when the rubber plantation was started, all those trees and plants were cut down to clear the land, and now people cannot collect those vegetables and medicine as they used to. He also mentioned that since the plantation began, the groundwater level has gone down. Sometimes the wells and handpumps dry up, and this creates problems for the local people in getting drinking water and water for daily use. When talking about the labourers situation, he said that there are very few workers in the plantation. Because of this, when there is more work to do, it becomes difficult to manage everything smoothly. The labourers collect rubber latex daily, and no harmful chemicals are used in the process. The rubber collected from the plantation is sold in outside markets at a good price, and the owner earns a good amount of income from these sales.

RESPONDENT 20-

He is 32 years old and belongs to the local area. He has been working as a permanent worker in the rubber plantation for the past two (2) years. His monthly income is ₹13,000, which is quite low considering the rising costs of living. Though this income helps him manage his own daily needs to some extent, it is not enough to properly support his family or save anything for the future. As a worker, he does his daily tasks sincerely, but he feels the salary does not match the hard work they do in the plantation. Despite everything, the job provides him with a source of income, which is preferable to being unemployed. He has seen that due to the plantation, many people from both the local area and Tripura have found work, which has reduced unemployment. Near the plantation, small shops and tea stalls have opened, which shows some economic growth in the area. In his view, rubber trees are not as strong in holding the soil like other trees, and this might slowly harm the land. He does not know much about government or private schemes that support rubber plantation, though he has heard such schemes exist. He believes that for better development, there should be more outside help from the company and government, and timely payments and fair wages for workers would improve the situation.

ANALYSIS

4.1: Employment & Livelihood

Rubber plantations are the primary source of employment for the respondents, with all twenty participants stating that their households depend heavily on plantation work for income. The nature of this dependence suggests limited availability of alternative livelihood options in the area. Rubber tapping is seasonal, but during the working months it provides a relatively stable, albeit modest, income.

A recurring issue raised was the shortage of labourers, which has resulted in increased workload for the remaining workers. This shortage often leads to extended working hours and heightened physical strain, especially during peak tapping periods. Despite the demanding nature of the work, most respondents continue to depend on this livelihood due to the absence of other viable income-generating opportunities in the region.

4.1.1:Stable income-

This sub-code reflects the role of rubber plantation work in providing a modest but relatively steady source of income during the tapping season. Most respondents shared that although the wages (ranging from ₹10,000 to ₹18,000) are not high, they are consistent during the working season, which makes a big difference in areas with few alternative job opportunities. For many families, this income forms the backbone of their household economy, covering basic needs like food, clothing, and sometimes education. However, respondents also noted that this income is usually not enough to save or support extended family, highlighting the economic limitations of such work.

4.1.2 : Job dependency-

This sub-code captures the heavy reliance of local and migrant workers on rubber plantations for employment. All twenty respondents indicated that their families are economically dependent on this work. Most participants had been involved in plantation work for several years (2–10 years), showing that this is not a short-term or casual job but a long-term livelihoodstrategy in the absence of alternatives. Many noted that other local employment options are either unavailable or insufficiently paid.

4.1.3: Overwork due to labourers shortage -

Several participants highlighted a decline in the number of available labourers, which has led to increased pressure on those still employed. The reasons for the shortage include delayed or insufficient payment, harsh working conditions, and some labourers returning

to their native places. As a result, the remaining workers are often burdened with longer hours and physically demanding tasks, especially during the high-yield tapping season. This condition affects their health and overall well-being, but many continue because they have no other source of income.

4.2: Payment Issues

A majority of respondents (15 out of 20) reported consistent problems related to their wages. The most common concern was the delay in receiving payments, which created uncertainty and financial strain, particularly for those living paycheck to paycheck. In some cases, payments were also incomplete, adding to the frustration. Another layer of the problem is the lack of transparency in how rubber prices are determined. Many workers are unaware of the grading, pricing, and selling processes, leaving them in a vulnerable position where they have little control or understanding of how their earnings are calculated. This lack of clarity reduces their sense of financial security and limits their ability to advocate for fair compensation.

4.2.1: Incomplete payments-

This sub-code refers to instances where workers reported not receiving the full amount of wages they were promised or expected. Out of the 20 respondents, many shared that they either received less than their due earnings or faced irregularities in the way payments were handled. These issues appear to be more common among temporary workers, though permanent workers also expressed similar frustrations, especially during periods of financial pressure on plantation owners.

4.3: Awareness of Government Schemes

Seventeen respondents indicated they were either unaware of or unable to access government schemes meant for plantation workers or rural communities. This reflects a significant gap in information dissemination and outreach. In many cases, only supervisors or those with better socio-economic status seemed to have access to such information or benefits.

Even when workers had heard of certain schemes, bureaucratic hurdles, lack of documentation, and digital illiteracy made it difficult for them to apply. As a result, most workers remained excluded from government support that could otherwise enhance their welfare and improve working conditions.

4.3.1: Lack of awareness or access to support programs-

This sub-code captures the widespread information gap and systemic barriers that prevent rubber plantation workers from benefiting from government or private welfare schemes. From the responses, 17 out of 20 participants reported either complete unawareness of such schemes or an inability to access them despite hearing about them. This reflects both a knowledge deficiencyandanaccessibility challenge, especially for those with low literacy, digital access, or social networks.

4.4: Development & Infrastructure

Fourteen participants reported observing significant infrastructural improvements associated with the expansion of rubber plantations. The most visible improvements included better roads, increased availability of public and private transport, and a rise in the number of small shops and businesses around plantation areas.

These changes have improved connectivity, allowing easier access to nearby towns, markets, schools, and healthcare facilities. Such developments have indirectly contributed to an improved quality of life for both plantation workers and the broader community. However, these benefits were often seen as a by-product of economic activity rather than targeted development initiatives.

4.4.1 Better roads-

Many respondents noted that road conditions have improved significantly since the introduction and expansion of rubber plantations in their area. These roads, which were once in poor condition often muddy and inaccessible during rainy seasons have now been upgraded to support the movement of plantation-related vehicles and workers. This change has helped ease daily travel for labourers and made transportation of goods smoother. Participants expressed that these improvements, while helpful, were not directly aimed at community development but served the operational needs of the plantation industry.

4.4.2 Shop-

Respondents also shared that with the growth of rubber plantation activity, small businesses and shops have started appearing near plantation zones. These shops cater mainly to the daily needs of plantation workers, offering food items, tea, groceries, and other basic supplies. For many, this means no longer having to travel to distant markets, thus saving time and money. Some respondents even mentioned that the presence of these shops has created new economic opportunities for local families, although these are mostly small-scale and informal.

4.4.3 Transport after plantation development-

Another area of improvement observed was public and private transportation. With better roads and increased activity around plantations, the availability of transport services has

improved. Workers shared that access to auto-rickshaws, shared vehicles, and occasional bus services has become more frequent compared to the past. This has made it easier not just for commuting to work, but also for accessing schools, markets, and health services. However, a few participants still mentioned that transport services are not always reliable and may be limited during non-working hours.

4.5: Environmental Impact

Thirteen respondents discussed environmental changes they had observed over the years. Deforestation emerged as a significant concern, with large areas of natural vegetation cleared to make way for rubber plantations. This has resulted in a noticeable decline in biodiversity, particularly in bird populations.

Respondents also reported changes in weather patterns, such as reduced and irregular rainfall, and a gradual depletion of groundwater sources. These environmental impacts are seen as long-term consequences of mono-cropping practices and the replacement of native vegetation with rubber trees. The community expressed concern about how these changes might affect their future livelihoods and ecological balance in the region.

4.5.1: Deforestation

A majority of respondents mentioned that large areas of forest and natural vegetation had been cleared to establish rubber plantations. This clearing of land was described as drastic in some areas, where dense tree cover once existed. The removal of native trees and plants has led to the visible loss of green cover and natural shade, which earlier supported a variety of plant and animal life. Some respondents expressed worry about how such deforestation may impact soil erosion, wildlife, and the long-term sustainability of the area.

4.5.2: Loss of Birds

Many participants noted that birds which were once commonly seen and heard around their homes and fields have decreased significantly. The respondents linked this decline in bird populations to the felling of big trees that served as nesting sites and food sources. A few also pointed out that with fewer trees and denser rubber rows, birds may not find suitable shelter. This loss of birds was felt not only as an ecological concern but also as a change in the natural beauty and soundscape of the area.

4.5.3 :Declining Rainfall

Several respondents shared their observations that rainfall in the area has become less frequent and more unpredictable in recent years. Earlier, the rains would come more regularly and support agriculture, but now, delays and shorter rainy periods are common. Some participants suspected that the expansion of rubber plantations and the loss of mixed vegetation may have influenced local weather conditions. The decline in rainfall was also seen as affecting other farming activities and daily life.

4.5.4: Groundwater Depletion

A noticeable number of respondents mentioned that water availability has reduced over time. Wells that once provided enough water throughout the year now dry up quickly, particularly in summer. They believe this issue is worsening, and many households have had to start buying water from tankers, especially during dry spells. Some workers suggested that rubber trees absorb large amounts of water, which could be contributing to the drop in groundwater levels. This has added pressure to daily household needs and farming.

4.6: Health and Safety

Sixteen respondents reported no major health issues related to their work in rubber plantations. While the job is physically demanding, especially due to the need for early morning tapping and long hours, it is generally not perceived as hazardous. The use of chemicals such as pesticides and fertilisers was reported to be minimal and controlled.

Workers stated that appropriate precautions are usually taken during chemical use, suggesting a basic level of awareness regarding safety practices. Overall, the work environment was perceived as relatively safe, particularly in comparison to other agricultural or industrial sectors.

4.6.1: No major health issues-

Most of the respondents (16 out of 20) stated that they had not experienced any serious health problems due to their work in rubber plantations. Although the nature of the job involves physical laboursuch as walking long distances, climbing small slopes, and working early in the morning workers did not identify these as health hazards. They viewed these conditions as part of normal agricultural labour and not harmful to their long-term well-being. A few workers did mention tiredness and body pain, especially after long hours, but these were seen as manageable and not severe.

4.6.2: Safe chemical use-

The majority of respondents believed that chemical usage in rubber plantations was limited and handled with caution. Fertilisers and pesticides are used occasionally, and when they are, workers reported that the plantation management usually follows basic safety measures. Some respondents indicated that spraying is done by specific persons or under supervision, which reduces exposure for regular tappers. While not all workers were fully aware of the exact chemicals used, there was a general sense that safety was maintained and the work did not pose a direct health risk from chemical exposure.

4.7: Migration & Labourers Dynamics

The dynamics of labourers within rubber plantations have been significantly influenced by migration patterns. Twelve respondents noted the presence of workers from Tripura, who are a key part of the plantation workforce. These migrant workers often stay in temporary settlements and contribute substantially to the plantation's operations. However, delayed payments and unsatisfactory living conditions often lead to high labourers turnover. Workers from outside the region frequently leave in search of better opportunities, resulting in disruptions in workflow and increased pressure on the remaining workforce. This turnover further exacerbates the labourers shortage mentioned earlier and creates instability in plantation operations.

4.7.1 Workers from Tripura-

A significant number of respondents (12 out of 20) mentioned the presence of migrant labourers from Tripura. These workers have become an important part of the rubber plantation workforce. Due to the shortage of local labourers, plantations rely on migrants to meet labour demands, especially during peak tapping seasons. The migrants usually live in basic temporary shelters near the plantation sites. Though they are hardworking and dedicated, they often face hardships such as poor living conditions and lack of access to basic services. Still, their presence helps maintain productivity in the plantations.

4.7.2 Labour turnover due to payment delays

Respondents highlighted that many migrant workers do not stay long due to delayed or irregular payments. Payment-related issues such as incomplete wages and long gaps between work and compensation frustrate workers who rely on steady income. As a result, some workers return to their home states or move to other places in search of more secure jobs. This high rate of turnover disrupts the efficient functioning of rubber

plantations. It creates gaps in the workforce, increasing the workload on permanent or remaining workers and sometimes leading to delays in tapping and latex collection.

4.8: Unequal Economic Benefits

Only eight respondents believed that the economic benefits of rubber plantation development were fairly distributed. Most believed that only landowners, traders, and shopkeepers had gained significantly. Workers and small farmers felt excluded from the profits generated by the plantation economy.

This perception of unequal development was especially strong among those who do not own land or operate businesses. For them, rubber plantation work offers subsistence-level income without any long-term economic mobility. As a result, while the region may appear to be economically developing on the surface, the benefits are not reaching the majority of the labourersing class.

4.8.1 Development benefits limited to those with money or shops-

Among the respondents, only 8 out of 20 felt that the benefits of rubber plantation development were fairly distributed. A large number expressed the view that the real economic gains were going to a few individuals mainly plantation owners, rubber traders, and local shopkeepers who could afford to invest or do business. These groups were seen as profiting from the increase in economic activity around plantations, such as higher latex output, local trade, and transportation services.

In contrast, most workers, especially those without land or additional income sources, felt left behind. Labourers earning monthly wages reported that their income remained low and irregular, offering little chance for financial improvement. Some also noted that while small shops had opened near the plantations, only those with capital could start such businesses something out of reach for the average worker. A few respondents even

remarked that although the area now seemed more developed, their own living conditions had not changed much.

CHAPTER V DISCUSSION & FINDINGS

This chapter offers a comprehensive discussion of the study's major findings related to rubber cultivation in Lakhimpur district, with a particular focus on its socio-economic andenvironmental implications. The analysis is grounded in the voices and lived experiences of the plantation workers and local stakeholders who are directly impacted by the spread of rubber plantations in the region. The narratives collected from 20 respondents provide a rich, qualitative insight into the daily realities of those engaged in this occupation.

The chapter begins by examining employment patterns and livelihood dynamics, highlighting how rubber plantations have become a primary source of income for most workers in the absence of other viable economic opportunities. While rubber tapping provides some level of income stability, especially during active tapping seasons, challenges such as labour shortages, wage delays, and lack of job securitywere repeatedly raised by the respondents. Many workers expressed concern over the increasing workload caused by the shortage of available labourers, which has led to overwork and physical exhaustion.

Another important theme explored is the awareness and accessibility of government schemes meant for plantation workers. Despite the existence of several welfare programmes, a majority of the respondents were either unaware of them or unable to benefit due to bureaucratic hurdles, illiteracy, or lack of proper documentation. This reflects a significant gap in policy implementation and information dissemination, particularly for marginalized rural populations.

The study also sheds light on the development of infrastructure resulting from the economic activity surrounding rubber plantations. Improved roads, transportation facilities, and the emergence of small businesses were commonly cited as positive outcomes. However, these benefits were often seen as indirect or incidental, rather than part of a deliberate development strategy aimed at uplifting plantation communities.

In terms of environmental impact, many respondents observed negative ecological changes, including deforestation, declining bird populations, reduced rainfall, and depleting groundwater levels. These changes were largely attributed to monoculture practices and the replacement of native vegetation with rubber trees. Such ecological shifts have raised concerns about the long-term sustainability of rubber cultivation and its effects on local biodiversity and agricultural viability.

Finally, the chapter explores howrubber cultivation has reshaped social and economic lifein the region. It has brought both opportunities for employment and improved connectivity, while also intensifying social and environmental challenges. By weaving together these varied experiences, the chapter presents a nuanced picture of rubber cultivation's role in the region as both a source of livelihood and a factor of socio-environmental transformation.

FINDINGS

1. Rubber Plantations as the Core Livelihood Source

For the respondents, rubber plantations are not just a source of income, they are the onlysource of livelihood for most families. All 20 participants expressed a strong reliance on rubber-related work, with little to no alternative employment opportunities in the vicinity. This dependency highlights the economic centrality of rubber cultivation in their lives, but also exposes them to risk, as fluctuations in rubber prices or work availability directly affect their household security. The lack of job diversification suggests a need for additional livelihood avenues to ensure long-term economic resilience.

2. Labourers Shortage and Overwork Burden Workers

A recurring concern among workers was the shortage of labourers, which forces the remaining workforce to take on extra responsibilities. This increased workload, particularly during harvesting periods, leads to physical exhaustion and mental stress.

Workers often begin their tasks before dawn, with little rest or recovery, especially when others quit or are absent. Despite their dedication, they are stretched thin, and many feel that the burden is unfair and unsustainable in the long run.

3. Widespread Payment Irregularities and Lack of Transparency

Delayed and incomplete payments emerged as a major grievance among 15 respondents. In many cases, wages were not paid on time or in full, making it difficult for families to meet basic needs. This issue is compounded by the lack of transparency in how rubber is priced and how earnings are calculated. Workers are rarely informed about market rates or plantation profits, leaving them in a powerless position. The lack of financial clarity contributes to frustration and mistrust toward plantation management.

4. Poor Awareness and Unequal Access to Government Schemes

Despite the government's various schemes for labourers, most respondents (17 out of 20) were unaware of such programs or did not know how to access them. Only supervisors or plantation managers seemed to have some information, which points to a major communication and implementation gap. As a result, the intended beneficiaries labourers are left out of support networks that could improve their conditions. This knowledge barrier reinforces social inequality and economic stagnation among lower-income workers.

5. Improved Local Infrastructure Linked to Plantation Growth

Respondents acknowledged that the establishment of rubber plantations has led to some positive changes in local infrastructure. Roads have improved, transportation is more accessible, and new shops and services have emerged in nearby areas. These changes are indirectly tied to the economic activity generated by plantations. However, these benefits are not evenly distributed, and some respondents felt that only specific groups like landowners and traders gained the most from such development.

6. Environmental Concerns: Deforestation, Water Scarcity, and Biodiversity Loss

While the economic advantages of rubber cultivation are visible, they come at a cost to the environment. Several respondents raised concerns about the loss of forest cover, which has reduced local biodiversity especially birds and contributed to falling rainfall levels. Groundwater sources are also reported to be drying up, especially in areas where large tracts of land have been converted to rubber monoculture. These environmental changes directly affect the sustainability of both agriculture and daily life in the region.

7. Labourers is Physically Demanding but Perceived as Safe

Most respondents did not report serious health hazards related to plantation work. Chemicals used in the plantations were generally believed to be safe, and there were no major incidents of poisoning or chronic illness linked to their use. However, the nature of the work tapping rubber early in the morning and carrying heavy loads is physically taxing. The lack of mechanization or support tools adds to the strain. Despite this, workers seem to normalize the hardship, focusing more on job stability than on occupational safety.

8. Labourers Migration and High Turnover

A significant proportion of labourers are migrants from Tripura, reflecting inter-state labourers dependence. While these labourers are critical to maintaining the plantation workforce, they often leave due to wage delays or poor working conditions. This high turnover disrupts plantation productivity and increases pressure on those who stay behind. The fluid nature of the labourers force underscores deeper issues of instability and dissatisfaction within the rubber plantation system.

9. Inequitable Distribution of Economic Gains

Though rubber plantations have brought some prosperity to the region, not everyone benefits equally. Respondents noted that individuals with financial resources such as shopkeepers or landowners gain more from plantation-linked development. In contrast, workers feel marginalized, unable to access the same economic opportunities. This disparity creates a sense of exclusion and resentment among those who contribute the most labourers but receive the least in return.

CHAPTER VI CONCLUSION & SUGGESTIONS

This study explored the multifaceted impacts of rubber cultivation on land use patterns, the environment, and socio-economic conditions in Lakhimpur district. The findings highlight the critical role that rubber plantations play in shaping the livelihoods of local communities, providing a primary source of stable income for many workers and smallholders. Employment generated through rubber cultivation has contributed significantly to economic empowerment in the region, though this dependency has also introduced challenges such as labourers shortages, overwork, and payment irregularities.

While rubber cultivation has spurred infrastructural development improving roads, transportation, and market access these benefits have not been equitably distributed. Financial advantages tend to favor landowners and shopkeepers, often leaving marginalized groups with limited gains. Moreover, limited awareness and access to government schemes have further restricted opportunities for many workers and cultivators, underscoring the need for enhanced outreach and support systems.

Environmental impacts present another dimension of concern. The expansion of rubber plantations has been associated with deforestation, biodiversity loss, declining rainfall, and groundwater depletion. These changes threaten the ecological balance and long-term sustainability of the region's natural resources. Notably, the environmental degradation is compounded by the monoculture nature of rubber cultivation, which reduces landscape diversity and resilience.

On the positive side, the majority of respondents reported safe chemical use practices and no major health issues, indicating some level of awareness regarding occupational health and safety. However, ongoing vigilance is required to prevent future risks.

This study underscores the complex interplay between economic development and environmental stewardship in Lakhimpur's rubber-growing areas. It points to the urgent need for policies that promote sustainable land use, equitable economic benefits, and improved worker welfare. Strengthening local capacity through education, skill

development, and improved access to government support schemes is essential to empower communities and reduce vulnerabilities.

Ultimately, the future of rubber cultivation in Lakhimpur depends on balancing economic aspirations with environmental conservation. Collaborative efforts involving government agencies, local communities, NGOs, and the private sector are crucial to fostering sustainable practices that ensure the well-being of both people and the environment.

SUGGESTIONS

The following suggestions are proposed to enhance the sustainability of rubber cultivation while addressing socio-economic and environmental challenges in the Lakhimpur district:

• Strengthen Employment Stability and Labourers Welfare

Ensure fair wages and timely payments to plantation workers through regular monitoring and enforcement mechanisms. Introduce labourers contracts or agreements to safeguard workers' rights and reduce instances of delayed or partial payments. Establish worker welfare committees at the plantation level to voice concerns and resolve labourers related issues promptly.

Address Labourers Shortages and Improve Working Conditions

Promote local recruitment and skill development initiatives to reduce dependency on migrant labourers. Enhance mechanization and tool support in plantations to reduce physical strain caused by labourers shortages. Provide health insurance and safety gear, especially for tasks involving chemical usage or physically demanding work.

• Improve Awareness and Accessibility of Government Schemes

Conduct regular awareness drives at the village level to inform workers and small cultivators about government schemes and subsidies available for rubber cultivation, housing, healthcare, and education. Facilitate linkages between rubber workers and local government departments through NGOs or self-help groups to assist in availing benefits. Develop accessible information materials in local languages with pictorial guides for illiterate or semi-literate workers.

• Promote Inclusive Development and Equitable Benefit Distribution

Encourage plantation development models that include profit-sharing or cooperative ownership to ensure that benefits reach all stakeholders not just landowners or shopkeepers. Promote micro-enterprises and alternative income sources for families not directly involved in rubber cultivation, such as food stalls, tailoring, or handicrafts.

• Invest in Sustainable Infrastructure and Support Services

Continue improving road connectivity, transport services, and local markets, especially in remote plantation areas. Build community centres or rest facilities for plantation workers, particularly women and elderly workers, to improve their quality of work life.

• Address Environmental Concerns Proactively

Encourage mixed cropping and agroforestry models to reduce the monocultural nature of rubber plantations, thus mitigating biodiversity loss and deforestation. Promote rainwater harvesting and groundwater recharge practices to address concerns over declining water levels. Encourage plantation owners to retain buffer zones of native forest and avoid complete land clearance to preserve local ecosystems.

• Encourage Policy Interventions and Monitoring

Advocate for the formulation of district-level guidelines for sustainable rubber cultivation practices, including environmental clearances. Encourage collaborative platforms between the government, Rubber Board, and civil society organisations to monitor plantation expansion and its socio-economic effects. Support research and development in low-impact rubber harvesting and soil preservation techniques through agricultural extension services.

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APPENDIX

Informed Consent

I, **Deep Jyoti Saikia**, a student of the Social Work Department, Mahapurusha Srimanta SankaradevaViswavidyalaya, Guwahati Unit, promise that this interview schedule will only be used for my dissertation titled, "Rubber Cultivation and Land Use Patterns in Lakhimpur: Environmental and Socio-Economic Implications." under the supervision Dr. Deepshikha Carpenter, HOD(i/c) & Assistant Professor, Department of Social Work, MSSV, Guwahati Unit. I assure you that your answers will be kept confidential and used solely for educational purposes. Therefore, I kindly request your valuable input in responding to the following set of questions.

INTERVIEW SCHEDULE

- 1) How does rubber cultivation contribute to your household income?
- 2) Has rubber farming improve your family's standard of living?
- 3) If yes in what ways?
- 4) What challenges do you face in rubber farming?
- 5) Do you face any financial difficulties?
- 6) If yes, what kind of financial difficulties?
- 7) How has rubber cultivation affected job Opportunities and the local economy in your area?
- 8) Are there any government or private programes supporting rubber farming?
- 9) Have you benifited from private programe?
- 10) What improvement help do you think are needed to make rubber farming more beneficial for local workers?
- 11) Have you noticed any changes in the local environment since rubber cultivation started?
- 12) How has rubber farming affected soil quality and fertility in your area?
- 13) Are any chemicals used in rubber farming?
- 14) If yes, how do they impact human health on the environment?
- 15) What are the biggest difficulties you face in rubber farming?
- 16) Is labour availability a challenge in rubber farming? If yes/no elaborate.
- 17) Do you get fair prices for your rubber products?

- 18) If not what are the reason?
- 19) Are there any difficulties in selling on transporting your rubber?
- 20) What kind of support/help improve your rubber farming?
- 21) Are you aware of schemes for give rubber plantation?

